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The Effect of Recent Experience on Template Formation during Categorical Visual Search

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THE EFFECT OF RECENT EXPERIENCE ON TEMPLATE FORMATION DURING CATEGORICAL
VISUAL SEARCH

by

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A thesis submitted in partial fulfillment of the requirements
for graduation with Honors in the Psychology

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Andrew Hollingworth
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All requirements for graduation with Honors in the
Psychology have been completed.

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Abstract

Previous studies have shown that while searching for categorical objects (e.g. cars, clothing, fruits, etc.), we utilize a template as a reference to aid in our detection and identification of our target object. Even more, other research has proposed the capacity of this template to accommodate or modify based on the exemplars presented for that categorical group. In addition, they have shown the capacity of these same exemplars to broaden or further specify the template used during these searches. However, these findings do not consider the effect that recent exemplars have on existing templates. In the following experiment, we trained participants by exposing them to color-specific images of a particular category that (in the real world) would generally not be biased by color (e.g. dogs have many different types and colors). Our findings indicate that recent exposure to a color-specific exemplar of a category does indeed influence the template used during a search task. Our data suggests that the participants adopt a template that is biased to the exposed color, which later returns to the original template as they are exposed to more colors.

Introduction

There is continuous necessity for our visual system to be ready at any moment to search for an object in the environment. Without this capacity, it would be impossible for us to detect the objects required for us to accomplish the tasks at hand (e.g. making coffee, writing your lab report, operating on a patient, etc.). There needs to be mechanism through which our visual system is able to recognize an object as potentially pertaining to our target item and verifying that it indeed belongs to said category. Fortunately, it is argued that we utilize a *visual template* that aids in the search for target items (Maxfield, Stalder, & Zelinsky, 2014). From the moment we realize we need a coffee filter in order to make coffee, a *template* is called upon which helps us identify the

object in the environment and then verify that we have indeed found the coffee filter (and not a cupcake wrapper). This type of search is known as *categorical search*, and it has shown to be an important mechanism for the ability to search in our quotidian lives.

In previous work, research by Maxfield, Stalder, & Zelinsky (2014) has suggested the existence of a template to which we reference during our search of a particular object. In their experimental design, Maxfield, Stalder, and Zelinsky (2014) had participants search for categorical objects within a group of distractors. The objects would differ in typicality (extent to which the item was representative of its category) that was suggested to have an effect on RTs. Maxfield et al's (2014) findings demonstrated that the closer the item was to the *typical* appearance of the category the faster the participants were at searching for the target item. In addition, the items with high-typicality were fixated first more often than they were to medium- or low-typicality items. A critical finding of Maxfield et al's (2014) is the fact that the low-typicality items would at times appear to the participants as being too *different* from the typical category that they would sometimes believe the item to be *absent* in the trial. These findings are vastly invaluable as they argue the presence of a *template* for the target item during the searching process. Even more, the research indicates the possibility that the template exists in a versatile state that can slightly accommodate changes to the expected appearance (differences between high-, medium-, low-typicality).

As it was stated, whenever prompted to search for an object, we will call upon an object representation (i.e. *template*) of the search target (Bravo & Farid, 2013); however, we will do so regardless of the hindrance this verification step imposes to the performance of the search task (Bravo & Farid, 2013). In an experiment by Bravo & Farid (2013), it was observed that participants would utilize templates learned in a previous training phase despite the futility of a verification step to find the object. During the training phase, participants were asked to learn researcher-

designed butterflies that either differed on their top or bottom wings– the alternative wing would remain the same between butterflies; each distinct design was given a one-syllabic name cue. At the time of testing, the top wing or bottom wings were obscured with the background that resembled the design on the respective wings. Participants demonstrated a selectivity for a search template that prioritized the "distinctive cue" (the wings that differed between stimuli) than for the "common cue" (the wings that remained the same across stimuli). The critical finding in this experiment is the participants selectivity for a *long-term memory template* that favored a particular *distinctive* component of the stimuli, despite the similarity in the alternative wing which grouped them together. However, this experiment only purports the mechanism chosen for learning new subcategories: the overall category still remained butterfly between trials, and even the "common cue" remained identical between butterflies. Bravo & Farid (2013) appear to have identify the type of learning that would occur when a novel broad category (e.g. fox) is divided into further subcategories that share distinctive features (e.g. red fox, fennec fox, winter fox, etc.).

