An Analysis of Complexity Metrics for Website

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Abstract
With increasing contents and features, it is clear that the growth of the World Wide Web has brought benefits for individuals and organisations. For website users, they would be benefited by the frequently updated information as well as an available purchasing channel, while for companies websites become the tool for building effective communication with users, gaining profit and increasing their awareness. However, it may also cause some issues with the use of websites, such as lower loading speed. Since the website complexity is depended on the web design concept, while as one of the crucial components of website design, the colour would play an important role, the similar concept could also be raised as the colour complexity, referring to the richness of colour used during website design. Research finding as presented in this paper will be help to understand the influence of colour complexity and could be used to support the research on website complexity.

1. Introduction
The increasing contents and features of websites have brought users with convenience, while some drawbacks also existed
such as reducing loading speed. Some researchers believe that the lower level of contents could improve the usability and navigation experience, while others suggest that with more contents used on websites, the users’ satisfaction will increase. With these claim, the evaluation of website complexity becomes necessary. As an important element of website, the use of colours could bring some large impacts, while the proper use of colours on websites could attract more users, increase their willingness of finishing the tasks and increase their loyalty.

In this case, the complexity of website contents had raised awareness among researchers. For instance, according to the studies of previous researches by Nadkarni and Gupta (2007) as well as Wang et al. (2014), websites with more straightforward design might be more accessible regarding browsing while those with rich contents might instead increase the satisfaction of web users. With this claim, to evaluate the website complexity using proper complexity metrics becomes essential.

Further researches had found that colour could affect users mainly in terms of usability and aesthetics, while there were also the findings showing that the different combination of colour might also influence the behaviours of users such as increasing the willingness of clicking on some links and icons.

Since the combination of colour could also contribute to some impacts, colour complexity, defined as the richness of colour used for the item, could also be important for website design. However, few research had been
conducted previously for the investigation of colour complexity on overall website users, while the unified research about users' preferences on colour complexity were also limited. The research finding of this work could bring the benefits for both website designers and users. For designers, they could better understand the reasons for conducting lower or higher complexity of colour during the web design, while designing the sites that satisfy users' demands. For website users, the research could become their guideline for effectively using the websites.

Rest of this work has been organized as follows. In section 2, related work is detailed. In section 3, analysis and discuss on the factors which could have impact on colour complexity of web sites whilst conclusion and future work is given in section 4.

2. Related Work

As one of the most important elements in websites, the use of colour has raised people's concern, since it would influence users' moods and emotions (Pelet and Papadopoulou, 2012; G&d; et al., 2013), while as the first impression that decides whether to continue browsing the websites or not (Bonnardel, Piolat and Le Bigot, 2011). Singh (2006) predicted that it would take less than 90 seconds for a customer or user to decide the products while more than 60% of these decisions are made based on colours, which might also be applied to the concept of websites. This is also supported by Reinecke et al. (2013), in which they believed that users would spend more time on the appeal of websites before paying attention to more detailed contents. The proper selection of colour would help attract more
website users, leading them for decision making and increasing the conversion rates, while the inappropriate use colour scheme might influence the usability and even become a barrier for users to further browse the websites (Vitols et al., 2015).

Since there is the discussion of the complexity of website design, while colour plays an essential role in web design, the evaluation of colour complexity is carried out. Colour complexity referring to the richness of colour in contents (Zhou, Xu and Yang, 2015), or in other words, the number of colours used in an element. In terms of websites, colour could be used on various components such as texts, background, icons and so on. This increases the possibility of using different colours for these components, augmenting the complexity of colour used during web design.

So far, the previous sessions had focused on the various researches which indicated the importance of proper complexity of websites as well as the colour used for them with some claims, with the simpler design of sites creates ease of use and navigability advantages, while rich contents shown on websites could increase the satisfaction of users. Then, it analysed the colour complexity as the richness of colours used for website design, and also generally analysed the importance of colours on website users.

