Colour Perception on Facial Expression towards Emotion

Ching Yee Yong*, Rubita Sudirman, Kim Mey Chew
Faculty of Electrical Engineering, Universiti Teknologi Malaysia,
81310, UTM, Johor Bahru, Johor, Malaysia
e-mail: chiyong@fkegraduate.utm.my*

Abstrak

Kajian ini adalah untuk menginvestigasi persepsi manusia terhadap ekspresi muka emosi dengan warna. Sekumpulan 27 subjek yang terdiri utamanya dari generasi muda Malaysia telah mengambil bahagian pada kajian ini. Untuk setiap tujuh ekspresi muka yang mengekspresikan emosi dasar alami, kebahagiaan, terkejut, marah, muak, ketakutan dan kesedihan, warna tunggal dipilih dari delapan warna dasar untuk "bersesuaian" dengan visual terbaik ekspresi muka. Ciri-ciri emosi yang berbeda akan diwakili oleh satu warna tunggal. Pendekatan yang digunakan dalam eksperimen ini untuk analisis adalah disiplin psikologi dan rekayasa warna. Tujuh emosi yang disesuaikan oleh subjek dengan persepsi dan perasaan mereka. Kemudian, data 12 lelaki dan 12 wanita dipilih secara acak dari data terdahulu untuk membuat perbandingan persepsi warna antar jenis kelamin. Keberhasilan atau kegagalan dalam menjalankan pengujian ini bergantung kepada kemungkinan subjek untuk mengusulkan setiap satu warna mereka untuk setiap ekspresi muka. Hasilnya akan diterjemahkan dalam angka dan prosentase, sebagai panduan untuk perancang warna dan bidang psikologi.

Kata kunci: ekspresi muka, visual, emosi, ekspresi universal

Abstract

This study is to investigate human perceptions on pairing of facial expressions of emotion with colours. A group of 27 subjects consisting mainly of younger and Malaysian had participated in this study. For each of the seven faces, which express the basic emotions neutral, happiness, surprise, anger, disgust, fear and sadness, a single colour is chosen from the eight basic colours for the "match" of best visual look to the face accordingly. The different emotions appear well characterized by a single colour. The approaches used in this experiment for analysis are psychology disciplines and colours engineering. These seven emotions are being matched by the subjects with their perceptions and feeling. Then, 12 male and 12 female data are randomly chosen from among the previous data to make a colour perception comparison between genders. The successes or failures in running of this test depend on the possibility of subjects to propose their every single colour for each expression. The result will translate into number and percentage as a guide for colours designers and psychology field.

Keywords: emotion, facial expressions, universal expressions, visual

1. Introduction

A wide variety of human-machine interactions learning techniques have been used in human monitoring approaches for emotion or expression analysis. This employs a large number of visual and physiological features, a fact which usually impedes the training process [1-3].

The study described in this paper is to investigate the relationship between facial expression (emotion) of human and colours. The result are then illustrated and analyzed as it can be used as reference point for designing and psychology field. The result can be very useful and important especially for psychology field to find out the respected reaction and nature emotion of a patient after encounter with different colours. It is also important in managing the subject data effectively and providing scientific information about facial movement.

This paper is divided into six sections. The first section mainly introduces the whole study. It provides the general overview of the colours and expression analysis system. In addition, it lists the guidelines and scopes of this study. The second section includes the objectives of this study, which describes the aims that needed to be achieved. The third section discusses the background studies, literature review and the basic concept in this study. It will

first discuss a few basic concepts regarding human emotion based on six universal emotions including the sad, surprise, disgust, happiness, fear and angry. Besides, this chapter will also contain technical knowledge on programming language and theories used in the concept to come out with the support system proposed. Section 4 discusses about the study implementation. A specification list of the computer environment and thorough discussion on the developmental tool or assessment and analysis on various emotions is explained. Some major program flows will also be discussed briefly. Section five discusses the system performance. Finally, the last chapter contains the conclusions and future developments of this study. A brief but thorough summary of the study is provided. Also, the problems faced during the study and solutions for those problems are mentioned. The last part in this paper is about the possible enhancement and improvement of this study.

2. Problem Formulation

The hypothesized function of this monitoring system is to provide the users with information about what the subject are feeling in order to deliver useful information about their thinking with connection to the theory of emotions expressed through facial motion [4]. The subjective experience of expression or emotion is simply hypothesized as the feedback from facial muscles motion and movement.

In this study, the practice item of emotions was focused on Elman's neutral and six universal emotions. Ekman also established 11 characteristics which easily distinguish basic emotion from one another [5]. This study included some features from Ekman for face modeling and facial recognition.

