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“RED” Matters When Naming “CAR”: The Cascading Activation of Nontarget Properties

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Seven experiments tested, whether when naming a colored object (e.g., *CAR*), its color (e.g., *red*) is phonologically encoded. In the first experiment, adults had to say aloud the names of colored line drawings of objects that were each displayed among 3 black-and-white line drawings (Experiment 1a) or that were presented alone (Experiment 1b). Naming times were shorter in Experiment 1a, but not in Experiment 1b, when both the color and object names were phonologically related (e.g., *blue ball*). In Experiment 2a, adults had to name objects having diagnostic colors (e.g., *banana*, *tomato*) while hearing distractor words. Compared with unrelated distractors, object naming times were longer when the distractors were phonologically related to the names of the colors, indicating that the names of the colors were activated. In Experiment 2b, this inhibitory effect did not surface when the same pictures were displayed in black and white, indicating that it originates from the perceptual level. In Experiment 3a, we used the same paradigm as in Experiment 2 (a and b) with objects having “plausible,” but nondiagnostic, colors (e.g., *red CAR*). The inhibitory effect of color-related distractors turned out to be reliable but it vanished when regular colored-line drawings were used (Experiment 3b) and when colors and objects were spatially segregated (Experiment 3c). Taken together, the findings strongly suggest that under certain circumstances, an object’s properties are phonologically activated during object naming. These findings are accounted for in terms of the general attentional view of cascading of Oppermann, Jescheniak, Schriefers, and Görges (2010).

Keywords: picture naming, cascading, visual properties, colors, attention

Returning back to work after lunch, Peter and Mike are walking along the streets of a big city. Suddenly, Peter sees a beautiful red car driving quickly toward them and says to Mike “Oh, look at that car!” Is the color *red* linguistically encoded when Peter says “*Oh, look at that car!*” in this specific situation where a single red car suddenly enters your field of vision and catches your attention? Or, does only the concept of CAR get activated and linguistically encoded? The present study was aimed at shedding light on these specific questions and, more generally, we addressed the issue of the phonological activation of “nontarget” properties (e.g., *red*) when naming target objects among other objects (CAR in the above example), or when naming concepts having salient properties, such as colors.

When producing a word from a concept that we intend to express, there are several types of representations that are activated at different processing levels. According to most views of word production (e.g., Dell, 1986; Levelt, Roelofs, & Meyer, 1999; Roelofs, 1992; Starreveld & La Heij, 1996), producing a word from an idea starts with the conceptual level where a target concept (e.g., CHEESE) and related concepts (e.g., FOOD and MILKY) are activated. Then, there is a level where the corresponding abstract lexical representations, often referred to as lemmas, get activated. Finally, there is activation of phonological representations at the word-form level. Phonological codes are then used to build syllable-based phonetic representations that will serve as inputs to derive motor programs that will ultimately be executed by the articulators.

In the field of spoken language production, there has been a long-lasting debate on the principles of activation flow through the conceptual-lexical system (see Goldrick, 2006 for a review). A growing body of behavioral (e.g., Morsella & Miozzo, 2002), but also neuroscientific (e.g., Miozzo, Pulvermüller, & Hauk, 2014) evidence supports the view that there is some degree of temporal overlap (i.e., cascading processing) between the different processing levels involved in object naming. At one extreme is the “full-cascading” view which holds that *every* activated concept, and not only the concept to be named (= the target concept), is automatically phonologically encoded. This view has received some empirical support in the past, mainly from studies using the *picture-picture interference* paradigm (Meyer & Damian, 2007; Morsella & Miozzo, 2002; e.g., Navarrete & Costa, 2005; Roelofs,

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2008; Roux & Bonin, 2012 [in written naming]; but see Jescheniak et al., 2009). In these studies, two superposed line drawings were presented to participants, with line colors cueing the target picture (i.e., the picture to be named) and the nontarget picture (i.e., the one to be ignored). Shared phonological features between the two object names have been found to speed up vocal responses (e.g., Morsella & Miozzo, 2002; Navarrete & Costa, 2005), suggesting that the phonological codes of both concepts are simultaneously activated. However, a growing body of evidence challenges this view, suggesting that the mere presence of a nontarget object in a visual scene during naming is not sufficient to observe the retrieval of its phonological features (e.g., Oppermann, Jescheniak, & Schriefers, 2008; Oppermann, Jescheniak, Schriefers, & Görges, 2010). For instance, using the *picture-word interference* paradigm, Oppermann et al. (2008) designed a series of experiments in which participants were presented with target and nontarget drawings spatially arranged to form either a coherent scene (e.g., a MOUSE eating some CHEESE) or a noncoherent scene (e.g., a MOUSE standing next to a FINGER). The target pictures were cued either by their thematic roles (agent vs. patient in Experiment 1) or by their colors (green or red in Experiment 2). Auditory distractor words that were phonologically related or unrelated to the context object name (e.g., CHEESE) were used to assess whether the context object had become phonologically activated. Oppermann et al. (2008) found that in coherent scenes, naming was delayed when participants listened to distractor words that were phonologically related to nontarget objects (e.g., *chess* related to CHEESE) compared with unrelated controls. In contrast, there was no reliable effect of nontarget-related distractors when naming targets in noncoherent scenes. Thus, the inhibitory effect of nontarget-related distractors has been taken as evidence that nontarget objects are activated at the phonological level, suggesting that the conceptual coherence among displayed objects promotes the coactivation of their names. Other studies support the view that the coherence of visual information seems to affect the cascading of information in the conceptual-lexical system within a cascaded framework of spoken naming (the semantic relateness between objects, e.g., CUCUMBER and CARROT, Oppermann et al., 2010; the similarity of the visual shapes of pairs of objects, for example, PEAR and BELL, Oppermann, Jescheniak, & Görges, 2014; or the level of visibility of objects in the visual scene, Mädebach, Jescheniak, Oppermann, & Schriefers, 2011). Collectively, this reflects a more general principle of how an attentional control mechanism might be deployed to regulate the information flow in the conceptual-lexical system (Oppermann et al., 2010).

Taken overall, the findings of Oppermann and colleagues do not accord with the hypothesis that *every activated concept* can *automatically* spread activation up to its phonological features (e.g., Morsella & Miozzo, 2002). They are also consistent with previous findings reported by Bloem and La Heij (2003) and Bloem, Van den Boogaard, and La Heij (2004) that context pictures do not activate their names when participants are asked to translate a target word (a lack of phonological facilitation).

In the present study, we addressed the issue of cascading processing during object naming with regard to *object properties*. Indeed, cascading processing has been investigated mainly for object *identity*. In effect, to our knowledge, evidence showing that cascading processing occurs for the visual *properties of objects* is scarce at best. Certain studies have found that the *color* of an object was not phonologically encoded when saying aloud the name of a colored object. Dumay and Damian (2011) used line-drawings of objects whose names were either phonologically related to the color in which they were depicted (e.g., BOTTLE colored in BLUE) or unrelated (e.g., BOTTLE colored in RED). The phonological overlap between the objects and the color names facilitated color naming latencies, suggesting that object names activate their phonological codes while naming the color. In contrast, object naming was unaffected when saying the name of an object, and the phonological relationship between its name and its color name had no detectable influence on the naming speed. In line with other findings (Kuipers & La Heij, 2009; Mädebach, Alekseeva, & Jescheniak, 2011), this suggests that the activation of nontarget colors does not spread freely to the phonological level. We recently thoroughly addressed this issue by focusing on a visual object property other than color, namely object size (Roux, Bonin, & Kandel, 2013). In our study, participants were asked to name either the identity of depicted objects or their *size* (i.e., *big* or *small*). The size of the objects was manipulated either by having drawings of objects depicted on a computer screen in a small or large size, or by using objects that are large (e.g., a *gorilla*) or small (e.g., *an ant*) in the real world. In order to test for the phonological activation of the nontarget concept, we used object and size names that were (or were not) phonologically related (e.g., GRAND-GORILLE — *big-gorilla* for related trials). We found that shared phonemes speeded up vocal responses in size naming, but not in object naming. These findings therefore suggest that when an object is to be named, its identity, but neither its color nor its size, is phonologically encoded.

