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Cognitive Psychology

Find (and Remember) the Odd One Out: The Effect of Categorical Distinctiveness on Recognition Memory

Alexey Kotov[1a], Ivan Aslanov[2b], Tatyana Kotova[3c]

[1] Laboratory for Cognitive Research, National Research University Higher School of Economics, Moscow, Russia, [2] Center for Advanced Research in Education, Institute of Education, Universidad de Chile, Santiago, Chile, [3] The Russian Presidential Academy of National Economy and Public Administration, Moscow, Russia

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How does the relationship between the categorical membership of a target object and its surrounding context affect the memorization of the target object? We conducted four experiments to examine how categorical distinctiveness is related to memory. During the categorical discrimination stage, participants searched for a target to be remembered among five distractor images belonging to another category. In the low categorical distinctiveness condition, the target image was surrounded by perceptually similar images from the same superordinate category (e.g., a cat among dogs); in the high categorical distinctiveness condition, it was surrounded by dissimilar objects from another superordinate category (e.g., a cat among chairs). Participants also performed a recognition test. We expected an increase in the number of hits and false alarms in the recognition task for objects discriminated in the low categorical distinctiveness condition. This hypothesis was confirmed in Experiments 1 and 4, and the effect also partly remained in Experiments 2 and 3 (when we manipulated the memorization time), affecting only hits or only false alarms, respectively. Moreover, in Experiment 2, in which memorization was incidental, memorization among low-distinguishability objects was more accurate, which could indicate the advantages that categorical knowledge offers in such a memorization paradigm. This indicates the influence of categorical knowledge on the memorization and recognition of objects.

Introduction

In everyday life, individuals often navigate the surrounding world by utilizing their knowledge of various categories. For instance, when searching for a “stop” sign on the road, people can employ prior knowledge about the shape and color of such a sign to quickly locate it amidst irrelevant objects (Olivers, 2011). It is known that categorical information-based visual search is associated with semantic memory. For example, Maxfield, Stalder, and Zelinsky (2014) demonstrated that participants who were provided with the verbal label of a target object demonstrated more efficient visual search when the object had high typicality within its object class. A similar effect is also observed in early development research (Vales & Smith, 2015). Information regarding the category to which the target object belongs facilitates categorical attentional control, eliciting spatially selective modulations in visual-perceptual processing that lead to a successful object search (Nako, Wu, & Eimer, 2014, Exp. 1). However, in cases where a categorical search strategy cannot be employed (e.g., when the target and distractors belong to the same category), search efficiency is reduced (Lupyan, 2008b; Nako, Wu, & Eimer, 2014, Exp. 2). The facilitation of visual search through the use of category-based knowledge has also been demonstrated in color search tasks (Daoutis et al., 2006). At the same time, when employing more complex categorical schemes (or when relying on less familiar categories), the activation of selective attention may occur more slowly compared to simple non-categorical search for pre-specified targets (Nako, Wu, Smith, et al., 2014). Nevertheless, despite the context-dependent nature and the complexity of the target category, the general mechanism of categorical search is known to rely on a categorical model composed of features shared within the target class (Yang & Zelinsky, 2009).

a al.kotov@gmail.com

b Correspondence: ivan.aslanov@ciae.uchile.cl

c tkotova@gmail.com

Other studies have shown that the influence of categorical distinctiveness on visual search is mediated by the involvement of neural structures, specifically language-related areas. The detection of category-deviant objects among the rest of the objects occurs faster when they are presented in the right visual field (Gilbert et al., 2008), leading to an earlier assignment of compared objects to linguistic categories.

Thus, a considerable amount of evidence exists regarding how categorical knowledge aids in object search. However, a question arises concerning the relationship between visual memory and categorical knowledge. Can it be assumed that, when relying on semantic memory which contains categorical information, it is not only visual search that changes but memory for the found objects as well? It is known that, at least in categorization tasks, so-called representational shifts may occur (Lupyan, 2008a, 2012): when participants use categorical labels to name categorized objects, a categorical representation is activated, which can "blend" with the remembered object's image. Researchers investigating the phenomenon of categorical perception argue that people tend to flatten perceptual differences between objects belonging to the same category and to exaggerate differences between objects from different categories (Chkhaidze & Strother, 2022; Goldstone & Hendrickson, 2010; Newell & Bülthoff, 2002). Moreover, the influence of categorical knowledge occurs at the level of visual information processing (Lupyan et al., 2010), to the extent that categorical representation can affect the perception of feature intensity at the moment of its perception (Forder & Lupyan, 2019). Therefore, it can be hypothesized that referring to knowledge about the category to which the perceived object belongs will not only affect the speed and accuracy of search, as demonstrated in studies on visual search, but also the memory of the searched object, which will manifest in tasks involving recognition of previously seen category examples.

