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Influence of object size on baseline identification, priming, and explicit memory

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We investigated the influence of size on identification, priming, and explicit memory for color photos of common objects. Participants studied objects displayed in small, medium, and large sizes and memory was assessed with both implicit identification and explicit recognition tests. Overall, large objects were easier to identify than small objects and study-to-test changes in object size impeded performance on explicit but not implicit memory tests. In contrast to previous findings with line-drawings of objects but consistent with predictions from the distance-as-filtering hypothesis, we found that study-test size manipulations had large effects on old/new recognition memory test for objects displayed in large size at test but not for objects displayed small or medium at test. Our findings add to the growing body of literature showing that the findings obtained using line-drawings of objects do not necessarily generalize to color photos of common objects. We discuss implications of our findings for theories of object perception, memory, and eyewitness identification accuracy for objects.

Key words: Object identification, priming, implicit memory, eyewitness memory, size.

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INTRODUCTION

Does object size matter? Does it influence our ability to identify and to remember common objects? According to frequent theoretical claims in the perception literature, object size influences neither identification nor priming (e.g., Biederman, 1987). In contrast, a number of theorists in the memory literature have proposed that priming is hyperspecific to study-test changes in stimulus format, and thus, study-test changes in visual attributes, such as object size, affect priming (e.g., Roediger & Blaxton, 1987; Schacter, 1994; Tulving & Schacter, 1990). Moreover, researchers working on applied problems such as eyewitness identification, maintain that the distance between a witness and the crime scene (resulting in a smaller object image on the retina) has a negative effect on both initial identification and subsequent explicit memory for details of the crime scene (e.g., Loftus & Harley, 2005). While this line of research has focused primarily on eyewitness identification of perpetrators from line-ups and photo arrays because such line-ups and photo arrays are routinely used in courts, a recent proposal in criminal law literature also calls for use of physical evidence line-ups and “object” arrays during cross-examination of eyewitness (Steele, 1998). Thus, the influence of object size on identification, priming, and explicit memory has important theoretical as well as practical implications.

Interestingly, the majority of previous theoretically oriented studies within the perception and memory literature has investigated this question using black-and-white line drawings of objects (but see Uttl & Graf, 1996; Uttl, Graf & Santacruz, 2006); thus, their findings may have limited real-world applicability (Uttl & Graf, 1996). In contrast, the researchers focusing on eyewitness identification used either people or photographs of people (Brown, Deffenbarcher & Sturgill, 1977; Loftus, 1976; Loftus & Harley, 2005; Pezdek & Blandon-Gitlin, 2005). In this article, we depart from the majority of previous research on object perception and memory and use color photographs of common objects in an attempt to better mimic real-world perceptual experience.

Current theories of human object identification in perception and repetition priming lead to conflicting predictions about the effect of object size manipulations on the magnitude of priming. To illustrate, according to Biederman’s (1987) recognition-by-components (RBC) model, objects are represented in terms of geons, basic geometric building blocks, and special terms that define the relations between them (e.g., geon A is above geon B, geon C is to the right of geon B). Biederman assumes that to name or identify an object, the perceptual system computes a structural description by determining the object’s geons and the relations between them; this description then provides access to its name, information about its use, function and so on. According to

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this model, neither geons, nor the relations among them, are associated with size information; thus, any influence of object size on identification can only be mediated by lower level processes, such as edge and shape detectors, and neither object size nor other non-structural attributes ought to influence the magnitude of priming.