Even more, in previous research, the template for a given search target has been shown to be susceptible to biases imposed by the context (Bravo & Farid, 2016). Bravo & Farid (2016) used watches to demonstrate the capability of cueing (context) to decrease overall reaction times (RTs) in a search task. Participants were trained by asking to search for a watch in a cluster of watches where the distractor or the target varied between trials; each distinct distractor or target was displayed alongside a number ("1", "2", or "3") prior to each trial. During the testing phase, the cue provided would either be an informative cue (trained) or uninformative cue (unrelated to variations). According to this research, both cueing for the varying targets or distractors demonstrated to be effective in reducing the RTs of participant's search. This research indicates the capability of augmenting the template of a particular category (in this case watches); it is possible to form an object representation that includes extraneous information that would not be

necessary when generally trying to identify (search) the object; importantly, this research demonstrate a capacity of changing the template through training. Even so, the research focuses on the addition of information on the established template – adding a contextual number to help identify the object. Although they do differ the design for the target in one of the experiments, they do not test the effect of these design difference exclusively without its relation to the cue. As result, it does not expand on the effects of altering the fundamental target template (watches' designs) on the RTs during the search task.

Additionally, research by Hout et. al (2017) demonstrated the extent of the specificity of the representative templates of categorical groups. Participants were given a search task in which they were asked to search for a socially important (SI) vehicle (e.g. ambulance, police, school bus, etc.) or civilian vehicles (e.g. delivery truck, sedan, SUVs, etc.). The findings suggest that participants were faster as identifying SI vehicles than they were the – more variable – civilian vehicles. To question the homogeneity of the SI vehicles, they performed a second experiment where the participants were shown the vehicle they needed to locate and were asked to find it within a group of distractors identical to the SI vehicle. As would be predicted from homogeneity, the participants' RTs increased to due to the difficulty in locating the object due to the substantial overlap with the distractors. These findings clearly indicate a template capable of adjusting to variation in the *typical* object: the more varied a category is, the less specific its template will be. According to this research, it would reasonable to suggest that the template would modify with each exposure to a new exemplar of a category. For example:

- Child is initially exposed to their own poodle (category: dog).
- Child is exposed to new exemplar, friend's bull dog; template must now accommodate for both exemplars, so the template now broadens and becomes less specific.

- Child is again exposed to another exemplar, Dalmatian; template accommodates and broadens.

This suggests that the template is alterable and capable of being modified to adjust for new features that are considered representative of the category.

Bravo & Farid (2011) tested this very assumption of the templates capability for adjusting to varied exposure. In their experiment, Bravo & Farid (2011) had participants learn a set of 16 fishes that were divided into four fish species with each containing four representative images. The participants were trained under two different conditions: (1) those that were exposed to just one fish per block, and (2) those that were exposed to the category (all four images) per block. Later, the participants were cued with a word or an image (of the category fish) and asked to assess their presence or absence. Participants that were training in the block-by-category condition were able to more rapidly assess whether there was a presence of the cued fish regardless of whether it was novel (but identical in category) fish or the same fish seen in training. Bravo & Farid's (2011) findings suggests that participants in the block-by-category group used a broader template for identifying the category than did the block-by-image group. This is particularly important as it verifies that the template is capable of modification depending on the (at least) recent exposure of relevant information of the category. However, this research only identifies the effect of exemplar volume on the specificity of the template, but it doesn't assess the capability of modifying an established template.