The objectives of the fundamental studies are to investigate the relationship between colours and human facial expressions in order to implement the result obtained in psychology and art and design field. Besides, the study also compare the colour pairing perception between male and female.Counterbalancing should be implemented as a controlling mechanism and efforts is made to ensure that all subjects completed the given tasks. New task need to be developed by drawing the best features of existing tasks.

3. Literature Review

This section discusses a few basic concepts regarding human emotion based on six universal emotions and theories used in the facial assessment system proposed.

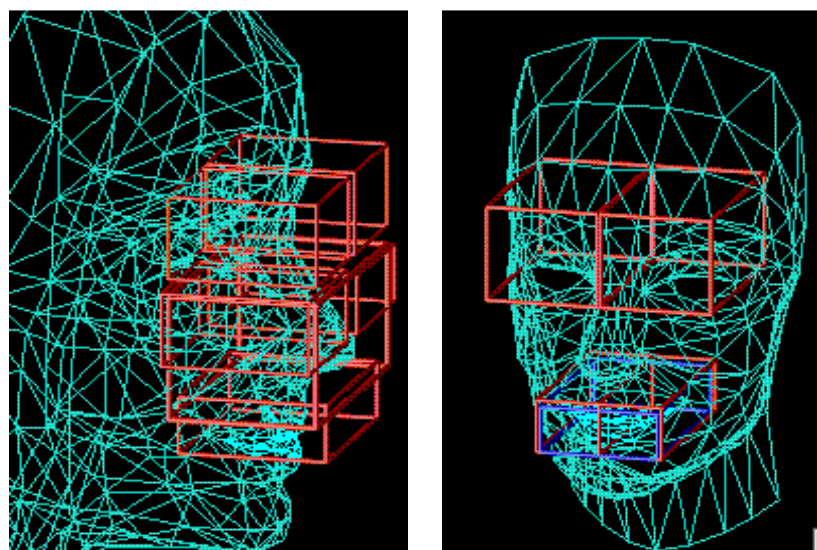### 3.1. Emotion Wheel and Six Universal Emotions

Figure 1. Emotions structural model adapted from Daly

Happiness, surprise, anger, disgust, fear, and sad had classified as the universal six facial expressions from psychological research [6]. It is interesting that, throughout all the six expressions, four of them are negative emotions.

All expressions are created over the appropriate bounding boxes via applying a sequential combination of sphincter or linear muscles. Sphincter muscles are blue in colour while linear muscles are in red as shown in Figure 1 as right side is emotion of disgust while right side is anger [7].

3.2. Colour and Emotion in Art and Design

For the artists, who may fear to express their own emotions, to get "right" colour may not be a problem. Their choice of colour is determined by their own feelings. Designers, on the other hand, it may be necessary to express the feeling that they may not experience itself. In this case they should be as an actor [8].

A selection of designer colours is to be more objective where the colour should be chosen for the same reasons so that the actors use the appropriate colour when they put a particular facial expression in the play. Antonio Damasio describes how there are differences among the facial expressions so that the natural expression of emotion and those who are aware assumed in social situations: "In order for a smile 'natural', you only have a few choices: learn to act, or get someone to tickle you or telling a good joke" [9]

The designer may have confidence in their own assessment, but the results of the assessment showed that not all will get the "right" colour. Each of the color represents the consensus of the perception, can be used as a point of reference by designers who do not have their own feelings to guide them.

3.3. Colour and Emotion in Psychology

Fun is the basic colour to display information about the nature of things. Colour can also stimulate the viewer to respond to a set of circumstances in a particular way. Among the features of an object is understood that we can measure the positive and negative values of the observer. If facial expressions are pre-language media of communication, the same may be required to colour the possibility that colour, such as facial expressions, can be associated with emotion [10].

There is increasing evidence that the relationship between emotions and colours are rooted in human biology. How we blush and turn pale can be a part of the story, but a variety of colours that can communicate emotions far beyond the range of pink to red exhibited by FeliceCasson. It seems likely, therefore, to clarify the rules of correspondence between colour and emotion [11].

Bakst's idea, stated in an interview, which was recorded by Mary Fanton Roberts: "I often see that in every prism of colour there are sometimes graded expression of honesty and purity, sensuality and sometimes even bestiality, sometimes proud, sometimes desperate. Thiscan be considered and given to people with influence who first made from a variety of shades [12].

3.4. Emotion Wheel

Emotion is a complex state of mind which includes correlation of physiology, the role of social and cognitive factors. Emotions provide the energy for a reactive behaviour with the possibility of delaying and thereby controlling the actual response [13].