In contrast, research on repetition priming with words has frequently shown substantial effects of study-test manipulations of font size and type (Graf & Ryan, 1990; Jacoby & Hayman, 1987; Kolers, 1973; Rudnicky & Kolers, 1984), display orientation (Graf & Ryan, 1990; Masson, 1986), and presentation modality (Jacoby & Dallas, 1981; Roediger & Blaxton, 1987). Indeed, theoretical accounts of repetition priming have frequently emphasized this format-specific nature of repetition priming (e.g., Roediger & Blaxton, 1987), with some even contending that repetition priming is hyperspecific to study-test changes in stimulus format, whereas explicit memory is unaffected by such study-test manipulation of stimuli physical features (e.g., Schacter, 1994; Tulving & Schacter, 1990). Within these studies, however, some authors have emphasized the variability of the findings (e.g., Graf & Ryan, 1990), noting that study-test changes in stimulus format do not always influence performance on repetition priming or explicit memory tests. It has been suggested that more flexible instance-based accounts of repetition priming are a better explanation of the variable priming effects (e.g., Craik, 2003; Feustel, Shiffrin & Salasoo, 1983; Graf & Ryan, 1990; Logan, 1988; Whittlesea, 2003). One of the main advantages of instance view theories is that they can account for frequency and familiarity effects on the magnitude of priming, the finding that frequently encountered words or objects are identified faster than less frequently encountered ones but that one exposure to less versus more frequent stimuli results in larger priming (Oldfield & Wingfield, 1965; Uttl & Graf, 1996).

Recent studies of repetition priming with objects parallel the variability of repetition priming effects with words; contrary to the predictions of structural description accounts such as the RBC, repetition priming is sometimes influenced by study-test changes of objects' non-structural attributes such as object orientation (Uttl & Graf, 1996) and color (Uttl *et al.*, 2006). Similarly, Tarr and his colleagues have found study-test viewpoint specific effects on repetition priming for computer-generated unfamiliar objects, stick figures, and novel objects (Tarr, 1995; Tarr & Pinker, 1989; Hayward & Tarr, 1997). As an illustration, Uttl and Graf (1996) used photos of common objects, manipulated object orientation in the picture plane between study and test and measured the magnitude of priming on the subsequent test. For objects that are frequently encountered in various orientations (e.g., scissors, beachball), the magnitude of priming was unaffected by study-test changes in object orientation. However, for objects that are usually encountered in a single, or cardinal, orientation (e.g., helicopters), the magnitude of priming was substantially reduced by study-test changes in orientation, especially when test objects were shown rotated away from their usual orientation.

In this paper, we examine the effect of object size on identification, priming, and explicit memory. If size-specific priming effects are found, similar to those already documented with orientation, color and viewpoint, it would provide further evidence against structural models of object identification such as Biederman's (1987) RBC model, and for theoretical claims that priming is hyper-specific to study-test changes in visual attributes (Tulving & Schacter, 1990). However, since we frequently encounter common objects in a variety of sizes – we see them from a variety of distances in everyday life – the instance view theory suggests that one additional study exposure may have only a weak effect on the magnitude of priming. Thus, we may expect a smaller effect of format-specific priming with size changes than those found with changes of color and orientation, which vary considerably less in everyday life.

With regards to explicit memory, everyday observations as well as research findings indicate that object size influences identification of everyday objects and our ability to recognize them as having been encountered previously (e.g., Biederman & Cooper, 1992; Jolicoeur, 1987). Objects are more difficult to identify from small compared to larger photographs and they are easier to recognize when they are close rather than farther away. There are at least two well-known reasons for this. First, the human visual system processes higher spatial frequencies (in terms of cycles/degree) increasingly more poorly due to the acuity limitations of human visual system including spatial density and distribution of rods and cones on human retina (e.g., Campbell & Robson, 1968; Thibos, Cheney & Walsh, 1987; Osterberg, 1935). Second, as an object is moved away from an observer, the observed spatial frequency of its image increases due to decreasing visual angle (combined with constant image spatial frequency expressed in terms of cycles/image). Thus, as objects are reduced in size or moved farther away, increasingly lower spatial frequencies are lost to the observer, resulting in the loss of increasingly coarser object details and impoverished representations of objects in memory. In turn, the impoverished representations decrease the observer's ability to remember small versus large objects accurately.

