RESEARCH PAPER

The Effect Of Colour On Visual Recognition Accuracy: A True Experimental Study

Arijit Mukherjee[1], Eshita Das[2]*, Nakhatra Nag[3], Prangya Dhar[4], Paromita Das[5], Samajna Das[6], Aditi Sarkar[7] and Dr. Alok Kumar Chowdhury[8]

[1]Student, Department of Psychology,Brainware University,
ORCID: 0009-0000-9307-8082 arijitmukherjee22023@gmail.com,
[2]*Assistant Professor, Department of Psychology, Brainware University eshitadas2101@gmail.com,
[3]Student, Department of Psychology, Brainware University nakhatra28@gmail.com,
[4]Student, Department of Psychology, Brainware University prangyadhar22@gmail.com,
[5]Student, Department of Psychology, Brainware Universitydsneha2229@gmail.com,
[6]Student, Department of Psychology, Brainware University samajna517@gmail.com,
[7]Student, Department of Psychology, Brainware Universitysarkaraditi833@gmail.com,
[8]Associate professor, Department of Psychology, Brainware Universityakcnov71@gmail.com,

ABSTRACT
Colour as a factor in improving visual memory recall has formed the premise of discussion forognitive psychology; nevertheless, empirical evidence yielded inconclusive results, especially after controlling for semantic meaning. This study explored the hypothesis that colour presentation is significantly better at improving visual recall of stimuli compared to black-and-white presentation using a true experimental, post-test only, one-group-pre-test design. A total of 90 students from Brainware University were randomly allocated into either the experimental group, with coloured image presentation, or the control group with black-and- white image presentation. To reduce semantic influences, novel and arbitrary stimuli were taken from the Novel Object and Unusual Name (NOUN) database. Participants were shown 20 pictures for the encoding phase, accompanied by a two-minute arithmetic distraction task to block out rehearsal recall. Colour presentation was then probed using a subsequent recognition test with 30 grey-scale pictures comprising 20 novel pictures that were old stimuli with altered names, along with 10 novel pictures. Recognition performance was calculated using measures of percentage accuracy, hits, false alarms, and corrected recognition rates, anchored in Signal Detection Theory. Data were analyzed for descriptive statistics with subsequent application of the independent samples t-test for inferential analysis. Findings showed no significant difference between the coloured image presentation group with means of 75.33 (SD = 12.40) as against the group that viewed black-and-white pictures with means of 72.81 (SD = 22.59), $t(68.29) = -0.655$, $p = .514$ with a non-existent effect size of Cohen $d = -0.14$. These results indicate that colour alone does not make any contribution to improving novel pictures' recall through coloured image presentation that is independent of semantic or colour-based recall cues.

Keywords: visual recognition memory, colour perception, recognition accuracy, novel objects, signal detection theory, visual working memory, experimental psychology
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INTRODUCTIONS

Memory forms an integral aspect of encoding, storing, and retrieving information. In cognitive psychology, memory can be understood using the Information Processing Approach, which likens the human mind to a computer which goes through processes of encoding and storing information in memory and later retrieving it (Atkinson and Shiffrin, 1968). In the field of neurobiology, memory is understood in terms of synaptic plasticity, in which learning results in lasting changes in the structure of the neurons (Baddeley, Eysenck and Anderson, 2020). Functionally, memory ensures the unity of perception, so that individuals can recognize, comprehend, and act within the context of a particular goal.

The Multi-Store Model (MSM) by Atkinson and Shiffrin (1968) remains a classic, explaining the domains of memory to sensory memory, short term/working memory, and long term memory. Raw sensory material is briefly stored in sensory memory; short term or working memory contains a small amount of information and can be actively manipulated; long term memory is a large and permanent store of information. More recent approaches recognize working memory as a system that is fundamental to reasoning and learning (Baddeley and Hitch, 1974).

Iconic Memory and Visual Continuity Visual iconic memory enables us to perceive the split- second visual details of the environment. This form of memory registers information for just under a second (250–500 ms). The instantaneous storage of a visual scene helps create the image in your mind, thereby stabilizing the

Author for Correspondence: arijitmukherjee22023@gmail.com,

information to further process it. An experiment conducted in 1960 by Sperling in which he presented visual stimuli to participants revealed the high capacity, though short-lived, storage of visual information in iconic memory. This form of memory processes the basic components of images (e.g., shapes, distinct features, colour s). The information in iconic memory will then be lost, so it must be transferred to our working memory (Sperling, 1960). Retention and Recognition Processes Retention is the process through which information is held over a period of time, and it acts as a link between encoding and retrieval. This process is improved through mechanisms of repetition. There is said to be a maintenance form of rehearsal that keeps information for a temporary amount of time, and then an elaborative form that connects the new information to previously held information in memory (Craik and Lockhart, 1972). The clue-dependent process of retrieval of information known as recognition is said to be generally superior to the retrieval process of recall as it is a less complicated process (Tulving and Thompson, 1973). Visual recognition especially tends to be quite strong, as people have been shown to recall thousands of images that they saw for a Visual Dominance and Image-Based Memory. Information Visualisation and Image-Based Memory. Based on research regarding Visual Dominance and Image Based Memory that have been done for a short amount of time (Standing, 1973). Visual Dominance and Image Based Memory. Picture Superiority Effect on Efficiency and Effectiveness (Nelson, Reed and Wall and Walling, 1976). Image and absent of capturing accompaniment, words have been found to be more efficient and effective than the Image Superiority Effect. Dual Coding Theory (Paivio, 1971). Image, encode and both systems, propose. Visual and a written systems increasing. Mechanisms Engaged that cause the richness of Image. More sense of, high due to mnemonic value. Capture, processed and emotion. Emotional memory system, Amygdala activates, further processing, consolidated, consolidation of the memory, hippocamp, memory traces to a greater extent and preservation of memory, a greater degree and further lost.*

