A Comparison of Colour and Greyscale: How Colour Influences the Number of Images Recalled in Short-term Memory

Winston Bartle (S3684725 - w.c.bartle@student.rug.nl)
Department of Artificial Intelligence, University of Groningen
9747 AG Groningen, The Netherlands

Abstract

Research on the role of colour is extremely relevant especially in recent years, with the rising power of visual content. Motivated by previous research that had shown evidence of colour improving memory performance for different types of memory (Wichmann et al., 2002; Farley and Grant, 1976), this study explored the impact of colour on short-term memory. Sixteen university students randomly assigned to either a colour condition or a greyscale condition were tasked to recall as many images of objects as possible, that they were shown on a laptop. Resulting data of a greater mean number of images obtained from the colour condition than the greyscale condition provided support to the hypothesis indicating that the number of colour images recalled is greater than the number of greyscale images recalled.

Keywords: Short-term memory, colour, greyscale, recall

Introduction

Human memory, as a core cognitive process, plays an important role in our daily lives. In this paper, we deal with short-term memory, which is the limited amount of information in mind that is readily available for a short period of time ("Short-term memory", 2018). Among the few types of sensory memory, this study will focus on the properties of visual memory; specifically, the effects of colours on short-term memory will be discussed.

We live in a world where we are all consumers of visual contents. With the rising power of visual content in the 21st century, colour plays an increasingly important role in these projects, whether for artistic, entertainment, marketing or educational purposes. This is perhaps because colours expresses emotions people feel without using words (Cheng, 2002). Looking at inventions of colour photography, colour televisions, colour computers and now, virtual reality in full colour, it is undeniably clear that colours play an extremely important role in our visual representation of the world. If it was not for these inventions, viewing visual contents would be a completely different experience.

Now, what does colour have to do with memory? A long debated issue in the research of memory is the methods to enhance memory. Given the unique properties of colours that help with visualisation, and its ability to inflict emotion, it is often said to be a key influence in memory performance (Dzulkifli & Mustafar, 2013).

The ability to recall information is crucial for acquiring new knowledge; and not long ago information was presented through greyscale mediums such as projectors or even televisions. Therefore with the advancement of technology, the ability of short-term memory to recall colour stimuli is an important topic.

Previous research

Wichmann, Sharpe and Gegenfurtner (2002) compared the recognition of different coloured images of natural scenes including greyscale images in their paper. In one of their experiments, participants were shown 48 images, half in colour and half in greyscale. The images were later randomly intermixed with another set of 48 new images, and participants were tasked to indicate if they have seen the image before. The results showed that subjects performed 5-10% better for colour images than for greyscale images (Wichmann, Sharpe, & Gegenfurtner, 2002)

This research provided valuable insights into the effects of colour on memory, however their work focused on recognition, while we focus on short-term memory, where the functions are of separate part of the brain (Brown & Aggleton, 2001).

Farley and Grant (1976) conducted an experiment where participants were shown a slide-tape presentation in either colour or greyscale. They were later tested twice with a comprehension test consisting of 20 questions based on the slide-tape presentation, once immediately after the presentation and the second time a week later. The results supported their hypothesis of the colour condition having a greater incidence of reminiscence than the greyscale condition. As a result, they concluded that colours can influence the level of attention, which give rise to emotional arousal and

therefore enhance memory performance (Farley & Grant, 1976).

Research question

Although most studies had proven the importance of colour in memory performance, yet the extent to which it affects memory is still unclear. Numerous studies had found the magnitude of effect to be minimal, even though statistically significant (Wichmann et al., 2002). As a result, we aim to resolve this problem. This leads to our research question: Is the number of colour images recalled greater than the number of greyscale images recalled?.

Hypothesis

Subsequently, we hypothesised that the number of colour images recalled is greater than the number of greyscale images recalled. To test this hypothesis, an experiment involving a free recall test was designed. Participants were presented with images which were either in colour or in greyscale, and they were tasked to remember as many images as possible. This will measure the number of images recalled for both colour and greyscale conditions.

Method

Participants

Sixteen students from the University of Groningen were recruited to participate in this experiment. Participants were selected randomly. The range of age was between 18 and 23 years with a mean of 19.7 years old. Half of the participants were male. Participants with visual impairment or had sustained injuries in the head in the past were excluded from the test, as this often causes short term memory loss (Arciniegas et al., 1999). An informed consent form was given and they received a piece of cheese as reward.

Material and Stimuli

The participants were presented with only visual stimuli. A slideshow video containing 20 clear images of animals and everyday objects was created for the purpose of this experiment. Among the images, ten were in full colour while the remaining ten were in greyscale.

These images were randomly selected from a random object generator ("Random Lists", n.d.). All images were ensured to have a blank background (Figure 1) to remove confounding variables such as ambiguity within the images; for instance, to prevent participants focusing on other objects in the image. In addition, a greyscale image converter ("Browserling", n.d.) was used to convert colour images into greyscale images. Each image was labelled with a unique number, with that the sequence of images was randomized using a random sequence generator ("Random.org", n.d.). Instructions and examples were provided in the video and it was presented to participants using a laptop.

Figure 1: Example of a colour image (left) and a greyscale image (right) used in this experiment.