To our knowledge, there is only one study that supports the idea that, under certain circumstances, the activation of a nontarget property propagates to the phonological level. Indeed, Janssen, Alario, and Caramazza (2008) reported that English native speakers were faster when producing object names that were phonologically related to the name of the associated color (e.g., a *blue* BALL), whereas this is not the case in French native speakers. According to these authors, this is because color adjectives precede nouns in English but not in French, suggesting that word order constrains the flow of activation that is able to reach the phonological segment layer (but see Roux, Bonin, & Kandel, 2013). However, it must be stressed that these results have not as yet been replicated (see Kuipers & La Heij, 2009; Mädebach et al., 2011; see Dumay & Damian, 2011 for failures to replicate). In sum, with the exception the findings of Janssen et al. (2008), there is to date no available clear-cut evidence suggesting that nontarget properties get phonologically activated in the course of object naming. However, as the example provided at the beginning of the Introduction suggests, there may be certain circumstances where nontarget properties of objects are phonologically activated when saying their names aloud. Following Oppermann et al.'s (2014) proposal, the extent to which nontarget properties are phonologically processed could depend on the characteristics of the visual scene, such as the perceptual and/or semantic relationship(s) between colors and objects, and on the amount of attention that each receives. The failure in previous studies to find evidence for the activation of nontarget properties at the phonological level might have been due to the fact that the properties of the to-be-named objects were not salient enough. Thus, in our view, the properties of objects have to capture some amount of attention if they are to result in deeper processing by the speech production system. Following Oppermann et al.'s (2014) proposal, we assume that in object naming, from the conceptual level, there is some attention-driven restriction in the activation flow.

The goal of the present study was to assess the hypothesis that the properties of objects activated at the conceptual level are phonologically encoded when they are made salient, either "externally" because of a particular communicative situation (Experiments 1a and 1b) or "internally" because they lie at the core of the conceptual representations (Experiments 2a, 2b, and 3a). In Experiments 1a and 1b, participants had to name a colored object presented in an array of three black-and-white drawings (see Figure 1). Because in this task, the colors act as cues for the identification of the targets, we should find that the color names are phonologically encoded during object naming in communicative situations where the color property is made salient. Because colors are assumed to be an important dimension in the structure of conceptual object representations (e.g., Connell & Lynott, 2009), we assume that phonological encoding of nontarget properties could be observed for objects having diagnostic colors (e.g., *yellow* for *banana*; *red* for *tomato*). In Experiments 2a and 2b, we used the picture–word interference paradigm to test this hypothesis. As described above, in this experimental technique, participants are presented with target pictures they have to name and distractor words they have to try to ignore. The observation that colors activate their phonological codes during object naming in these situations would provide the first clear evidence for a cascaded activation of objects properties. The question of whether this cascading processing also occurs for objects having plausible but nondiagnostic colors was tested in Experiment 3a. Finally, we also performed two additional control experiments (Experiments 3b and 3c) whose rationale will be presented later.

Experiment 1: Colored-Object Naming in Context (Experiment 1a) and Standard Colored-Object Naming (Experiment 1b)

Experiment 1a: Colored-Object Naming in Context

Method.

Participants. Forty psychology students from the University of Bourgogne took part in this experiment in exchange for a course credit. All were French native speakers, had normal or corrected-to-normal vision, and did not report any color perception difficulties.

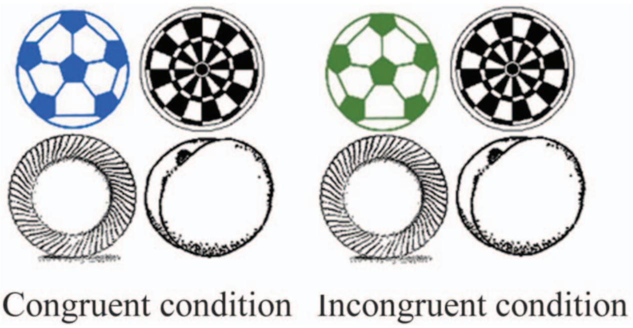

Figure 1. Example of congruent and incongruent pictures used in Experiment 1a (the example shows round-shaped objects, but there were other objects with different shapes). The ball is displayed in blue on the left and in green on the right, in the online version of this figure. See the online article for the color version of this figure.

Stimuli. Three colors were used (green, red, and blue).[1] For each color, seven target drawings that shared at least the first phoneme with the color name were selected from Alario and Ferrand (1999; e.g., BALL—blue). Colored target drawings were obtained from the original black-and-white drawings by coloring the outline in red (255, 0, 0), green (0, 128, 0), or blue (0, 0, 255), using the RGB color space in Photoshop CS5. These will be referred as "congruent drawings" below (see Figure 1). Conversely, as illustrated in Figure 1, "incongruent" drawings were obtained by coloring each drawing in the two remaining colors, with no phonological overlap between colors and object names (e.g., BALL—*green* and BALL—*red*).

Each colored picture was associated with three other drawings (taken from the same picture database), referred to as "flanker" drawings below. Flanker drawings were depicted in their original black-and-white format. Importantly, there was no phonological overlap and no semantic relatedness between their names and the name of the colored target drawing. Their names were never phonologically related to any of the three colors used in this experiment (i.e., red, blue, green). Flanker drawings always served as "context" objects and were not included in the experimental set of target pictures. As illustrated in Figure 1, these four drawings were spatially arranged within composite pictures that fitted a 20 cm square.

In each composite picture, all drawings had approximately the same global shape and size to ensure that color was the only perceptual dimension distinguishing the target object from the context items. To avoid anticipatory strategies, the position of the colored object within the composite pictures was counterbalanced (i.e., top left, top right, bottom right, bottom left). Each target drawing (e.g., *ball*) was associated with one and the same set of flanker objects (e.g., *plate*, *target*, and *peach*) for each of the three colors in which it was displayed (e.g., BALL in blue, green, and red). Finally, in order to reduce the percentage of congruent pictures, we created 42 "filler" pictures from experimental composite pictures. One of the flanker objects was colorized (and so became the new—unrelated—target) while the original target was changed to black and white (and so became a flanker object). Thus, overall, any given spatial arrangement (one target, three flankers) was displayed five times (three times in the experimental set and two times in the filler set).

Procedure. The participants were tested individually in a quiet room. They sat approximately 60 cm from the computer screen. Before the naming experiment, to familiarize participants with both target and context objects, each individual drawing was presented twice in a black-and-white format. The participants had to pay attention both to the drawings and to their intended names displayed on the screen. They were instructed to name, as quickly and accurately as possible, the colored object presented among three black-and-white drawings. The experimental phase included 105 trials (i.e., 21 congruent trials, 42 incongruent trials, and 42

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[1] To reduce the number of stimuli, we decided to use only three colors. Unlike Dumay and Damian (2011; see also Janssen et al., 2008), we did not use orange since it would have been too close to red.

filler trials), divided into five blocks of 21 randomly presented trials each. Overall, the proportion of congruent trials was 20%. Each block began with a filler trial. The presentation of experimental trials within a block was randomized for each individual participant. The order of presentation of the five blocks was counterbalanced, thus yielding 120 possible combinations. Each participant was then randomly assigned to one of these experimental lists, so that any given combination of blocks was presented only once. The presentation and randomization of the stimuli were controlled by E-prime 2.0.8.22, running on a Dell Latitude E5500 computer. Each trial began with a fixation cross presented for 700 ms, followed by a 200 ms blank screen. A target picture was then displayed in the middle of the screen of a ProLite LCD Monitor. Each picture remained visible until the beginning of the vocal response. Naming latencies were then recorded with a Sennheiser ME 64 microphone. If no response was recorded after 3,000 ms, the trial ended and the next trial began. A 2,500 ms delay was introduced between two consecutive trials. The experimental phase was preceded by a training session. The pictures displayed during the training session were not included in the experimental set. The whole experiment lasted about 40 min.

Results. Latencies associated with technical errors or with performance errors (i.e., including hesitations and the production of an unexpected name) were excluded from the analyses. Latencies exceeding 3 standard deviations above or below each participant and item mean were considered as extreme latencies and were also set apart. Analyses of variance (ANOVAs) were performed on naming latencies and error rates, with congruency introduced as a factor, and with participants (*F*1) and items (*F*2) as random factors. Two items elicited more than 20% of naming errors in both naming conditions (i.e., REQUIN, *shark*, and BOUTEILLE, *bottle*) and were removed from the analyses. Four percent of the data corresponded to technical errors, 0.8% to performance errors, and 0.4% to extreme naming latencies.