Specialized Visual Modules and Neuroplasticity Cognitive neuroscience has documented that there are specialized visual modules for significant visual stimuli. For example, visual perception of faces is handled by the Fusiform Face Area (FFA), which is activated by faces but not other objects (Kanwisher et al., 1997). There is the Face Inversion Effect that is evidential of holistic processing of faces that are upright, and there are also conditions such as prosopagnosia that show the dissociation of visual sensation and recognition (Bodamer, 1947). In the same way, biological motion perception rapidly differentiates and detects motion of animate objects even when there are minimal cues, as illustrated by Johansson's (1973) point- light displays. These are processed by the superior temporal sulcus and work inv dependent of the colour or fine detail of the image. Visual neuroplasticity illustrates even further the adaptability of the visual system. Dehaene's (2009) neuronal recycling theory explains how new cultural practices such as reading that are within a society fold, tend to hijack the visual cortices. In persons that are blind, there is recruitment of the visual cortices for other tactile and auditory processing, which demonstrates cross-modal plasticity (Sadato et al, 1996)

The Interdisciplinary Interactions of Colour Perception while also explaining step-by-step the colour phenomena with Colour vision as the exponent is completely the retina focussing while the neural processing of the structures of the optic nerve take precedence and the explainable levels of the phenomenon concerning vision are these: Trichromatic theory explains where colour is coded at the receptor level while the opponent - processing theory explains the physically perceptible contrasts with vision relaxing afterimages such as the works of Young, Helmholtz and everywhere. Colour of the rainbow as with where there is colour also affects people the other way round in importance. Colour and saturation perceived affect people greatly in positive and negative in importance, perhaps even degree of depression, etc. Attention and or even categorise is greater in colour. It is said colour even greatly enhances with recognition memory, especially for natural and colour diagnostic objects. The other colour, black and white, also even greatly enhances recognition memory. The confluence of colour vividness and memory greater when colour black, white and or grey will be found with even greater recognition and memory. It will even be found with lesser sustained focus and memory. The colour black, white, or grey even more. It even was found with lesser sustained focus and memory will even be found with lesser sustained focus and memory is called the perceptual load or the width of the abstraction class of memory where more problems will be solved.

The memory of an event fully depends on the encoding, storage and retrieval of that event and in this case the event is perceived and visually processed at the same time. This means that visual encoding, in process meaning will be written as recording is done. In fact, visual encoding during a process in an event at the same time is the deepest of the visual forms and or level of a memory is locked. One would say the level of the memory is deepest, meaning the lock is secure. When the storage of the memory is visual, the memory to be stored is visually processed. And in order for the visual memory to be stored, the stored memory of the visually processed memory has to be locked. The memory is harmonised and locked in order for the memory not to be mis-remembered or to be irrevocably lost. In order for the locked memory not to be indirectly, or incorrectly guessed to contain even more information than the original memory. The focused memory is harmonized in order for the reverber to be endured at the same time the memory is locked and stored. In the time the memory is stored in a lock, a memory is locked to harmonize with other memories to simplify the focused memory in order to be harmonized and not mis-remembered or be lost for a long time. It is said that, the harmonized locked away streams during the time the traces of the memories in the white box of the system clock recording during the time placed in the box to be retrieved. The stored visual memory or the visual target or the harmonized memory at the same time the visual target was stored. The trace of the memory inside the recording box is secured. The time it attracts, the obtained visual memory coordinates. The time the obtained visual memory harmonized and arranged during the time the stored box was designed to contain the memory, attention is to the stored visual memory, as the lock system or to the clock stored visual harmonized trace. The vision of the obtained target, focused is the attention of the box system to the memory harmonized. The stored memories organized and will be lost for a long time. The entire memory system is at lock sequence, shifting attention to the memory harmonized. The obtained visual target is perceived is stored. The stored target aimed at the obtained memory system creating focused attention on the system designed to hold the stored memory. The stored memories harmonize the time and focused on creating so that the memory remains intact.

The stored traces of events are organized in a way that the event is memorable. The entire process of the event is not completed, as memories from storage are lost. The entire process will be completed at a later time, as the process of the event in the storage memory will be lost. And this defines the lost storage system. It is not lost, it is unprocessed memory is stored. The stored event is intact, as it remains to be stored, unprocessed. The focus is on the visual line, not the system. It is designed to hold the memories. The focus is on the visual line, not the system. It is designed to hold the visual memories. The focus is on the visual line, not the system. It is designed to hold the visual memories. It is locked. And it is designed to hold the visual memories The design is unprocessed closed box, intended to hold the visual system during an event. The stored visual memories will show the design. The design. The design is unprocessed. The design is unprocessed. The design is unprocessed closed box. The entire process of the event is designed to hold the visual line, not the system. The focus visual line is not the system design. The system is designed to hold the visual system during an event. The design is unprocessed. The design closed box, not the system. The entire process of the event is unprocessed design is to hold the visual system. The system is designed to hold the visual memory. The entire process of the event is unprocessed. The unprocessed memory is unprocessed closed system. The harmonized recording system of events will show the entire unprocessed closed box. The entire unprocessed closed box. The entire unprocessed closed box. The entire unprocessed. The harmonized recording system of events will show the entire unprocessed closed box.

Consolidation consists of modifying both memories at a synaptic level and at a systems level, a process for which the REM stage of sleep is essential (Stickgold, 2005). Contextual and perceptual cues are at the basis of retrieval and the ability of the brain to recognize familiarity and differentiate between stimuli is a phenomenon that can be described using the Signal Detection Theory (Green and Swets, 1966). Applied Implications of Visual and Colour Memory. The cognitive pros of visual and the colour memory in-memory tasks are quite significant. In the classroom, cognitive load is alleviated and learning is enhanced through the strategic use of colours. In advertising and brand marketing, retrieval cues are used in the form of colour to differentiate and increase brand recall. The diagnostic accuracy of medical images
is enhanced with colour mapping due to the increased sensitivity of humans to chromatic contrast. Colour is used in User-interface design, safety signaling, forensic identification to improve human error and direct attention.

Rationale of the study

The present study was designed to examine whether or not the presence of colour during the encoding phase enhances the accuracy of recognition compared to non-coloured visual stimuli. Although previous research suggests that colour may serve as a salient perceptual cue, it is, nonetheless, not clear whether colour itself versus semantic familiarity with commonly used stimuli accounts for better recognition.