In the present experiment, we aimed to determine the effect recent exposure of an exemplar of a category has on the template representation of said category: more specifically, the effect of recent exposure of an exemplar that is consistent at a single, manipulated feature. Participants were asked to run two experiments that were presented as having no relation to each other. In the first experiment (training phase), participants were shown an image and prompted to select a button to

state whether that the image was either "manmade" or "natural". However, each of these categories would contain two exemplar groups that were different in color (e.g. black/brown dogs, red/black MP3s, blue/orange butterflies, etc.). During the second experiment (testing phase), participants were given a categorical word (e.g. butterfly, MP3, dog, etc.) and were asked to find the image of that word which contained an "F" oriented towards the left or right (mirrored). We hypothesized that if participants were utilizing templates that had been modified based on the color, then the participants would be faster at identifying the novel image of the category that contained an identical color as the images to which they were exposed in training. However, if participants did not adopt a new template for the category, which in the real world would be color independent due to variation – that broadens the template, and lessens the specificity (Hout et. al, 2017), then the RTs for the search task would be identical regardless of whether the search item was identical to or different from the color in the trained images.

Methods

Participants

A sum of 43 participants (28 Females) were recruited from Psychology undergraduate courses through the SONA system at the University of Iowa. All participants self-reported normal or corrected vision and were rewarded a credit hour for their respective courses.

Apparatus

The experiment was run on a SilverStone and Optiplex 990 computer. Both computers used a Benq monitor approximately 45 x 25 cm in size. Participants made their selection on a Cedrus RB response pad. Participants were also positioned on a chinrest the maintained a constant position

for their head throughout the experimentation; the participants were seated approximately 77 cm away from the screen.

Stimuli

Our set of images consisted of 40 unique categories which contained 20 images each (total 800 images). Those 20 images where then divided into two further subgroups that were different only by color (e.g. blue butterfly and orange butterfly). From the 40 unique categories, half of them were representative of manmade objects (e.g. shirts, MP3s, tricycles, etc.), while the other half was representative of natural objects (e.g. fruits, vegetables, animals, etc.). These images were obtained from a variety of websites utilizing the Google Image Search function with a transparency filter added to the search. Some of images (esp. those from the natural category) were edited manually to remove the environment in which they found themselves in, leaving only the target object in the display. None of the images were ambiguous as to whether their identity belong to the natural or manmade categories: for example, pancakes, which could be argued to be either, we're not chosen as a target category. Even more, 175 distractors were also obtained through this same methodology; however, we ensured that these distractors were as distinct as possible from the target groups and were cautious of choosing colors that were not found in any of the forty categories.

Discontinuity

To ensure that the participants were not aware of the relationship between the training phase and testing phase, we pretended that the participants would be running two unrelated experiments. We ensured to use phrases such as:

- "You will be running two *different* experiments today"

- "One experiment was so short that we had to group it with *another* experiment to provide you with the most credit"

- "Now this experiment has a *distinct* set of procedures"

Participants were also debriefed after the first experiment (training phase) with a false purpose for the investigation: "we ran this experiment to see whether people are better at identifying manmade or natural objects."

Training - Procedure

Participants were asked to observe an image that appeared at the center of the screen and determine whether they considered that object natural or manmade. Prior to staring each trial, the participants were presented a screen which read, "Press a Button." The participants would select either a green or red button on the response pad in order to move forward. After selecting either of the buttons, the participants would be presented with an image of one of the objects in the 40 categories. Participants would either press the blue button for natural images or yellow button for manmade images. Regardless of the rapidity of their response, participants would be exposed to the image for a total of 2 seconds: for example, if the participant made a selection at 700 ms, then participant would continue to the see the image for 1300 ms. Going from one trial to the next, there was a delay of 500 ms. If the participants took longer than 2 seconds to respond, the experiment would consider this an incorrect response. Slow (>2 seconds) or incorrect responses would display an image with the statement "INCORRECT" in red that lasted 2 seconds.