However, limited research has been conducted about the influence of colour complexity on overall website users. Some research such as the one provided by Bonnardel, Piolat and Le Bigot (2011) only mentioned the complexity of colour in terms of the monochrome colour scheme;
others mentioned the impact of it on the specific user groups. Besides, since web users might have different characteristics such as age, gender, culture and others, they might react differently to the degrees of colour complexity of web pages, making the evaluation more complicated. Moreover, there lacks an efficient way of evaluating specifically the complexity of colour used on websites, although various website evaluation criteria and aspects were developed by different previous researchers to access the complexity of websites. In this case, it would be difficult to determine to what extent would colour complexity bring the most benefits to users on websites. The focus of next section is on analysing factors which could have impact on colour complexity of web sites.

3. Analysis and Discussion

It can be well understood in the light of the above discuss that an analysis of this area could be benefit in terms of understanding several related concepts.

3.1. The Relationship Between Website Design and Colour

The development of web design concept had changed tremendously in the last several decades, while the designs of websites were becoming increasingly complex to satisfy users’ preferences. However, there were some concepts which remained common, such as the recommendations for effective website design listed by Gehrke and Turban (1999) around 20 years ago in terms of increasing page-loading speed, increase the efficiency of navigation, security and so on, some of which were still meaningful for the design at
present. For example, to increase loading speed, designers could use simple graphics and minimise the file size, while nowadays there are some websites followed this concept and using more plain style. Besides, providing search engine within websites was regarded as an efficient way of increasing navigation performances as well as information findability, while a large number of websites have included the search box in the homepage at present.

Although the guidance from Gehrke and Turban (1998) was still useful to some extent, for other recommendations, there might be some different attitudes towards them at present. As another method for increasing web loading speed, to provide text-only version is no longer common now because of the increase of Internet speed using the latest communication technology. In addition, to avoid opening new browsers or new page when click on hyperlink might be another way of increasing navigation experience. This trend is now common in most countries, but in China, a large number of websites are designed to open a new page when clicking on links. With these differences, it is more convincing that the evolution of design concept follows the development of technology as well as other factors such as cultural preferences.

As one of the important elements in web design concept, colour plays an important role. Various researchers have found the importance of colour used for websites. Lin, Lo and Huang (2016) indicated that colour is an essential visual element which influences visitors’ attitude towards web aesthetics. In addition, according to Cyr, Head
and Larios (2010), colour could influence humans' emotion, reactions and behaviour with its features like hue, brightness and saturation. For websites, multiple choice of colours and colour combinations could be achieved since the use of RGB and hex values would help achieve around 16.8 million colours to be present on the web (O’Grady, 2015). Such a huge amount of colour available for web design could enhance the richness of information and contents, leading to the concept of colour complexity.

However, the evolution of colour used in terms of website design might not be significant, as limited research was conducted to evaluate the trend of colour used for websites. Besides, Holtze (2006) indicated the influence of colour in terms of the psychological response from people, so in this case, the trend of using colour might be constant since it is related to humans' own features, while for other trends of design, the aim could be continually improving users' experiences. The changes of concepts of applying colour to the website design might be changed with the more researches and findings related to colour theory and colour psychology. Although the trend of using colour is highly associated with users' features which might be constant, when considering it as the element of web design, the aim might be using the proper colour as well as the combination of colour to meet users' preferences.

3.2. The Influence of Colour and Colour Complexity

There are various findings related to website and visual complexity, with some believe that users would prefer simple websites, others suggest the richness of
information could increase user's satisfaction (Wang et al., 2014). This could be similar to the concept of colour complexity of websites which involve with the richness of colours and colour combinations.

The colours used in web could be included as the contents and appearance that evaluated website quality by different researchers (Aladhawi and Palvia, 2002; Hernández, Jiménez and Martín, 2009), while the use of colours is highly associated with their own meanings. These meanings are related to different region and culture (Maguire, 2011), gender (Mess, Gunn and Heller, 2006) and others. Maguire (2011) listed some meanings of colours and believed that designers should avoid the inappropriate use of colours when designing the websites for the different region which might lead to negative effects. There is a close relationship between colour and colour complexity, although there might be some difference in terms of focus. Colour complexity could be a part of the concept of colour. In this case, the impact of colour complexity should be based on the analysis of the influence of single colour.