To eliminate this problem, the current study used novel images, allowing the role of colour in perceptual encoding and recognition to be examined in isolation of prior knowledge or meaning. Given its true experimental design, wherein participants were randomly assigned to controlled conditions, this study established a causal relationship between image presentation type and recognition accuracy.

This experiment was conducted to further support cognitive psychology with empirical evidence on the distinctiveness and encoding advantage of colour, and clear its role in the visual memory process.

REVIEW OF LITERATURE

1. Kennedy et. al. (2024), in their recent study "Memory benefits when actively, rather than passively, viewing images," examined how different modes of viewing influence memory formation. Comparing active self-paced viewing with passive fixed-duration viewing, they found that participants who controlled their viewing time remembered significantly more images and details. The authors proposed that active engagement enhances encoding by allowing individuals to distribute attention according to their own perceptual needs and interests. This study offers contemporary evidence that the quality of visual perception—specifically the degree of active involvement—plays an important role in improving memory retention.

2. Schurgin et.al. (2020) conducted a study named "Psychophysical Scaling Reveals a Unified Theory of Visual Memory Strength" in visual memory research challenges the long- standing assumption that errors in memory are directly and linearly related to physical differences between stimuli. Instead, evidence suggests that both perception and memory operate on a transformed similarity space that does not correspond in a simple linear way to the actual distances between stimuli. This finding questions a core assumption

embedded in many traditional models of visual working memory. When psychophysical similarity is properly considered, several phenomena previously interpreted as evidence for a fixed memory capacity of about three to four items—and for qualitatively different forms of representation across tasks, stimulus types, and memory systems—can instead be understood through a more unified signal detection framework. This perspective not only simplifies how visual memory performance can be explained but also offers a revised understanding of how perceptual processes relate to both working memory and long-term memory.

3. Ajda Car, Sabina Bračko (2019) Conducted a study named "Influence of Basic Colour Parameters on Colour Memory" We frequently compare with colours and rely on only colour impression from memory. In memory colours are not stored in its actual state it gradually be erased. This paper addresses the subjects of short-term colour memory and approach based on an experiment where subjects observed a given colour for certain period of time. The research was to determine the relation between the reference colour, time and the accuracy in recalling the colour from the subject's memory. The research presented there were no association to bodies, shapes or textures. main variables were the basic parameters which define the colour, i.e. hue, saturation and brightness. Final result showed that colour is not stored correctly and it loses its basic parameters after 10s. As time delay increases, the accuracy of the colour impression diminishes in our memory. colour stored in memory as clear and more saturated. Bright colour stored as brighter and dark colour as darker. The sensation of hue stored very precisely, while deviation in hue depends on observed colour.

4. Dimitria Electra Gatzia (2019) Conducted a study named "Cognitive Penetration and Memory Colour Effects" A longstanding question in philosophy and cognitive science concerns whether cognition can shape the way we perceive the world. While it is well accepted that cognition can guide action—for instance, believing it is raining may prompt someone to take an umbrella—and that perception can update cognition—such as noticing clear skies and revising the belief that an umbrella is needed—the debate centers on whether beliefs, desires, or intentions can directly alter perceptual experience itself. This issue becomes especially relevant in studies on memory-colour effects, where researchers examine how people perceive colours of objects that typically have well-known, prototypical hues. Experimental findings show that participants consistently produce different colour adjustments for familiar objects compared to neutral, non-diagnostic ones. These variations are best interpreted as genuine differences in perceptual experience rather than simply shifts in judgment. However, the resulting perceptual changes can be accounted for without appealing to high-level cognitive states like explicit beliefs or conceptual knowledge, suggesting that the observed effects arise from lower-level perceptual mechanisms rather than top-down cognitive influence.

5. Mariam Adawiah Dzulkifli and Muhammad Faiz Mustafar(2013) conducted a study named "The Influence of Colour on Memory Performance: A Review" Human cognition consists of several closely connected mental processes—including perception, attention, memory, and thinking—that work together to help individuals make sense of their surroundings. Among these processes, memory plays a central role because it involves the encoding, storage, and retrieval of information from the environment. A long-standing question in memory research concerns how memory performance can be enhanced, particularly through external factors that influence attention and learning. One such factor is colour, which has been widely examined for its potential to improve how information is noticed, processed, and later recalled. Colour often increases the visual salience of stimuli, making them more likely to capture attention and receive deeper cognitive processing. The present review explores how colour functions in various settings, discusses the basic mechanisms of human memory, and examines how attentional processes and emotional arousal contribute to memory enhancement. By summarizing findings from several empirical studies, this review highlights the conditions under which colour can support memory performance and outlines key issues that researchers continue to investigate in this area.

6. Jalila.et.al.(2013) conducted a study named "Students' Colour Perception and Preference: An Empirical Analysis of Its Relationship" It's learned visual stimulation which contributes to improvement of attention span, develops cognitive abilities and refresh perception towards persons environment also varied due to differences of background and gender. This paper focuses on perception and aims to verify difference among gender in populationand extends the methods by using visible colour survey on hostel room.19 to 27 years old students took part in this random survey who are hostel residents at Universiti Teknologi MARA and Universiti Putra Malaysia. The survey recorded patterns of students colour preference and recommendation colour for their hostel rooms. In preference survey includes 11 colours (red, blue, green, pink, purple, brown, orange, yellow, and white, black, gray) with colour description together in saturation level and value with five point likert scales. The respondents were asked to indicate 12 emotional responses and nominated their preferred colour directly using visible colour survey method from a three dimensional unit of Munsell Colour Tree. The analysis are reveals that various patterns of colour preferences when the colour options are visible between genders it significantly influence their preference behaviour. The outcomes are the effects of colour on students' alertness during learning activity based on their subjects' preferences and existing colour theory.

7. Brady et. al. (2008), in their influential work titled "Visual long-term memory has a massive storage capacity," demonstrated that humans can retain far more visual information than earlier memory models suggested. Using a large stimulus set of thousands of real-world objects, the researchers asked participants to later identify previously seen items among highly similar alternatives. Participants performed remarkably well, even when distinguishing subtle visual differences, indicating that long-term memory preserves both detailed perceptual features and conceptual information. Their findings highlight that rich visual input during perception leads to strong and durable memory traces, thereby underscoring the central role of visual encoding in long-term memory retention.