Some emotions are considered basic [5], because they cannot be revealed to others, and their external manifestations play an important role in adaptive social interactions [14]. Basic fundamental emotion seems universal, and they seem to miss the external manifestations of culture and personal experience [15]. For this reason they may be exposed to the facial expression without interference from verbal language [16].

Six basic emotions, with appropriate facial expressions, have been identified: anger, surprise, disgust, sadness, happiness and fear. Emotional state through facial expressions to an intentional but, to some extent, it is possible to carry out conscious control over facial expressions to serve specific social purposes. According to Michael Argyle, "is the final part of a deliberate facial expressions of social signals, but they also reflect the true emotional state" [17].

Emotional state that most clearly marked by facial expressions, but the human face is also a limited repertoire discolouration; emotions can be accompanied by an increase or

decrease blood flow to the face leads to blushing or pale. Examples of unusual cases, in which the colour of the face more clearly than facial expression as an indicator of emotional state was reported by John Berendt [18].

4. Methodologies
There are 5 main parts in the support system:

4.1. Questionnaire and Face Model Forming
In this section, Microsoft visual C++ and FaceGenModeller application tool are used to produce different types of facial expressions model.

4.2. Data Acquisition and Management
There are few scopes to ensure the study is conducted within the boundary set, and heading to the right direction to achieve the intended objectives.This form of experimental research conducted as an experiment by using face-to-face approach, online questionnaire, email sending and online social networking activities. Time is limited for the experiment. Participants are not subject to colour vision tests. Participants need to focus on the work itself, the apparent concentration in the images created at the time.

Experiment started with the approach on a 27 subjects with 13 male and 14 female as dataset for the emotion analysis system. The performances of the monitoring system then recruited into the decision making for classification from the neutral and six basic emotions. The characteristics features of the data captured need to be extracted in order to obtain relevant information that is unique to the database during classification [19]. Hence, the producing of subject's facial motion must operate in a suitable background. All the subjects are making their colours pairing in a common background.

Age of the participants was not recorded, but most of the subjects are under 25. Other participants are older, most in the 20"s or 30"s, some in their 40s. Response from the participants, men and women are recorded separately. The only comparison can be made is that the responses from the two groups as this is collected separately. Since the average age of all the participants somewhat a bit difference and not are likely to find differences in response according to age.

4.3. Experimental Process
Experiment gives participants the opportunity to experience, first hand, psychological research methods and discusses how the study findings may apply to the design. Participants are asked to select a single colour of the "appropriate" best each of the seven faces. Face is expressive of the neutral and six basic emotions, but emotions themselves are not named. By choosing a colour to match the face of the participants are expected to respond immediately to associate facial expressions and faces with the colours without verbal language as a medium [20].
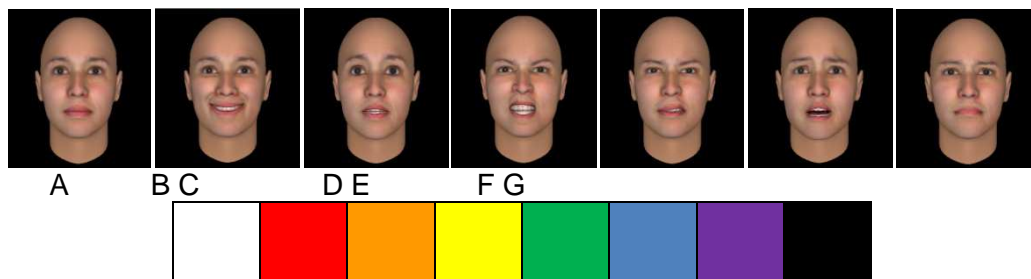

Figure 2. Unnamed emotional faces and colours

In the experiment we study the colour of a selected group of people associated with the face showing a particular emotion. Studied neutral six basic emotions are: anger, surprise,

disgust, sadness, happiness, and fear. To reduce the effect of combining verbal and emotional colours we use black and white faces selected from FaceGen Modeller collection as representative of universal basic emotions. Colour samples from the Natural Colour System (NCS), a proprietary perceptual colour model published by the Scandinavian Colour Institute of Stockholm, Sweden [21]. It is based on the colour opponency description of colour vision. Task was to select participants from the NCS colour sample collections that they deem most appropriate to face and to introduce a cut-out faces in the middle of the colour samples (Figure 2) [22], [23].

4.4. Report Generation
The agreement are able to get from 27 randomly subjects in UTM campus for the assessment. In this kind of experiment, the range of emotions for the database was constrained to the one genuinely felt by the subjects which were neutral, happiness, surprise, anger, disgust, fear and sad because the naturally occurring emotions were only can be captured.