Working on the eyewitness identification problem, Loftus and Harley (2005) recently proposed that these two factors – visual system difficulty in processing increasingly higher spatial frequencies, and increasing spatial frequency of an object image as it moves away from an observer – are sufficient to explain the effects of distance on identification of human faces (the distance-as-filtering hypothesis; DAF). That is, seeing a face at a particular distance can be simulated by either shrinking the face or by filtering the face with a low-pass filter. They confirmed their proposal in a series of elegant experiments using human faces. Moreover, their experiments demonstrated the difficulty of recognizing the perpetrator of a crime when a face is observed from afar,

Table 1. *Previous studies of object size effects on priming and old/new recognition*

Source	Exp.	Test task	Sizes	Stimuli	Effect	Comments
Priming						
Biederman & Cooper (1992)	1	Naming	3.5° to 6.2°	LD	+	Name exposure prior
Biederman & Cooper (1992)	3	Naming	3.5° to 6.2°	LD	+	Name exposure prior
Fiser & Biederman (1995)	1	Naming	3.5° to 6.2°	PH (b&w)	+	Name exposure prior
Cave & Squire (1992)	2	Naming	1:1.5	LD (shade)	+	
Zimmer (1995)	3	Word-picture matching	5 to 8 cm	LD	–	
Srinivas (1996)	1	Size typicality	8.8° to 17.22°	LD	++	Rt: LL > SSns
Srinivas (1996)	2	Pf identification	8.8° to 17.22°	LD	++	Rt: SS > LLsg
Stankiewicz & Hummel (2002)	2	Naming	2.5° to 5°	LD	+	3 s Prime to Target
Ryan *et al.* (2003)	1	Naming	5.7° v 10°	LD (colored)	–	collapsed
Seamon *et al.* (1997)	2	Affective preference	1:2.5	LD (possible)	–	MExp
Furmanski & Engel (2000)	3	Ident. thresholds	8.2° to 16.5°	LD	+	MExp/TP
Furmanski & Engel (2000)	4	Ident. thresholds	8.2° to 16.5°	LD	+	MExp/TP
Old/new recognition						
Biederman & Cooper (1992)	2	Old/new recognition	3.5° to 6.2°	LD	++	
Jolicoeur (1987)		Old/new recognition		LD	++	
Srinivas (1996)	3	Size typicality	8.8° to 17.22°	LD	++	>0.90; rt: LL > SSns
Seamon *et al.* (1997)	2	Affective preference	1:2.5	LD (possible)	++	MExp
Zimmer (1995)	1	Old/new recognition	5–8 to 12–15 cm	LD	n/i	CEs >0.95
Zimmer (1995)	2	Old/new recognition	5–8 to 12–15 cm	LD	++(S)	CEs for L >0.90
Zimmer (1995)	3	Old/new recognition	5 to 8 cm	LD	n/i	CEs >0.96

Notes: Zimmer's (1995) experiments 1 and 2 are not included in the review of priming effects because priming was not observed. LD = line drawings; PH = photographs; MExp = participants were given multiple exposures to objects during the study; MExp/TP = participants were give many identification trials with each object in one size followed by a transfer test block with the objects in different sizes; "name exposure prior" = participants were asked to read names of all objects prior to the experiment; CEs = performance is uninterpretable due to severe ceiling effects. – = non-significant size difference in opposite direction; + = non-significant but numerically larger size effect; ++ = significant size effect. Pf = picture fragment. n/i = non-interpretable.

with only impoverished memory representations lacking high spatial frequencies available to the observer on a subsequent memory test.

An immediate corollary of the DAF account is that effects of study-test changes in object size may be asymmetric. Specifically, presentation of a small object at study will result in impoverished, less detailed representations than presentation of a large object at study due to low pass filtering. However, the extra detail included in the study representations of large objects will not be beneficial on subsequent memory test when an observer compares such detailed representations to small test object displays lacking detail. In contrast, the extra detail in large object study representations may be beneficial when an observer compares it to large object test displays, resulting in better performance when an object is seen in the same (large) size at study and test than when it is seen in small size at study and large size at test.