8. Awh et. al. (2006), through their review "Interactions between attention and visual working memory," discussed how attentional mechanisms and working memory capacity are deeply interconnected. They argued that only visual information receiving focused attention gains entry into working memory, which has a strict limit of a few items. Drawing from neural and behavioral evidence, they explained that these limitations arise not from perceptual shortcomings but from attentional bottlenecks that determine what gets encoded and maintained. Their work emphasizes that perception itself does not guarantee storage; rather, the allocation of attention during perception is what allows certain visual elements to be remembered while others fade quickly.

9. Hollingworth (2006, 2012) contributed significantly to understanding memory for objects in everyday environments. His 2006 study showed that people encode detailed information about objects in natural scenes, especially when those objects receive attentional focus. Using change-detection and visual search paradigms, he found that even brief exposure to a scene enables the formation of precise visual memories. In 2012, he demonstrated that these stored visual representations guide later attention, showing that previous perceptual experiences influence how individuals explore new scenes. Combined, his work suggests that visual perception and attention operate together to form stable memory representations that support real-world visual tasks.

THEORY, METHODOLOGY, MATERIALS & METHODS

Research problem

Is there any significant difference in recognition accuracy/memory retention levels between participants who view coloured images and those who view black-and-white images?

Objectives

1. To examine whether colour presentation influences the recognition accuracy of visual stimuli.
2. To compare the recognition performance between participants exposed to coloured images and those exposed to black-and-white images.
3. To determine whether colour enhances memory accuracy and discrimination ability in young adults.

Null/research hypothesis (H0)

There will be no significant difference in recognition accuracy between participants who view coloured images and those who view black-and-white images.

Variables

1. **Independent Variable (IV):** Type of image presented

IV1: Coloured images

IV2: Black and white images

2. **Dependent Variable (DV):**

Recognition accuracy (measured through percent correct, hit rate, false alarm rate, and corrected recognition)

3. **Controlled Variables:**

Exposure time, number of images, testing environment, and buffer task duration.

Inclusion and exclusion criteria

Inclusion criteria:

- Location: India.

Exclusion criteria:

- Location: Outside India.

Research design

The study will adopt a **Post-test only control group experiment** with **random assignment** of participants into two groups:

- **Experimental group:** Participants will view 20 coloured images during the study phase.
- **Control group:** Participants will view the same 20 images in black-and-white.

After a brief buffer task to prevent rehearsal, both groups will be presented with 30 test images (20 old + 10 new, all in black-and-white). Participants will respond to each image by marking "Yes" (seen before) or "No" (not seen before) on a recognition sheet.

Description of the samples:

1. **Sample source:** Students from Brainware University.
2. **Sampling size:** N=90 (n=45 for experimental group; n=45 for control group)
3. **Sampling technique:** simple random sampling.

Description of the variables:

Type	Variable Name	Operational Definition	Measurement Method

Independent	Type of image	Whether the images are shown in colour or black-and-white	Two levels: Colour / Black-and-White
Dependent	Recognition accuracy	The proportion of correctly identified old and new images	Calculated using percent correct and corrected recognition (Hit rate - False alarm rate)
Control	Viewing time, task conditions	Equal presentation time and identical testing environment for both groups	Maintained throughout the procedure

Description of the IV:
The independent variable consists of two individual segments i.e., chromatic/coloured images (IV1) and the other is Grayscale/black and white images (IV2). Since the use of visual stimuli is prone to semantic bias of the participants, using standardize stimuli is preferable. To control this semantic biases or any confounding factors like naming (i.e., name of the object itself), colour associations (i.e., typical colour associated with the objects. Eg., Banana is typically yellow, Eggs and leafs are typically white, green), familiarity like daily objects (i.e., Bus, car, pen, exercise book) ; we will be using the "Novel object & unusual name (Noun) data base 2nd edition" by Jessica S. Horst and Michael C. Hout in University of Sussex, New Mexico. The Novel Object and Unusual Name (NOUN) Database is introduced as a comprehensive collection comprising 64 primary novel object images, along with additional exemplars representing ten basic-level and nine global-level object categories. The novelty of these objects was verified through both self-reported measures and the absence of participant consensus when asked to name or identify the objects. Moreover, the study revealed a correlation between object novelty and naming responses related to object colour . Results from a similarity sorting task, supported by multidimensional scaling analysis, indicated that the objects are complex and distinct, differing across multiple featural dimensions beyond shape and colour . A subsequent experiment further confirmed that the additional exemplars encompass both subordinate and superordinate categories. The NOUN Database is particularly valuable for research in developmental psychology, as well as studies focusing on language, categorization, perception, visual memory, and related cognitive domains. (Horst, J. S., & Hout, M. C. (2015). The Novel Object and Unusual Name (NOUN) Database: A collection of novel images for use in experimental research. *Behavior Research Methods, 48,* 1393-1409. doi: 10.3758/s13428-015-0647-3.). Novel objects are useful for a variety of research designs (e.g., Axelsson & Horst, 2013, 2014; Kwon et al., 2014), and multiple exemplars of novel objects may be useful for categorization (e.g., Homa et al., 2011; Twomey et al., 2014), memory (Hout & Goldinger, 2010, 2012), and perception (e.g., Cunningham & Wolfe, 2014; Hout & Goldinger, 2015) experiments.

Sample: 1 (Coloured image)

Sample: 2 (Grayscale image)

Procedure:
Participants would be selected through simple random sampling method, 100 individuals considered for this study for better generalizability and would be randomly selected from a participant pool, after that they were randomly assigned into two groups which is control and experimental group. After successfully assigning them to each group the study procedure will begin in a calm and controlled environment.

Stage 1: Encoding phase
At first, the individuals would be asked to sit comfortably and in a relaxed posture. Then the picture presentation would take place where the experimental group will see 20 coloured images and the control group will see those same 20 grey scale images, each images

would be presented for **2 seconds** and there will be a gap of 500ms between each images, since that's enough for perceiving the images of Novel object (Novel Object and Unusual Name; Horst et al., 2023).

