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理事長序

2019 年 6 月 14 日「第 12 屆台灣數位媒體設計學會國際研討會」在亞洲大學隆重展開。本次大會議題主軸為「數位人文與科技跨域創新應用」，結合當前數位前瞻議題如互動設計、情感設計、遊戲設計、視覺藝術、動畫敘事、藝術創作、智慧應用等創意設計重要資源融入人文特色與題材，進行數位人文科技跨領域運用，廣泛討論交換數位科技與設計開發的產業創新應用方向，以提升台灣產業的競爭優勢。大會活動提供產業實務分享、AI 專題演講、產學面對面交流討論平台，以及 56 篇學術論文宣讀，共同分享最新創見及成果的應用，透過不同的觀點能夠讓與會學者、研究生及產業界人士有更多的討論、想法外，對台灣的數位媒體設計產業發展創造具體貢獻。

本期為今年發行之第十一卷第 1 期期刊，共收錄兩篇英文研究論文、三篇中文論文。探討內容包括有(1)英文論文「A Design Study of Accessible Web Menus」，針對最廣泛使用的五種 Web 選單設計，以個案情境探討其存取性；(2)英文論文「Application of color modularization to the design of reusable bags for environmental sustainability」，為解決環保手提袋產品可持續性問題，使用解釋結構模型(ISM)方法分析消費者對可持續產品所偏好的配色方案，案例研究為蒙德里安藝術風格的設計。切入色彩設計之商品化營運績效及產品週期延長，協助產品研發之良好研究；(3)中文論文「從彩度、亮度、色相三方面探討記憶色對彩色影像品質之影響前測」，探討實物的顏色與人們在腦中所記憶的顏色色差的具體數值的同時，根據人們對於「喜歡」和「漂亮」的感性定義，分別從彩度、亮度、色相這三個方面得到具體數值，作為實際印刷影響色彩影像品質的最終判定；(4)中文論文「空間文化創意研究—以高雄市老屋再利用之餐廳個案調查為例」，透過老屋再利用文獻進行探討，形成論述依據；針對高雄市具有 40 年以上歷史老屋再利用成餐廳的 14 個案進行調查發現舊元素修護與新舊元素對比的設計手法最為改造方案採用；(5) 中文論文「高齡者面對網路謠言困境之探討」，針對網路傳播假消息之熱門議題，透過內容分析法，由高齡者 Line 群組各式訊息中過濾出謠言，進行內容編碼與找出訊息頻率與群組內成員互動情形。研究發現高齡者行容易被操縱，謠言經過變形，利用高齡者所關心的議題，透過人為改寫增加可信度，達到傳播謠言的目的。

本期來稿 14 篇，經專家匿名審查後，5 篇論文接受刊登。感謝各方學術先進賜稿，擴展本刊研究範疇，以及協助審查的委員們給予學術專業協助，深化本刊學術深度及內容專業。

理事長

范國光

Foreword by Chair

June 14th 2019 “the 12th Taiwan Digital Media Design International Conference” has been held in Asia University. The topic is “Digital Humanity and Technology Cross-Field Innovative Application”. Many proactive topics about contemporary digital including interactive design, affection design, game design, visual aesthetic, animation narration, art creation and wisdom application have been incorporated into the features and themes of humanity. This digital humanity and technology cross-field application regarding digital technology exchange and industry innovative design applications will be widely discussed for Taiwan industries competition. We provide some platforms for you to share industry businesses, and also have AI-related lectures, and for industry and academia face to face exchange, as well as 56 academic theses reviews, by which you can share the latest ideas and innovative performances. Through the different viewpoints and visions, we can have better discussions between scholars, researchers, and businesspeople. This contribution to Taiwan digital media design industry development will count heavily.

The first issue of journal in the 11th volume, there are two overseas theses and three Chinese theses that have been published including (1) original thesis, “A Design Study of Accessible Web Menus”, which is focused on five Web interfaces design that have been widely used, as to examine the situations among the designs in applications; (2) original thesis, “Application of Color Modularization to the Design of Reusable Bags for Environmental Sustainability”, in order to solve the problem of bags sustainability, ISM is applied to analyze consumers’ preferences to bags colors. This research took Piet Mondrian style as a way to design; with color designs, help sustain and develop the products for business benefit; (3) Chinese thesis, “Discussing the Influence of Memory Color on the Quality of Color Image from Saturation, Brightness and Hue”, study examines the color differences between objects color and memory color, meantime based on the “like” and “beauty” that have been defined by people to obtain the value of saturation, brightness, and hue. The findings will be the values that affect the color image quality for printing; (4) Chinese thesis, “Cultural Creativity Strategy – Case Study in Restaurants Converted from Old Houses in Kaohsiung City” , based on old house reuse related literature reviews to explore how the over 40 years old houses in Kaohsiung city can be reused and become restaurants; among 14 cases, the research found out that old elements repairing and old-new elements comparing are the best way doing recreation; (5) Chinese thesis, “The Preliminary Study on the Information Processing Dilemma of Internet Rumor in Elderly Person”, which is focused on the fake news on the net. By means of content analysis, examine the rumor conversation in the elders’ line as to carry out the content code and explore the

interaction between massagers. Research found out that the elders are easy to be controlled by the rumors and the topics that the elders may concern with. Through rewriting to reach the purpose.

Out of 14 theses in this issue of journal, there are five theses have been published after the examination by the anonymous experts. Thanks for the academic papers from different fields. By which we can expand the study range as to assist examiners to process professional academic researches.

Kuo-Kuang Fan

2019.6.29

A Design Study of Accessible Web Menus

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ABSTRACT

To meet the needs of society for allowing disadvantaged people to have better access to the internet, the Taiwanese Government has been actively promoting web accessibility since 2002. However after years of trial, they are still unable to achieve the expected progress. Menus are the main media type that users interact with a website and also where the users receive most of the information. Therefore, it is essential to focus on the importance of Web Menu Accessibility. This research aims to focus on Web Menu Accessibility. We first established the most common menu design from case studies, then applied it to the five different templates of web accessibility sites provided by Taiwan Foundation for the Blind. Results show that Drop-down menu, Fixed menu, and Synchronized menu should be the types of menu most appropriate to be utilized in web accessibility sites. The availability of these menus is also a major factor to be considered for web accessibility.

***Keywords*:** Availability, Human-Computer Interaction, Menu, Visual Aid, Web Accessibility

1. Introduction

To date, the majority of web designs have not been considerate to the handicapped, causing unpleasant user experience and forming negative association. To change this issue, many countries have been actively promoting the concept of web accessibility. Countries such as the United States, Australia, Portugal, Canada, and England had already commenced the legislative process for web accessibility within the government as early as 2000 to aid the needs and secure the rights of people with disabilities. In Taiwn, the issue was brought to public awareness late and unclearly. It also has not been given any significant consideration, resulting in underdevelopment of internet access for the disabled.