For all forty categories, each participant was randomly assigned one of the two colors for exposure. During this training phase, the participants would only be exposed to 6 of the 10 total images for that color; the last four in that same color group and the different color group (8 total)

would be later used in the testing phase. These images were then divided into six blocks with each containing one of the images from the six images of the color the participant was assigned.
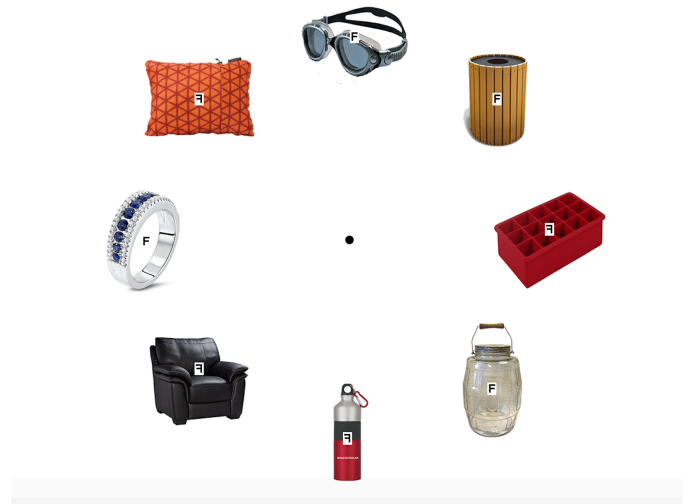

Image 1: Example of the format that would presented during the test trials.

Testing - Procedure

Prior to the second experiment, the participants underwent a practice session (10 trials) which used target images that were not found in any of the target groups or in the distractor group. Participants would be presented a word cue for the image they had to locate. Participants then were instructed to determine whether an "F" found within the target image had its prongs facing to the right (normal F) or left (mirrored F); participants would select the blue (right) button for the normal F or the yellow (left) button for the mirrored F. Participants would again be shown a screen with the statement "Press a Button" in which they would press either the green or red button to move forward. Once the button was pressed a fixation hollowed circle was presented in the middle of the screen for 400 ms; afterwards, a word cue would then appear for 800 ms; subsequently, another fixation circle would appear for 1,000 ms. After the fixation circle expired, an array of eight images all evenly spaced from each other and the center was presented on the screen (Image 1). Seven of those images would be randomly selected from the pool of 175 distractors, while one of the images was choosing from the additional 8 images remaining in each category (last 4 images per color [2]

per category). There was total of four blocks with each block containing 80 search trials (40 categories: 2 colors each). As a result, in each block, participants would be tested on both colors in each category. The order of testing was randomized between participants.

<div align="center">

Results
</div>

Accuracy

To ensure that participants were indeed performing the search task correctly and were focused during the experimentation, participants that performed with an accuracy lower than 85% would be removed from the analysis. A total of three participants were removed from the analysis data due to their accuracy being below the 85% mark. The rest of the participants (40) performed with accuracies higher then 85% with a range between 85% and 100%.

Testing Phase - RTs

We ran analysis of the RTs for the color conditions (identical color versus different color) and blocks (1 - 4). A 4 x 2 ANOVA of the color conditions and blocks was performed to identify the main effects and interaction between these two variables. The analysis identified a main effect of color condition ($F(1,39) = 66.279$, $p < .001$, $pn^2 = .63$), suggesting that the participants were faster at identifying images that contained the color to which they were exposed during training, slower for whenever the color differed. Even more, the ANOVA did not find a main effect of block on the RTs ($F(3,117) = .337$, $p = .798$, $pn^2 = .009$), suggesting that the participants did not become more efficient at identifying: alternatively, the participants performed equally between blocks, and so equally fast at finding their items between blocks. Additionally, the ANOVA did determine an interaction between the color condition and blocks ($F(3,117) = 4.401$, $p = .006$, $pn^2 = .101$),