Indeed, several studies indicate that the representational shift induced by categorical knowledge influences the recognition of previously presented stimuli. In particular, De Brigard et al. (2017) demonstrated that if participants learn a new category, it increases hits for previously seen category members and false alarms for new examples of the same category. Continuing the work within the same paradigm, Yin et al. (2019) replicated these results and found that participants who learned the category better showed improved discrimination between old and new stimuli in a recognition test, compared to those who learned the category worse, suggesting that experience in category learning enhances memory performance. The increase in hits and false alarms during the learning of a new category was also demonstrated in the study by O'Neill et al. (2022), with the results being independent of the categorical learning strategy. Activation of a categorical schema in the study by Souza et al. (2022) yielded similar results concerning typical representatives of natural categories, improving the recognition of atypical exemplars. The authors explained this by pointing to the initiation of processes that deal with new information that does not fit within the stored prototype model.

In our study, we aimed to further investigate the relationship between categorical knowledge and recognition memory by modifying the approach to activating categorical knowledge. Often, this task is accomplished either by invoking categorical knowledge through verbal labels or by directly learning a previously unknown category (De Brigard et al., 2017). Other studies linking categorical distinctiveness and visual memory rely on loading visual memory with multiple examples, with categorical distinctiveness referring to the degree to which an object is unique among a number of others, such as a number of different images of apples among a set of images of furniture (Konkle et al., 2010). These studies show that categorically distinguishable objects cause less memory interference, reducing the number of false alarms during recognition (Konkle et al., 2010). Given that visual memory relies not only on visual images but largely on semantic meaning (Shoval & Makovski, 2022), we expected that a different semantic context would influence the results of memorization, and categorical distinctiveness can be understood not simply as a number of examples from the same category to memorize, but as the degree of semantic contrast between the target object and distractors.

Thus, in our experiments, we did not directly specify the target object to find and / or remember. Instead, we presented participants with the task of finding the "odd" object among a set of distractors. We hypothesized that, for a target object with high categorical distinctiveness (finding the odd object among members of a different superordinate category), visual search would be relatively straightforward. The odd object would automatically stand out due to its distinct perceptual features. However, in cases of low categorical distinctiveness (when the odd object belongs to the same superordinate category as the distractors), categorical knowledge would need to be engaged to recognize the distinctive features. We suppose that in the case of searching within a single superordinate category, participants cannot rely solely on explicit perceptual differences between objects. For example, a cat visually differs from a lamp so distinctly that individuals do not need to activate their knowledge of what cats and lamps are inherently to distinguish a cat among several lamps. The "odd" object looks so different that it involuntarily attracts the participant's attention. However, when searching under "Same Superordinate" conditions, participants more extensively engage semantic memory (distinguishing features of cats from dogs, for instance) and, therefore, pay less attention to the perceptual features of the target object (specific visual images of "paws", "tails", and "fur") and more to the semantics of these features (what are the substantive differences between the two categories?). As a result, the features of the memorized object are stored to a lesser extent in visual memory (in the form of visual images, a "picture" of the memorized object) but to a greater extent in semantic memory (in the form of information that the memorized object was, for example, a "cat" and had "cat paws" and a "cat tail"). A somewhat similar effect was described by

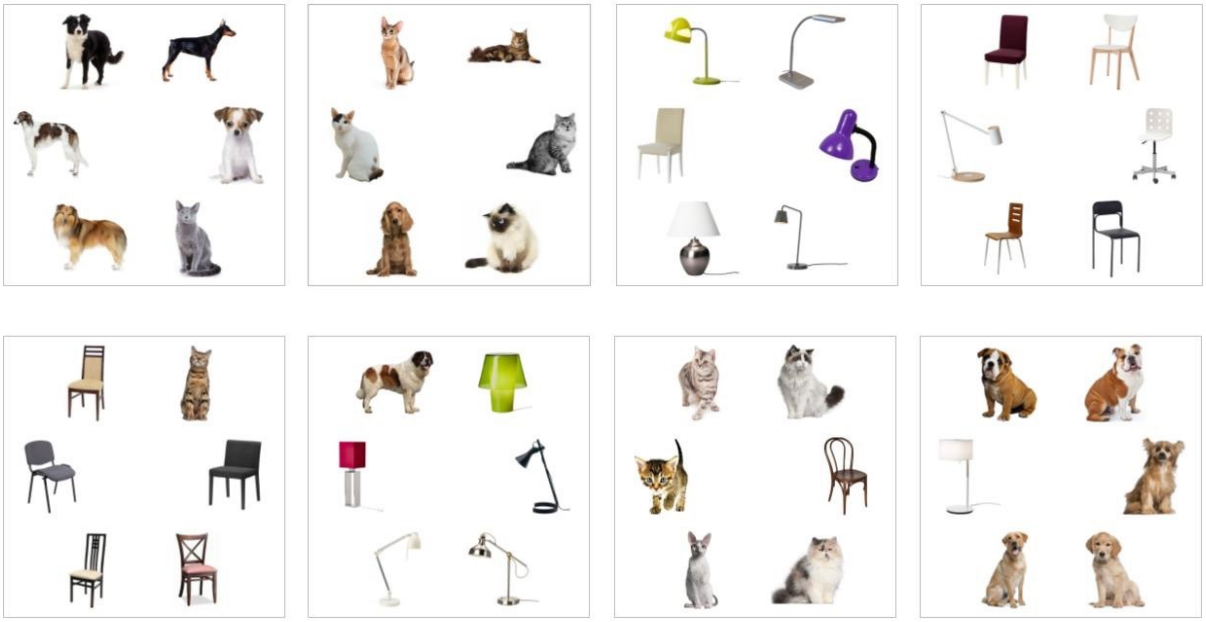

Figure 1. Examples of a target object surrounding by objects from the same / different superordinate category

Markov and Utochkin (2022) when they showed that people can confuse positions in space for categorically similar objects during recall because, as the authors hypothesized, subjects can use "conceptual labels" to label locations. Of course, both systems will be active during search and encoding, but categorical knowledge will be utilized more when searching within a single superordinate category to identify which perceptual differences are salient.