The effect of the congruency factor on naming errors was not significant, $F < 1$. However, naming latencies in response to black-and-white drawings were significantly shorter for congruent pictures (715 ms; $SD = 72$) than for incongruent pictures (731 ms; $SD = 78$), $F_1(1, 39) = 8.834$, $MSE = 541$, $p < .01$, $\eta_p^2 = .185$; $F_2(1, 18) = 8.925$, $MSE = 309$, $p < .01$, $\eta_p^2 = .331$.

Experiment 1b: Standard Colored-Object Naming

Method.

Participants. Forty psychology students from the University of Bourgogne took part in this experiment and were rewarded with course credits for their participation. They fulfilled the same selection criteria as those of Experiment 1a.

Stimuli. The stimuli were created from those used in Experiment 1a by removing flanker black-and-white drawings. Thus, each congruent or incongruent drawing was set alone against a white background.

Procedure. The procedure was in all respects identical to the one used in Experiment 1a, except that the participants simply had to name the colored object that was displayed alone on the screen.

Results. The data of two participants were discarded due to technical errors during the recording of the latencies. Latencies associated with technical (4.4%) and performance errors (1.3%), along with extreme latencies (less than 1%), were discarded following the same criteria as those used in the previous experiment. ANOVAs were performed on naming latencies and error rates, with congruency introduced as a factor, and with participants (*F*1) and items (*F*2) as random factors. There was no reliable main effect of congruency on naming errors, $F < 1$. Crucially, no significant effect of congruency was found on the naming latencies: Latencies did not differ reliably between the related (642; $SD = 77$) and unrelated (633; $SD = 78$) conditions, $F_1(1, 37) = 3.09$, $MSE = 571$, $p > .05$; $F_2(1, 18) = 3.1$, $MSE = 259$, $p > .05$.

Discussion of Experiments 1a and 1b. In line with previous findings (Dumay & Damian, 2011; Kuipers & La Heij, 2009; Mädebach et al., 2011), we found that the time taken to name an object was not reliably affected by the phonological overlap between object and color names in the standard colored-object naming condition (Experiment 1b). However, and importantly, as illustrated by Figure 2, a reliable phonological facilitation effect was observed on the naming latencies when a colored drawing of an object was presented among black-and-white drawings of objects (Experiment 1a), suggesting that the color name was activated at the phonological level.

However, one alternative explanation stems from the observation that naming times were longer when pictures were displayed among flanker objects (Experiment 1a) than when they were presented alone (Experiment 1b). Indeed, naming latencies were significantly longer when the same pictures were displayed in a black-and-white context (723 ms; $SD = 75$; Experiment 1a) than when they were presented alone on the screen (638 ms; $SD = 78$; Experiment 1b), $F_1(1, 76) = 25.51$, $MSE = 11029$, $p < .001$, $\eta_p^2 = .251$; $F_2(1, 18) = 66.8$, $MSE = 2036$, $p < .001$, $\eta_p^2 = .788$. Thus, it could be argued that this extra time increases the probability that lexical processing of the color name will occur whereas, at the same time, lexical processing of the name of the object itself is delayed. This would lead one to predict that a phonological facilitation effect should occur mostly on longer latencies, because activation from nontarget colors has more time to reach the phonological level. To test this hypothesis, we performed a median-split on the naming latencies for both experiments. In Experiment

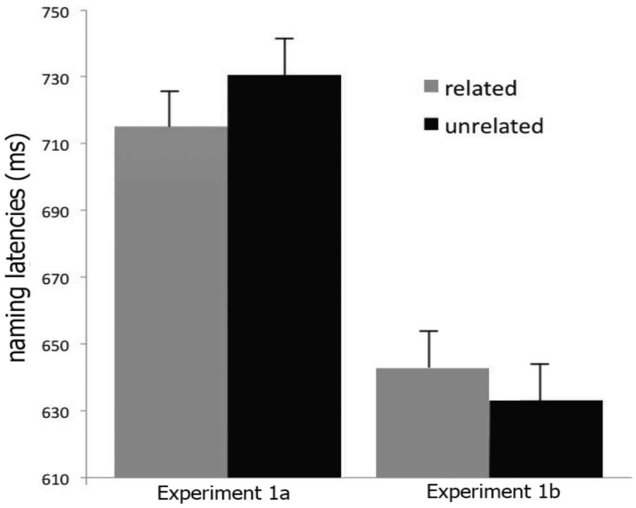

Figure 2. Naming latencies for congruent and incongruent target pictures in Experiments 1a and 1b, with bars representing standard errors.

1a, the mean latency for the slower participants was 772 ms, and 674 ms for the faster ones. A reliable phonological facilitation effect was observed for both faster speakers (-15 ms), $t(19) = 1.856$, $p < .05$, and for slower speakers (-16 ms), $t(19) = 2.33$, $p < .05$. In contrast, in Experiment 1b, the mean latency for the slower participants was 700 ms and 576 ms for the faster ones. Importantly, according to this "extra-time" account, a facilitation effect should have been observed for the slower participants in Experiment 1b, because they took more time to respond (and color activation therefore had more time so spread), than for the faster participants in Experiment 1a. However, this critical assumption was not supported by the data. Indeed, there was still no reliable effect of phonological overlap either for the slower speakers or for the faster ones. Thus, we believe that the phonological facilitation effect in Experiment 1a reflects the cascading processing of color names that occurs only when pictures are displayed in a black-and-white context in which colors serve as cues to identify the to-be-named object.

Why does cascaded processing of nontarget colors occur when object naming takes place in a context where there are other noncolored objects, but not during standard picture naming where a single object is presented? It may be that the color property of the targets in the context of multiple black-and-white drawings captures speakers' attention while they are naming the target objects, leading to the cascaded processing of colors as observed in Experiment 1a. Another reason could be the visual contrast between the colored picture and the other black-and-white pictures, because this enhances the saliency of the color. Previous attempts to manipulate visual saliency by coloring the entire surface of the target object instead of the lines of the drawing (Dumay & Damian, 2011) failed to provide evidence of the phonological activation of nontarget colors. However, it remains possible that the contrast used in our experiment makes object colors more salient. Alternatively, it could be that the naming instruction per se had the effect of increasing the level of attention allocated to the color property. In effect, although speakers were not required to name the color of the target object, they had to take this property into account in order to localize the target drawing among the other drawings. Whether the visual contrast, the instructions, or both are responsible for the attentional capture of the color property, it seems clear that when a specific communicative context leads speakers to focus their attention on nontarget colors, these become phonologically encoded.

Experiments 1a and 1b revealed that nontarget colors can be processed in a cascaded fashion when a visual multiple-object display enhances the attention speakers pay to colors. However, these experiments do not allow us to answer the question of whether cascaded processing of objects colors can also occur in a (standard) *single* object display. As reviewed in the beginning of the article, this issue has been previously addressed in several studies which have, however, all failed to provide evidence for phonological activation of nontarget colors. How can we account for these failures? We have very carefully examined the stimuli used by Kuipers and La Heij (2009), by Mädebach, Alekseeva, and Jescheniak (2011) and by Dumay and Damian (2011). A shared feature of the stimuli used in these experiments is that the colors used in the line-drawings were implausible with regard to the objects depicted. To give some examples, the participants were presented with a HORSE colored in purple (PAARS-*paard*; Kuipers & La Heij, 2009, in Dutch), a SHARK colored in red (REQUIN-*rouge*; Dumay & Damian, 2011, in French), or a LION colored in purple (LÖWE-*lila*; Mädebach et al., 2011, in German). Obviously, such naming situations have little chance of occurring in real life. Indeed, the same is true of other pictures depicting manufactured items such as RAKE colored in *red* (RATEAU-*rouge*; Dumay & Damian, 2011, in French). In spite of the fact that it is possible to find such items in real life, it is surely not the most common color in which they are depicted. Overall, for a large number of the pictures used in previous studies, the displayed colors did not correspond to canonical object representations. Therefore, the finding that nontarget (and nonplausible) colors are not phonologically encoded in these experiments tells us nothing about how real colors would be processed in real-life naming situations.[2] Experiments 2a and 2b addressed this issue by using pictures for which the colors and the depicted objects are "conceptually coherent." Here we use the term "conceptually coherent" in a somewhat elusive way to talk about situations where two entities are frequently associated, as for example in the case of *cheese* and *mouse* and, in the present case, *red* and *tomato.*[3] Indeed, it should be remembered that Oppermann et al. (2008) showed that the conceptual coherence of two line-drawings promotes the phonological activation of nontarget objects. Following the same reasoning, we expected that because the color property is a core representation for objects with "diagnostic" colors (e.g., LEMON colored in *yellow*), it would promote the retrieval of color names.