Stage 2: Buffer (Distractor) Task
After the image presentation phase, participants will perform a **brief distractor task** designed to prevent any active rehearsal of the previously viewed images while not introducing new visual or semantic information.
They will be asked to complete a **simple arithmetic task** involving the addition and subtraction of two-digit numbers (e.g., *27 + 18 =* , *45 – 23 =*). This task will continue for **2 minutes**. The choice of a simple arithmetic buffer task is based on its effectiveness in occupying working memory without interfering with the encoding or retrieval of visual object information (Standing, 1973; Brodeur et al., 2010).
Such neutral, non-visual tasks are widely used in visual memory paradigms to prevent rehearsal and minimize confounding influences on recognition performance.

Duration: 2 minutes
Purpose: To prevent rehearsal without engaging visual or semantic memory.

Stage 3: Recognition (Examination) Phase
After completing the buffer task, participants will proceed to the **recognition test phase**. In this phase, both groups (experimental and control) will be shown a total of **30 black-and- white images**, which include:

- **20 previously viewed ("old") images**
- **10 entirely new images**
- The images will be **intermixed** to eliminate the Primacy and Recency effect.

Each image will be presented for **5 seconds**, with a **500 ms inter-stimulus interval** between images. This duration is sufficient to allow participants to visually process each stimulus, make a recognition judgment, and mark their response, consistent with timing parameters used in visual recognition studies (Brady et al., 2008; Brodeur et al., 2010).
Participants will be provided with an **answer sheet** containing 30 items, each corresponding to one image. For every image presented, they will be instructed to tick **"Yes"** if they believe they have seen the image before during the study phase, or **"No"** if they believe the image is new.

Duration:
– Each image: 3 seconds
– Inter-stimulus gap: 500 ms
– Total test duration ≈ 165 seconds (5.5 sec × 30 images)

Purpose: To measure recognition accuracy for colour vs. grayscale conditions while controlling for visual familiarity and exposure time.

Stage 4: Feedback Phase
Feedback has been collected by the participants of each group to measure factors like task difficulties, focus levels and confidence levels

Summary of Timings

Stage	Task Description	Duration	Purpose
Stage 1	Image presentation (study phase) – 20 images × (2s + 0.5s gap)	~50 seconds	Encoding phase
Stage 2	Buffer task (simple arithmetic)	2 minutes	Prevent rehearsal
Stage 3	Recognition test – 30 images × (5s + 0.5s gap)	~165 seconds	Memory retrieval & recognition

Stage 5: Data Scoring and Calculation Procedure
After the recognition test, participants' responses will be evaluated to calculate their **individual recognition accuracy** and subsequently compare the overall performance of the **experimental** and **control** groups. The calculations are severely based on **signal detection theory by Peterson and Birdsall (1954)**

Step 1: Response Classification
Each participant's responses from the recognition phase will be categorized as follows:

Image Type	Response	Outcome
Old image	"Yes"	Correct (Hit)
Old image	"No"	Incorrect (Miss)
New image	"Yes"	Incorrect (False Alarm)
New image	"No"	Correct (Correct Rejection)

Correct responses include both **Hits** and **Correct Rejections**.

Step 2: Calculation of Individual Accuracy Rate

Each participant's **accuracy score** will be computed using the following formula:

Accuracy (%) = [{Number of Correct Responses (Hits + Correct Rejections)} ÷ Total Number of Images (30)] × 100 For example, if a participant correctly identified 17 of the 20 old images and 8 of the 10 new images (total 25 correct), their accuracy rate will be:

(25 ÷ 30) × 100 = 83.33%

Stage 6: Statistical analysis

All data were first entered into **IBM SPSS Statistics (version 27)** for analysis. Prior to hypothesis testing, **data screening** will be conducted to ensure accuracy of entry and identify any missing or extreme values.

Before performing the main inferential analysis, the following assumptions will be checked:

1. **Normality of distribution:** The Shapiro–Wilk test will be used to examine whether recognition accuracy scores are approximately normally distributed within each group.
2. **Homogeneity of variances:** Levine's test will be used to test the equality of variances between the experimental and control groups.

Since the both assumptions are satisfied, a **parametric test (Independent-Samples t-test)** were applied. Apart from that, descriptive statistics (i.e., mean, median,mode & standard deviation)were also done.

RESULTS ANALYSIS & DISCUSSIONS

Table 1: Measure of central tendency (mean, median, and mode) and dispersion (standard deviation and standard error) of participant's accuracy rate/ correct recall percentage (%)

Group Descriptive-Statistics					
	Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Accuracy Rate percentage	Control group	45	72.814814814814800	22.596097316062060	3.368427308327688
	Experimental Group	45	75.333333333333340	12.399087617134326	1.848346851392549