If this is the case, we would expect an increase in the number of hits and false alarms in the recognition task for objects searched in the low categorical distinctiveness condition compared to those that been searched in the high categorical distinctiveness condition, in accordance with the results described by De Brigard et al. (2017).

Experiment 1

Method

Participants. The study involved a total of 31 participants. They were undergraduate students from Moscow universities, aged 18 to 21 years (M=18.74 years; 22 females and 9 males). As a reward, participants received additional credits in academic disciplines.

Stimulus. The stimulus material comprised a set of 48 probe images. Each probe image presented five objects belonging to the same basic category, accompanied by a single target object that either belonged either to the same superordinate category as the probe objects or to a different category (Figure 1).

The images of chairs and lamps were obtained from an IKEA catalog. The images of cats and dogs were selected using an image search service. Each image was combined with others in the following manner: 48 images were arranged in sets of six examples with different ratios between the target image category and the background category. Specifically, there were six trial examples containing images of a dog among cats, six examples of a dog among lamps, and so on. All six images were placed in a circular arrangement at equal distances from the center. Thus, in each trial, the target object could appear in one of six possible locations. The experiment was designed in a way that there was no case where a specific image was used as a target in one trial and a distractor in another trial.

We randomly substituted half of the target images in each category with similar-looking pictures to prepare the materials for the recognition test. They were chosen as follows: the test image had to have some insignificant difference from the target image, such as the target and test images of dogs being of the same breed but differing in the pose of the dog. The furniture underwent color variations while maintaining the same object shape. Thus, the test stage consisted of 48 examples: 24 target examples that had been previously presented in the categorical discrimination task and 24 novel examples.

Procedure. The experimental material was displayed on a 14" laptop screen. Stimulus presentation and response recording were conducted using the PsychoPy software (Peirce et al., 2019). The first stage of the experiment involved a categorical discrimination task under conditions of either a shared or a different superordinate category. Participants were given instructions displayed on the screen: "You will need to find the differing object among others. If you find it in the left half of the screen, press the LEFT ARROW key. If you find it in the right half of the screen, press the RIGHT ARROW key. Try to respond as quickly and accurately as possible. Once you find the object and press the key, it will remain on the screen for 3 seconds. During