Result is then transformed into image (Figure 3 and Figure 4), chart (Figure 5) and calculation in percentage and standard deviation. Standard deviation used for measurement of variability or diversity used in statistics and probability theory. It shows how much variation or "dispersion" there is from the "average" (mean, or expected value) of the colour selection. A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data are spread out over a large range of values.

4.5. Monitoring System Performance Evaluation
Probability theory is used in this study to evaluate with analysis of random phenomena. In probability theory, the matching problem pertains to the probability that in a set of randomly chosen people some pair of them will have the same colour matching.

By the pigeonhole principle, the probability reaches 100% when the number of people reaches 500. But perhaps counter-intuitively, 99% probability is reached with just 235 subjects and 50% probability with 39 subjects. These conclusions are based on the assumption that every emotion of the faces is equally probable for matching a single colour.

A related question is, among all the subjects in this study, which one is most likely to have the same colour matching with another? That is, the probability that a subject has the same matching colour in this study same as other particular subject (for example, author) is given by:

$$q(n;d) = 1 - (\frac{d-1}{d})^n \tag{1}$$

In the standard case of d=56 (total probability) substituting n=27 (number of subjects take part) gives about 38.52%.

$$q(n) = 1 - (\frac{56-1}{56})^{27} \tag{2}$$

For a greater than 50% chance that a subject in the study of 27 people has the same colour matching as another subject (for example the author), *n* would need to be at least 39 as shown in Figure 6. Note that this number is significantly higher than 56/2 = 28: the reason is that it is likely that there are some colour matches among the other people in the study.

5. Discussion
Experiment described here can be regarded as a contribution to a larger project with two different lines of research for future studies. Psychologists interested in the extent to which people from different cultural background colour associations are the same or similar emotional facial expressions, the designer is interested in knowing what colours are possible.