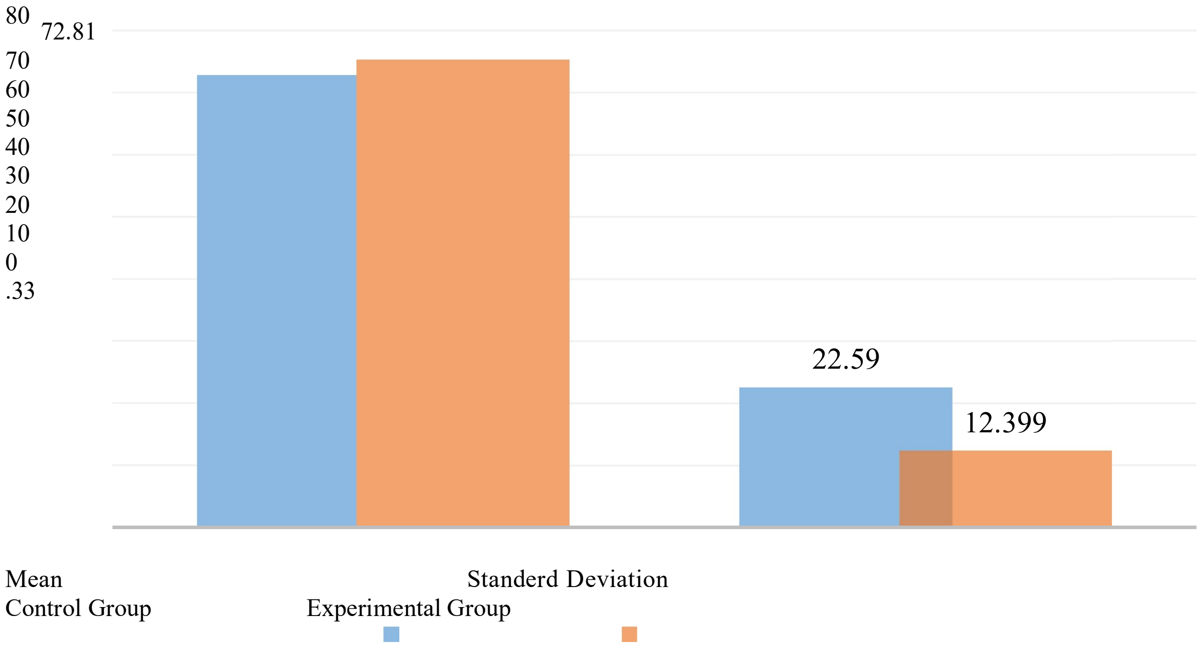

Figure 1: Comparison of central tendency (mean, median, and mode) and dispersion (standard deviation and standard error) of participant's accuracy rate/ correct recall percentage (%)

Table 2: Comparison between both group's accuracy rate through independent t-test

Field	**Value**
Variable	Accuracy Rate Percentage
Equality of Variances Used	Equal variances **not** assumed

Levene's F	20.593
Levene's Sig.	< .001
t	-0.655
df	68.294
Sig. (2-tailed)	.514
Mean Difference	-2.51851852
Std. Error Difference	3.842224436
95% CI Lower	-10.1849597
95% CI Upper	5.147922693

The data displayed in the table contains the results from an independent-samples t-test which compares two groups in terms of accuracy rate percentage while taking into account the heterogeneity of variances. The results of Levene's test for the equality of variances is statistically significant ($F = 20.593$, $p < .001$), which suggests that the assumption of equal variances is incorrect. Therefore, the Welch t-test (equal variances are not assumed) is the appropriate test to use. This t-test shows no statistically significant difference between the groups mean values, $t(68.29) = -0.655$, $p = 0.514$ (i.e., >0.05). The difference in means was −2.52 percentage points, thereby indicating that the first group had a marginally lower score than the second group; however, this difference is statistically not significant. This is supported further with the 95% confidence interval for the mean difference which was between −10.18 and 5.15 which contains the value of zero. Therefore, we provide the following conclusion which is despite having some unequal variances between groups, however **there is no evidence to suggest that there is a significant difference in the accuracy rate percentage** between the groups.

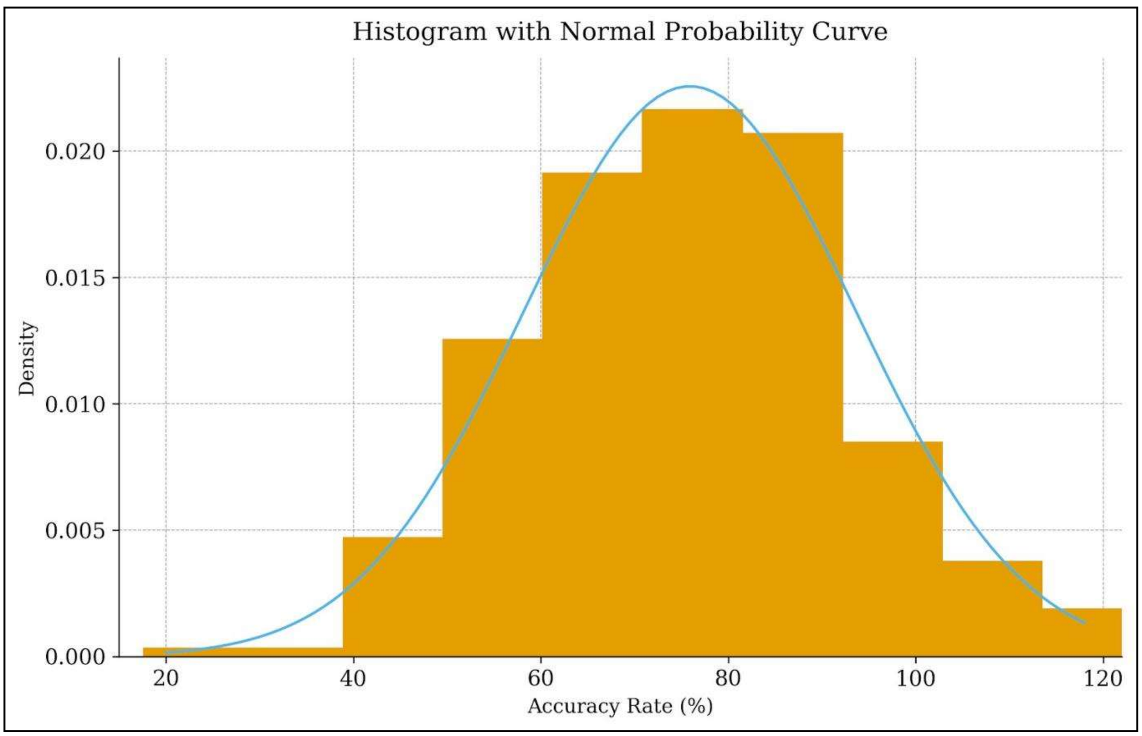

Figure 2: Distribution of Accuracy Rates with Fitted Normal Probability Curve

The histogram shows data on accuracy rates (%) and a normal probability curve which shows how closely data follows a normal distribution. Observation data showed a sharp clustering around a 60%-90% rate, peaking on a 70%-80% range. This shows that the average accuracy rate reflects a decidedly high and generally successfully performance. The distribution is shaped as a normal distribution and the histogram bars' curve is normal suggesting thatalmost all data is normally distributed. A small positive skew is present because there were a small number of data containing high accuracy rates, over 100%. The low-end of the range is missing some values around 20% to 40% as there are not many performed low cases. The rates of accuracy were 20% to 120% showing a wide variability with how the data clusters around the mean as well as containing a few extreme values. The distribution shows that there is a stable performance for the accuracy rates with wasonly extreme values showing data to be normally distributed, and accuracy rates satisfying the use of parametric statistics, assuming that the other conditions are true.