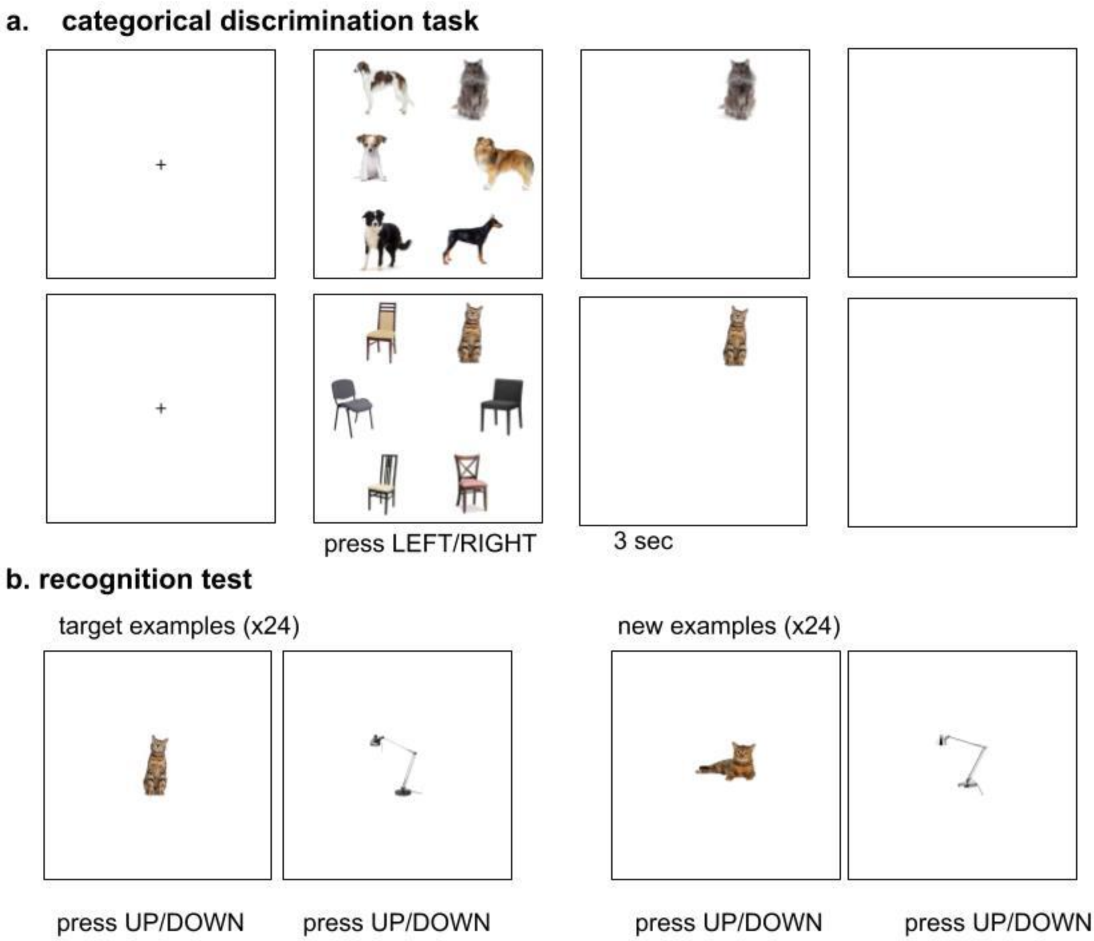

Figure 2. Experiment 1 procedure

In the categorical discrimination task (Task A), the Same Superordinate and Different Superordinate conditions alternated in blocks. There were 8 blocks of 6 trials each. In the recognition test (Task B), participants pressed UP if they thought the example was a target and DOWN if they thought the example was new. Target and new examples were randomized.

this time, you should try to memorize it as best as you can. Later, we will ask you to recall which objects you saw."

At the beginning of each trial, an image with a fixation cross was presented at the center of the screen (see Figure 2). Then, a trial with six images was presented, including one target object and five others from either the same superordinate category or a different one. Immediately after the response, the background images disappeared from the screen, leaving only the target object visible for 3 seconds, which participants were required to memorize.

The trials were presented in blocks: participants were first shown six trials where they had to find the target object among objects from the shared superordinate category (e.g., a cat among dogs), followed by six trials where they had to find the target object among objects from a different superordinate category (e.g., a cat among chairs). There were a total of 8 blocks. Half of the participants received the trials in this order, while the other half received them in the reverse order. The presentation of trials within each block was randomized.

After completing the initial stage of categorical discrimination, participants immediately proceeded to the recognition test. In the test stage, they were given the following instructions: "Now, we will show you images, some of which you have already seen (these are the images you searched for in the previous stage), and new images. You need to remember whether you have seen each image before or if it is new. If you believe you have seen the image before, press the UP key; if you haven't seen it, press the DOWN key. Try to respond as accurately as possible, and there is no time limit for your response." In the test, examples from all categories were presented in a random order, with each example displayed in the center of the screen on a white background and at the same size as in the discrimination trials. The test included three target examples from the discrimination stage with a shared superordinate category and three target examples from the discrimination stage with a different superordinate category (e.g., three examples of the cats that participants searched for among dogs and three examples of the cats that they searched for among chairs). This pattern was applied to all categories. In total, 24 images that participants had previously seen during the categorical discrimination and 24 new examples were used in the test.

The experimental design was within-subjects. The independent variable was the condition of the target example's environment during the discrimination: shared superordinate category or different superordinate category. In the categorical discrimination stage, the dependent variables were response time and success rate in detecting the target example. In the recognition test, the dependent variable was the accuracy of recognition. We used signal detection measures: the number of correct detections (hits) and false alarms or each participant, considering the examples from the trials in conditions with different environments. Based on these measures, a discriminability index (d') and decision criterion (c) were calculated.

Results and discussion

In comparing the times for distinguishing the target object in both conditions, we excluded wrong answers (15 out of 1515) and calculated the mean reaction time for each subject. Since the Shapiro-Wilk test detected a violation of the assumption of normality (W=.84, p<.001) for data from the discrimination stage, we conducted a Wilcoxon signed ranked test to compare the mean reaction times for both low categorical distinctiveness ('Same Superordinate') and high categorical distinctiveness ('Different Superordinate') conditions. There was a significant difference between 'Same Superordinate' (M=1.82 seconds, SD=0.92) and 'Different Superordinate' (M=1.21 seconds, SD=0.69) conditions (W=0.0, p<.001). Participants were faster in distinguishing the target object in a 'Different Superordinate' compared to a 'Same Superordinate' condition, as expected.

When analyzing the success of recognition, we compared the signal detection measures: hits, false alarms, d', and c for examples in the same and different categorical environments.

A signal detection analysis transforms the proportion of hits and false alarms into two statistics: d', a measure of detection sensitivity, and c, a measure of response bias (Macmillan & Creelman, 1991): d' = z(HR) - z(FAR) and c = -[z(HR) + z(FAR)]/2.

We found differences in the number of hits: t(30) = 2.15, p = 0.04, Cohen's d = 0.39. As shown in Table 1, the recognition success rate was higher in the 'Same Superordinate' categorical environment compared to the 'Different Superordinate' environment. Additionally, the number of false alarms was higher in the 'Same Superordinate condition compared to the 'Different Superordinate' condition: t(30) = 6.45, p < 0.001, Cohen's d = 1.15. The Wilcoxon signed ranks test indicated that sensitivity (d') was higher in the 'Different Superordinate' condition compared to the 'Same Superordinate' condition: z = -2.49, p = 0.013, SE effect size = 0.21. Analysis of the decision criterion revealed that the criterion was more liberal in the 'Same Superordinate' condition compared to the different condition: z = -4.18, p < 0.001, SE effect size = 0.87.