Prior research examining the effects of object size on the magnitude of priming is summarized in Table 1. While the results of all but one study (Srinivas, 1996) were interpreted as supporting the view that object size is not coded in representations mediating priming, consistent with structural description accounts, when taken together, these studies do suggest an effect of size. Of the 12 studies listed, nine reported small advantages for objects studied and tested in the same rather than different sizes. Further, two investigations found the effects of such study-test changes in object size to be statistically significant in at least some conditions (Srinivas, 1996; Experiments 1 and 2).

With regards to explicit memory, the studies in Table 1 reveal an advantage in old/new recognition accuracy for objects studied and tested in the same rather than different sizes, when the null results from studies with severe ceiling effects are excluded as uninterpretable (e.g., see Uttl, 2005). It is noteworthy that none of the studies in Table 1 found an asymmetric effect of study-test changes, as might be predicted from the DAF view and other empirical findings with human faces (e.g., Kolers, Duchnicky & Sundstroem, 1985). All of the prior investigations suffer from a variety of critical limitations, however, that may have precluded the discovery of such asymmetric study/test size change effects. For example, the prior investigations used primarily line-drawing stimuli and only small study-test changes in object size (1:2). This combination is unlikely to result in any loss of detail beyond the thinning of the drawing outlines (i.e., the same features would be available in large as well as small images; for examples of this phenomenon see Biederman & Cooper, 1992 and Stankiewicz & Hummel, 2002). Moreover, it is unlikely that the findings from these kinds of studies provide an accurate description of human object identification in real life since these stimuli differ in critical ways from real objects or even photographs of real objects. Indeed, the use of line drawings would bias findings towards minimizing effects of object size, as well as other surface features, by removing detail and by allowing only the perception of overall shape and major object parts. Consistent with this bias, when priming and memory for detail-impoverished line drawings and detail-rich color photos of real-life objects is compared directly, the overall magnitude of priming as well as explicit memory is reduced for line-drawings compared to color photos (Uttl & Graf, 1996).

To rectify the shortcomings of earlier research and to investigate predictions derived from the DAF hypothesis, we investigated the extent to which object size influences identification, magnitude of repetition priming, and performance on explicit old/new recognition tests. First, we used color photographs of common objects rather than line-drawings; second, we employed a greater range of object sizes (1:4); third, we used two study-test delays (a few minutes versus one week), in part to avoid frequently found performance ceiling effects on immediate explicit memory tests; fourth, we used a large number of objects (120) to ensure generalizability of our findings; and fifth, we designed the study to be powerful enough to detect even a 20% reduction in priming due to object size. These design features were employed to provide as strong a test as possible of any influence of size on identification, priming, and explicit memory.

Participants studied a series of color photographs of real-life objects displayed in one of three sizes: small (4° visual angle), medium (8° visual angle), and large (16° visual angle) (visual angle reflects the diagonal of small, medium, and large images). At test, the photos were displayed either in the same size or in a different size as at study. Memory was assessed with either an identification test (implicit memory) or with an old/new recognition test (explicit memory). On both tests participants were shown photos of objects that were slowly faded in for identification or recognition. The identification test required participants to identify each object as quickly as possible, whereas the old/new recognition test required them to decide for each object whether it had been seen at study. Participants were tested twice, both a few minutes after study and again after a 7-day delay.

METHOD

Participants and design

Ninety-six undergraduate students participated for course credit or for $10.00. The design had one between-subjects and four within-subjects factors. The between-subjects factor was test type (identification, old/new recognition). The within-subjects factors were the size of objects at study (small, medium, large), the size of objects at test (small, medium, large), history (studied, non-studied), and test delay (a few minutes, 7 days). Forty-eight participants were assigned randomly into each of the two conditions defined by the between-subjects factor.