In order to preserve the rights of the disabled group, the World Wide Web Consortium (W3C) first proposed that web design must comply with the "Web Accessibility" concept. The purpose was to allow every user to easily receive information and messages through the internet.

Accessibility can be defined as "availability" in this paper. The executive branch in Taiwan has classified each website, which contains web accessibility functions under Web Accessibility websites, and started promoting the construction of web accessibility websites starting in 2003. But overviewing the web field in our country today, the concept of web accessibility is still not generally being considered; in addition to that, the lack of resources, software, and educational training has caused low progress on web accessibility and made it a challenge to the country's web accessibility project plan.

The usage of websites in the modern world has been growing widely and quickly, thus assisting users to correctly find the information they need through websites has become an important issue. In order to help users successfully obtain the information they need, web menus have become the most common tool and are an important element in website structure. If a web menu is not designed properly, it can often cause difficulty for the users navigating the website. As web technology continues to improve, styles and designs of web menus start to vary and become distinctive; aside from the traditional web menu design, more multifunctional, well decorated, and interactive menu designs emerge. Not all types of web design menus match the requirements of web accessibility websites though. Most of the complicated interactive web menu designs cause users to lose focus, are misunderstood, and/or cause failure of navigation (King, Evans & Blenkhorn, 2004; Thatcher et al., 2006), especially for the visually impaired. This study focuses on web menu designs that could cause the failure of navigation for visually impaired users and discusses the feedback from web users of different types of web menu design. The research aims to assist in resolving the problem and improving user experience of websites at all levels.

2. Literature Review

2.1 Web Accessibility

Accessibility defines the different levels and needs of web users, or the technology aiding disabled people to receive information from a website. To allow disabled users to efficiently navigate and receive information through the

internet, one important factor for a website is its accessibility (Slatin & Rush, 2002). Web accessibility means the disabled can utilize all functions of the internet through supportive tools and successfully receive information from the web page. The founder of the World Wide Web, Tim Berners-Lee, stated that the objective of web accessibility was how to globally achieve "public sharing" through the internet (as quoted in Chang, 2007).

In the field of web design, the principle of achieving simple navigation has always been the first thing to consider when creating a website. With the promotion of web accessibility, web design conceptualization elevates to a deeper level, causing much confusion for web designers in judging the difference between simple navigation and accessibility. This study aims to not limit any possible web design while maintaining web accessibility. What must be done is to satisfy different types of users and to allow them to give similar feedback for a website. Simple navigation thus means, under certain circumstances, how a website can provide effective navigation and user satisfaction.

WAI (Web Accessibility Initiative) made use of web accessibility as their subject of promotion. In 1999, WAI published the first version of "Web Content Accessibility Guidelines 1.0" (WCAG), but some content and guidelines were not clearly defined, thus causing a lot of confusion. In June of 2018, "Web Content Accessibility Guidelines 2.1" (W3C, 2018) was published as a W3C recommendation web standard. Based on WCAG 1.0 of WAI, Taiwan produced an instructional web accessibility guidebook to provide more detail and information for web designers to accurately understand how to create an accessible website.

2.2 Visually Impaired Internet Usage

The objective of web accessibility website design is to satisfy all internet users. However since interface design generally uses a visual sense to provide communication, visually impaired users deal with the most difficulty in navigation (Huang & Chao, 2007). Visual impairment ranges from poor visual acuity, narrow field of vision and other barriers, to the common designation of complete blindness, all of which can cause one to feel uneasy. Generally, this could be categorized into two subjects, "blind" and "amblyopia", depending on the degree of visual barrier.

2.3 Sitemap and Menu

Specially mentioned in the "Web Accessibility Building Specifications," to avoid users being disoriented in the process of using websites, web pages must provide guiding information, a site tour, a sitemap etc., allowing users to successfully search for their desired information. Liang (2002) explained the importance of menu design towards guiding users, especially the homepage menu. It could define the entire website structure, allowing users to find the browsing path and their current position on the webpage. Kuo (2006) stated that a web menu not only presents the entire site structure but also serves as an entrance for each subpage, providing users with a clear point of direction. Beaumont, Gibbons, Kerr, and Stephens (2002) believed that menus are a very important element of web design. They can directly provide users with clear understanding of the structure of the website. Every website contains at least one set of menu design. Proper design for a web menu is important because it has a direct impact on whether the website has good maneuverability and whether it provides the message correctly.

This study combines the perspectives of Norman (1991), Shneiderman (1998), Fang (2003), and Kuo (2006) to consider the connection between different options of the action of the mouse trigger, then applying it to the five types of web menus - Fixed menus, Synchronous menus, Drop-down menus, Laminated menus, and Pop-up menus.

2.4 Principles of Web Menu Accessibility

Currently, researchers across the world only discuss the principles of maneuverability towards web menu design. Study and research towards the guide of web accessibility showed that some of the guidelines stated are similar to the principles of the researchers. So, this study lists 18 maneuverability web menu design principles (Whitaker, 1998; Fleming, 1998; Beaumont et al., 2002).

3. Research Method

3.1 Research Structure

This research project was separated into three different stages. The first stage was the "Pretest", where a literature review and research conceptualization were studied, then finalizing a resolution for an experimental website and questionnaire.

The second stage was the "Evaluation", wherein the process of evaluating and experimenting on the website were done. During this process, the evaluators should not only discover the principles of web accessibility but also come up with a solution to modify the design of the website. Evaluators handed out questionnaires to visually impaired people and web designers, and evaluated the result and feedback of both parties to fix and adjust the experimental website.

The third stage was the "Experiment." Subjects to be given the experiment to were regular computer users; they tested using the modified web accessibility website by following the directions given by the Instructor. Then, the subjects were asked to fill out a questionnaire based on a Likert Scale. Based on the experiment result, researchers derived the best menu design for web accessibility.

3.2 Pretest

The researchers studied the 50 websites that joined the contest "Free on Web." Judging from the structure, content, design, and accessibility requirement of each website applied, the website of the Taiwan Foundation for the Blind (TFB) was selected as a reference for this research. Based on the reference, the research focuses on five different menu design modifications for TFB, including a Fixed menu, a Synchronous menu, a Drop-down menu, a Laminated menu, and a Pop-up menu (Figure 1), for its linked pages, information, and content, while maintaining the original structural design.