Experiment 2: Naming Objects With Diagnostic Colors (Experiment 2a) and Naming Objects With Diagnostic Colors in Black-and-White Format (Experiment 2b)

Color is an important part of the conceptual representations of familiar objects (see Connell & Lynott, 2009, for a review). Several studies have reported that object recognition is more affected by the knowledge of the *diagnostic* colors of objects (e.g., yellow is the diagnostic color of LEMON) than by the actual color that is perceived. For instance, in Tanaka and Presnell's (1999) study, participants took less time to identify pictures of objects with highly diagnostic colors than the same objects in a black-and-white format or with incongruent colors (e.g., LEMON drawn in red). Because no such differences were found for objects with low-diagnostic colors, color diagnosticity is assumed to play an important role during object recognition. As reviewed above, despite evidence that the color names of colored line-drawings do not cascade up to the phonological level during standard (isolated) object naming (Dumay & Damian, 2011; Kuipers & La Heij, 2009), it remains possible that this type of processing occurs for

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[2] The requirement to use shared phonological features between object names and colors in the "related" conditions, on which our assessment of the phonological activation of colors was based, undoubtedly constrained the choice of target concepts and nontarget colors. It should be noted, however, that such nonplausible colors could be phonologically encoded when they become relevant for the naming task, as observed in Experiment 1a.

[3] According to this definition, most of the stimuli used in previous studies (Dumay & Dumian, 2011; Mädebach et al., 2011), such as *red*-RAKE, or green-FISH, did not exhibit conceptual coherence.

objects having "conceptually coherent" (diagnostic) colors. This hypothesis was assessed using the picture–word interference paradigm. This technique has frequently been used to evaluate phonological code activation in object naming (e.g., Oppermann, Jescheniak, & Schriefers, 2008). In Experiment 2, the participants were presented with objects having "diagnostic" colors, and simultaneously heard distractor words that were related either to the object name (obj-REL), or to the color name (col-REL) or were unrelated (UNR) to both. We expected to observe a phonological facilitation effect with distractors related to the object name (e.g., shorter naming times with obj-REL distractors than with UNR-distractors). Importantly, if the color's name activates its phonological features during the naming of objects with diagnostic colors, an inhibitory effect of the distractor word related to the color name should have an observable effect on the naming latencies (i.e., longer naming times with col-REL than with UNR). In this case, a distractor that is phonologically related at color level would enhance the activation of the phonological codes of the color name, which would then be in competition with those of the object name. Such a competition process would delay the production of the target object name. Therefore, the finding of an inhibitory effect of color-related distractors on object naming latencies would indicate the phonological (cascaded) activation of the name of diagnostic colors. This hypothesis was tested in Experiment 2a. Alternatively, a color-related distractor effect could also emerge because of the knowledge participants have about objects (i.e., knowing that a lemon is typically yellow). In this case, this effect would be rooted at the conceptual level, and would not originate from the actual perception of the displayed object color. To test this alternative hypothesis, Experiment 2b used a black-and-white line-drawing version of the stimuli used in Experiment 2a.

Experiment 2a: Naming Objects With Diagnostic Colors

Method.

Participants. Thirty psychology students from the University of Bourgogne were rewarded with a course credit for their participation. All were native French speakers and had normal or corrected-to-normal vision. None of them reported hearing problems or color perception difficulties.

Stimuli. Seventeen colored drawings were selected from the Rossion and Pourtois (2004) database. We assessed the diagnosticity of pictures in 10 participants who did not take part in the main experiment. They had to rate on a 5-point scale (1 = *low diagnostic*; 5 = *highly diagnostic*) how diagnostic the color used was in each picture of the object represented by the picture (e.g., to what extent is *yellow* diagnostic of a LEMON). The mean score was 4.6 (*SD* = 0.75), thus indicating that the selected pictures were rated as having highly diagnostic colors. For each of the 17 diagnostic pictures, we selected three types of word distractors: (a) words phonologically related to the object's color, (b) words phonologically related to the object's name, and (c) unrelated words. Related and unrelated words were matched on several dimensions that are listed in Table 1. The 51 distractor words were recorded by a male voice on a digital Sony audiotape with Sound Edit 16. A complete list of the experimental stimuli is provided in Appendix B. Seventeen "filler" pictures, with no diagnostic colors (mean score = 2.8; *SD* = 1.4), were selected from the same database. Fifty-one filler auditory distractors, unrelated to either the names or the colors of the filler pictures, were also selected and recorded.

Table 1
Statistical Characteristics of Auditory Distractors Used in Experiments 2a and 2b

	Phonologically related distractors			
	To color name	To object name	Unrelated distractors	
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	*p*-values
Lexical frequency	.91 (.62)	1.04 (.51)	1.11 (.61)	Ns
Nb of phonemes	4.67 (1.24)	4.83 (.99)	4.61 (1.04)	Ns
Nb of syllables	1.89 (.47)	1.89 (.47)	1.83 (.38)	Ns
PU	4.44 (1.29)	4.44 (.98)	4.56 (1.04)	Ns
PN	6.72 (6.06)	8.17 (9.83)	7.28 (6.24)	Ns
pld20	1.62 (.41)	1.62 (.39)	1.57 (.39)	Ns
Acc. dur.	579 (80.3)	576 (86.9)	577 (85.5)	Ns

Note. *SD* = standard deviation; Lexical frequency = logarithm of lexical frequency (freqlivres2), computed from Lexique 3 (New, Pallier, Ferrand, & Matos, 2001); Nb = number; PU = Phonological Uniqueness Point; PN = number of phonological neighbors as defined by Coltheart, Daavelart, Jonasson, and Besner (1977); pld20 = phonological Levenstein's distance (see Yarkoni, Balota, & Yap, 2008); Acc. dur. = acoustic durations (in ms).

Procedure. The participants sat in a silent room in front of the computer screen. As in Experiments 1a and 1b, the participants were first familiarized with the objects and their names. The experimental phase contained 102 trials, divided into three blocks whose presentation was counterbalanced. Each block contained 17 diagnostic pictures and 17 fillers. Overall, the 17 diagnostic pictures were displayed once with each type of auditory distractor. On each trial, the participants first saw a fixation cross (700 ms), then a blank screen (200 ms) before, finally, the target object was displayed on the screen. The auditory distractor was presented through headphones simultaneously with picture onset. The participants had to name the depicted object while ignoring the distractor word. The picture remained on the screen until the beginning of the vocal response. If no response was provided after 3,000 ms, the next trial began. There was an interval of 2,500 ms between the trials. The randomization and the presentation of the stimuli and the latency recordings were all controlled by the experimental software PsyScope 1.2.5 (Cohen, McWhinney, Flatt, & Provost, 1993), running under MacOS × 10.5.8. There were 15 warm-up trials that were not included in the experimental set.

Results.

The data for one participant were discarded due to a technical failure during recording. Latencies associated with technical errors (8%), along with performance errors (3%), and extreme latencies (0.1%), were discarded following the same criteria as those used in Experiment 1. ANOVAs were performed on naming latencies and error rates, with the type of distractors introduced as a factor, and with participants (*F*1) and items (*F*2) as random factors.

The effect of the type of distractor factor was reliable neither on technical errors, nor on naming errors, all *F*s < 1. However, an effect of the type of distractor emerged on naming latencies, $F_1(2, 56) = 12.88$, $MSE = 1304$, $p < .001$, $\eta^2_p = .315$; F_2(2,

32) = 8.76, *MSE* = 999, $p < .005$, $\eta_p^2 = .354$. Objects were named significantly faster with distractors related to their names (656 ms; *SD* = 99) than with unrelated distractors (683 ms; *SD* = 70), $F_1(1, 28) = 6.58$, *MSE* = 1555, $p < .05$, $\eta_p^2 = .190$; $F_2(1, 16) = 5.449$, *MSE* = 857, $p < .05$, $\eta_p^2 = .254$. Crucially, color-related distractors yielded longer naming latencies (704 ms; *SD* = 89) than unrelated distractors, $F_1(1, 28) = 9.9$, *MSE* = 674, $p < .005$, $\eta_p^2 = .261$; $F_2(1, 16) = 4.378$, *MSE* = 1176, $p < .05$, $\eta_p^2 = .179$.

