

Colour and Memory: Colour as an aid to memorization

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ABSTRACT

Can memory enhance recall? It could be anticipated that increased salience due to colour contrast would lead to better short-term memory and object recall. However, previous studies have shown mixed results, with some suggesting that colour enhances attention and strengthens neural encoding, while others finding that the effects are negligible. To test the idea, 20 participants were asked to recall objects from AI-generated images, using semantically unrelated visual stimuli and standardized test conditions. Participants were presented with both greyscale and coloured sets of image, and they recalled on average 45% of items from both colour and grayscale images. Analysis showed that there was no correlation between recall performance and colour attributes; however, relative object size was positively correlated indicating that spatial attributes had a greater influence on the likelihood that an item was correctly identified in the recall phase.

Keywords: memory, colour attributes, salience

INTRODUCTION

Memory is a complex cognitive process influenced by numerous factors, and colour has long been hypothesized to play a significant role. Previous studies have indicated that colour enhances attention, but its effect on recall is contested. The results of previous studies on the impact of colour on memory are mixed, with some research claiming enhanced recall on colour-coded information, while others demonstrate negligible effects [1]. It has been proposed that colour acts as a memory cue, strengthening neural encoding [2]. Others argue that the effects are negligible without meaningful context. Some of the variation in results may stem from differences in experimental design, such as the use of semantically related stimuli, and insufficient control of the time duration of test phases.

This study investigates whether colour enhances recall of everyday objects compared to grayscale stimuli, by using a controlled experiment with randomized, non-associated generated images to eliminate guessing bias. This technique isolates colour as the primary variable.

METHODOLOGY

The study measured observer recall accuracy for sets of colour and grayscale objects using standardized scoring techniques. Participants' replies were categorized as either correct (exact match) or incorrect [3].

Participants

Twenty young adults (ages 20-28) took part the study, comprising both university students and working young adults. This target group is commonly used in cognitive tests to ensure maturity while minimizing age-related variability [4]. All participants reported normal vision and successfully completed the Ishihara test of colour vision, which has high sensitivity for red-green colour deficiency [5].

Test design

A test design known as Kim's Game, based on a game described in a novel by Rudyard Kipling [6], was used for the experiment. In a previous version of Kim's Game designed for young children [7] participants recalled items from a visual display featuring two familiar scenes: a vibrant farmers market stall (high recognisability, diverse colours); and an office setting with typical office or school supplies. Pilot testing revealed that participants could logically reconstruct forgotten items based on the remembered ones. This semantic risk inflates recall rates, as both scenes had items related to each other. A modified version of Kim's Game was used: each trial presented an image of unrelated objects, either in full colour or grayscale, on a display for 15 seconds, followed immediately by a 10-second period in which participants counted down backwards before commencing the recall task. This approach aided in isolating pure visual memory, and simulated real-world situations where distractions can affect memory by blocking rehearsal through a cognitive task. This is intended to give more accurate results by minimizing confounding variables.

Stimuli

A colour test images were generated using ChatGPT [8], with the prompt "Generate a photorealistic image containing 20 clearly visible household objects arranged naturally on a table. Include items like a wristwatch, pen, and Post-it notes with varied colours and sizes, ensuring all objects are distinct and non-overlapping." A second image was generated using the same prompt but specifying black and white instead of varied colours. The two images are shown in Figure 1 and Figure 2. This ensured minimal semantic overlap to prevent clustering effects during recall. Each image displayed different items, with some duplication; in the case of the grayscale image there were only 17 unique objects, whereas the colour image had 20 unique objects. This would have placed a slightly lower burden on participants completing the task with the grayscale image. It can also be noted that recall is likely to be highest (for Western participants at least) for objects presented at top left, since observers tend to scan a visual array in a Z pattern and the first objects viewed will be less affected by limits on the capacity of short-term memory [9].



Figure 1: Colour stimulus generated via ChatGPT 4.0, showing 20 household items.



Figure 2: Greyscale stimulus generated via ChatGPT 4.0 (OpenAI, 2023), showing 17 household items.

Experimental

Each trial presented 20 unrelated objects, either in full colour or grayscale, for 15 seconds, followed immediately by a 10-second backward countdown task before recall. This retention recall served a critical purpose. It isolated pure visual memory, and replicated real-world situations where distractions can affect memory by blocking rehearsal through a cognitive task. This yields more accurate results by ensuring that performance differences could be attributed solely to the presence or absence of colour. The order of colour/grayscale trials was

randomized across participants to offset any sequence effect. Verbal recall responses were recorded to minimize motor interference, and only exact matches were recorded as correct.

1. Encoding Phase: Participants observed images for 15 seconds per set (colour or grayscale).
2. Retention Interval: To prevent rehearsal, a 10-second countdown task ("count aloud backward from 10") was implemented.
3. Recall Phase: Participants verbally listed all remembered items within 60 seconds. Responses were audio-recorded and manually scored.