The impact of colour on web users are mainly based on aesthetic as well as usability. First, as for aesthetics, Lavie and Tractinsky (2004) mentioned visual aesthetics was important which affects the attitudes of people who browse websites, while the colour was one of the components that influence aesthetics. Besides, Krauss (2005) believed that aesthetic should be considered as the important part for building effective communication with users. Bonnardel, Piolat and Le Bigot (2011) agreed and
recommended that designers should pay more attention to the aesthetic value rather than only focusing on usability, and they provided relevant studies showing that different colour used in websites would have the different impact on visitors related to navigating and memorising.

In terms of usability, Pelet and Papadopoulou (2012) supported the influence of colour on improving individuals' memorisation on e-commerce websites which increase the buying intention of them. Holtze (2006) indicated that using the proper colour for certain contents could help guide the users to know the structure of websites efficiently. Some general articles such as the ones provided by Beever (2017) and Maino (n.d.) suggested that the proper use of colour in key areas of websites such as pop-ups, borders, background hues and buttons could affect users most. He mentioned buttons as an example, in which the use of yellow instead of green for “sign up” buttons increases users' willingness to click on it. Although significant research does not prove these claims, the studies from other researchers had shown the effective use of colours on links that increase the likelihood of clicking on them. For example, the one conducted by van Schaik and Ling (2003) showing that if the colour of links was blue while the background colour was white, more positive responses could be generated while increasing the quality of display compared to those links with black colour displayed on white background. Since the majority of words used on sites are black, the contrast colour used to show some unique elements could help users find the target information quickly.
When colours are combined together and used in websites, there will be some unique impacts, which leads to the issues of colour complexity. Although there were various researches indicating the impact of colour used on websites, the limited amount of them was conducted in terms of colour complexity impact. Most of the influences were from some empirical studies of general articles, such as the one related to web design mentioned that a more richness of colour used in websites such as using bright and vibrant colours like red, yellow and green would be more preferable for children. While less richness of colour used such as the black and white as theme colours would show the sense of luxury (Smith, 2014), although there is limited evidence to prove them. In addition, as mentioned by Bonnardel, Piolat and Le Bigot (2011), the websites with the lower richness of colour would have the negative impact on users' behaviour while more richness of colour used in websites would help improve users' ability to navigate and memorise.

The above review of previous literature somehow showed the impact as well as the importance of colour and colour complexity. It is necessary to raise the attention of web designers in terms of designing the more useful, interactive, attractive and efficient websites for users. With limited research conducted on colour complexity's influence on website users, while there is the close relationship between colour and colour complexity. In this case, it might be assumed that the impact of complexity on website colours being similar to the impact of colour. With this assumption, the following session would mainly discuss the characteristics of
users that influence their preference of colour complexity, which would also include their reaction of the different colours.

3.3. Factors that Influence Users Colour Complexity Preferences

With the current findings above, there could be some conclusions generated for colour and colour complexity. For example, each colour has its unique meaning and emotion, while some general and academic articles have introduced the common associations of colours, such as red represents warmth, passion and alertness, blue represents peace, coolness and calmness (Damer, 1968, cited in Jacobs et al., 1991; Barker, 2010). In addition, the related old research had found a list of preferred colours by participants, as blue becomes the most preferred colour while yellow was the least preferred (Guilford, 1959, cited in Hall and Hanna, 2004). However, since each individual has different characteristics, the use of colour on websites would bring some specific outcomes. For example, as some general articles said, a more richness of colour used for websites such as using bright and vibrant colours like red, yellow and green would be preferable for children. Besides, less richness of colour used such as the black and white as theme colours would show the sense of luxury, which might be more preferred by adults. More proved shreds of evidence have not verified these statements, but these could bring to the assumptions that the attitude towards colour could be influenced by people with the different background such as age, gender and nationality, which had been evaluated with more researchers. As a result, these factors affecting the preference
of colour on websites would be evaluated below.