Thus, recognition in the 'Different Superordinate' condition was more accurate (d'). In contrast, in the 'Same Superordinate' condition, both measures (hits and false alarms) were higher, consistent with our hypothesis. The more liberal c suggests that participants more often tended to "recognize" objects based on their categorical membership rather than visual memory in the 'Same Superordinate' condition.

Since this was the first experiment in the series, we examined whether there was a contribution of category type to the result. To test this, inferential analysis was carried out using a mixed-effects regression approach with the lme4 package (Bates et al., 2015) package in R. The model considered the binomial dependent variable (accurate hits or correct rejections vs. false alarms or misses), representing a binary outcome (1 or 0), in relation to fixed effects of the type of the category ("cat", "dog", "chair", and "lamp") and random effects for each subject as well as random effects for each item, encompassing both fixed and random effects for the type of the category. The intercept in the model was rotated to test all possible contrasts between the categories (Schad et al., 2020). As can be seen, the observed differences are not significant: "cat" vs. "chair" (Estimate = −0.279, se = 0.309, z-value = 0.902, p = 0.367), "cat" vs. "dog" (Estimate = 0.307, se = 0.376, z-value = 0.816, p = 0.415), "cat" vs. "lamp" (Estimate = 0.093, se = 0.298, z-value = 0.312, p = 0.755), "dog" vs. "lamp" (Estimate = −0.214, se = 0.345, z-value = −0.620, p = 0.535), dog vs. chair (Estimate = −0.028, se = 0.355, z-value = −0.079, p = 0.937), "lamp" vs. "chair" (Estimate = 0.186, se = 0.270, z-value = 0.688, p = 0.491). Therefore, we consider that the category type does not impact the outcome of the memory test.

To investigate the extent to which memory depends on a participant's intention to remember target examples while performing a different task, namely categorical discrimination, we conducted a second experiment. In this experiment, during the categorical discrimination task, we eliminated the time for object perception after discrimination and omitted the instruction to remember the target objects. Therefore, since Experiment 1 tested the effect within the intentional learning paradigm, Experiment 2 was designed to test the effect on memory within incidental learning. Since there is contradictory evidence as to how intentional versus incidental learning influences the recognition of images (e.g., Goetschalckx et al., 2019) showed that there are no impacts on memory and recognition while Popov and Dames (2023) demonstrated the advantage of intentional learning), we did not have any prior hypothesis choosing a more exploratory approach.

Experiment 2

Method

Participants. The experiment involved 27 individuals aged 18 to 24 years (M=19.22 years; 20 females and 7 males).

Materials and Procedure. In Experiment 2, an alteration was made to the instruction by removing the following sentences: "Once you find the object and press the key, it will remain on the screen for 3 seconds. During this time, you should make an effort to memorize it as best as you can! Later, we will ask you to recall the objects you have seen." Consequently, participants were unaware of the need to memorize the target stimuli, and they were not provided with additional time for memorization. The experimental

Table 1. Mean proportion (and standard deviation) of hits, false alarms, d', and c for Experiments 1–4

Conditions	Hits	False alarms	d'	c
Experiment 1	*	***	*	***
Same Superordinate	.73(.16)	.42(.19)	1.05(.97)	-0.22(.68)
Different Superordinate	.66(.15)	.21(.14)	1.47(1.08)	.29(.52)
Experiment 2	***		**	***
Same Superordinate	.62(.16)	.47(.19)	.41(.37)	-.13(.46)
Different Superordinate	.47(.15)	.46(.16)	.02(.54)	.10(.32)
Experiment 3		***	*	***
Same Superordinate	.62(.13)	.40(.16)	.62(.47)	-.03(.35)
Different Superordinate	.58(.21)	.25(.17)	1.08(1.04)	.32(.56)
Experiment 4	*	***		***
Same Superordinate	.73(.17)	.39(.20)	1.07(.99)	-.28(.79)
Different Superordinate	.65(.18)	.26(.19)	1.47(1.31)	.20(.71)

*** p<.001, **p<.01, *p<.05

materials and the testing stage procedure remained unchanged.

Results and discussion

In order to analyze the results of the categorical discrimination stage, we excluded incorrect answers from the dataset (18 out of 1296) and calculated the mean reaction time for each subject in both conditions. A paired-samples t-test was conducted to compare the mean reaction times for both the same and different environment conditions. As in Experiment 1, there was a significant difference between the 'Same Superordinate' (M=1.57 seconds, SD=0.37) and 'Different Superordinate' (M=0.87 seconds, SD=0.23) conditions: $t(26)= -12.01$, $p<.001$.

We found differences in the number of hits: $t(26) = 4.65$, $p < 0.001$, d-Cohen = 0.9. The recognition accuracy in the 'Same Superordinate' condition was once again higher than in the 'Different Superordinate' condition. However, unlike the first experiment, the number of false alarms did not differ between the 'Different Superordinate' and 'Same Superordinate' conditions: $t(26) = 0.28$, $p = 0.78$, d-Cohen = 0.05. Sensitivity (d') was higher in the 'Same Superordinate' condition compared to the 'Different Superordinate' condition: $t(26) = 3.18$, $p= 0.004$, d-Cohen = 0.61. Analysis of the decision criterion revealed that the criterion was more liberal in the 'Same Superordinate' condition than in the 'Different Superordinate' condition: $t(26) = -3.20$, $p = 0.004$, d-Cohen = -0.62.