(a) Fixed

(b) Synchronous

(c) Drop-down

(d) Laminated

(e) Pop-up

Figure 1. Five types of menus to explore

Before the actual experiment, the researchers must first conduct an interior test. Testing standards were built on the country's "Web Accessibility Testing System", and after passing the minimum requirement for AAA level set by the Executive Branch, the research may move on to the next process, which was the actual user experimentation.

3.3 Evaluation

After the Pretest, space for improvement and revision remained. Thus moving on to the second stage, we evaluated the experimental website and revised the parts that needed alterations. Evaluators were divided into two different groups.

The first group was 2 people with visual impairment. Due to their weak vision, the visually impaired often face the difficulty of web browsing, which means that their feedback and comments are valuable and objective.

The second group contained 30 web designers who, with their professional background, may produce an effective web design to solve the problems visually impaired people experience.

The evaluating method was first allowing each subject to navigate the experimental website. Next in the process was "Question and Answering", where the proponent asked questions based on principles of accessibility and offered suggestions for modification. After both steps, a compiled chart was made from the results of the most agreed upon solution and suggestion.

3.4 Experiment

Based on the results of the previous stage, corrections and modifications to the menus were executed in this stage, both satisfying the needs of visually impaired people and adhering to the requirement of the web accessibility principle.

Each designed experiment was executed independently. The target subjects for the experiments were regular web users who volunteered, or were randomly selected at national libraries across the country. Each experimental website required 40 users; a total of 200 subjects were needed as there were 5 different websites. To distribute without bias, the subject was asked to draw a raffle to determine which website they would be navigating. Each subject was given specific directions, and after the experiment, the subject was requested to answer a questionnaire. The feedback provided helpful reference to improve each web design and its menu, then the evaluation was checked and scaled using the Likert Scale.

3.5 Questionnaire Design

The questionnaire designed for this research is "semi-structural." Internet experience and accessibility evaluation questions were asked with multiple choice answers provided, as well as tasks given to the subject requiring him/her to fill in the blanks of the questions. Upon completion of the questionnaire, researchers and evaluators checked the responses to ensure that they were credible to be considered as an effective

questionnaire. The questionnaire included three parts.

The first portion of the questionnaire was to gain insight into the user experience towards the internet, allowing researchers to understand the effects of the menu design on different levels of users.

The second part of this questionnaire was to check on the task completion given to the subject. The subject could find the information needed through the experimental website. The answers of the subject allowed the researchers to correctly know if the subject had navigated the website properly based on their given task.

The third part of the questionnaire (see Appendix) was the evaluation of website's accessibility; this section was divided into 4 categories which were Perceivable, Operable, Understandable, and Robust. The subject was asked to answer the questions based on their feeling while navigating the website. Each set of questions also contained a throwback question to help justify the effectiveness of this questionnaire.

3.6 Reliability and Validity

The test on reliability was based on Cronbach's α value to justify the consistency between the categories of Perceivable, Operable, Understandable, and Robust. When the value of α increases, it means the content and detail of each page are closely related, and the content is strongly consistent.

The test on validity used the Content Validity method. This method allows the questionnaire to accurately evaluate the accessibility and design principles of the website menu. Then based on the subjects' feedback, changes and modification could be made.

4. Data Analysis

4.1 Analysis of Single Factor Value Change towards Menu Style and Accessibility

In the evaluation of accessibility, there is a significant difference between different groups of website examinees ($F=8.024$, $p<0.001$), meaning that examinees of different websites provided varying evaluation results (Table 1).

4.2 Analysis of Each Menu and its Accessibility towards Single Factor Value Change

Examinees of different websites provided differing values under these categories.

Perceivable ($F=5.028$, $p<0.001$), Operable ($F=10.554$, $p<0.001$), Understandable ($F=3.606$, $p=0.007$), and Robust ($F=6.537$, $p<0.001$). These values show that different groups of examinees provided dispersed feedback and evaluation towards different types of category. See details in Table 2.

4.3 Analysis of the Accessibility of each Related Category

On the analysis of each category, the results prove the connection between each category. Among them, Perceivable and Operable hold the closest relation with a high value ($r=0.799$, $p<0.001$) while the least connected is between Robust and Understandable ($r=0.722$, $p<0.001$). See details in Table 3.

4.4 Reliability Analysis

The summed up reliability value of this questionnaire is 0.945. Based on the research of Nunnally (1978), as long as Cronbach's α value is greater than 0.7, it is in the range of acceptability. Therefore the reliability of this questionnaire is credible. See details in Table 4.

5. Discussion

5.1 Evaluation of Accessibility

The results show that Fixed menus and Drop-down menus provide effective accessibility, thus a higher rating received on the evaluations. Meanwhile, Laminated menus and Pop-up menus received a lower rating of evaluation in the experiment. Drop-down menus are the best option

Table 1. Analysis result of menu and accessibility

Dimension	Menu	Mean	Std. Deviation	F	Sig.
Accessibility Evaluation	Fixed	82.650	13.716	8.024	0.000**
	Synchronous	77.975	15.464		
	Drop-down	85.050	14.828		
	Laminated	74.750	15.700		
	Pop-up	67.650	16.717		

*p<0.05, **p<0.001

Table 2. Results of menu and accessibility towards single factor value change

Dimension	Menu	Mean	Std. Deviation	F	Sig.
Perceivable	Fixed	21.600	3.790		
	Synchronous	20.870	4.040		
	Drop-down	21.700	3.770	5.028	.000**
	Laminated	19.920	4.300		
	Pop-up	17.820	4.590		
Operable	Fixed	20.600	5.0778		
	Synchronous	19.200	5.0647		
	Drop-down	22.475	5.0433	10.554	.000**
	Laminated	18.200	5.1150		
	Pop-up	15.550	4.9920		
Understandable	Fixed	21.550	3.5873		
	Synchronous	20.250	4.3308		
	Drop-down	21.625	4.1428	3.606	.007*
	Laminated	19.775	3.5983		
	Pop-up	18.700	4.8155		
Robust	Fixed	18.900	2.8084		
	Synchronous	17.650	3.5845		
	Drop-down	19.250	3.1029	6.537	.000**
	Laminated	16.850	4.3415		
	Pop-up	15.575	4.4886		

*p<0.05, **p<0.001

Table 3. Analysis on the result of each category

		Perceivable	Operable	Understandable	Robust
Perceivable	Pearson's r	1	0.799**	0.796**	0.796**
	sig.(2-tailed)		0.000	0.000	0.000
Operable	Pearson's r	0.799**	1	0.757**	0.754**
	sig.(2-tailed)	0.000		0.000	0.000
Understandable	Pearson's r	0.796**	0.757**	1	0.722**
	sig.(2-tailed)	0.000	0.000		0.000
Robust	Pearson's r	0.769**	0.754**	0.722**	1
	sig.(2-tailed)	0.000	0.000	0.000	

Table 4. Reliability analysis

	No. of Questions	Cronbach's Alpha Value	Total Value
Perceivable	6	0.792	0.945
Operable	6	0.891	
Understandable	6	0.767	
Robust	5	0.832	

for web accessibility, as they effectively satisfy the users and lower the navigation difficulty; Pop-up menus remain to be the type of menu that does not fit into the design for web accessibility.