3.3.1. Gender as an Influence Factor

As for gender, both men and women are essential website users and designers, while they might perform differently towards website design. Tuch, Bargas-Avila and Opwis (2010) reviewed the previous findings and believed the aesthetic difference would exist between males and females, for example, females would prefer more abstract types in terms of the art style of painting, while they also perform better than males for the appreciation of art. It appears that there could be some difference of attitude toward aesthetic between males and females, while there was a close link between different features of colour and aesthetic, so the preference of colour and colour combination might also be different. For instance, some researchers mentioned that males prefer colours with dark themes and females like to use lighter ones (Djamasbi et al., 2007). Besides, there were also the results showing that males would prefer yellow while red was less preferred compared to females (Dittmar, 2005, cited in Coursarlis, Swierenga and Watrall, 2008). With these factors and findings, a detailed review of previous research should be evaluated.

There are some related empirical studies aiming at both web designers and users. For the web designers, the one made by Moss, Gunn and Heller (2006) which evaluated the difference of website design between male and female designers. The results showed that for typeface colour amount, two to three colours were mostly accepted by males which contributed to around 70% of
total respondents, and no designers were using more than seven colours for the typeface. For female designers, although 2 to 3 colours were also mostly accepted which was around 47%, the distribution was more even, with around 23% and 27% of them choose to use single colour or 4 to 6 colours respectively. There were even 3% of females use more than seven colours for the typeface. Then, for background colour number, males tend to use black and white or the combination of these two, while only a few of them prefer to use more than two colours. Compared to female designers, there was a higher percentage of them using more than two colours for web page background. These results of colour complexity used on websites could be concluded that women tend to use more numbers of colour for typeface and more bright colours for background than men.

Regarding users’ aspects, Fisher and Craig (2010) use both quantitative and qualitative methods to research the influence of web design on people with different gender when finishing some tasks on web pages. They chose 8 sites and set tasks for respondents in two groups as the male group and female group. Some feedbacks as qualitative data from these two groups react differently in terms of each visual element in websites, which include the difference of colour preferences. For example, for the Motel site which required participants respondents to book a room, males complained the colours were difficult to read while females react differently and appreciate the colours used for this site. In terms of a site selling jewels, males believed that the overuse of colour for test
caused the significant reduction of readability. Although females also complained about the font colour, the influence was slighter. These not only showed that females might prefer the colours that males unappreciated for websites but also provided evidence that males might not prefer the higher complexity of colour since the influence of readability have been increased.

Although these results and evaluations somehow support the difference of preference of colour in terms of gender difference, there are other people disagree with these researches. Some of them found that there was a slight difference of attitudes toward colour for male and female, while others found the results different from the above research. An example of the research with less difference is the one provided by Hsu (2006), which lead to the results that there was no significant connection in terms of gender and preferred colour value, although it varies from ages as people with younger ages might have more diversity of preference for colour value according to different gender. Besides, there was empirical research of Coursaris, Swierenga and Watrall (2007) using statistics evaluation comparing the preference of respondents about four web versions with different colour temperature combinations. They changed the theme colour and content colour to create the four versions of sites with cold-cold, cold-warm, warm-cold and warm-warm colour temperature. The result of statistics found that gender might not be closely related to the preference of aesthetics. However, they also mentioned that by comparing the group of cold theme colour and
warm ones, there would be some significances of the difference, so it may somehow explain the gender difference that influences users' preference.

Then, for the research with contradicting results, Pearson and Pearson (2008) found that for the view of usability of websites from males and females, females would prefer more for ease of use as well as navigation while males focused on others such as download speed. This might support that females might prefer more uncomplicated and clear contents of websites, it increases the navigation experiences and usability, while fewer colours used might increase the simplicity of sites. However, this research mainly focused on evaluating the usability of a larger scale of web design, while it lacks the direct evaluation of specific components like the colour. Hence, it might not be possible to support that women prefer less complexity of colour on websites compared to male.