Comparing the first and second experiments (Figure 3), we observed that, in the absence of time for memorization and forewarning about the test, recognition accuracy was determined solely by the number of hits, rather than false alarms. Incidental learning led to a higher number of false alarms in the "Different Superordinate" condition ($t(54) = 6.02$, $p < 0.001$, d-Cohen = 1.61). Because of the large number of false alarms, sensitivity in this condition was reduced to an almost random response rate. While the intention was important for encoding when participants relied on distinguished perceptual differences, the influence of categorical knowledge on recognition was weakened but remained present. We suppose that it was automatically evoked by the categorical distinctiveness task. However, in the Experiment 1 (intentional learning), participants not only received a warning about the need for memorization but also had time for memorization. During this period, participants could focus and better encode the target objects. The importance of this time can be further examined by a condition in which the target objects remain on the screen after categorical distinctiveness, but with the duration of their presentation reduced.

Experiment 3

Method

Participants. The experiment involved 25 individuals aged 18 to 28 years (M=22.01 years; 16 females and 9 males).

Materials and Procedure. Experiment 3 utilized the same stimulus material as in the previous experiment; however, we retained the instruction warning about the necessity to memorize the target exemplars. Furthermore, the duration for which the target object remained on the screen was reduced from 3 seconds to 0.5 seconds.

Results and discussion

We excluded wrong answers (24 out of 2088) and calculated the mean reaction time for each subject. According to the results of the Shapiro-Wilk test, there was a violation of the assumption of normality ($W=.86$, $p<.001$) in data from the categorical discrimination stage. We conducted a Wilcoxon signed ranked test to compare the mean reaction times for both the same and different environment conditions. There was a significant difference between the 'Same Superordinate' (M=1.57 seconds, SD=0.46) and 'Different Superordinate' (M=1.01 seconds, SD=0.37) conditions ($W=0.0$, $p<.001$).

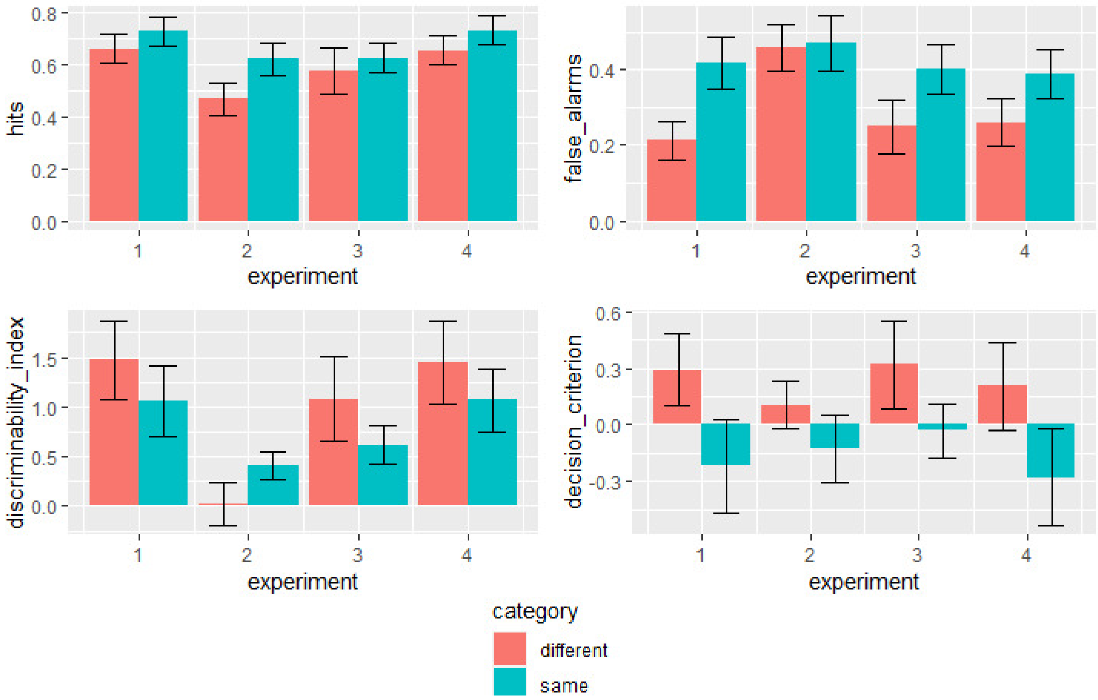

Figure 3. Signal Detection Theory scores for Experiments 1-4

Error bars represent 95% confidence interval.