Experiment 2b: Naming Objects With Diagnostic Colors Presented in Black-and-White Format

Method.

Participants. Thirty psychology students from the University of Bourgogne were rewarded with course credits for their participation. Participants fulfilled the same selection criteria as those in Experiment 2a.

Stimuli. The same 17 objects as in Experiment 2a were used in this experiment, except that we used black-and-white drawings (taken from Alario & Ferrand, 1999) instead of the colorized version of these pictures.

Procedure. The procedure was entirely identical to Experiment 2a.

Results. The data for two participants were discarded due to a technical failure during recording. Latencies associated with technical errors (9%), along with performance errors (3%), and extreme latencies (0.3%), were discarded following the same criteria as those used in Experiment 1. ANOVAs were performed on naming latencies and error rates, with the type of distractor introduced as a factor, and with participants (*F*1) and items (*F*2) as random factors.

The Type of distractor factor was reliable neither on technical errors, nor on naming errors, all *Fs* < 1. Naming latencies were significantly shorter for distractors that were phonologically related to the name of the target (671 ms; *SD* = 81) than for unrelated distractors (699 ms; *SD* = 71), $F_1(1, 27) = 10.2$, *MSE* = 1036, $p < .005$, $\eta_p^2 = .289$; $F_2(1, 16) = 11.58$, *MSE* = $p < .005$, $\eta_p^2 = .430$. However, latencies remained unaffected by distractors that were phonologically related to the name of the nontarget color (705 ms; *SD* = 81), F_1 and $F_2 < 1$.

Discussion of Experiments 2a and 2b. As reported in earlier studies (e.g., Oppermann et al., 2008), compared with unrelated distractors, auditory distractors that are phonologically related to the object names speed up object naming. This suggests that the to-be-ignored auditory distractors were actually processed by the participants. Crucially, as illustrated by Figure 3, auditory distractors that were phonologically related to the color names of objects with diagnostic colors in Experiment 2a hampered object naming. This inhibitory effect supports the hypothesis of the cascaded processing of object colors. To our knowledge, this result provides the first evidence that visual object properties can be processed in a cascaded fashion during single-object naming.

In contrast to what was found in Experiment 2a, in Experiment 2b there was no reliable effect of phonologically related distractors when diagnostic colors were removed from the pictures. This suggests that the cascaded processing of nontarget colors reported in Experiment 2a originates in the actual perception of colors on the screen and not in the conceptual knowledge of object properties. Taken together, the findings of Experiments 2a and 2b suggest that visually perceived colors are phonologically activated during single-object naming when they are diagnostic of the depicted object, although it is obviously not necessary to perform the naming task. Alternatively, it could be argued that the color-related distractor effect emerged in Experiment 2a because of the use of more realistic pictures and colors, and not because of color diagnosticity per se. This hypothesis was tested in Experiments 3a, 3b, and 3c.

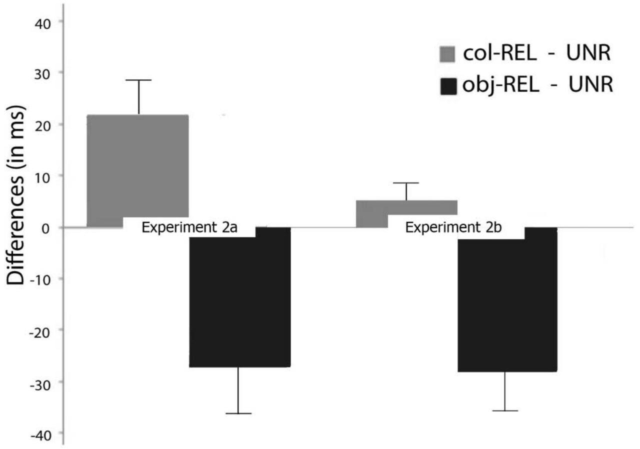

Figure 3. Differences (in ms) in naming latencies between the color-related condition (col-REL) and the unrelated condition (UNR), and between the object-related condition (obj-REL) and the unrelated condition, in Experiments 2a and 2b, with bars representing standard errors.

Experiment 3: Naming Objects With Nondiagnostic Colors (Experiment 3a), Naming Colored-Line Drawings (Experiment 3b), and Naming Line-Drawings With a Colored Background (Experiment 3c)

Why did a color-related distractor effect emerge during single-object naming in Experiment 2a, suggesting cascading processing of nontarget colors, whereas previous studies failed to provide evidence to support this account (e.g., Dumay & Damian, 2011)? The discrepancy may stem from the kind of drawings used. First of all, it should be pointed out that previous studies which were designed to test whether the color property cascades have mostly relied on artificially colorized drawings, leading to nonplausible target objects (e.g., a *purple* HORSE). In contrast, in Experiment 2a we used diagnostic colors that also corresponded to highly plausible drawings (e.g., a *yellow* lemon). Second, previous studies have used *line-drawings* taken from the Snodgrass and Vanderwart (1980) database. We, however, used the colorized pictures taken from the Rossion and Pourtois (2004) database, which are thought to be more "realistic" than the corresponding black-and-one images. Third, the amount of color information contained in the "realistic" pictures (in which the entire surface was colored; Experiment 2a) was much greater than in the colored-line drawings (for which only the lines were colored; e.g., Dumay & Damian, 2011). A reasonable assumption could be therefore that the more colored drawings are, the more likely it is that color information will catch the speaker's attention (and therefore that it will activate its phonological features). In sum, color diagnosticity may not be the only condition that favors cascading processing of object colors. Therefore, it could be that either (a) plausible colors per se, (b) more realistic drawings of objects, or (c) a huge amount of color information is needed in order for the color to capture the speaker's attention and then to be processed up to the phonological level. These issues were addressed in Experiments 3a, 3b, and 3c.

Experiment 3a: Naming Objects With Nondiagnostic Colors

In this experiment, we used nondiagnostic colors (e.g., a *red* CAR) to test whether color diagnosticity is a key condition if the color name is to be phonologically activated during object naming. If this is indeed the case, naming latencies should remain unaffected by color-related distractors. On the contrary, if color diagnosticity is not required, color-related distractors should have an inhibitory effect as in Experiment 2a.

Method.

Participants. Thirty-two students from the University of Bourgogne were rewarded with a course credit for their participation. The participants fulfilled the same selection criteria as the participants in the previous experiments.

Stimuli. Twenty-one colored (nondiagnostic) drawings were selected from the Rossion and Pourtois (2004) database (see Figure 4 for an example). All the pictures had been recolorized with "plausible" colors using RGB color levels, so that seven pictures appeared in RED (255, 0, 0), seven pictures in GREEN (0, 255, 255), and seven pictures in BLUE (0, 0, 255).

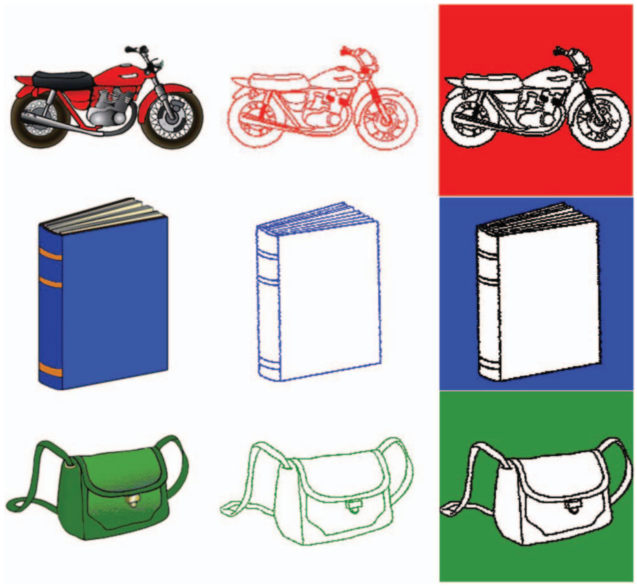

Figure 4. Example of target pictures used in Experiment 3a (realistic drawings), 3b (line-drawings), and 3c (black-and-white drawings with a colored background). The motorcycle, book and bag are colored in red, blue, and green respectively on the left, with the same respective contour colors in the middle and with the same background colors on the right, in the online version of this figure. See the online article for the color version of this figure.