RESULTS AND DISCUSSION

Participants correctly recalled between 7 and 11 of the 20 images from Figure 1, and 4-11 images from the black-and-white Figure 2. However, the difference between the average proportion correctly recalled from the two figures was negligible, as shown in Table 1.

Table 1: Proportion of objects correctly recalled from test image

Colour	Grayscale
0.448	0.450

The results for Figure 1 (coloured objects) were further analysed to determine the correlation between image attributes and recall performance. Two colour-related attributes (lightness and chroma) were selected, together with two spatial attributes (relative size and entropy (or randomness)). Well-lit areas of the images were sampled to extract RGB values, which were then converted to XYZ using an ICC profile for sRGB, and then to CIELCh. The size was found from the number of pixels in the region occupied by each object. The entropy, H , of each object was found by converting the image to greyscale and calculating the entropy in Matlab according to Eqn (1), [10] where p , the probability of any grayscale intensity value, is the 2D array of normalized frequencies of pixel values.

$$H = - \sum p \log_2(p) \quad (1)$$

Pearson correlation coefficients were calculated between the attribute values and the average recall performance of observers for each image. The results are shown in Table 2. It can be seen that only image size has a significant positive correlation, suggesting that spatial attributes (specifically the relative object size), rather than colour attributes, were the more important factors influencing recall for this set of images.

Table 2: Correlation coefficients between image attributes and proportion recalled for each image

L* lightness	C* _{ab} chroma	Size	Entropy
-0.032	-0.199	0.531	-0.122

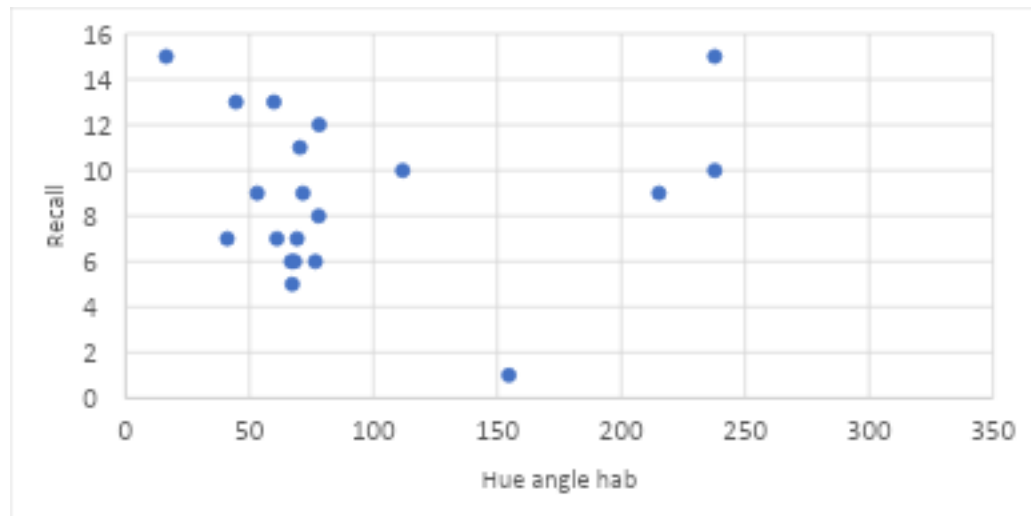


Figure 3: Recall performance by hue angle.

The correlation coefficient for hue angle with recall performance was also calculated, and found to be 0.046. This is also not significant, although somewhat less meaningful since hue angle is not a continuous scale. Object hues were dominated by colours in the red region including browns and pinks, as shown in Figure 3. Categorical colour names (using 10 of the 11 basic English terms identified by Berlin and Kay [11]) were assigned to the objects and again no pattern could be discerned in relation to recall performance.

The outcome of this admittedly small study runs counter to much previous work. It has been proposed that highly salient visual components like colour are processed automatically, even when cognitive restrictions are present [12]. Colour is claimed to be effective in directing attention and improving memory; according to studies on attentional capture: for example, colour is said to automatically focus attention without requiring verbal processing [13]. According to Domain-Specific Attention Theory [14], colour improves memory best when it is diagnostic of item identification. This could be reflected in greater recall of the tomato, for example (65%), where the colour is more strongly associated with the item, in comparison with those items that have arbitrary coloration.

CONCLUSION

Although it could be expected that colour would increase salience and hence aid in object memorization and recall, no such effect was found in this small study. Object identification is mediated by appearance attributes, which include edge contrast, texture, gloss, translucency and colour, and it may be that the familiar objects in this study were readily identifiable by those attributes which contribute to the apparent shape, leaving little or no further improvement to be gained from the dimension of colour. The greater correlation of object size with recall performance points to spatial attributes having greater importance than colour attributes for the task undertaken in this study. A larger study, with more trials and a greater number of observers, might further clarify the role of colour in recall.

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