5.2 Detail Evaluation of Accessibility

Menus may be set to be the main function of a website, but to justify whether the menu allows users to properly navigate, the menu must be evaluated by the four categories - Perceivable, Operable, Understandable, and Robust. This research analyzes each type of menu based within the four categories and obtained higher ratings for Fixed menu, Drop-down menu, and Synchronous menu. The difference is also least between the three above menus, which means that they meet the standard requirement for web accessibility. On the other hand, based on the Operable category, the value differences between each menu are higher, meaning that user feedback varies under the evaluation of Operable. From the rating result, Drop-down and Fixed menus received the highest rating, Drop-down menu being the best. Ergo the research believes that based on the four types of categories for evaluation, the rating from the Operable category has the most impact towards Web Menu Accessibility design.

5.3 Appropriateness between Menu Design and Web Accessibility

Multiple analyses had shown that Drop-down menu provides the best accessibility, but when web designers are producing web accessibility websites, they cannot be limited to only Drop-down menus. Yu and Roh (2002) suggested that a Drop-down menu provides effective searching while a Fixed menu provides better browsing, both possessing their own advantages.

Based on the research result of Tullis et al. (2005), a Drop-down menu minimalizes web layout spaces, not requiring scrolling; a Synchronous menu allows users to view all buttons at once, providing a lot of convenience.

Hochheiser and Shneiderman (1999) stated in their research that a Synchronous menu takes up more space in the webpage; though convenient for some users, they suggested not to use this in the majority of web design.

From previous researches and studies by different scholars, Fixed menus, Synchronous menus and Drop-down menus all received good feedback under consistency evaluation, but based on the evaluation of Operable, Synchronous menus fell behind the other two.

During the Evaluation Stage, several designers mentioned that a Synchronous menu provided too much information when hovering and led to long scrolling for the web page, while the two visually impaired examinees considered this type of menu convenient. The feedback supports the research claim that Fixed menus, Synchronous menus, and Drop-down menus all provide good accessibility for web accessibility sites; web designers may choose among the three types when constructing websites, but must be cautious when choosing Synchronous websites, as it may distort and/or complicate user vision when operating the menu.

6. Conclusion

6.1 Appropriate Web Menu Accessibility Style

Web Accessibility aims to allow all users to successfully retrieve information they need from a website, especially for those visually impaired. Assisting disabled users to effectively obtain information is very important. This research studied five menus under web accessibility, attempting to determine the appropriate type of menu for different user groups. The experiment results showed that Drop-down menus, Fixed menus, and Synchronous menus have the highest rating, providing good accessibility for websites and at the same time satisfying the needs of visually impaired users. However when using a Synchronous menu, the appropriate amount of buttons must be considered otherwise it may disturb users.

6.2 Menu Operation is the Key to Accessibility

Even with fulfilling the standards of Perceivable, Understandable, and Robust, the operating function of menu design must be properly assessed. Especially for web accessibility, it must provide a distinctive type of operation. For instance, the most common tools to operate a personal computer are a keyboard and mouse; utilizing these tools to properly manage the web menu is important. Aside from studying the guidelines and principles for web accessibility, making changes to the settings of a website menu can improve the accessibility of a website.

6.3 Importance of Menu Accessibility

To create a good web accessibility website, the first requirement is to design the page under the web accessibility criteria. For the menu portion, design studies may be referenced from proponent's research on web accessibility. Menu accessibility may be divided into four categories: Perceivable, Operable, Understandable, and Robust. The effects of these four types vary, but the ability to maintain their consistency means that the menu is constructed with good accessibility. After website production, allowing different users to test the website and provide feedback and suggestions can prompt revisions and improvements for creating the ideal "web accessibility" website.

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Appendix. Questionnaire of accessibility

Perceivable	
Q1.	It is easy to find each button under the menu of the website.
Q2.	Menu buttons are clearly displayed.
Q3.	The menu of the website is unified in every page.
Q4.	Menu buttons and website content are designed differently.
Q5.	Desired menu button can easily be found.
Q6.	Each section of the menu is properly organized.
Q7.	The menu is not well presented.
Operable	
Q8.	It is easy to operate the menu.
Q9.	The web menu can easily be navigated through the keyboard.
Q10.	Menu operation aligns with user's habit.
Q11.	Menu operation allows user to quickly find the desired link button.
Q12.	It feels easy to navigate the menu through the keyboard.
Q13.	Menu operation meets user expectation.
Q14.	Menu operation does not meet user habit.
Understandable	
Q15.	Menu helps lead to the desired content and information.
Q16.	Menu does not require user memory.
Q17.	Menu allows user to understand the website structure.
Q18.	Menu displays visited webpage.
Q19.	Menu's main and sub categories are well divided.
Q20.	Amount of menu buttons displayed are adequate.
Q21.	It takes a lot of time and memory to understand the menu.
Robust	
Q22.	Menu works properly.
Q23.	Menu leads user to their desired pages.
Q24.	Menu adequately gives user feedback.
Q25.	Menu provides enough detail and information.
Q26.	Menu satisfies user needs.
Q27.	Menu does not function properly.

Application of Color Modularization to the Design of Reusable Bags for Environmental Sustainability

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ABSTRACT

To resolve the problem of product sustainability for reusable bags, the interpretive structural modeling (ISM) approach was used in this study to determine and analyze the correlation between different color combinations of reusable bags. Afterwards, the product hierarchy is then built by the decision making trial and evaluation laboratory (DEMATEL) approach so that the importance of color to design and the resulting effects can then be determined. The cluster analysis by the analytical network process (ANP) is also implemented in order to analyze the market. The framework with the optimal weight among several modularized color schemes is determined accordingly. A case study on the design of reusable bags was inspired by a Mondrian artwork. Based on the linguistic information, it demonstrates the creation of new color schemes from the proposed systematic grouping method. A color coding rule is proposed and applied to the modularized development of colored products. The results that are obtained from this case study allows a designer to determine the factors of common color schemes and color matching. As a result, the most effective colors can be highlighted for improving the color schemes of sustainable products.