suggesting that the color condition RTs did differ from block to block – potentially, the loss of the trained template as exposure to both colors increased.
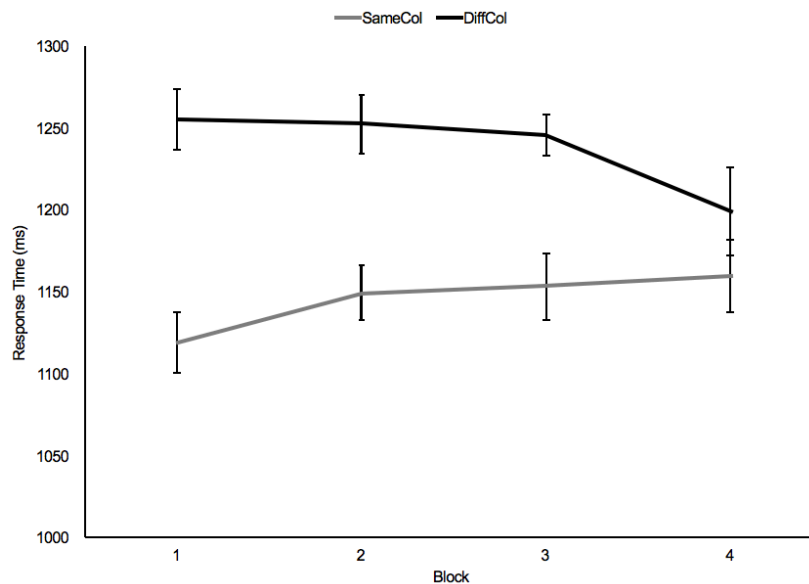
Graph 1: The graph compares the average response times between the same or different color condition going from block to block.

A pairwise comparison of the color condition in each block yielded the following: Block 1: t(39) = 6.694, p <.001 | Block 2: t(39) = 4.651, p <.001 | Block 3: t(39) = 4.586, p <.001 | Block 4: t(39) = 2.255 p = .115. These findings suggest that the color condition was meaningful for the first three blocks (1,2, & 3) but become irrelevant in the fourth block (4); this could be the result of equal exposure to both colors during the testing phase.

An additional two-way ANOVA was also performed on the RTs, but, in this analysis, the object type (manmade vs. natural) was accounted as a factor for potential differences. According to the analysis, there was no main effect of object type (F(1,39) = .177, p = .676, pn^2 = .005) and there was no interaction either. This suggest that the difference of the object type had no effect on the RTs of the participants during the search trials.

Finally, a two-way ANOVA was performed on the accuracy of the participants as a function of the color conditions and blocks. There was no main effect of color condition on accuracy ($F(1,39) = 1.411$, $p = .242$, $pn^2 = .035$), suggesting that the participants were equally accurate for both conditions (identical or different color). There was also no main effect of block on accuracy ($F(3,117) = 1.267$, $p = .289$, $pn^2 = .031$), suggesting that the participants were equally accurate going from block to block. In addition, there was no interaction between the color conditions and blocks on accuracy ($F(3,117) = .042$, $p = .987$, $pn^2 = .001$), suggesting that there was no accuracy difference between the color conditions that changed between block to block.

Discussion

As demonstrated by Maxfield, Stalder, Zelinsky (2014), our visual system makes use of a memory template that encompasses the typicality of the category of importance. Even more, it has been shown that is possible to alter this template through recent exposure of exemplars of that category (Hout et. al, 2017). In the present, study we branched off from this vast literature in categorical search in order to identify the effect exposure of a *manipulated* exemplar has on the template for a category group. According to our finds, the data suggests that it possible to alter the established template of a category through exposure of images of that category that are selected for a specific color.

Each participant was exposed to a single color for every category that was tested in this experiment: one participant may be exposed to brown bears, while the other would be exposed to black bears. With a thorough attempt at occluding the relationship between the first experiment (training phase) and second experiment (testing phase), participants were asked to participate in a search task that tested them on both color conditions for each of the categories. According to our findings, the participants were faster at finding the exemplars of a category that matched the color

for the exemplars that were shown in the training phase. On the other hand, participants were significantly slower at finding the target exemplar, whenever the color was different from that seen during the training. This data is consistent with Hout et. al's (2017) findings; however, the difference in our experiment is the location at which the alteration of the template occurs. In Hout et. al's (2017) research, the alteration of the template would be assumed to have occurred outside of the lab through quotidian exposure of the civilian vehicles, while, in this present experiment, the alteration occurred in the lab through exposure of color-biased images. It would appear that we have induced the template to accommodate the recent exposure of the color-biased image and, as a result, biased the template itself.