We did not find any differences in the number of hits: t(24) = 1.10, p = 0.28, d-Cohen = 0.22. However, the number of false alarms was higher in the 'Same Superordinate' condition compared to the 'Different Superordinate' condition: t(24) = 4.43, p < 0.001, d-Cohen = 0.89. Sensitivity (d') was higher in the 'Different Superordinate' condition compared to the 'Same Superordinate' condition, t(24) = -2.26, p < 0.03, d-Cohen = -0.45. Analysis of the decision criterion revealed that the criterion was more liberal in the 'Same Superordinate' condition than in the 'Different Superordinate' condition: t(24) = -4.11, p < 0.001, d-Cohen = -0.82. The results indicate that the effect on recognition in the 'Different Superordinate' condition was again attenuated compared to Experiment 1, but now in the absence of differences in the number of hits rather than false alarms (Table 1). However, both d' and c also differed. Thus, in the second and third experiments, we demonstrated that factors related to the task and its instructions can influence this effect.

Nevertheless, in our experimental design, there is another factor that potentially amplifies the effect — participants' expectation about the content of the probe within each block. As we presented the probes grouped into blocks, participants expected that the categorical contrast would be maintained throughout the six blocks. This expectation could also influence memorization. In the fourth experiment, we eliminated these expectations by presenting all the probes in different conditions in a random order.

Experiment 4

Method

Participants. The experiment involved 39 individuals aged 18 to 25 years (M=21.35 years; 26 females and 13 males).

Materials and Procedure. Experiment 4 utilized the same stimulus material as in the previous experiment; however, the categorical discrimination stage procedure was modified so that all trials were presented in a random order rather than being grouped into blocks.

Results and discussion

Similar to the procedure described above, we excluded wrong answers (30 out of 1650) and calculated the mean reaction time for each subject. Given that the Shapiro-Wilk test detected a violation of the assumption of normality (W=.80, p<.001) for data from the search stage, we conducted a Wilcoxon signed ranked test to compare the mean reaction time for both 'Same Superordinate' and 'Different Superordinate' environment conditions. There was a significant difference between 'Same Superordinate' (M=2.23 seconds, SD=0.95) and 'Different Superordinate' (M=1.42 seconds, SD=0.74) conditions (W=31.0, p<.001).

We observed differences in the number of hits: z=2.43, p=0.02; SE effect size=.21. As seen in the table, the recognition success in the 'Same Superordinate' condition was again higher than in the 'Different Superordinate' condition. The number of false alarms was higher in the 'Same Superordinate' condition compared to the 'Different Superordinate' condition: t(38)=4.13, p<0.001, d-Cohen=.18. Sensitivity (d') in the 'Different Superordinate' condition did not differ from sensitivity in the 'Same Superordinate' condition: z=1.43, p=0.16; SE effect size=-.27. The analysis of criterion once again showed that the criterion was more liberal in the 'Same Superordinate' condition than in the 'Different Superordinate' condition: z=-4.07, p<.001; SE effect size=-.77.

Thus, we have demonstrated that the effect of categorical knowledge on memory retention persisted, but it did not affect all aspects of the signal detection task. This suggests that participant expectations play a role in memory retention.

General Discussion

In the present study, we tested the hypothesis that participants rely on categorical knowledge when searching for a distinguished object in the low categorical distinctiveness condition (when distractors belong to the same superordinate category), in contrast to the high categorical distinctiveness condition. We expected an increase in the number of hits and false alarms in the recognition test when participants memorized objects with low categorical distinctiveness. This hypothesis was fully confirmed in Experiment 1, when participants had time to memorize the object. This is consistent with the results of De Brigard et al. (2017), who showed that teaching subjects a categorical schema increases hits for old examples and false alarms for new ones if these examples are congruent with the categorical schema. Although De Brigard et al. (2017) did not give a clear interpretation of the mechanism of this effect, they suggested that different memory systems are involved when memorizing objects with versus without reliance on a categorical schema. In our study, we also showed that the use of categorical knowledge can lead to interference in recognition memory, and hence we can assume that similar cognitive mechanics are involved.

According to our interpretation, in the "Same Superordinate" condition participants had to use categorical knowledge to identify semantically meaningful differences between objects, whereas in the "Different Superordinate" condition perceptual differences between apparently distinct objects were sufficient. In a sense, we can assume that in our experiments subjects engaged different memory systems to varying degrees, relying more on semantic memory in the "Same Superordinate" condition. When distinguishing between objects, the visual component of features may not have been as important because, for example, distinguishing paw A from paw B can be problematic based on their external features alone (whereas distinguishing a paw from a chair leg is very easy because their appearance is very different). Instead, participants needed to use categorical knowledge to pay attention to salient differences between perceptually similar objects (e.g., category of cats vs category of dogs). Thus, whereas in the "Different Superordinate" condition subjects remembered more information about what the object looked like, in the "Same Superordinate" condition they remembered more about what the object was (what category it belonged to). At the moment, we cannot describe the mechanism of categorical knowledge participation more precisely, assuming that subjects may shift attention from the perception of features to their semantic properties; at the same time, there may be a representational shift in which the category prototype distorts the representation of the memorized object, which leads to the observed differences in d (Lupyan, 2008a). Obviously, the mechanism of categorical knowledge involvement will need to be investigated in the future.