***Keywords*:** Product Color System; Color Module; Interpretive Structural Model; Analytic Network Process; DEMATEL.

1. Introduction

Connectivity exists between independent colors, and by adopting different arrangements or combinations of color, the same colors being selected may possibly generate different types of imagery or feelings. As a result, the connecting relation of the product color system (PCS) is an important factor. It will affect the image in the human eyes. To satisfy various customer demands in a highly competitive market, a new method of color combination is proposed in this study for the design of PCS. Hanada (2013) conducted the semantic differential (SD) of color with emotions, and analyzed the statistical characteristics of individual factors and data. There are three factors and components that is being extracted from the factors and independent components. Based on the analysis results of the independent components, the potency factor of the evaluations is determined to be individual emotion colors. Moon and Kim utilized emotions and colors related to music, and classified emotion colors by modules, and each constituent music color can be divided into small segments to phrase music colors (Hsiao & Liu, 2005). Chin proposed a color combination scheme with a design implantation by a hierarchical scene structure which is the same color as the buildings. He provided a scheme with automatic color combination, utilized true images which served the purpose of color arrangement and employment, and made color layouts even more flexible (Chin, 2012). Unever (2002) proposed that colors of buildings are different, because of distinguishing features of different types of culture and history. To prevent color combinations or surface colors from disharmony, he proposed that colors should possess the impression of being attractive, warming to the heart, and delightful to the eye based on his study on separated color blocks. He studied the design of a complicated color block arrangement on housing. And determined the position where it's easy to see and perceive at the inlet blocks (U¨. never R. & O¨, ztu¨ rk LD, 2002). To make room colors more diversified, Xiao investigated a variation of color blocks and appearances of real room colors by psychological experiments and research, and his results showed rooms with colors which appear to be lighter, richer, and more colorful (Xiao, et. al.,2010; Lee, et. al.,2012).

Lee diversified the product development by employing ISM techniques (Hsiao & Liu, 2005). He adopted the method of structured models with a clear hierarchy to assist the design of user interfaces, in order to satisfy different requirements of a design, and to enhance the design efficiencies. In 1972, Warfield conducted the relevance analysis of society system by ISM (U¨. never R. & O¨, ztu¨ rk LD, 2002) to resolve

the problem of complicated society relevance. Lin et al. adopted a method of AHP which had been adapted to assess the importance of customer requirement during the developmental process of the product, and clarified the structural relations between the interdependency of customer requirements by using ISM techniques (Lin, et.al., 2006). Wang proposed an evaluation model which integrates FDM, ISM, and ANP, which assists decision-makers in the selection of developmental items, and reduce the costs and risks (Wang, et.al., 2013). Lee demonstrated with real cases that ISM can deconstruct by using the fuzzy analytic network process (FANP) of conceptual models. And opportunities of sales, costs, and risks of product complications can be effectively and precisely calculated (Lee, et.al., 2011). Tseng proposed to simultaneously employ the theory of mixed fuzzy set and the method of ANP. He checked the two types of structures which provided the capability of investigating the problems and the standards in the field of the green supply-chain in the management (Tseng, et.al., 2014). Yeh utilized methods of DEMATEL and ANP to investigate the factors of investments on the development of wind power and the community on safety, quality, environment, and ecology. He gathered relative weights of the related standards, and these can serve as a reference for enterprises and governments (Yeh & Huang, 2014). Chang utilized the method of DEMATEL to analyze and predict potential suppliers in the electronics industry, and assisted enterprises in precisely predicting supplier performance including the key indicator of cargo consignation. His approach affects the selection of suppliers, although it may not comply with the expectation on the supplier, it can still effectively assist enterprises in selecting the most suitable supply-chain management to manage the suppliers (Hsu, 2012). Cheng utilized DEMATEL to investigate the causal relationship between food and the service quality provided by restaurants to determine improvements of service-quality in resturants. He treated the results as a reference for the strategic planning of service quality and the resource for the recombination of strategic decisions (Yang, et. al., 2013). The results provided the industry with a new perspective, increasing the dimensions of hotel service quality based on limited resources (Cheng, et.al., 2012).

Based on the reviews mentioned above, a new method that had not been practiced before will be proposed in this study. This new method generates color modules by the means of division by ISM into groups, clusterization by DEMATEL and ANP. This study is based on the concept proposed by Dutch artist Piet Mondrian (1872 ~ 1944) that "basic forms of beauty" are constituent of geometry forms. His works are mostly constructed by vertical and horizontal lines, but the composition of his works presents the aesthetic perception of harmonious order (Chijiiwa, 1990). The methods of ISM, DEMATEL, and ANP are utilized in this study to establish a system of color combinations, and the work "Composition A" by Mondrian is selected as the case study. The color combination of his artwork is reproduced in a more rational way with a certain regularity. The professional swatch was published by Dainippon Ink and Chemicals, Inc is adopted as the color encoding system in this study. Inside this swatch, colors are organized by tonality (Wright, et. al., 2012). The ISM approach is utilized in this study to analyze the relations between various color schemes of PCS and DEMATEL is used to calculate the intensity and the relation between various color schemes (Chang, et. al.,2011; Milani, et. al., 2013).

For the purpose of analyzing the market demands, a questionnaire survey was conducted in this study. The questionnaire includes the evaluation of imagery of the semantic differential proposed by US scholar, Osgood. (Charles, et.al., 1957; Osgood, 1952). Besides, most of the earlier studies did not establish the modularization of PCS in various markets and neither had the optimized weight distribution of the general-purpose colors and individual colors had been discussed. At the moment, many applications of colors are typically developed based on customer demands. As a result, the concept of market segmentation, there is a interlacing relation between products with diversified colors and the diversification of consumers. The investigation in this study is to find the arrangements of color schemes demanded by each cluster and the market segment and the results serve as the overall distribution (Bañulsa & Turoff, 2011; Feng, et.al., 2010). Finally with the analysis of ANP, a supermatrix can be established to acquire new schemes of color combination.

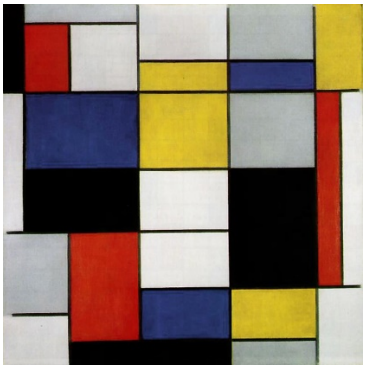


Figure 1. The artwork of "Composition A" by Mondrian.