Participants were tested between nine in the morning and two in the afternoon. Furthermore, they were tested individually. They were randomly assigned to two groups of eight: the *colour-greyscale* group and the *greyscale-colour* group. Participants were then asked to recall as many images as possible and to record their answers in a given answer sheet. Since this is a free recall test, the order of which the participants have to write down their answers is not restricted.

Procedure

This experiment was carried out in an empty room with only a table, chair, laptop, experimenter and participant present. The participants were allowed to familiarise themselves with the rules and any uncertainties regarding the procedure of the experiment were cleared at this point. The experiment consisted of two rounds, for each round ten images were displayed either in colour or greyscale. Participants were required to observe all ten images consecutively in silence without making any physical notes; they were only given time to recall the images after each round. Each image was shown for two seconds.

The flow of procedures for the *colour-greyscale* group and *greyscale-colour* group is shown in Figure 2 and Figure 3. After the first round, the slideshow was paused for the participants to recall as many images as possible before starting the second round.

Figure 2: The flow of procedure for the *colour-greyscale* group.

Figure 3: The flow of procedure for the *greyscale-colour* group.

Design

The independent variable of this experiment is the colouration of images. There are two levels that make up this variable, one level being full colour and the other level being greyscale.

On the other hand, the dependent variable is the number of images remembered in each round. This data was collected from the answer sheets given to participants, recorded and transferred to Excel for further analysis.

Results

Previously, it was mentioned that our hypothesis states that the number of colour images recalled is greater than the number of greyscale images recalled. To test our hypothesis, we compared the number of objects remembered of the colour condition and the greyscale condition.

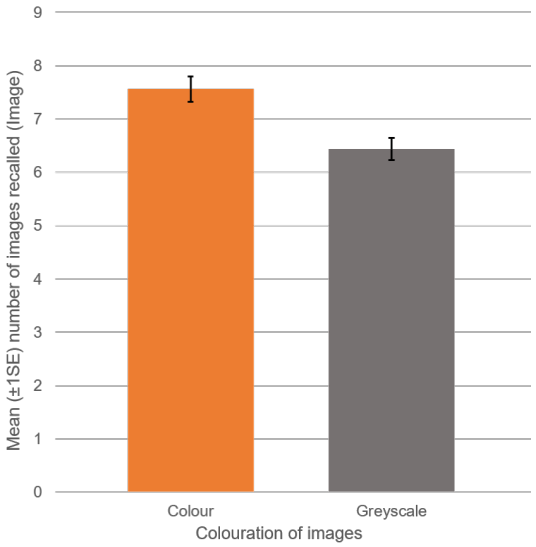

Figure 4: The mean number of images recalled of colour condition and greyscale condition.

As expected, participants remembered more objects in the colour condition than the greyscale condition. The results of the colour and greyscale condition are shown in Figure 4, with the standard error bars plotted into the graph. It can be seen that the mean images recalled is greater for the colour condition than for the greyscale condition. In addition, there were no outliers nor any other reason to exclude any data.

Statistics A significance test was carried out using the R (R Core Team, 2018) package (Maechler, Rousseeuw, Struyf, Hubert, & Hornik, 2018) to find out if there was a significant difference between the set of data. It was decided that since the data was interval based data with only two conditions, a t-test would be the most suitable. Furthermore considering the fact that the design of the experiment was within subject, a paired difference t-test was used.

It was found that there was a significant difference in the results for colour and greyscale conditions ($t(15) = 3.737$, $p < 0.05$).

Discussion

This study investigated the influence of colour on short-term memory by measuring and comparing the number of images recalled by participants in

colour and greyscale conditions. It was hypothesised that the number of colour images recalled will be greater than the number of greyscale images recalled.

The mean number of colour images recalled was greater than that of greyscale images. This serves as scientific evidence in support of our hypothesis. We concurred with previous studies concluding that colour significantly improves memory performance (Wichmann et al., 2002; Farley and Grant, 1976).

What can be learned from this research is of great significance to the design of visual contents, especially for educational purposes, whether in classrooms or even working environment. This is because it shows that colour is efficient in stimulating our brain hence improving memory performance. Therefore it is strongly recommended for a greater number of colour images or figures to be used during lessons for a more productive learning experience. Students are also advised to include more colour diagrams in their notes and to make full use of highlighters. Textbooks writers are urged to increase the number of colour figures in educational materials to help readers memorise facts as well.

Limitations and future directions This study had several limitations. First, the group of participants was not representative of the general population, as the participants were from one age group and educational level (university-aged students) only. The results obtained in this study may not be accurate for people from other age groups such as elderly people, as memory performance tends to deteriorate as age increases (Bromley, 1958). This can be improved by increasing the sample size and recruiting participants of various age groups and educational levels.

On the other hand, given that this study focused on short-term memory, it may be helpful if in the near future research can be conducted on investigating the effect of colour on long-term memory, to test if the same result obtained in this study applies. It is commonly suggested that humans possess three kinds of memory: sensory, short-term and long-term (Atkinson & Spence, n.d.). Sensory memory only retains information for a short time of a few seconds while short-term memory lasts about 20 seconds. In contrast, long term memory has unlimited capacity and long duration of retention that can even last a lifetime. Therefore, even though this study shows that colour helps with short-term memory, it will be interesting to compare the effect of colour on other types of memory too, especially long-term memory which stores a greater amount of information.

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