University students' perception of shapes and colours in dynamic and static images

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ABSTRACT: Developments in digital media technology have enabled the display of information in numerous forms. Consequently, viewers can receive information through various media. In numerous exhibitions, interactive design, learning materials and applied technologies have been used to help viewers interact with information, and produce various sensory experiences to communicate the ideas of artwork creators. The colours and shapes of dynamic images produced through technological applications can visually stimulate users and elicit emotions. In this study, a computational technique was employed to produce projected dynamic images. In the images, various colours were combined with various shapes to visually stimulate viewers. The author used a semantic differential questionnaire to investigate the subjective feelings of university students about various combinations of shapes and colours, and to explore how dynamic images influenced viewer emotions.

INTRODUCTION

With advances in technology, digital content has become ubiquitous. Technological devices have been used to produce sound and light effects in entertainment and to achieve interactive entertainment that involves user activity. In the digital era, various forms of expression have been deeply integrated with modern technology to enhance the effects of traditional art, thus producing interactive digital art, a favourite of contemporary artists.

Typical interactive digital artwork not only employs technological media in its creation, but also demonstrates characteristics of particular technologies [1]. Unlike conventional static presentations, digital presentations involve technology and interaction between viewers and creators. Numerous exhibitions have focused on using technology to help viewers interact with artwork, and to use their sensory experiences to understand the creators' concepts.

By the integration of technology and artwork, the shape and colour of an image can influence the experience of viewers. An image contains two elements: shape and colour. The two elements must coexist for people to perceive an image. Shape or form can influence the perception of colour [2]. How a combination of colour and shape can influence peoples' perception of an image is crucial.

In the present study, the author used projection mapping to produce dynamic images and used the virtual features of projected images to create realistic fantasy art. By employing computers and sensors, viewers were able to interact with artwork. A semantic questionnaire was used to investigate the subjective feelings of viewers about images and how images influenced the visual perception of viewers. Understanding the influence of shape and colour on the visual perceptions of viewers facilitates the use of projection mappings to present a creator's emotional message.

LITERATURE REVIEW

Explored in this study were the emotional responses of viewers to shapes and colours in dynamic projected images. The purpose of this study was to understand the relationship between shape, colour and emotion. Outlined in the following sections is the review of the literature and clarification of the definitions of various terms.

Digital Interactive Art

Digital interactive art stimulates the senses of viewers through interaction and involves sounds, devices and images. Without participants, digital interactive art becomes meaningless. For example, in *The Death of the Author*, Roland Barthes argues that the artist surrenders the *initiative* to the reader and makes the reader become part of the work. Such art creates value by creating a new thinking style through the integration of the work and the reader's consciousness.

As indicated by Heidegger, the gist of digital interactive art is to remove the original viewpoints of the works, to rethink the meaning of the art based on digital technology, and to enable the artwork to bridge the gap between itself and the viewers [3].

Digital art interactions are not a type of media, but a mode; audience engagement and participation are prerequisites for interactive digital art; communication must mediate between an audience and a work [1]. For example, in human-computer interactions, technology is used to produce communication interfaces between humans and computers. Excellent communication interfaces can help users to communicate instinctively with computers.

In recent years, projection mapping, a computational technique, has been applied on a number of occasions. For example, projection mapping was applied to creative entertainment in Walt Disney World [4].

In the present study, projection mapping was employed to present digital interactive artwork projected on to the surface of a 3D model, and the feelings of viewers were recorded.

Colour, Shape and Emotion

Images are a type of language for visual communication. They are useful for thinking and formulating consciousness, and can show perfection, harmony and order. The process in which an image enters the eye, reaches the brain, and causes colour perception includes three stages. At the first stage (the physical stage), the characteristic and quantity of light is involved. At the second stage (the physiological stage), visual cells transmit light and colour signals to the brain. At the third stage (the psychological stage), psychological changes occur [5]. When human eyes receive stimulation, some psychological activities (selection, combination, attention, memory, understanding and thinking) occur, according to previous experiences, to give meanings to a series of images [6].

With the development of optical theories, it was found that colour can cause various visual responses and is an extremely crucial element for any form of design. In addition to disseminating information, colour influences people's visual perceptions and psychological feelings. In the visual perception of an image, colour can cause a strong response. Human eyes are highly sensitive to colour, which is an expressive element, and can directly and immediately influence human emotion [7]. According to colour perception, various colours can influence human emotions in various ways [8].

Ren and Tang [9] investigated semantic differentials between various combinations of colour and shape and found that acute angled triangles imparted an active feeling, and an acute yellow triangle could substantially stimulate viewers. Moreover, they found that right-angled triangles induced a calm feeling, and a right-angled triangle in red could highly stimulate viewers (Table 1).

Table 1: Colour-shape combinations that elicited enhanced feelings [9].