With the findings stated above, there was the difference of males and females use colours during web design as well as the preference of different colour combination, in which female designers use more combinations of colour for background and typeface. However, the findings were not convincing since some other researches indicated that the difference might not be significant. In this case, the corresponding research would be meaningful to find the influence between genders.

3.3.2. Culture as an Influence Factor

Culture is another factor that influences users' attitude towards colour and colour complexity of
web pages, as the association of colours is different in different cultures (Holtze, 2006), while this association could be deeper than appearance (Zahir, Dobing and Gordon Hunter, 2002). Some previous researches had provided some outcomes of the relationships between culture and colour, such as the colour red represents joyful in China but might bring the feeling of danger in other countries such as United States (Cyr and Trevor-Smith, 2004; Cyr, 2008). Another example was for the colour of death, in which people from United States regard black as the colour of death while the death colour in China is white and red in Mexico (Yunker, 2002, cited in Holtze, 2006). With these differences of colour meanings and emotions for each culture, it is necessary for web designers to consider these factors, especially when involved with the localisation of global company websites. As Sun (2001) indicated, localisation not only involves with the word’s translation but also related to the change of structure, format, colour and other elements to meet the requirement of a specific culture.

In terms of designer’s view, for example, Cyr and Trevor-Smith (2004) researched the localisation issues of web design and evaluated websites from three different countries. They found some similarities including the majority use of white as a background colour, while blue, bluish purple and black is widely used as the colours for links. The difference was that designers in Japan prefer to use red compared to those from Germany and the United States. In addition, sites in Japan also used a large number of other colours like yellow, green, blue and purple. In this case, it is
considered that people in Asia might prefer to use brighter colours as well as more colour combinations for web page design compared to western countries like Germany and America. Besides, Hermeking (2005) separated countries and region with high and low context communication groups by previous researchers with the figure showing the levels of communication for different cultures, in which Japanese gained the highest level, English and Anglo-Americans gained the medium level, and finally, some European cultures gained the relatively lower level. Then he evaluated and found that high-context cultures would prefer more interactive contents, which also included the use of backgrounds with more colour combinations, with the evidence of homepage design of Japanese company Sony in the Japanese market and American market. Although the findings above had somehow shown some evidence that some culture would prefer brighter colour as well as the higher complexity of colour for web pages, however, some other outcomes illustrated that the cultural difference might be a more complex issue. Zahir, Dobing and Gordon Hunter (2002) listed national portals in different countries and evaluated the visual elements of each site. Regarding the numbers of colour used, the results could be more diversified. For example, in terms of countries in Asia, Chinese national portal Sina used 4 colours while Japanese portal called Isize used the higher complexity of colour which was 12. The similar results also happened for European countries, such as Mirago in the United Kingdom used 10 colours for their national portals, Canoe in France contained 9 colours on the site. But for German national
portal Ins-Netz, only 6 colours were used, while the Italian national portal even used 5 colours for their site design. These diverse results had brought the evaluation more difficult.

However, these data were collected more than 10 years ago, while the design of these national portals had been changed, or some of them were no longer be the national portal. There might be the changes of website design concept in some countries, for example, the development of information technology might have improved the web design quality and style in China and other developing countries to be similar as the international level design. In this case, these data should be evaluated again to know the comparison at present. Furthermore, the evaluation of these websites was based on the national portals, while as they mentioned, the features of these websites were different compared to the evaluation standard Yahoo!

There were some missing features as well as some unique features exist for those websites compared to Yahoo!. In other words, the focus could be different so that the design will be largely influenced by the different focus. Because of this reason, it could not simply deliberate a conclusion that the cultural difference of website colour complexity preference was not significant, while the evaluation of website with same contents in different culture could more convincing.

With the evaluation of previous research, it is believable that culture would be a critical factor that influences the users' colour preferences of specific websites. For example, Japanese designers would prefer to use brighter
colours as the backgrounds compared to those from Germany and United States, while users with high-context cultures like Japan might prefer more complexity of colour used for the background. Although the findings from other researchers argued that the difference might not be significant in terms of numbers of colour used, the more precise evaluation should be carried out and to evaluate the culture difference by separating them into different groups.