2. Outline of The Research Process

The purpose of this study is to establish the modularized relation between market segmentation and color layouts from their correlation and to carry out the design of product families. The flowchart of the research process is shown in Fig. 2. The methods which are adopted include: ISM, DEMATEL, and ANP and the operating procedure is summarized below:

(1) Construct the relation matrix.

(2) Generate the reachability matrix.

(3) Illustrate the hierarchical relation of elements.

(4) Draw the distribution chart of elements.

(5) Establish the DEMATEL matrix from the reachability matrix.

(6) Determine intensities of their relevance.

(7) Investigation group samples.

(8) Establish supermatrix sets.

(9) Obtain weights of elements.

(10) After establishing groups and market segments by ANP, the presentation of the optimal weight of the PCS module can be obtained

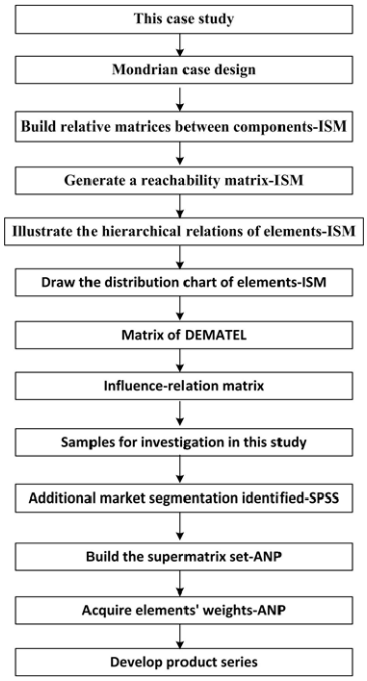


Figure 2. The flowchart of research methodology.

3. Theoretical Background

By means of the color modular design, a partially common color, products with different types of imagery can be created. As a result, it is important to effectively utilize modular design methods from the beginning to establish the corresponding relation between various color modules. And this approach assists in the diversified designs of products. The methods adopted by this study and their related theories are explained respectively in the following:

3.1 Basic concepts and the development process of ISM

The relativity between elements of PCS can be analyzed by means of the method of ISM. And the allocation of various color elements can be optimized to develop a series of diversified color products (U¨. never R. & O¨, ztu¨ rk LD,2002; Hsiao & Liu, 2005; Lin, et. al., 2006; Lee, et. al., 2011; Tseng, et. al., 2014). The operating procedure of ISM is explained and summarized by Hsiao and Liu (2005) in the following.

Step 1: Construct a relation matrix

compare the relations, a directional relation matrix [A] is formed using the relation (aij) between one element and another. The four major principles are as follows:

(1) For the constituent element aij, if i has an impact on j, aij=1; if not, aij=0.

(2) For the constituent element aji in the reverse direction, if j has an impact on i, aji=1; if not, aji=0.

(3) If the two elements do not affect each other, aij=0 and aji=0.

(4) If the two elements affect each other, aij=1 and aji=1.

Step 2: Generate a reachability matrix

The reachability matrix [R] is deducted from the incidence matrix [A] if a Boolean n-multiple product of [A] + [I] uniquely converges to R for all integers , where is an appropriate positive integer, [I] unity matrix, and + is addition in Boolean sense. Matrix [R] represents all direct and indirect linkages between components. Relation transitivity is a basic assumption in ISM.

Step 3: Generate a pairwise output matrix

According to the result of the reachability matrix, select elements with aij=aji=1; that is, the elements that affect each other (aij=1and aji=1). A technique for cluster retrieval is inserted in the ISM process to identify components that influence one another and form a loop. Similar algorithm has been used in the graph theory. The reachability matrix [R] multiplies the transposed matrix of [R], say [R]T; thus in $[\mathrm{R}]\cdot[\mathrm{R}]^{\mathrm{T}}$, components and mutually interact if $r_{ij}r_{ji}$ = displays the output matrix of $[\mathrm{R}]\cdot[\mathrm{R}]^{\mathrm{T}}$, in which clusters of components can be identified easily by rearranging component order.

Step 4: Generate a rearranged matrix

Clusterize the elements that affect one another in the output matrix of the reachability matrix. reveals four clusters in the system, namely {1}, {2, 6}, {3, 5, 7}, and {4}. Trace back to the element correlations in the reachability matrix to generate a rearranged matrix. The order of reachability matrix [R] is rearranged, and the clustered components are integrated and treated as a single entity.

Step 5: Illustrate the element hierarchical relations

The hierarchy graph then is obtained by identifying a set of components in matrix R that cannot reach or be reached by other components outside the set itself, removing the set from the original matrix [R], and then repeating this process for remaining matrix until a unique set of nodes that no other nodes can reach is then obtained.

Step 6: Draw the D+R_D-R element distribution graph

According to the reachability matrix, adding up the scores of the elements in each row to generate D and the elements in each column to generate R. Calculate the values of D+R and D-R to generate a reachability matrix determinant.

3.2. Decision Making Trial and Evaluation Laboratory (DEMATEL)

As shown above, this approach can assist in the understanding of complicated causal relationships and calculate the causal relationships and the degrees of influence between all of the factors. This method can further establish structural models of network relations and investigate the complex relations of influence between factors by graphical methods. The procedure of the investigation in this study is divided into four steps (Keramati & Salehi, 2013; Gabus & Fontel,1972; Gabus & Fontela, 1973; Fontela & Gabus, 1976; Fontela & Gabus, 1974]:

Step 1: Obtain the average influence matrix

The reachability matrix obtained by using ISM is then further utilized by DEMATEL to carry out the analysis of the degrees of influence between various indices. In other words, the degree of relation of direct influence of index *i* on index *j* between various perceptions can assist in acquiring an $n \times n$ direct influence matrix $\boldsymbol{A} = [a_{ij}]_{n\times n}$.