Materials

A total of 188 color photos of real-life objects (e.g., dog, camera, bus) were obtained, digitized, "cut out" from their background, and scaled to fill three rectangles of different sizes: 640 × 480 pixels, 320 × 240 pixels, and 160 × 120 pixels. The scaled objects were then superimposed and centered on a white background of 640 × 480 pixels. Of the 188 photos, 120 were critical targets, 60 were fillers, and 8 were used for instruction and practice. The 120 critical items were randomly divided into two equal sets (set C_A and set C_B) of 60 items. For purposes of counterbalancing items across participants and conditions, each of these sets was then further subdivided into 12 equal subsets of 5 items. Similarly, the 60 fillers were randomly divided into 2 sets (set F_A and set F_B), and each set of fillers was subdivided further into three equal subsets. All pictures were displayed on a 14-inch color monitor in 16.7 million color mode in 1024 × 768 resolution and pixel size approximately 0.25 × 0.25 mm (including inter-pixel gap).

Procedure

The study was described as examining perception and memory for pictures of objects. Participants were tested individually in two sessions, separated by 7 days, each lasting from 30 to 50 minutes. Their eyes were approximately 80 cm away from the monitor screen. The first session consisted of a study phase and a test phase. The study phase was the same for all participants. On each trial, a photo of an object was displayed in the center of the computer monitor, in one of three sizes (small, medium or large), and participants rated its familiarity using a five-point scale ranging from 1 – not very common to 5 – very common. Participants practiced the rating task on three photos, proceeding at their own rate. Following the practice phase, a randomly arranged list with 90 photos was presented according to the same procedure. Each participant was shown 30 photos in each of the three sizes, small, medium, and large.

Each test list (immediate, one week later) also consisted of 90 photos: all 12 subsets of critical items from either set C_A or set C_B (9 studied and 3 non-studied, 60 photos), as well as filler set F_A or F_B (30 photos). The fillers were included to equate the ratio of old (studied) and new (non-studied) items on the test list. Ten fillers were shown in each of the three sizes, small, medium, and large. The fillers were used in a counterbalanced manner so that across participants, each appeared equally often in each display condition. One of the three subsets that appeared in each size condition at study was displayed in each of the three different size conditions at test. Similarly, for the three subsets of non-studied photos, one subset was tested in each size condition. Across participants, counterbalancing ensured that each subset appeared equally often in each of the 12 counterbalancing conditions that were obtained by crossing study and test display sizes and including three non-studied subsets, one in each size.

The first test phase followed immediately after study. Depending on the test condition, participants were given either an identification test or an old/new recognition test. On each trial of the identification test, a photo was faded in on the center of the monitor screen using the fade-in procedure described in detail in Uttl and Graf (1996). This fade-in procedure is similar to picture-fragment completion methods used by prior investigations (e.g., Roediger & Blaxton, 1987; Snodgrass & Feenan, 1990; Srinivas, 1996) but provides finer distinctions between levels, greater reliability, and faster presentation. Participants were told that the goal was to measure their ability to identify objects displayed in different sizes. They were instructed to identify each object as quickly and accurately as possible, to press the left mouse button as soon as they had identified it, and upon identification to say the name of the object aloud to the experimenter. Pressing the left mouse button stopped the fade-in procedure, cleared the computer screen, and caused the display of a prompt to enter the name of the object on a second monitor screen, visible only to the experimenter. The experimenter responded by typing the object name on the keyboard. The program recorded the proportion of pixels turned "on" at the time of the participant's response.

On each trial of the old/new recognition test, a photo of each object was also slowly faded in on the computer screen. However, participants were instructed to decide, as quickly and accurately as possible, whether each object had appeared in the study list, regardless of the size in which it had appeared previously. Participants pressed the left and right mouse buttons to record their old and new recognition decisions, respectively.