3.3.3. Age as an Influence Factor

Next, there will be the influences of ages, which is listed as one of the critical factors for colour responses of users (Manav, 2007). The previous general articles had shown the results that children would prefer websites with brighter colour used, while adults might prefer less bright colours and colour combinations. Although more evidence should be presented to support these claims, it is possible to show that there would be a close relationship between ages and colour preferences on the web, while the colours that are preferred by one generation might not be appreciated by others (Holtze, 2006).

Some researchers indicated that it is important to consider ages as the factor that influences users’ attitudes towards websites. Most of them would be related to the usability and accessibility aspects. For instance, Zaphiris, Ghiawadwala and Mughal (2005) indicated the increasing age would cause some disability for older users, thus becoming the barriers for accessing web pages. They highlighted the reduction of colour sensitivity that elders might have, so they listed some recommendations of designing.
websites for these target people and improve users’ experience, including the high contrast of colour between different elements such as background and text, avoiding the use of specific colours such as blue and green, avoiding the frequent changes of brightness on screens, and others. The high contrast colour used is also supported by Saito et al. (2006) who conducted the research for the web-safer colours with the combination of white background and tested several users with different age groups to know the effectiveness of visibility. They found the result that the contrast of those web-safer colours with white background increased in terms of users’ feelings when the age rises.

With these limited findings, there might be some assumptions based on it. Since the high contract of colour combination could be more recognised by elders, while the suggestions for designing targeted websites also indicated the use of the high contrast of colour. In this case, it is possible to assume that with the increase of age, the possibility of preferring the higher complexity of colour would also increase.

3.3.4. Related Knowledge as an Influencer Factor

Some of the discussions listed above in the factors of gender, culture and age, there are the views from web designers, as they could be more professional to these areas. However, the vast majority of web users might have few bits of knowledge related to aesthetics, usability and others, and the outcomes could be different. So, the comparison of professional users and non-professional ones are also necessary. The previous analysis of factors had somehow included
different views of colour as well as colour complexity on web pages. Most of them showed some similar results, such as women prefer more colour complexity compared to men for both designers’ and users’ perspectives. However, the analyses above were not integrated with the comparison between two or more groups of users. So, it could not conclude that the differences were not significant.

There was limited research showing some possible difference between users with professional knowledge related to design and those without related knowledge. One research was from Hartmann, Sutcliffe, and De Angeli (2007) who designed the experiment which required respondents to browse three websites designed for Stanford University and then interviewed with them. The respondents were university students with different characteristics, including the difference of course background like technical and design. Regarding the choice of sites, three websites were for the different departments in the university with diverse design features. The results showed that there was some significant difference between respondents with the background of technical design for aesthetics factors, in which both of them chose the one with colourful contents and a large number of images as the most preferred site. However, for respondents with the technical background, they would regard site with traditional design which includes the medium complexity of colour used as the second preferred, while for design students, they preferred the one with a plain, text-based and straightforward complexity of colour. The comments of them
showed that for the second preferred website of respondents with the technical-related background, some of them appreciated the colour scheme, while for design students, there was some opposite reaction, as some of them held negative attitudes towards the colour scheme.

With these comments, however, there were some limitations. As this research focused on all the factors of web design, the difference of preferences, in terms of training or knowledge level might also be influenced by other components of websites. Although the comments shown above indicated the different attitude towards the colour scheme, there were more comments on the related to other factors such as the use of images. So, the results related to web colour used might not be significant. Besides, the indications from design students showed more professional and accurate comments. In this case, the related comments would more regard the design as a whole, while more focus would be applied on other elements since the colour is one of the components to be considered during website design.

4. Conclusion and Future Work

The limited research in the area of colour complexity brings to the further analysis for the influence of related knowledge, in which colour complexity would act as the main benchmark. It is predicted from the findings as presented in this paper that with less related knowledge about web design, there would be a higher probability of users preferring the higher complexity of colour. These findings could possibly be
expands in one of the related area in this field.

References