Step 2: Transformation into normalized direct influence matrix

The direct influence matrix $\boldsymbol{A}$ can be further normalized by Eq. (1) and Eq. (2), and the direct influence matrix after normalization is $\boldsymbol{D} = [d_{ij}]_{n\times n}$, which is a matrix with zero diagonal.

$$\boldsymbol{D} = k\boldsymbol{A} \quad (1)$$

$$k = \min\left\{1/\max_i \sum_{j=1}^{n} a_{ij}, 1/\max_j \sum_{i=1}^{n} a_{ij}\right\}, \quad i, j \in \{1, 2, \ldots, n\} \quad (2)$$

Step 3: Calculate total influence-relation matrix

After acquiring the normalized direct influence matrix, Eq. (3) can be used to construct the overall influence matrix $\boldsymbol{T}$ of network relation chart, where $\boldsymbol{I}$ is an identity matrix.

$$\boldsymbol{T} = \boldsymbol{D} + \boldsymbol{D}^2 + \boldsymbol{D}^3 + ... + \boldsymbol{D}^k = \boldsymbol{D}(\boldsymbol{I} + \boldsymbol{D} + \boldsymbol{D}^2 + ... + \boldsymbol{D}^{k-1})$$
$$[(\boldsymbol{I} - \boldsymbol{D})(\boldsymbol{I} - \boldsymbol{D})^{-1}] = \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D}^k)(\boldsymbol{I} - \boldsymbol{D})^{-1}$$

$$\boldsymbol{T} = \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D})^{-1}, \text{when } k \to \infty,\ \boldsymbol{D}^k = [0]_{n\times n} \quad (3)$$

When $\boldsymbol{D} = [d_{ij}]_{n\times n}$, $0 \le d_{ij} < 1$, $0 < \sum_{j=1}^{n} d_{ij} \le 1,\ 0 < \sum_{i=1}^{n} d_{ij} \le 1$

Step 4: Result analysis

The summation along columns ($\sum_{j=1}^{n} t_{ij} = t_i$) and the summation along rows ($\sum_{i=1}^{n} t_{ij} = t_j$) of the matrix mentioned above are utilized to establish influence index vectors $\boldsymbol{r} = (r_1, ..., r_i, ..., r_n)'$ and $\boldsymbol{c} = (c_1, ..., c_j, ..., c_n)'$ which are defined by Eq. (4) and Eq. (5), where *r* represents other indices being affected by *r*, *c* represents being affected by other indices. The horizontal axis vector (*r* + *c*) could be obtained by adding *r* and *c*. This value indicates the degree of relation between indices, and is called prominence. Similarly, the vertical axis vector (*r* - *c*) is obtained by subtracting *c* from *r*. This value represents the intensities of affecting or being affected by indices, and it is also called relation. Generally speaking, when (*r* - *c*) is positive, this indicates that the index is in the reason group. Contrarily, if (*r* - *c*) is negative, then this indicates that the index is in the effect group.

$$\boldsymbol{T} = [t_{ij}]_{n\times n}, \quad i, j = 1, 2, ..., n$$

$$\boldsymbol{r} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} = [t_{i.}]_{n\times 1} = (r_1, ..., r_i, ..., r_n)' \quad (4)$$

$$\boldsymbol{c} = \left[\sum_{i=1}^{n} t_{ij}\right]'_{1\times n} = [t_{.j}]_{n\times 1} = (c_1, ..., c_j, ..., c_n)' \quad (5)$$

where vector $\boldsymbol{r}$ and vector $\boldsymbol{c}$ respectively represent the summation of rows and columns of the overall influence matrix $\boldsymbol{T} = [t_{ij}]_{n\times n}$.

ISM can assist in finding the correlation between various factors, but it fails to identify the intensity of influences between factors. The reachability matrix that is obtained by ISM in this study is utilized in order to make up for the ISM approach's deficiency. And the DEMATEL matrix has also been utilized to determine the connection intensities of factors, which serve as an important index of the connectivity between colors.

3.3 Cluster analysis

Cluster analysis is typically conducted on data which has been processed in advance. Based on the distribution of similar data, objects are divided into several groups and similar objects will be assigned to the same group. Based on the distribution attributes, data that require to be classified will be divided into a plurality of domains. Data in the same group is provided with homogeneity (or similarity), while data in different groups is provided with varying heterogeneity. Cluster analysis is based on the degree of varying density of data. Firstly, specimens are placed in an n-dimensional space (N = variable), and the distances or the degree of similarity between specimen in the space will be calculated. In this study, the main representative users on the market are selected as the specimen for carrying out the classification of different groups.

AHP is one type of multi-objective decision method, and it is majorly applied to uncertain situations and decision problems with multiple assessment criteria. The purpose of developing this approach is for the systematization of complex problems and for decomposing the hierarchy from different levels. Via the determination by quantization, the priority of hierarchy elements can be found and comprehensive assessments can be conducted to provide decision-makers with the adequate selection of various schemes (Keramati & Salehi,2013).

When applying AHP to handle complex problems, there are generally six steps as follows:

Step 1: Delimitation of problem: For a system where problems reside, all essential factors which could possibly affect the problem are included into the problem. The planning group is simultaneously established to limit the range of problems.

Step 2: Construct hierarchical framework: The members who conduct the cluster planning should brainstorm to find the assessment criteria and sub-assessment criteria which will affect the problem behaviors and the characteristics of alternative schemes.

Step 3: Questionnaire designing and investigation: The pairwise comparison of each hierarchy element is conducted on certain elements within the upper level of a hierarchy as the assessment criteria. For this

purpose, a questionnaire was designed for each pairwise comparison. On a scale of 1 to 9, decision-makers or members within the decision group were asked to fill in a form and the questionnaire has to clearly narrate the problem of each pairwise comparison.

Step 4: Examination of the hierarchy consistency: Based on the results obtained by the questionnaire survey, pairwise comparison matrices can be established. Then the eigenvalues and eigenvectors of each pairwise comparison matrix can be determined by using calculators or computers, and the consistency of a matrix can be examined at the same time. This procedure is a preliminary examination.

Step 5: Selection of schemes: If the overall hierarchy passes through the examination for consistency, then the prioritized vectors of alternative schemes can be obtained. Under the condition of only one decision-maker, it is required only to acquire the combined scores (priorities) of alternative schemes. When there are multiple decision-makers, then the combined scores of alternative schemes of each decision-maker must be calculated respectively. Finally the weighted combined scores can be acquired by means of a weighted-average method (such as the method of geometric mean) to determine the priority of alternative schemes.

Similar to AHP, ANP also assists in acquiring the relation between each other by pairwise comparisons. There is also a scale of 1 to 9, and a scale of measurement for comparison. ANP allows for an inner dependence inside clusters and an outer dependence between clusters as well. It supplies a full framework which comprises a link between clusters and elements (Yu, 2002). The method of ANP is divided into two major portions:

1. The first portion is the control hierarchy, which means the network relation between the criteria and the sub-criteria. It affects the interior relations between the two systems.

2. The second portion means the network relation between elements and clusters.

The network relation can present the relevance between various criteria. The limiting influence between each control criteria can then be calculated and form a super matrix. Finally, each super matrix will be assigned an adequate weight according to its own priority in the control hierarchy after a comprehensive assessment.

4. Application Of Case Study And Case Verification

The Mondrian design serves as the foundation for this study (Chijiiwa, 1990), and the DIC encoding system serves as the basis of the modular design of product colors (Wright, et. al., 2012). The case study design shown in Fig. 3(a) has twenty color combinations, and the corresponding DIC codes are shown in Fig. 3(b).