The second test phase followed after a delay of seven days. Participants were given the same type of test as the one they had completed in the first phase, either the old/new recognition test or the identification test. However, participants who were tested using C_A and F_A item sets in the first phase were tested using C_B and F_B item sets in the second phase and vice versa. This procedure ensured that, prior to testing, participants had seen each studied photo only once. Counterbalancing ensured that each item was presented equally often in each of the experimental conditions.

RESULTS

The critical dependent measure for the identification test was the proportion of pixels "turned on" for successful identification. For the old/new recognition test, the dependent measures were hits (the proportion of pictures correctly classified as old/previously studied) and correct rejections (the proportion of pictures correctly classified as new/non-studied).

Identification and priming

Figure 1 shows proportions of pixels required for correctly identifying object photos in each condition. Overall, new non-studied objects were identified equally easily in the immediate (0.455) and delayed (0.452) condition and identification was easiest for large objects (0.340), harder for medium objects (0.445), and hardest for small objects (0.574). An ANOVA of performance on non-studied items, with test delay (minutes, 1 week) and test display size (small, medium, large) as within-subjects factors, showed a significant main effect for test display size, $F(2, 94) = 122.11$, $MSe = 0.011$, $\eta^2 = 0.72$. No other effects approached significance.

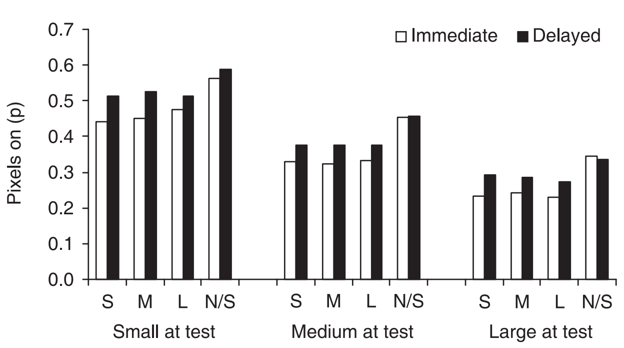

Fig. 1. The mean proportion of pixels required to identify photos of objects either on immediate or delayed test, as a function of study size (small, medium, large), test size (small, medium, large), and history (studied, non-studied). n/s = non-studied.

Because of the differences in performance on non-studied objects, all subsequent statistical analyses were conducted on priming scores – the proportion of pixels required for identification of non-studied minus studied objects. The amount of priming was significant in all experimental conditions, with the smallest effect, $t(47) = 3.75$, when targets were small at study and large at test, in the delayed test condition. Overall there was more priming on the immediate test (0.113) than on the delayed test (0.070). An ANOVA of the priming scores, with test delay (minutes, 1 week), test display size (small, medium, large), and study/test condition (same, different) as within-subjects factors showed a significant main effect for test delay, $F(1, 47) = 41.49$, $MSe = 0.007$, $\eta^2 = 0.47$, and a significant interaction between test delay and test display size, $F(2, 94) = 3.31$, $MSe = 0.005$, $\eta^2 = 0.07$. No other effects reached significance. A series of exploratory *t*-tests showed that the effect of study/test size manipulation did not reach significance for any of the test size conditions, for immediate or delayed testing (largest $t(47) = 1.31$ for large objects on the immediate test).

The significant test delay × test display size interaction was followed by separate ANOVAs of the immediate and the delayed test priming data, with test display size (small, medium, large) as a within-subjects factor. The ANOVA of the immediate test data showed no effect of test display size, $F(2, 94) = 0.21$, $MSe = 0.002$, $\eta^2 < 0.01$. In contrast, the ANOVA of the delayed test data showed a significant effect of test display size, $F(2, 94) = 6.38$, $MSe = 0.002$, $\eta^2 = 0.12$. Follow-up *t*-tests showed that priming was comparable for objects displayed in small and in medium size at test, $t(47) = 0.74$, but that priming was smaller for objects displayed in large size than for objects displayed in medium or in small size, $t(47) = 2.67$ and $t(47) = 3.73$.