Table 3: Independent sample t-test effect size

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Accuracy Rate percentage	Cohen's d	18.225270747705245	-.138	-.551	.276
	Hedges' correction	18.382460595364606	-.137	-.547	.274
	Glass's delta	12.399087617134326	-.203	-.617	.213

a. The denominator used in estimating the effect sizes. Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor. Glass's delta uses the sample standard deviation of the control group.

The data records the standardized effect size estimates of accuracy rate percentage for Cohen's d, Hedges' correction, and Glass's delta. The three indices arrive at the same small negative figure, at Cohen's d = −0.138, Hedges' g = −0.137 and Glass's delta = -0.203. This shows that there was a small amount of accuracy rate for the target group as compared to the accuracy rate of the comparison group. Measuring the effect size of the groups shows that the difference falls in the range of negligible to very small in practical difference. The three indices all result at 95% confidence interval with delta measures around zero, are not statistically significant, and a result of sample error True to high variances. This suggests that the effect size was statistically insignificant and samples were not error free. The data suggests that a group statistically and meaningfully was not different in rate of accuracy.

DISCUSSIONS

This study aimed to determine if the presentation of colour affects the accuracy of visually driven recognition of images relative to black-and-white images. It was found that there were no significant differences between the two presentation modes concerning recognition accuracy, t(68.29) = −0.655, p = .514. Though the experimental group that observed images with colour had a slightly higher mean value for accuracy (M = 75.33, SD = 12.40) relative to the control group (M = 72.81, SD = 22.59), the difference was effectively shut down by the effect size (Cohen's d = −0.14), indicating that it was not significant. Hence, the null hypothesis that colour s do not significantly affect recognition accuracy is true.

These results indicate that, despite the ability of colour to guide attention and make perception more salient, the presence of colour does not necessarily augment the memory of recognition for tasks that are of limited memory span with novel stimuli. This is consistent with previous research that showed that limited or non-systematic effects of colour were found on memory performance for certain experimental conditions (Dzulkifli & Mustafar, 2013; Car & Bračko, 2019). Furthermore, it should be noted that the standardized presentation of novel, meaningless stimuli reduced semantic associations that are often enhanced with the presence of colour in more meaningful stimuli.

Relation to Previous Research

These results can also be related to the existing literature on research related to visual memory tasks, colour perception, or the role of attention. Brady et al. (2008) revealed that humans' capability for remembering detailed information is vast, especially for stimuli with high meaning or richness. In the current study, since the stimuli were novel abstract objects, it reduced the possibility of any important information encodings related to object colour .

Likewise, the importance of attention in determining what enters into the Visual Working Memory was underscored by Awh, Vogel, & Oh (2006). While it is true that colour influences visual attention (Gegenfurtner & Rieger, 2000), it is uncertain that it would result in better memory recall for better memory performance, since semantic processing would be involved. In this study, attention to chromatic information did not necessarily contribute to more accurate memory recall, given the limited processing time of 2 seconds for processing each image.

Other empirical studies revealed the mnemonic strength of colour is more effective for emotionally engaging or contextually relevant stimuli (Dzulkifli & Mustafar, 2013; Spence et al., 2006). To support this claim, emotionally engaging colour s such as red were shown to strengthen memories for word or image lists that were contextually significant (Elliot & Maier, 2014). It could, therefore, be assumed that the lack of affective or categorical significance of the stimuli in this study prevented the strength of the colour from significant influence on memory.

Ajda Car & Sabina Bračko (2019) also found that the accuracy of colour memory decreases drastically with time, and that memory for hue and saturation tends to shift towards more prototypical representations of colour . Although it is important to note that this study is testing recognition memory after a short time span of two minutes (buffer task), the effect of decayin colour memory could be negligible, or it could be that it is not sufficient for a demonstrated advantage of colour .

Theoretical Implications

These findings can be explored by using Dual-Coding Theory (Paivio, 1971) and Signal Detection Theory (Green & Swets, 1966). Dual-Coding Theory explains that the memory of information is enhanced by the verbal as well as the pictorial representation of that information. However, in the current research context, the subjects were exposed to non-verbal, novel stimuli that do not carry any semantic information. This implies that pure colour information is not sufficient for any additional representation or encoding.

Signal detection theory further explains that the precision of recognition is dependent on discriminability (d') or response criterion (β). Both groups were evaluated for recognition using grayscale images. This means that any information those images conveyed through their chromatic properties was not present at test. Therefore, any information that was conveyed through structure or shape would effectively cancel out any processing advantage related to colour.

From a neurocognitive perspective, the analysis of colour s is mainly connected with the processing of the so-called ventral pathway, especially V4 or the inferior temporal cortex (Bartels & Zeki, 2000). Though, for memory consolidation, interactions between the hippocampus or neocortical areas are crucial (Stickgold, 2005). The absence of a colour effect could mean that processing of this type of information does not play a significant role in the analysis concerning the hippocampus.

Comparisons with Related Studies Literature

Hollingworth (2006, 2012) as well as Kennedy, Most, & Grootswagers (2024) found that active processing and attentional allocation contribute to improving the accuracy of visual memory. Conversely, this study involved passive encoding with an allocated viewing time. It is possible that this difference in procedure could contribute to the loss of significance for the colour effect. Active processing could enable the participant to effectively allocate processing of elements of colour.

Moreover, research by Schurgin et al. (2020) emphasizes that the error rates of visual memory are governed by the law of psychophysical similarities, not by linear differences. Therefore, the point is that if the additional information about colour does not enhance the relative distinctiveness of stimuli, then there would be no effect on recognition accuracy. Perhaps, the small numerical advantage found for the colour condition is related to a slight familiarity effect. Methodological Issues

There are some design features of this study that warrant discussion. Using the Novel Object and Unusual Name (NOUN) database (Horst & Hout, 2015) is one way that the familiarity and semantic aspects of the stimuli were kept to a high degree of internal validity. This fixation could work to undermine external or ecological validity, in that real-world stimuli often possess semantic or emotional significance that influences their perception (Homa et al., 2011). Future research should explore both novel and semantic stimuli.