The average values shown in Table 1 and Figure 3 show that the level of analysis of recognition that are higher than all the expressions are D (anger) with 85.9% for red colour while E (disgust) below 20% for orange colour. An angry face with the pressing of lips and bulging of eyes easily being is detected by subject.These significant emotional criteria have been easily classified as red colour.
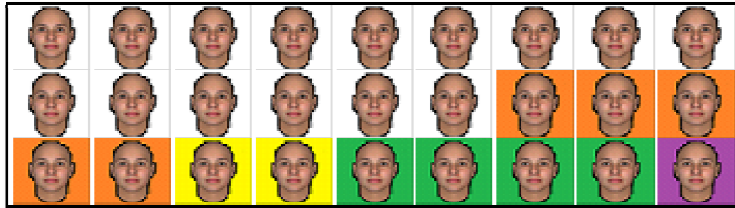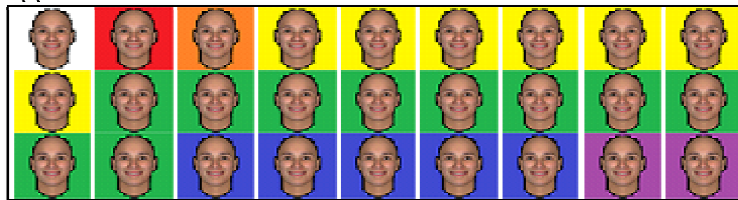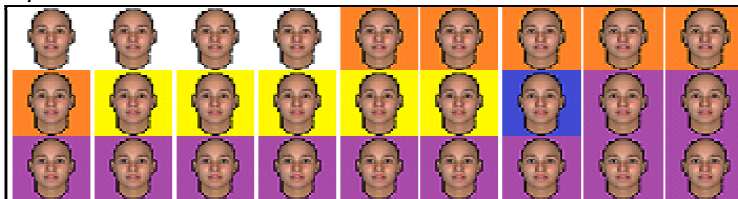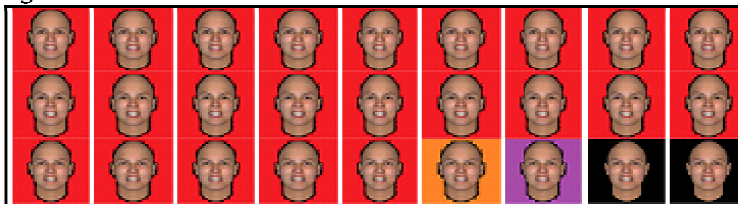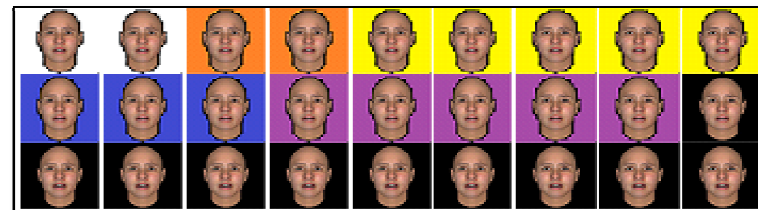
Figure 3. Result in colour image
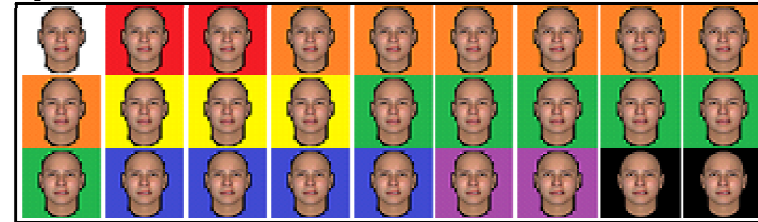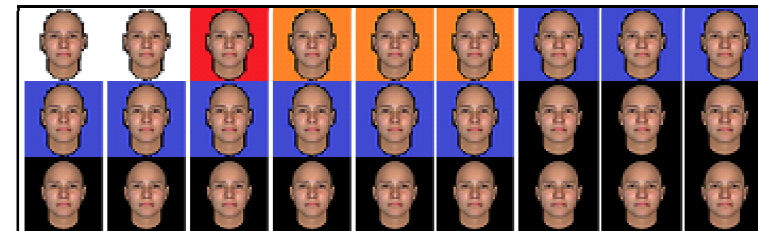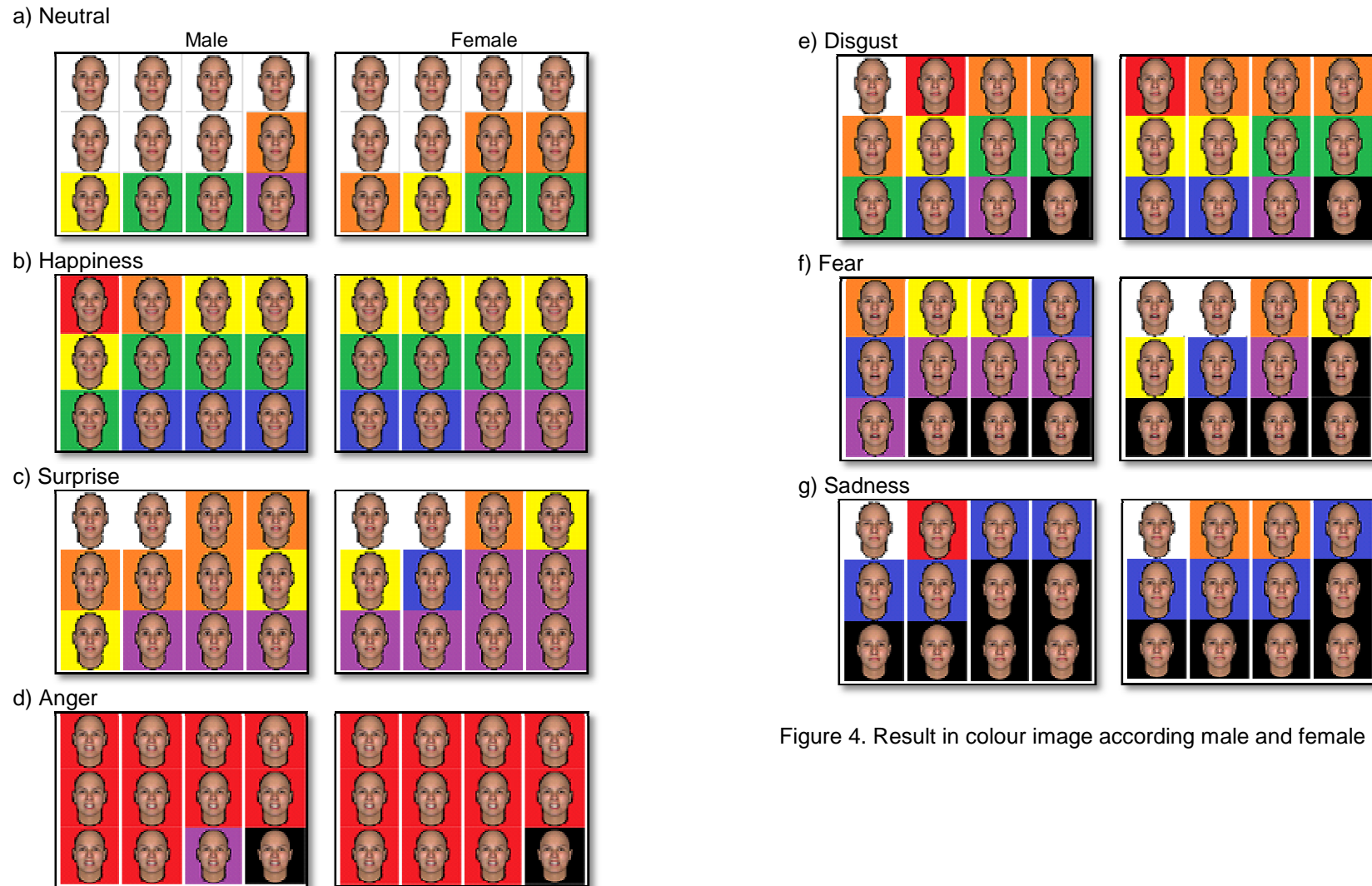
Figure 4. Result in colour image according male and female