Recognition

Figure 2 shows the mean proportion of "old" responses – hits (H) for previously studied objects and false alarms (FA)

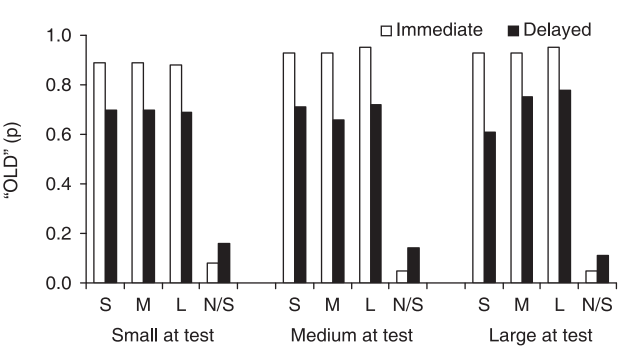

Fig. 2. The proportion of "old" decisions (hits for previously studied items and false alarms for new, non-studied items) on the old/new recognition test for photos of objects either on immediate or delayed test, as a function of study size (small, medium, large), test size (small, medium, large), and history (studied, non-studied). n/s = non-studied.

for new, non-studied objects. Performance on the immediate recognition test was extremely high, over 90%, and therefore, limited by ceiling effects (Uttl, 2005). Preliminary analyses showed that 58% of all corrected recognition scores (H-FA) were perfect, and the overall mean of these scores was 0.87 (H = 0.92, FA = 0.05). Thus, the immediate recognition test data were not further analyzed. In contrast, performance on the delayed recognition test was lower and off the ceiling. On the delayed test, performance on non-studied items showed that subjects made more false alarms on small size displays (0.16) versus medium or large size displays (0.13 and 0.12).

Because of the differences in false alarms, corrected old/new recognition scores were computed by calculating H-FA, and these were submitted to an ANOVA which had test display size (small, medium, large) and study/test condition (same, different) as within-subjects factors. This analysis showed a significant main effect of test display size, $F(2, 94) = 5.55$, $MSe = 0.03$, $\eta^2 = 0.11$, and a significant interaction between test display size and study/test condition, $F(2, 94) = 4.08$, $MSe = 0.03$, $\eta^2 = 0.08$. Follow-up tests showed a significant study/test condition effect for objects displayed as large at test, $F(1, 47) = 10.65$, $MSe = 0.02$, $\eta^2 = 0.19$, but not for objects displayed as small or medium, $F(1, 47) < 0.01$, and $F(1, 47) = 0.68$, respectively. Objects displayed as large were recognized more accurately when they were previously studied as large versus medium or small.

The analysis of *correct decisions only* showed that proportions of pixels required for making old/new decisions were similar on old/new recognition and implicit identification tests. Participants required overall 0.349 and 0.372 pixels for making correct old/new decisions on immediate and delayed tests, respectively, and they required overall 0.368 and 0.409 pixels for identifying objects on immediate and delayed tests, respectively.

DISCUSSION

Several critical findings were revealed in this experiment. First, there was a strong influence of the size manipulation on baseline identification. This finding is consistent with our experience in identifying objects from small photos as well as identifying objects from afar when higher spatial frequencies and corresponding detail are lost from the image. In turn these findings are consistent with the DAF hypothesis that we can simulate distance by shrinking the image or by filtering it through a low pass filter (Loftus & Harley, 2005).