However, it is important to point out another fact: although we found a similar pattern in the increase in hits and false alarms as in the De Brigard et al. (2017) experiments, we also obtained significant differences for d' in Experiment 1. Specifically, d' was significantly lower for the "Same Superordinate" condition. This may also indicate that in the "Same Superordinate" condition, semantic memory played a more significant role, leading to a reduced criticism to new instances (as they exhibit different perceptual characteristics but the same semantic features compared to the old instances). In principle, this could be interpreted as a stronger influence of categorical knowledge in the recognition task than De Brigard et al (2017). found, which may be due to the fact that De Brigard et al. (2017) used more "weird" artificial categories and trained participants with new schemas rather than activating familiar and long-known ones (which may have increased control for the influence of categorical information on the part of participants).

In Experiment 2, we tested whether the effect would persist with incidental learning. The hits rate was still significantly higher in the Same Superordinate condition, but the FA rates almost equalized due to the increase in FA in the "Different Superordinate" condition. This resulted in d' being significantly higher in the "Same Superordinate" condition (reversing the results of Experiment 1). We can conclude that memorization relying on categorical knowledge proved to be less sensitive to the change in learning paradigm (intentional versus incidental), whereas effective use of visual memory requires intention. This is consistent with some previous findings. For example, the incidental memory for stimuli like colors and digits is generally reported to be low (e.g., H. Chen & Wyble, 2015). In contrast, more meaningful and novel stimuli may exhibit better retention in incidental memory (e.g., W. Chen & Howe, 2017). Sasin et al. (2023) demonstrated that the incidental storage of objects occurs at the exemplar level rather than at the state level. Thus, incidental memory, when requiring the engagement of categorical knowledge and semantic memory, may indeed be more accurate.

In Experiment 3, when there was little time for memorization, the influence of categorical distinctiveness persisted, and the "Different Superordinate" condition again resulted in a reliably higher d'. In Experiment 4, we also demonstrated that the influence of categorical distinctiveness is not dependent on expectations during encoding: the influence persisted (in terms of correct detections and false alarms) when participants could not form expectations about the type of categorical distinctiveness of the stimulus. Taking all this into account, we can conclude that the need to use categorical knowledge to find an "odd" object leads to a distortion of recognition memory due to a more liberal c and a lower d', which suggests that in this case target objects are remembered less as perceptual images and more as representatives of certain categories. However, considering the results of Experiment 2, we can assume that this mechanism provides an advantage in the situation of incidental learning.

It is also worth pointing out several aspects of this study that require further investigation and potentially suggest alternative interpretations for the effect found. First, since the search task was more difficult in the "Same Superordinate" condition, this could result in a reduced dual-task impact in the "Different Superordinate" condition concerning visual search and memory encoding, which might, to some extent, account for the higher d' observed in the "Different Superordinate" condition in Experiments 1 and 3. That is why Experiment 4 could have experienced a weakened effect on d', possibly due to the intermixing of the two conditions. Second, due to the different difficulty level in the two conditions, the object search time also differed, which resulted in the overall encoding time of the memory targets being higher for the "Same Superordinate" condition. This might have had more impact in Experiment 2 where an incidental learning paradigm was applied. In addition, although we attribute the observed effect mainly to the influence of categorical knowledge, it should be noted that objects in the two conditions differed perceptually as well. Therefore, the effect may be partially explained by the perceptual, rather than semantic, similarity of the objects for the "Same Superordinate" condition. In future studies, it will be necessary to control for the degree of perceptual similarity for objects in both conditions.

An additional limitation of our research findings is that the effect of categorical distinctiveness varied across different conditions. The most pronounced effect was observed in the first experiment. In this experiment, the difference in recognition performance between high and low categorical distinctiveness conditions was evident in terms of hits, false alarms, and overall sensitivity. However, in the other experiments, we failed to observe the same influence across all measures. The effect was significantly attenuated by the presence of instructions and time for memorization (Experiments 2 and 3), as well as the formation of expectations regarding categorical distinctions and the categories to which the target object and background belong. Given that the categorical discrimination task required memorization of a large number of exemplars, these limitations appear to be natural. Finally, it should be noted that there was quite a large variation in the number of subjects in the four experiments. In order to make a more consistent comparison of results in future experiments, it will be necessary to increase the samples and make them more quantitatively comparable. We recognize a shortcoming in this aspect and believe that the key effects found in our experiments should be replicated with more appropriate samples in the future.

In conclusion, we have identified the effect of categorical context on memory retention: recognition under conditions of low categorical distinctiveness is associated with higher numbers of correct detections and false alarms, and with more liberal decision criterion as well. Our study provides evidence for the role of situational factors in activating categorical knowledge. Additionally, we found that the observed effect is amplified by participants' expectations and strategies, showing the importance of categorical knowledge in incidental memorization. A more precise explanation of the involvement of these factors and their interaction in the activation of categorical knowledge during encoding should be explored in future research, including the involvement of previously studied factors such as category schema automatization and language (category labels).

Contributions

Conception and design: AK, TK
Data acquisition: AK
Analysis and interpretation of data: AK, IA
Article drafting and/or revision: AK, IA, TK
Approval of the submitted version for publication: AK, IA

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Competing Interests

The authors declare that no competing interests exist.

Data Accessibility Statement

All stimuli and participant data can be found on this paper's project page https://osf.io/27dq5/.

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Supplementary Materials

Peer Review History

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