Table 1. Average assessment result (all) matrix

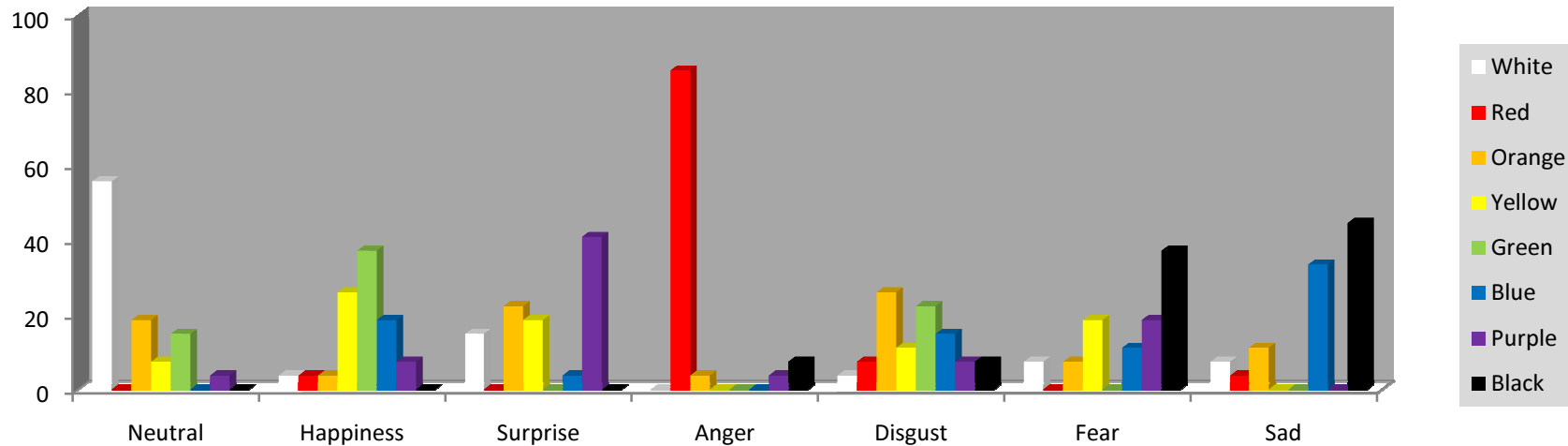| Universal Emotions	White	Red	Orange	Yellow	Green	Blue	Purple	Black	Variance σ^2	Std Deviation σ
Neutral	**55.56**	0	18.52	7.41	14.81	0	3.70	0	308.4798	17.5636
Happiness	3.70	3.70	3.70	25.93	**37.04**	18.52	7.41	0	154.1619	12.4162
Surprise	14.81	0	22.22	18.52	0	3.70	**40.74**	0	184.9678	13.6003
Anger	0	**85.19**	3.70	0	0	0	3.70	7.41	761.2030	**27.5899**
Disgust	3.70	7.41	**25.93**	11.11	22.22	14.81	7.41	7.41	54.6595	7.3932
Fear	7.41	0	7.41	18.52	0	11.11	18.52	**37.04**	130.1176	11.4069
Sad	7.41	3.70	11.11	0	0	33.33	0	**44.44**	253.5103	15.9220