Second, consistent with the prior research with line-drawings, study-to-test changes in size had only a minimal and statistically non-significant effect on the magnitude of priming. This result cannot be attributed to insufficient experimental power because the power of our study to detect, a 20% or 30% *reduction in the amount of priming* due to a study-to-test change in size was 0.93 and 1.0, respectively. Accordingly, our results indicate that effects of study-to-test changes in object size are small, resulting in less than 20% reduction in priming, and that they are smaller than effects of study-to-test changes in object orientation (Uttl & Graf, 1996) and object color (Uttl *et al.*, 2006) at least when comparable color photo stimuli and methods are used. In turn, these results counter the notion that the absence of size-specific priming effects in previous research was not observed because of impoverished object stimuli (line-drawings), low statistical power or a small number of peculiar objects. Our results extend the previous research by showing that even larger size manipulations (1:4) than those used in the previous studies fail to produce appreciable reductions in priming. The weak finding may indicate that, in contrast to orientation and color information, size information is not coded or is coded only minimally in the episodic memory representations that mediate priming of familiar objects (i.e., a coalescence of all prior episodic representations recruited for identification). In turn, the absence of size-specific priming effects is consistent with both structural and instance views of object recognition but it disfavors any claims of hyperspecificity of priming. However, it must be noted that orientation and color specific priming effects found in other studies are inconsistent with the structural accounts and favor instance views of object recognition. Moreover, recent research indicates that while absolute size manipulations such as the one used in the present study need not influence priming, when the study task required processing of object size (Srinivas, 1996) or when objects are presented in the context of another object highlighting their displayed relative size, strong object size effects emerge (Uttl, Graf & Siegenthaler, 2007).

Third, we found that old/new recognition decisions were more accurate for objects displayed as large at test and that study-test changes in object size reduced the accuracy of old/new recognition decisions. In turn, these findings confirm previous findings with line-drawings and extend them to new materials (color photos), tasks, and a greater range of object size manipulations within a single experiment.

Fourth, more importantly and in contrast to previous research with line-drawings, we found that study-test size manipulations had large effects on objects displayed in large size at test but not for objects displayed small or medium at test. Although this asymmetric effect of study-test changes in object size has not been discussed nor explained previously, it is not without precedent. To our knowledge, Paul Kolers and his colleagues (1985) were the first to report such a pattern of findings using gray-scale photos of human faces; in two experiments, they found that large faces were remembered better and that old/new recognition for large versus small test faces was affected more by size changes between the first and second presentation of each face during a continuous old/new recognition test. In parallel with our findings, they found the effects of face size primarily when the size change ratio was as large as 1:5 but not when it was only 1:2.

This asymmetry of study/test size changes on old/new recognition is consistent with the predictions derived from the DAF hypothesis (Loftus & Harley, 2005) as well as directly from drawing a parallel between spatial resolution of each image displayed on a computer monitor and spatial resolving power of human visual system in combination with higher spatial frequencies of retinal images of objects seen from a distance. By a way of an example, let's assume that a large test display includes 100 features (or bits of information) whereas small test displays include only 25 features and that the stored representations of large objects are more detailed and include as many as 100 features whereas representations of small objects include at most 25 features. Thus, participants are most likely to find a match between information provided by large test displays and information included in study trial representations of large but not small objects, and therefore, participants will be more affected by study/test size changes when they are tested using large versus small test displays. By contrast, information provided by small test displays is most likely included in the representations of small, medium, as well as large objects, and therefore, old/new recognition decisions are unaffected by study-test size manipulations. In turn, our findings add to the growing body of literature showing that the findings obtained using line-drawings of objects do not necessarily generalize to color photos of common objects (see, for example, Uttl & Graf, 1996, who directly compared line-drawings and color photos and showed that effects of study-to-test manipulations were smaller with line-drawings than with color photos). Moreover, they support the proposal (Steele, 1998) in the criminal eyewitness literature to use object arrays to cross-examine eyewitnesses about their ability to correctly identify crime scene objects seen from afar because even relatively small size change (1:4 cf. 1:15 or even more for faces investigated by Loftus & Harley, 2005) resulted in an appreciable drop in participants' ability to correctly recognize previously encountered small objects as previously seen.

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