To ensure that the selected items could be considered as nondiagnostic pictures, 10 participants, who were not included in the main experiment, were asked to rate on a 5-point scale (1 = *low diagnostic*; 5 = *highly diagnostic*) how diagnostic the color of each picture was with regard to the depicted object (e.g., to what extent is *green* diagnostic of a SCOOTER). The mean score was 1.98 (*SD* = 0.3), thus indicating that the selected pictures were rated as having very low-diagnostic colors.[4] For each of the 21 nondiagnostic pictures, we selected three types of distractor words: (a) words phonologically related to the object's color, (b) words phonologically related to the object's name, and (c) words unrelated to either. Related and unrelated words were matched on several dimensions that are listed in Table 2. The 63 distractors were recorded by a male voice on a digital Sony audiotape with Sound Edit 16. A complete list of the experimental stimuli is provided in Appendix C. Twenty-one "filler" pictures, with no diagnostic colors (i.e., gray, yellow, and brown), were selected from the same database. Sixty-three auditory "filler" distractors, unrelated to both the names and the colors of the filler pictures, were also selected and recorded.

Procedure. The procedure was identical in all respects to the one used in Experiments 2a and 2b.

Results. The data for two participants were discarded due to a technical failure during recording. Latencies associated with technical errors (10%), along with performance errors (4%), and extreme latencies (0.5), were discarded in accordance with the same criteria as those used in the previous experiments. ANOVAs were performed on naming latencies and error rates, with type of distractors introduced as a factor, and with participants (*F*1) and items (*F*2) as random factors.

The main effect of the type of distractor factor was reliable neither on technical errors, nor on naming errors, all $Fs < 1$. However, an effect of the type of distractor emerged on naming latencies, $F_1(2, 58) = 10.1$, $MSE = 1708$, $p < .01$, $\eta_p^2 = .268$; $F_2(2, 40) = 8{,}171$, $MSE = 1140$, $p < .01$, $\eta_p^2 = .290$. Naming latencies were significantly shorter for objects associated with distractors related to their names (715 ms; *SD* = 86) than for objects associated with unrelated distractors (738 ms; *SD* = 75), $F_1(1, 29) = 8.2$, $MSE = 1004$, $p < .01$, $\eta_p^2 = .220$; $F_2(1, 20) = 7.3$, $MSE = 776$, $p < .05$, $\eta_p^2 = .268$. Importantly, color-related distractors yielded longer naming latencies (762 ms; *SD* = 92) than unrelated distractors, $F_1(1, 20) = 4.7$, $MSE = 1928$, $p < .05$, $\eta_p^2 = .139$; $F_2(1, 20) = 4.8$, $MSE = 772$, $p < .05$, $\eta_p^2 = .193$.

Experiment 3b: Naming Colored-Line Drawings

If cascading processing of color names occurs only when plausible colors are used—whether diagnostic (Experiment 2a) or nondiagnostic (Experiment 3a)—the inhibitory effect of color-related distractors should not depend on the picture for-

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[4] A comparison between the ratings for "diagnostic" and "nondiagnostic" pictures revealed that the colors were judged significantly more diagnostic for the objects used in Experiment 2a (e.g., *red* for TOMATO) than for the objects used in Experiment 3a (e.g., *red* for SOFA), $t(36) = 24.3$, $p < .001$.

Table 2
Statistical Characteristics of Auditory Distractors Used in Experiments 3a, 3b, and 3c

	Phonologically related distractors			
	To color name	To object name	Unrelated distractors	
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	*p*-values
Lexical frequency	8.06 (13.15)	7.33 (13.30)	9.05 (16.18)	Ns
Nb of phonemes	5.10 (.94)	4.95 (1.02)	5.10 (.94)	Ns
Nb of syllables	1.90 (.30)	1.86 (.36)	1.95 (.38)	Ns
PU	4.76 (.83)	4.38 (1.28)	4.71 (.78)	Ns
PN	3.52 (3.39)	5.81 (6.37)	5.81 (6.00)	Ns
pld20	1.79 (.31)	1.68 (.42)	1.69 (.40)	Ns
Acc. dur.	565.52 (75.43)	563.14 (72.33)	562.95 (65.24)	Ns

Note. *SD* = standard deviation; Lexical frequency = logarithm of lexical frequency (freqlivres), computed from Lexique 3 (New et al., 2001); Nb = number; PU = Phonological Uniqueness Point; PN = number of phonological neighbors as defined by Coltheart, Daavelart, Jonasson, and Besner (1977); pld20 = phonological Levenstein's distance (see Yarkoni, Balota, & Yap, 2008); Acc. dur. = acoustic durations (in ms).

mat (realistic drawings vs. colored line-drawings). However, if cascading processing depends on the picture format, color-related distractors should not affect object naming when (non-realistic) simple line-drawings are displayed (see Figure 4). This issue was addressed in Experiment 3b in which colored-line drawings were used.

Method.

Participants. Thirty-one students from the University of Bourgogne were rewarded with a course credit for their participation. The participants were recruited in the same way as in the previous experiments.

Stimuli. Forty-two black-and-white line-drawings, corresponding to the same 21 targets and 21 filler concepts used in Experiment 3a, were taken from the Snodgrass and Vanderwart (1980) database. The target and filler drawings were colored with the same "plausible" colors used in the previous study (i.e., targets were colorized in red, blue, and green; fillers were colorized in yellow, gray, and brown).

Procedure. The procedure was strictly identical to that used in Experiment 3a.

Results. The data for one participant were discarded due to a technical failure during recording. Latencies associated with technical errors (11%), along with performance errors (3.5%), and extreme latencies (0.5%), were discarded in accordance with the same criteria as those used in the previous experiments. ANOVAs were performed on naming latencies and error rates, with the factor type of distractor, and with participants (*F*1) and items (*F*2) as random factors.

The main effect of the type of distractors factor was reliable neither on technical errors, nor on naming errors, all *Fs* < 1. However, an effect of the type of distractors emerged on naming latencies, $F_1(2, 58) = 11.8$, $MSE = 1253$, $p < .001$, $\eta_p^2 = .289$; $F_2(2, 40) = 4.78$, $MSE = 2129$, $p < .05$, $\eta_p^2 = .313$. Naming latencies were significantly shorter for objects associated with distractors related to their names (772 ms; $SD = 105$) than for objects associated with unrelated distractors (813 ms; $SD = 100$), $F_1(1, 29) = 22$, $MSE = 1140$, $p < .001$, $\eta_p^2 = .431$; $F_2(1, 20) = 6.9$, $MSE = 2707$, $p < .05$, $\eta_p^2 = .256$. Importantly, however, latencies associated with color-related distractors (807 ms; $SD = 92$) and unrelated distractors did not differ significantly, both F_1 and $F_2 < 1$.

Experiment 3c: Naming Line-Drawings With a Colored Background

In this experiment, we tested whether cascading of nontarget colors occurs only when a significant amount of color information is displayed. To do so, we used the same line drawings as in Experiment 3b, except that we colorized the entire background of each object to increase the colored surface displayed on the screen. We were therefore left with nonrealistic drawings with a large colored surface. If cascading activation of colors depends on the amount of color that is actually perceived, the color-related distractor effect found in Experiment 3a should also be found in this experiment. Alternatively, if a realistic picture format is needed for colors to be processed in cascaded fashion, naming latencies should remain unaffected by color-related distractors.

Method.

Participants. Thirty-one students from the University of Bourgogne were rewarded with a course credit for their participation and were recruited following the same criteria as those used in the previous experiments.

Stimuli. The 42 objects used in this experiment were the same as in Experiments 3a and 3b. Forty-two black-and-white line-drawings were used in this experiment and depicted the same objects as in the two previous studies. Each drawing fitted a 9 cm × 9 cm square whose white background had been recolorized with the same colors as in Experiments 3a and 3b. The color background of each picture was plausible with regard to the depicted object (e.g., BIKE with a *red* background). The backgrounds of the 21 target drawings were colored in red, blue, or green, whereas the backgrounds of the 21 filler drawings were colored in yellow, gray, or brown (see Figure 4).

Procedure. The procedure was identical in all respects to Experiments 3a and 3b.

Results. The data for one participant were discarded due to a technical failure during recording. Latencies associated with technical errors (7%), along with performance errors (3%) and extreme latencies (less than 1%), were discarded following the same criteria as those used in the previous experiments. ANOVAs were performed on naming latencies and error rates, with type of distractors taken as a factor, and with participants ($F1$) and items ($F2$) as random factors.