Even more, we further support the findings of Bravo & Farid (2011). In their research, they determined that participants were capable of adopting distinct templates depending on the type of training they received: (1) block-by-image, and (2) block-by-category. As can be seen in graph 1, the difference in the RTs between the two color conditions diminished over time (block to block), becoming statistically insignificant by block 4. This suggests that the participants no longer use the recently altered template as their source for a search reference. The participants appear to adjust their templates to the new exposure that evenly accounts for both color possibilities. Similar to Bravo & Farid (2011), once the exposure condition changes, the template changes in order to accommodate this difference; there is a versatility in the template that allows it to be malleable.

In addition, our accuracy analysis did not show any main effects of color condition or block number. This suggests that participants were equally effective at distinguishing the target item despite the color or the block number in the trial. Because of the equality in accuracy, it is possible to deduce that the template used for searching the target item was the same for both colors, which would explain the slow response for different color exemplars. If the exposure created a template that was only useful for that specific color exemplar, then we might see accuracies that were higher

for the identical color exemplar than for the different color exemplar. However, since the accuracies are identical then it possible to argue that the template used was the same for both searches and the RT difference results from the features used to identify the object (i.e. color manipulated and typicality features).

Although we do identify the effect of color manipulation on template, our research does not determine the mechanism with which the search undergoes its selection. If search was based on features beyond color, then it would be feasible to argue that the RTs should have not differed since color is not the dominant determinant, yet, according to our research, it would indicate that it is color that was the major influencer in recognizing the item. However, is it color alone or a dual-processing mechanism – that uses both non-color and color features – that was used to identify the object? Because the distractors were ensured to not replicate any of the colors trained and tested, we do not have data on the effect that these same color distractors may have on RTs. It could be possible that a low-level search criterion is set upon reading the word cue (if the participant was exposed only to black bears, they might think black instead of black bear), as a result, due to the lack of same color distractors, the participants might still be able to identify the object simply on the bases of color; hence, if there is a distractor with a similar color, then the RTs would increase due to this color-based conundrum. Furthermore, since in the different color condition, the color is not present in any of the images, then it is possible a higher-level search criterion was called upon in which features besides color are referenced, leading to slower RTs since color is used first prior to the higher-level criterion. To verify this two-step mechanism, it possible to use an eye-tracking system to determine whether color itself is the initial criterion: participants would make eye movements towards the different color exemplar, but then move away as identification via color was not accomplish; afterwards, the adjustment to the new criterion would allow for the identification and return of the eye movement towards the item.

In addition, our research design fails to answer whether this template alteration is enduring or ephemeral. Although our research does indicate that exposure to varying colors does alter the template so it accommodates both colors, it does not indicate whether this template would last after time has passed between the training and testing phase. It may be possible that the effects are only kept while they remain temporally relevant; once the template alteration becomes irrelevant, the template returns to its previous state. A change in the design would be to have the training phase occur seven days prior to the testing phase to determine whether the effect remains despite the passage of time and temporary irrelevancy.

In conclusion, our findings demonstrate the capacity of altering the template used during search tasks. Specifically, we have been able to bias the template through exposure of categorical exemplars that were selective for a specific color. However, once the testing phase began, the participants were exposed to both colors, and there was a decrease in the significance of the difference in the RTs between the color conditions, indicating that the template is accommodating as it did during the training phase. These findings are extensively important in fields in which observations of hundreds of images/objects is a requisite of the job: medicine, police work, defect detection, screenings, etc. According to our findings, exposure to specific types of examples of a category can lead to the template of that category to be altered in way that is biased towards that specificity. For example, if a factory worker is responsible for detecting defects on medical syringes, and this worker has only been exposed to defects that involve bent needles, they will (according to our conclusions) be better at detecting these defects, then they would to identify defects that allow air into the syringe such as a perforation. However, if this same worker, it asked to take practice defect detection sessions on a monthly basis, then we can replicate what was seen in our testing phase and cause their template for "defect" to broaden and expand beyond just bent needles.

In the end, the aim of our experiment was to add to the plethora of the existing literature in categorical search in order to provide a node from which future experiments can branch off. In addition, it was the aim of this experiment to open up a path of inquiry in order to further question the versatility and adjustability of the templates we use on quotidian basis for our searching purposes.

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