Type of angle	Shape	Feeling	Colour	Enhanced feeling
Acute	Triangle	Active and bright	Yellow	Exciting
Right	Square	Calm	Red	Strong and powerful
Obtuse	Circle	Flowing, cool and free from tension	Blue	Deep and subtle

A combination of colour and shape can influence the emotions and feelings of users. For example, Tadayon and Afhami found that allowing students to scrawl graffiti helped those students to concentrate and enhanced their learning performance [10]. In addition, concentration and meditation can relieve stress and enhance happiness [11][12]. In sum, the shape and colour of an image can stimulate eyes and brain, triggering emotions and subsequent feelings. Therefore, in digital interactive artwork, besides lines and shapes, colour also plays a crucial role.

METHODS

The author, in this study, compiled a questionnaire by referencing previous studies on colour and shape, and adopted the semantic differential technique proposed by Osgood et al [13]. This technique can be used to show how people understand specific concepts, and has been widely applied to explore the meaning of colour and shape.

The method used a series of bipolar adjectives and adopted a five- or seven-point scale to investigate the semantic judgments of participants about specific images. In the pre-test, a questionnaire was used to investigate the feelings of university students aged 18 to 22 years regarding particular colours and shapes.

According to the results of a semantic analysis, projected dynamic images were fabricated using the projection mapping technique. Subsequently, in the post-test, the feelings of the university students regarding the static and the converted dynamic images were recorded. Figure 1 shows the research framework.

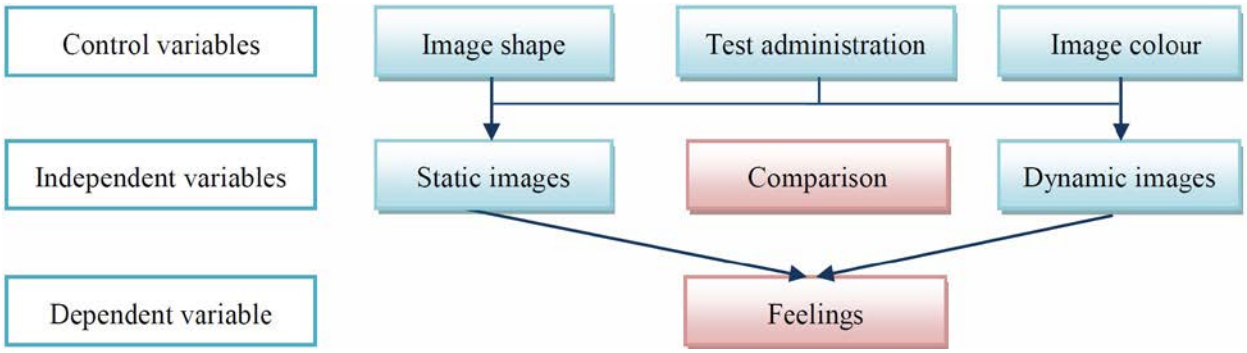

Figure 1: Research framework.

The pre-test used the static semantic differential questionnaire, referred to above, to investigate the emotional reactions and feelings of 61 university students. To avoid interaction effects, three basic shapes were combined with four colours (red, yellow, blue and white). Various colours and their corresponding emotions for static and dynamic comparisons were listed.

In this manner, the feelings of university students regarding various combinations of shapes and colours were explored. In the pre-test, the static questionnaire included three sets of bipolar phrases (tension/relaxation, sadness/happiness and repulsion/attraction). The dynamic images were fabricated on the basis of the combinations of colour and shape represented by the three sets of extreme words. In the post-test, a dynamic questionnaire survey was conducted with 38 participants.

The projected images were expected to make participants feel relaxed and happy. Therefore, the results of the semantic differential questionnaire survey in the pre-test served as a basis for the technological interactive artwork used in this study. In the post-test, the semantic differential questionnaire survey was conducted with the participants to see whether the specific dynamic images could elicit specific feelings.

The experiment for this study was undertaken in a quiet laboratory with light, temperature, sound level and humidity controlled, and cameras installed. During the experiment, participants filled out the semantic differential questionnaire and their facial expressions were recorded when they viewed the images.

At the end of the experiment, the collected data were analysed to understand the feelings of the university students about various colours and shapes. An independent-samples *t*-test was performed to explore whether the feelings of the university students about static images differed from their feelings about dynamic images.

RESULTS

Investigated in this study were the feelings of university students about dynamic artwork produced using the projection mapping technique. A seven-point scale was adopted in the semantic differential questionnaire to assess the subjective feelings about the images of the university students.

Table 2 shows the results for various static combinations of colours and shapes; specifically, it shows the mean scores for the feelings of the university students for various static combinations of colours and shapes.

Table 2: Statistics for various combinations of colours and shapes.

	Combination		Mean	SD	Mode	Ranking
Semantic analysis of relaxation and tension	Red	Triangle	3.08	1.03	3	12
	Blue	Circle	4.70	1.47	5	1
Semantic analysis of happiness and sadness	Blue	Triangle	3.26	1.06	3	12
	Yellow	Circle	5.39	1.00	5	1
Semantic analysis of attraction and repulsion	Red	Circle	4.51	1.28	5	1
	White	Triangle	3.52	1.31	4	12

Regarding tension and relaxation, blue circles (mean = 4.70) made participants feel most relaxed and red triangles (mean = 3.08) most nervous. Regarding happiness and sadness, yellow circles (mean = 5.39) made participants feel most happy and blue triangles (mean = 3.26) most sad. As for attraction and repulsion, red circles (mean = 4.51) were most attractive and white triangles (mean = 3.52) were most repulsive. Also investigated was whether dynamic images provoked stronger feelings than static images. Table 3 shows the results for static and dynamic images.