The main effect of the type of distractors factor was reliable neither on technical errors, nor on naming errors, all $Fs < 1$. An effect of the type of distractors emerged on naming latencies, $F_1(2, 58) = 11.1$, $MSE = 1254$, $p < .001$, $\eta_p^2 = .271$; $F_2(2, 40) = 6$, $MSE = 1550$, $p < .01$, $\eta_p^2 = .223$. Naming latencies were significantly shorter for objects associated with distractors related to their names (828 ms; $SD = 113$) than for objects associated with unrelated distractors (863 ms; $SD = 125$), $F_1(1,29) = 13.7$, $MSE = 1403$, $p < .01$, $\eta_p^2 = .313$; $F_2(1, 20) = 10$, $MSE = 1257$, $p < .01$, $\eta_p^2 = .323$. Crucially, color-related distractors did not yield longer naming latencies (866 ms; $SD = 122$) than unrelated distractors, both F_1 and $F_2 < 1$.

Discussion of Experiments 3a, 3b, and 3c

The same pattern of results as was observed in Experiment 2a also emerged in Experiment 3a, namely an inhibitory effect of color-related distractors, suggesting that colors were phonologically encoded during object naming. Thus, it appears that colors can be processed in a cascading fashion during a single picture naming task, even if the color is nondiagnostic of the depicted object. Once again, these results are clearly at odds with previous studies that failed to report phonological activation of nontarget colors (e.g., Dumay & Damian, 2011). As mentioned above, one explanation of this failure could be the use of nonplausible colors (e.g., *red* for a SHARK) in these studies, because we observed phonological encoding of colors in Experiments 2a and 3a when plausible colors (i.e., conceptually coherent with the depicted object) were displayed. As Figure 5 illustrates, this inhibitory effect vanished in Experiment 3b (where basic line drawings were used) and in Experiment 3c (in which the pictures included a huge amount of color information).

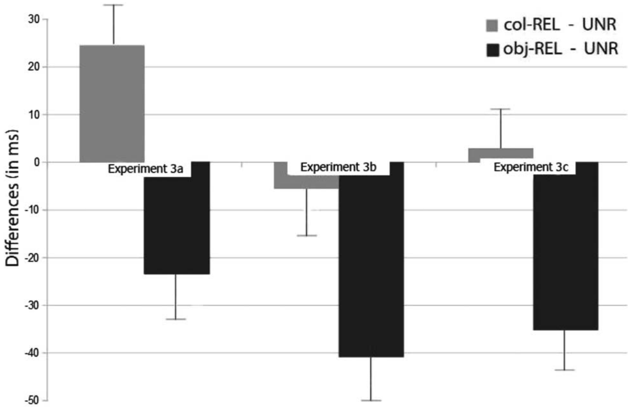

Figure 5. Differences (in ms) in naming latencies between the color-related condition (col-REL) and the unrelated condition (UNR), and between the object-related condition (obj-REL) and the unrelated condition, in Experiments 3a, 3b, and 3c, with bars representing standard errors.

These findings suggest that cascading activation of nontarget colors no longer occurred when objects depicted in the form of line-drawings—and therefore less realistic—were to be named, thus supporting the idea that colors can be processed in a cascaded fashion when they are associated with realistic drawings of objects. They also rule out the hypothesis that the amount of color on the screen is the key condition for causing cascading activation of the color property to occur. At the same time, the findings suggest that colors are not processed in a cascaded fashion when nonrealistic line-drawings are used. We assume that this finding provides a suitable explanation for the failure to observe cascading activation of nontarget colors in previous studies (e.g., Dumay & Damian, 2011).

Collectively, the findings of Experiments 3a, 3b, and 3c suggest that cascading processing of object colors can be observed when realistic object drawings (including even nondiagnostic drawings) are used.

General Discussion

The aim of the present series of experiments was to investigate whether object properties are processed in a cascaded fashion under specific conditions, given that previous studies (Dumay & Damian, 2011; Janssen, Alario, & Caramazza, 2008; Kuipers & La Heij, 2009) failed to provide unequivocal evidence for such a processing mode. In particular, as we pointed out in the beginning of the article, the Janssen et al. (2008) study suggested that word order has a constraining role on the flow of phonological code activation for colors. However, various research teams have failed to replicate these findings (Dumay & Damian, 2011; Kuipers & La Heij, 2009; Mädebach et al., 2011). We focused on the color property because it is a fundamental component of object representations (Connell & Lynott, 2009). Experiments 1a and 1b tested whether the names of colors are activated in object naming when a visual display is designed in such a way that the salience of object colors is enhanced. To achieve this aim, participants had to say aloud the name of a colored object seen among a number of other black-and-white drawings. In this situation, we found that object naming was indeed faster when there was an overlap between the phonology of the object and the color names. However, the phonological facilitation effect was no longer reliable when the context pictures were removed from the design, that is to say when naming was performed on the basis of isolated pictures. The pattern of findings in Experiments 1a and 1b suggests that the object's color spreads activation from the conceptual level up to the phonological level only when it is salient in the communicative context, for instance by helping speakers to localize the target object within a visual scene. Following Oppermann et al. (2014), we assume that object colors captured speakers' attention because of the specific display, leading to the cascading activation of the phonological codes associated with colors (Oppermann et al., 2014).

In Experiments 2a to 3c, we tested whether cascading processing of nontarget colors could also occur in a standard single picture display. Our idea was that conceptual coherence—the high congruency—between certain objects and their colors would promote the phonological activation of nontarget color names (Oppermann et al., 2008). Participants had to ignore distractor words presented auditorily while naming objects having "conceptually coherent" colors, that is, either "diagnostic" colors (i.e., *yellow* in the case of a lemon) or other plausible colors (i.e., *red* in the case of a car). In Experiment 2a, naming times were slower when the target objects were accompanied by color-related distractors (e.g., *young* related to yellow) than when they were accompanied by unrelated distractors. This inhibitory effect was interpreted as suggesting that nontarget colors have undergone processing up to the phonological level. The inhibitory effect from word distractors related to object color names found in Experiment 2a vanished in Experiment 2b when the same objects were displayed as black-and-white drawings. This finding suggests that the phonological activation of nontarget colors stems from the actual perception of colors on the screen and not from semantic knowledge about the typical colors of objects. In Experiment 3a, the inhibitory effect of color-related distractors was still reliable when plausible (but nondiagnostic) colors were used (e.g., CAR colored in *red*). Following Oppermann et al. (2008), the cascading activation of colors reported in Experiments 2a and 3a can be accounted for in terms of attention: In the case of single objects with diagnostic or plausible colors, because there is a conceptual coherence, or high level of co-occurrence, between a color and a corresponding object, there is a greater attentional focus on the color property. In effect, the red color property is a core defining feature of TOMATO (Experiment 2a), while red is also one of the colors frequently associated with CAR (Experiment 3a). This enhanced allocation of attention to the color of objects would be the underlying process leading to more exhaustive processing at the conceptual level, which, in turn, leads to the activation of the phonological codes corresponding to color names. Experiment 3b tested the hypothesis that cascading activation of color in the present study occurred because of the more "ecological" format of our stimuli. When colored-line drawings were used instead of Rossion and Pourtois's (2004) more realistic stimuli, the inhibitory effect of color-related distractors on single object naming vanished. This latter finding also fits nicely with the lack of reliable phonological effects in Experiment 1b, which used the same kind of colored-line drawings stimuli (i.e., with no black-and-white context). Finally, black-and-white drawings were displayed on a colored background in Experiment 3c, with the result that colors and objects were spatially segregated. Naming latencies remained unaffected by color-related distractors, thus suggesting that not every color displayed in the visual scene automatically activates its associated phonological codes.