Figure 5. Result in chart

Table 2. Average assessment result (male/female) matrix

| Universal Emotions	White		Red		Orange		Yellow		Green		Blue		Purple		Black	
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Neutral	29.17	25.00	0	0	4.17	12.50	4.17	4.17	8.33	8.33	0	0	4.17	0	0	0
Happiness	0	0	4.17	0	4.17	0	12.50	16.67	16.67	16.67	12.50	8.33	0	8.33	0	0
Surprise	8.33	8.33	0	0	20.83	4.17	8.33	8.33	0	0	0	4.17	12.50	25.00	0	0
Anger	0	0	41.67	45.83	0	0	0	0	0	0	0	0	4.17	0	4.17	4.17
Disgust	4.17	0	4.17	4.17	12.50	12.50	4.17	8.33	12.50	8.33	4.17	8.33	4.17	4.17	4.17	4.17
Fear	0	8.33	0	0	4.17	4.17	8.33	8.33	0	0	8.33	4.17	16.67	4.17	12.50	20.83
Sad	4.17	4.17	4.17	0	0	8.33	0	0	0	0	16.67	16.67	0	0	25.00	20.83
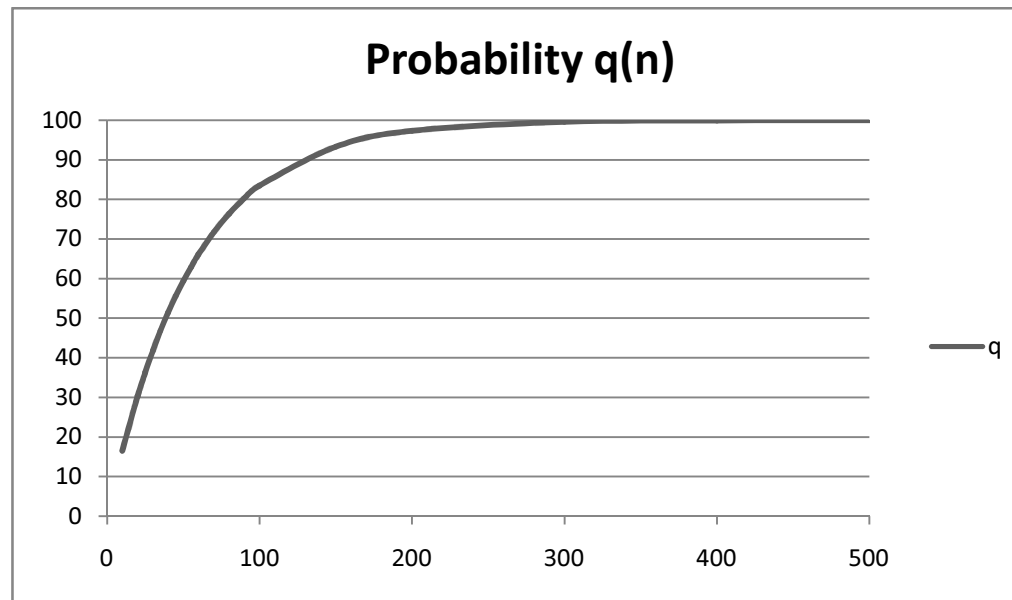
Figure 6. Probability in percentage versus number of object

Standard deviation for angry face has also marked the highest score with 27.59 because almost all the selected colour for an angry face is red. It can be concluded that when people thinking of angry, surely it will related to red colour. If not, the emotional sense of disgust (E) is recorded with a standard deviation below 10. This is the only face that included with all the colours giving with orange the highest amongst.

In comparison between male and female in Table 2 and Figure 4, a surprisingly result is obtained for face C (surprise) in colour choosing. Male prefer orange colour to represent disgust with 20.83% while female recorded 4.17%. On the other hand, female prefer purple colour for surprise feeling with 25% that is 50% more than male's reading.

A study of relationship between colour and emotion was conducted by college students which led by Naz Kaya in year 2004. 98 subjects were participated in this study with five principle colours (red, yellow, green, blue and purple). The colour green evoked mainly positive emotions such as happiness and surprise because it reminded most of the respondents of nature. The results also revealed that anger can be represented by red colour. These data are almost the same with the study conducted in UTM. But then, result from Naz indicated that the purple colour had the highest number of negative responses (disgust and sad) since no black colour is provided in Naz's study [24].

It is necessary to conduct further research with other groups from other parts of the world, especially Europe and Africa. It will also be required to review the experimental methodology. It is possible that these results might be different if people were making their choices in isolation, with no possibility of outside influence, and under standard lighting. Although there are different ages, there were more female than male participants and the majority have a strong interest in colour design. A larger group, from more diverse backgrounds and with both sexes equally represented, will have the potential to provide more convincing data. If personal data are recorded will also be possible to compare responses from different groups.

Another question to be answered conclusively is whether the choice of colour solely influenced by the emotions conveyed by facial expressions or whether there are other factors involved.

The evidence from this experiment showed that the dominant emotion is conveyed. The selected colour to the face of F and G, quite similar in some respects and could be taken to reflect the emotions as there are similarities between the fear and sad due to the feeling of sickness. The distinction between the colours chosen for the face of A and D increase the possibility that there may be other factors at work. The difference lies in the choice of colours. For those faces, a lot of people prefer white and red but the rest have a lot to choose orange for neutral and many are choosing to anger black.

In comparison between male and female, the orange and purple may have more to do with the fact that the face of the face model because the face model for surprise looks a bit shocked.