Table 3: Group analysis.

	Status	No.	Mean	SD	Standard error of mean
Blue circle Relax	Static	61	4.70	1.476	0.189
	Dynamic	38	5.26	1.005	0.163
Red triangle Nervous	Static	61	4.16	1.463	0.187
	Dynamic	38	4.79	1.189	0.193
Yellow circle Happy	Static	61	5.39	1.005	0.129
	Dynamic	38	6.18	0.692	0.112
Blue triangle Sad	Static	61	3.26	1.063	0.136
	Dynamic	38	3.39	1.079	0.175
Red circle Attractive	Static	61	4.51	1.286	0.165
	Dynamic	38	5.08	1.171	0.190
White triangle Reject	Static	61	3.52	1.312	0.168
	Dynamic	38	5.89	0.798	0.129

An independent-sample *t*-test was performed to compare static with dynamic images; $p = 0.028$ for blue circles that elicited a relaxed feeling; $p = 0.029$ for red triangles that evoked a nervous feeling; $p = 0.000$ for yellow circles that brought about a happy feeling; $p = 0.029$ for red circles that were attractive; and $p = 0.000$ for white triangles that were repulsive.

These results were significant. No significant difference existed between the static and dynamic images regarding blue triangles that elicited a sad feeling ($p = 0.550$). Table 4 shows the results related to the comparison between static and dynamic images.

Table 4: The statistical results regarding attention and relaxation.

		Levene's test for equality of variances		*T*-test for equality of means				
		F	Sig.	*t*	df	Sig. (2-tailed)	Mean	Std.
Blue circle relax	*EVA*	5.243	0.024	-2.052	97	0.043	-0.558	0.272
	EVNA			-2.237	96.165	0.028	-0.558	0.250
Red triangle nervous	*EVA*	1.009	0.318	-2.218	97	0.029	-0.626	0.282
	EVNA			-2.327	90.202	0.022	-0.626	0.269
Yellow circle happy	*EVA*	8.845	0.004	-4.260	97	0.000	-0.791	0.186
	EVNA			-4.632	95.951	0.000	-0.791	0.171
Blue triangle sad	*EVA*	0.103	0.750	-0.599	97	0.550	-0.132	0.221
	EVNA			-0.597	77.743	0.552	-0.132	0.222
Red circle attractive	*EVA*	0.855	0.358	-2.221	97	0.029	-0.571	0.257
	EVNA			-2.270	84.170	0.026	-0.571	0.251
White triangle reject	*EVA*	9.867	0.002	-10.031	97	0.000	-2.370	0.236
	EVNA			-11.177	96.970	0.000	-2.370	0.212

Note1: $p < 0.05$ defines significance

Note2: EVA stands for equal variances assumed; EVNA stands for equal variances not assumed

According to the semantic analysis of the dynamic and static images, the mean values for relaxed, nervous, happy, attracted and repulsed emotions caused by the dynamic images were significantly higher than the mean values for those emotions caused by the static images. The reason may be that the dynamic images were more vivid than the static images and, therefore, augmented emotions. However, the mean value for sadness caused by a dynamic image did not significantly differ from the static image. The reason may be that identical dynamic display modules were adopted for dynamic and static images to be presented in identical experimental conditions. The tempo associated with varying emotions (such as a fast tempo for happiness and a slow tempo for sadness) was not adjusted when presenting the dynamic images. Thus, for sadness, no distinctive dynamic or static image was identified.

CONCLUSIONS

For this study, a semantic differential questionnaire survey was conducted to explore participants' feelings about static images. Subsequently, a computational technique was used to produce projected dynamic images, which were used in the experiment. A projection mapping technique to produce artwork was used to investigate university students' perceptions of dynamic and static coloured images. The aim was to understand whether the use of this projection mapping technique influenced the feelings of participants in addition to causing aesthetic appreciation.

The following conclusions were drawn:

- Regarding semantic differentials for static images, results showed that blue circles, red triangles, yellow circles, blue triangles, red circles and white triangles gave rise to relaxation, tension, happiness, sadness, attraction and repulsion, respectively.

- The mean values for relaxed, nervous, happy, attracted and repulsed emotions caused by dynamic images were significantly higher than the mean values for those emotions caused by static images. However, the mean value for sadness caused by a dynamic image did not significantly differ from that for sadness caused by a static image.

- Squares did not elicit any prominent emotion.

To understand how to use the technology to present images, an experiment was conducted to understand the emotions of participants who viewed various images; the results can serve as a reference for future studies. If specific dynamic images were combined with various sound effects, emotional responses could be positively reinforced. In the future, in addition to colour and shape, sound effects could be included in a study to explore the influence of overall atmosphere on detailed facial expressions and to understand the effect of colour combinations. The author hopes that this type of research can lead to technological applications.

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