By showing that the phonological activation of nontarget concepts can also occur for object color properties, the present study challenges previous findings (e.g., Dumay & Damian, 2011). Importantly, however, this cascading processing is somehow restricted. First of all, it depends on the saliency of the properties within the naming scene, which can be enhanced by flanker objects (Experiment 1a). Second, as far as displays of single objects are concerned, the cascading processing of properties depends on the conceptual coherence between the depicted object and the nontarget property. This is the case for "ecological" drawings, that is to say realistic objects: either objects having diagnostic colors (e.g., *yellow* for a *lemon*, Experiment 2a) or objects having plausible colors (e.g., *red* for a CAR, Experiments 3a to 3c). It should be pointed out that in the current studies, cascading processing of nontarget properties was observed only for realistic drawings (Experiments 2a and 3a). Perhaps this is due to the fact that the conceptual coherence between objects and their properties is greater for pictures that look like real-life objects than is the case for simple line-drawings (Experiments 3b and 3c). This finding should encourage further studies aimed at investigating more thoroughly the boundary conditions of cascading processing using even more ecological material such as photographs of objects. Finally, it is worth stressing that the cascading processing of nontarget colors only occurred when the colors were actually properties of the depicted objects and therefore attracted the speaker's attention, since no phonological encoding was observed when the objects and colors were spatially separated (Experiment 3c). In sum, the physical properties of objects can be phonologically activated when they capture the speaker's attention. Otherwise, the activation of nontarget colors is restricted to prelexical stages of spoken naming.

The present findings seem to be consistent with those of previous studies on color naming. It has been found that children find it more difficult to name the colors of objects (e.g., a red CAR) than to name the colors of abstract forms, a finding referred to as color-object interference (Prevor & Diamond, 2005). This finding has been replicated by La Heij, Boelens, and Kuipers (2010) in young children (5- to 7-years-old) but it has not been observed in adults. La Heij et al. (2010) provided evidence that this interference effect is not due to the activation of the object name. Instead, they suggested that color-object interference in children is due to immature executive control, that is to say a familiar form activates the picture naming task which is then in competition with the (target) color naming task (see La Heij & Boelens, 2011 for further evidence). Thus, there is no interference when adults are asked to name the colors of meaningful pictures. However, the findings of Navarrete and Costa (2005) and Kuipers and La Heij (2009) suggest that the names of objects do get activated when their color is named (as is revealed by the presence of phonological facilitatory effects). The full pattern of findings suggests that, when the color of a pictured object is named, the name of the object is activated to a level at which it can lead to phonological facilitation, but not strongly enough to induce interference.[5]

Overall, our data dovetails neatly with the hypothesis put forward by Oppermann et al. (2014) that the activation flow of nontarget properties is constrained at the interface of the conceptual and lexical stages. Of course, this raises the question of how this constraint occurs, that is to say, what is the mechanism that underpins the restriction of the activation flow. It should be clear that the mechanism at work in the regulation of the activation flow in the situations examined in the current experiments is different from the lexical-selection mechanism invoked in various influential models of spoken word production (Caramazza, 1997; Dell, 1986; Levelt et al., 1999).

It is possible that the control mechanism is an "all-or-nothing" process, in that activation from a not-to-be-named color is not allowed to spread beyond the conceptual level. This boundary would not be crossed until a given amount of attention is captured by nontarget concepts or properties. Indeed, our suggestion is close to Bloem and La Heij's (2003) proposal of a threshold of activation at the conceptual level. In their conceptual selection model

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[5] We thank Wido La Heij for having pointed this out to us.

(Bloem, Van Den Boogaard, & La Heij, 2004), it is assumed that only concepts that receive "task activation" (selective attention) pass that threshold. Alternatively, it is possible that the object's color is always processed in a cascaded manner, but that the activation sent to the phonological level is most often too weak to be detected in the naming latencies. Following Dumay and Damian (2011), this might occur because an object's identity takes precedence over its properties during the cascading of information. As a result, it would not be possible to observe the phonological activation of an object's color unless its processing is boosted by the attentional focus. We therefore assume that the lack of phonological effects in previous colored-picture naming studies is due to the degree to which colors are able to activate their phonological codes.

To conclude, our data extend previous studies (e.g., Oppermann et al., 2014) by showing that cascading processing is not confined to an object's identity in spoken naming. Our findings accord with the hypothesis that, under certain circumstances, object properties are phonologically activated when naming objects.

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Appendix A

Target Objects Names Used in Experiments 1a and 1b With Their Approximate English Translation

Target names	Approximate English translation
ballon	balloon
banc	bench
barbecue	barbecue
bougie	candle
bouteille	bottle
bouton	button
bureau	office
rateau	rake
règle	rule
renard	fox
requin	shark
robe	dress
robinet	tap
roue	wheel
vache	cow
valise	suitcase
vase	vase
verre	glass
violon	violin
vis	screw
voiture	car

(*Appendices continue*)

Appendix B

Nontarget Colors, Target Objects, and Auditory Distractors Used in Experiments 2a and 2b. Approximate English Translation in Parenthesis

		Auditory distractors		
Colors	Targets	Related to target color	Related to target name	Unrelated
JAUNE (yellow)	banane (banana)	jauge (gauge)	bague (ring)	lande (heathland)
	citron (lemon)	jockey (jockey)	ciseaux (scissors)	fusée (rocket)
	lune (moon)	joli (nice)	lueur (glow)	bébé (baby)
	soleil (sun)	joseph (joseph)	solution (solution)	journal (newspaper)
ORANGE (orange)	carotte (carrot)	orage (storm)	carré (square)	talent (talent)
	citrouille (pumpkin)	oral (oral)	citerne (tank)	pivot (pivot)
ROSE (pink)	cochon (pig)	roman (novel)	colère (anger)	santé (health)
ROUGE (red)	homard (lobster)	routine (routine)	aumône (alms)	levier (lever)
	pomme (apple)	rougeur (redness)	pommade (ointment)	chorale (choir)
	tomate (tomato)	roulotte (caravan)	topaze (topaz)	corbeau (raven)
	coeur (heart)	route (road)	couteau (knife)	jeune (young)
	fraise (strawberry)	rouille (rust)	frêle (frail)	jouet (toy)
VERT (green)	arbre (tree)	verbal (verbal)	ardoise (slate)	estrade (platform)
	crocodile (crocodile)	vertige (dizziness)	crochet (hook)	esclave (slave)
	feuille (leaf)	verseau (aquarius)	fenouil (fennel)	glaçon (ice cube)
	grenouille (frog)	vertical (vertical)	grenade (grenade)	caserne (barracks)
	poivron (pepper)	verger (orchard)	poison (poison)	cantine (canteen)
	salade (salad)	vernis (varnish)	salive (saliva)	tricot (knitting)

Appendix C

Nontarget Colors, Target Objects, and Auditory Distractors Used in Experiments 3a, 3b, and 3c. Approximate English Translation in Parenthesis

		Auditory distractors		
Colors	Targets	Related to target color	Related to target name	Unrelated
BLUE (blue)	camion (truck)	blague (joke)	calme (calm)	liste (list)
	flèche (arrow)	blouson (jacket)	flacon (bottle)	cantine (canteen)
	lampe (lamp)	blaireau (badger)	lentille (lens)	sifflet (whistle)
	livre (book)	blessure (injury)	limite (limit)	carrière (career)
	parapluie (umbrella)	blond (blond)	page (page)	nerfs (nerves)
	pull-over (sweater)	blocage (blocking)	puéril (childish)	casting (casting)
	stylo (pen)	blocus (blockade)	stupeur (stupor)	corsage (corsage)
ROUGE (red)	accordéon (accordion)	rouleau (roll)	acompte (down payment)	hangar (hangar)
	bus (bus)	roulette (roulette)	buvette (bar)	moquette (carpet)
	canapé (couch)	rouquin (ginger)	caveau (vault)	bandeau (headband)
	casque (helmet)	roumain (Romanian)	casseur (breaker)	panthère (panther)
	gant (glove)	routine (routine)	gang (gang)	mouton (sheep)
	moto (motorcycle)	roulotte (caravan)	maussade (surly)	crampon (crampon)
	pince-à-linge (clothes peg)	rougeole (measles)	pintade (guinea fowl)	vidange (emptying)
VERT (green)	ballon (balloon)	vertige (dizziness)	barrière (barrier)	crevette (shrimp)
	bouton (button)	verdict (verdict)	bourgeoise (bourgeois)	spaghetti (spaghetti)
	brosse-à-dents (tooth brush)	vermine (vermin)	brutal (brutal)	critique (critical)
	chaussette (sock)	verger (orchard)	chauffard (roadhog)	lasagne (lasagna)
	chemise (shirt)	vernis (polish)	chenille (caterpillar)	fossile (fossil)
	robe (dress)	vertu (virtue)	rocher (rock)	major (major)
	sac (bag)	verdure (greenery)	surfeur (surfer)	mortier (mortar)

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