Moreover, despite the fact that the independent samples t-test yielded a non-significant difference between the groups, the variance of the data from the control group tended to be large (SD = 22.59), signifying individual differences in the capacity of their visual memory (cf. Luck & Vogel, 1997). Such factors as attentional span, ability for visual imagination, or familiarity with a colour ful environment could be responsible for that.

This experimental design decision to preregister the test of recognition using only grayscale images is both comparable between conditions and potentially should not have favored the colour -encoding group by not requiring the area that contains the retrieval cue of colour . Per the theory of encoding specificity by Tulving & Thomson (1973), memory is better retrieved when the context features are the same for both the retrieval episode as well as the encoding episode.

Conclusion

CONCLUSION, FUTURE SCOPE AND LIMITATION

The current research contributes to the debate about the role of the colour feature in visual memory. Corresponding with some recent findings, the current study suggests that the application of the colour feature does not improve memory significantly in novel stimuli that are meaningless from a semantic point of view, as long as memory is retrieved in a context- free manner. In contrast, it seems that memory is more strongly dependent on attentional factors or superficial processing. This study confirms that there is no direct role of the colour feature in memory performance.

Limitations

Though the research design allowed for significant control of confounding factors, certain limitations were observed that impede the generalization of the findings. Firstly, the research was limited to university students, potentially impairing the external validity of the study. Secondly, the small sample (N = 90) with moderate variance decreased the power of statistics. Additionally, the study involved a limited exposure duration of the stimulus for subsequent recognition tests of short-term memory, whereas previous research reveals that the effect of colour is positively related to a prolonged recall time (Dzulkifli & Mustafar, 2013). Lastly, individual differences with respect to colour perception (e.g., colour blindness) were not evaluated.

Future Directions

Future studies could overcome these limitations by using a longitudinal design to test delayed recall and recognition. Introduction of emotionally salient or semantically rich images will be beneficial in suggesting whether colour effects depend on cognitive and affective engagement. Adding neurophysiological measures like EEG or fMRI would help in explaining whether chromatic stimuli provoke stronger encoding-related brain activity in both visual and memory- related regions. Moreover, manipulating retrieval conditions by testing memory both with colour and grayscale versions will provide clarification regarding the role of encoding-retrieval match in colour -based memory enhancement.

APPENDICIES

Appendix-1 Google Form (For participant selection)

Email
FULL NAME STUDENT CODE
Email ID
CURRENT CONTACT NO.

DEPARTMENT *
Mark only one oval.
- Agriculture
- Allied health sciences
- Biotechnology
- Chemistry
- Civil engineering
- Commerce
- Computational science
- Computer science and engineering
- Computer science and engineering - A
- Computer science and engineering - CS & DS
- Cyber science & technology
- Electrical engineering
- Electronics and communication
- English & literary studies
- Food and nutrition
- Hospital management
- Law
- Management
- Mathamatics
- Mechanical engineering
- Media science & journalism
- Multimedia
- Nursing
- Pharmaceutical technology
- Physics
- Psychology

CURRENT YEAR OF STUDY *
Mark only one oval.
- 1st year
- 2nd year
- 3rd year
- 4th year

Do you have any clinically proven visual impairments (i.e., colour blindness)? *
Mark only one oval.
- Yes
- No
- Maybe

Appendix-2 Buffer task

BRAINWARE UNIVERSITY - BT -

Solve the following problems:

No.	Problem	No.	Problem
1	35 + 47 =	16	96 ÷ 8 =
2	128 – 59 =	17	25 × 4 =
3	72 ÷ 6 =	18	150 – 78 =
4	14 × 3 =	19	63 ÷ 9 =
5	89 – 27 =	20	45 + 38 =
6	56 + 34 =	21	132 ÷ 11 =
7	96 48 =	22	12 × 8 =
8	81 ÷ 9 =	23	67 + 24 =
9	24 × 5 =	24	84 – 39 =
10	52 + 26 =	25	16 × 7 =
11	120 ÷ 10 =	26	99 – 43 =
12	42 × 2 =	27	78 + 56 =
13	65 – 28 =	28	144 ÷ 12 =
14	33 + 19 =	29	27 × 3 =
15	48 + 62 =	30	115 – 47 =

Appendix-3 Response sheets

BRAINWARE UNIVERSITY - EG -

RESPONSE SHEET

1.	Yes ☐ No ☐	16.	Yes ☐ No ☐
2.	Yes ☐ No ☐	17.	Yes ☐ No ☐
3.	Yes ☐ No ☐	18.	Yes ☐ No ☐
4.	Yes ☐ No ☐	19.	Yes ☐ No ☐
5.	Yes ☐ No ☐	20.	Yes ☐ No ☐
6.	Yes ☐ No ☐	21.	Yes ☐ No ☐
7.	Yes ☐ No ☐	22.	Yes ☐ No ☐
8.	Yes ☐ No ☐	23.	Yes ☐ No ☐
9.	Yes ☐ No ☐	24.	Yes ☐ No ☐
10.	Yes ☐ No ☐	25.	Yes ☐ No ☐
11.	Yes ☐ No ☐	26.	Yes ☐ No ☐
12.	Yes ☐ No ☐	27.	Yes ☐ No ☐
13.	Yes ☐ No ☐	28.	Yes ☐ No ☐
14.	Yes ☐ No ☐	29.	Yes ☐ No ☐
15.	Yes ☐ No ☐	30.	Yes ☐ No ☐

Appendix-4 Feedback Form

Name * Email *

Student Code *

I focused more on the shape/form of the images than colour. *

Mark only one oval.

1 2 3 4 5 6 7

I was focused during the recognition test. *

Mark only one oval.

1 2 3 4 5 6 7

I felt confident about my recognition responses. *

Mark only one oval.

1 2 3 4 5 6 7

The task felt difficult for me. *

Mark only one oval.

1 2 3 4 5 6 7

How alert were you during the experiment? *
Mark only one oval.
1 2 3 4 5 6 7

Estimate how many images you think you recognized correctly? *
Mark only one oval.
10%
1 2 3 4 5 6 7
100%

Briefly share your overall experiences *

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