Designers can learn from the work of artists like Munch, van Gogh and Germany, and from designers like Bakst, but they can also learn from this type of experiment described here [25-27]. With only seven faces, however, this study is limited. Attempts continued to do more specifically with the needs of designers in mind. Greater variety of pictures can be completed, with the actors expressing various emotions more subtle and emotional. A valuable accompaniment to such research programs will work in parallel to the definition to clarify the distinction between emotions, emotional state, mood, feeling, sensation, perception, denotations, connotations, and cognition.

6. Conclusion

The subjects took part in this experiment agree closely in the production of colour associations with facial expressions and emotions. Results seem to confirm the concordance among the observed expression of human emotions, colours and their relationships, perhaps on the basis of universal biological roots. Further research, involving a larger participant, can help to confirm this proposition.

Trial decisions, in the form of colour choices made by those who participated in the experiment, also can serve as a guide for designers in the use of colour for communication. The

questions raised by the results showing more lines of research that could give designers more broad vision and a greater confidence.

References
[1]   Russell JM. Measures of Emotion. Emotion: Theory, Research, and Experience.Vol4, London: Academic Press Inc. 1989.
[2]   Nyoman RE, Suyanto NFN. WarihMaharaniIsolated Word Recognition Using Ergodic Hidden Markov Models and Genetic Algorithm. *TELKOMNIKA Indonesian Journal of Electrical Engineering.* 2012; 10(1):129-136.
[3]   Mardiyono M, Reni S, Azlan A. Intelligent Monitoring System on Prediction of Building Damage Index using Artificial Neural Network.*TELKOMNIKA Indonesian Journal of Electrical Engineering.* 2012; 10(1):155-164.
[4]   Ekman P.Cognition and Emotion.1992; 6: 169–200.
[5]   Ekman P, Davidson RJ. The Nature of Emotion: Fundamental Questions*.* New York: Oxford University Press. 1994.
[6]   Ekman P. Are There Basic Emotions?*Psychological Review.* 1992a; 99(3): 550-553.
[7]   Daly EM,Lancee WJ, Polivy J. A Conical Model for the Taxonomy of Emotional Experience. *J PersSoc Psychol.* 1983; 45:443–457
[8]   Stang R,Munch E. The Man and the Artist. London: Gordon Fraser. 1979.
[9]   Damasio A. Descartes' Error.London: Papermac. 1994: 142.
[10] Valdez P,Mehrabian A.*J. Exp. Psychol. General.*1994; 123**:** 394–409.
[11] Xifu Z.*ActaPsychologicaSinica.* 2003;35(3): 352–357.
[12] Roberts MF.*The Craftsman.*1915; 29(3): 257–269, 322.
[13] Mandler G. Mind and Body: Psychology of Emotion and Stress. New York: Norton. 1984.
[14] Duffy E. The Psychological Significance of the Concept of Arousal or Activation. *Psychol Review.*1957; 64:265–275.
[15] Lane RD, Nadel L. Cognitive Neuroscience of Emotion*.*Oxford: Oxford University Press. 2000.
[16] Darwin C. The Expression of Emotions in Man and Animals. Chicago: University of Chicago Press. 1965.
[17] Argyle M. The Psychology of Interpersonal Behavior*.* London: Penguin Books. 1994.
[18] BerendtJ. The City of Falling Angels*.* London: Sceptre. 2005: 79.
[19] Ching Yee Yong, RubitaSudirman and Kim Mey Chew. *Facial Expression Monitoring System Using PCA-Bayes Classifier*. IEEE International Conference on Future Computer Sciences and Application (ICFCSA). China: Hong Kong. 18-19 June 2011: 187-191.
[20] Albert-Vanel M. Proc. ForsiusSymposium on Colour Order Systems. Stockholm: Scandinavian Colour Institute. 1983.
[21] Green-Armytage P.ColourZones – Connecting Colour Order to Everyday Language. Proc. AIC 01.New York: Rochester. 2001.
[22] Da Pos O, Valentini S. Proc. AIC Colour 05. Granada. 2005.
[23] Green-Armytage P.ColourZones – Explanatory Diagrams, Colour Names and Modifying Adjectives. Proc. AIC 01.New York: Rochester. 2001.
[24] KayaNaz, Helen H. *College Student Journal.* 2004;38*.*
[25] Van Gogh V. TheComplete Letters of Vincent van Gogh. London: Thames and Hudson. 1958.
[26] Ekman P, Friesen W.V.Manual for Facial Action Coding System. Palo Alto: Consulting Psychologists Press. 1978.
[27] Sivik L. Goteborg Psychol. *Reports.*1974; 4: 1–11.