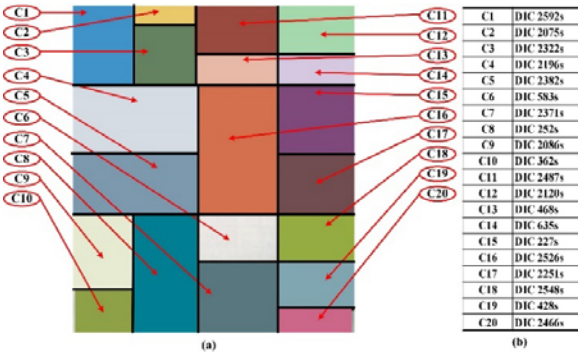


Figure. 3. The figure of case study design.

4.1 ISM Calculations

By means of pairwise comparisons between various color schemes, the relation matrix of ISM can be established and the connection relation can be formed from small color blocks connecting to a large color block and weak color schemes connecting to strong color schemes (shown in Fig. 4a and 4b). There will be color schemes left behind and these color schemes will fail to achieve any connection relation. From the analogous color blocks and color schemes in Fig. 4c, the relation matrix of colors can be established as shown in Table 1. By adding the 20*20

matrix in Table 1 to the identity matrix and carrying out the Boolean operation, the reachability matrix between color schemes can be obtained after the operations converged and the results matrix are shown in Table 2.

Based on the reachability matrix, the interacting elements can be determined, i.e., elements with which $a_{ij}=a_{ji}=1$. The output matrix generated is shown in Table 3. The output matrix of the reachability matrix of all elements affecting each other is shown in Table 2, and the relativity between elements of the reachability matrix can be traced back to generate a rearranged matrix as shown in Table 4. From the means of the fifth step of the analysis by ISM, which is mentioned in Section 3.1, the reachability matrix can be divided into a six-level hierarchy and the flowchart of ISM relations is shown in Fig. 5.

From the means of the sixth step of the analysis by ISM, the values of D+R, D-R can be obtained by calculations and the results are shown in Table 5. And the results can be used in drawing the relation chart of D+R and D-R, such as shown in Fig. 6.

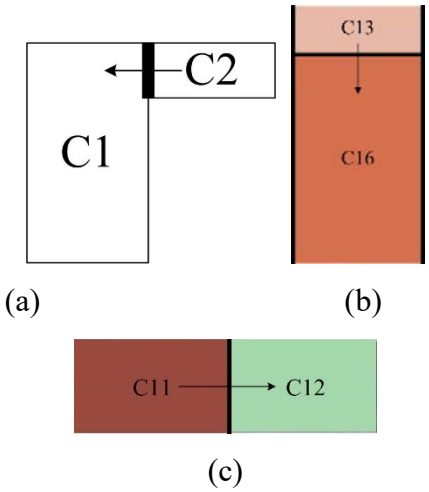


Figure 4. ISM-related connection graphs.

TABLE 1. The relation matrix between colors.

Color	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
C1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
C5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
C6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C10	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C11	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C12	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
C13	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
C14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
C15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
C16	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
C18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
C19	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 2. The reachability matrix between colors.

Color	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
C1	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C2	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C3	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C4	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C5	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C6	0	0	1	1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0
C7	0	0	1	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0
C8	0	0	1	1	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0
C9	0	0	1	1	1	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0

C10	0	0	1	1	1	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0
C11	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
C12	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
C13	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C14	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0
C15	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0
C16	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C17	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0
C18	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0
C19	0	0	1	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	1	0
C20	0	0	1	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	0	1

TABLE 3. The output matrix of the reachability matrix between colors.

Color	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
C1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C4	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
C10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
C11	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
C12	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
C13	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
C15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
C16	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
C18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
C19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
C20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

TABLE 4. The rearranged matrix between colors.

Color	1	2	5	6	7	3	4	13	16	8	9	10	11	12	14	15	17	18	19	20
1	1	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	1	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	1	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	1	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
8	0	0	**1**	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
15	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	1	1	0	0	0
17	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	1	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
19	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
20	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 5. Element values of D+R_D–R by ISM.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
D	5	6	4	4	5	7	7	6	7	7	2	2	4	7	6	4	5	6	8	8
R	2	1	18	18	8	1	3	7	1	1	2	2	18	1	2	18	4	1	1	1
D+R	7	7	22	22	13	8	10	13	8	8	4	4	22	8	8	22	9	7	9	9
D-R	3	5	-14	-14	-3	6	4	-1	6	6	0	0	-14	6	4	-14	1	5	7	7

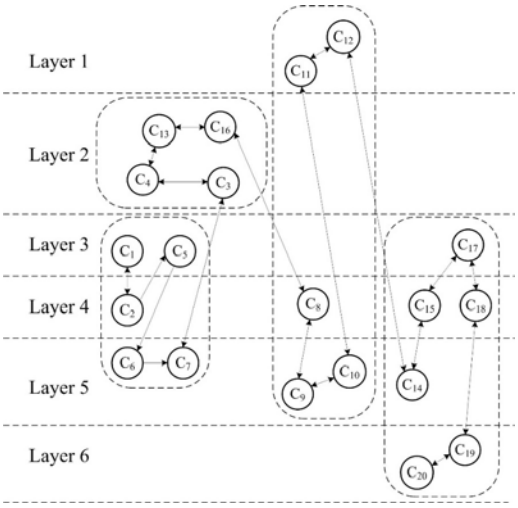


Figure 5. The flowchart of ISM correlations.

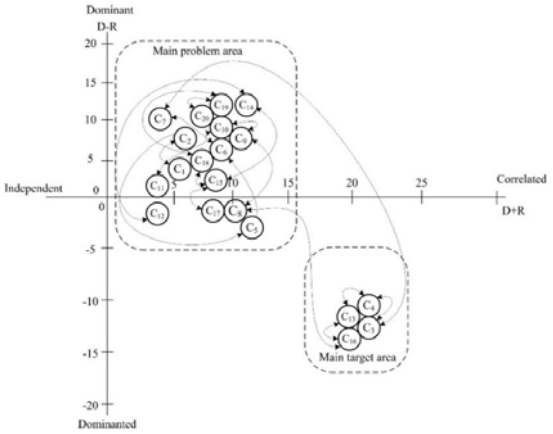


Figure 6. The relation chart of D+R and D-R

The modularization of colors can then be established based on ISM by taking advantage of the relations shown in Fig. 6. By applying the correlations obtained in Fig. 5, four modularized clusters can be generated and the definitions of which are in the following:

Modularized cluster 1: M_1={C1, C2, C5, C6, C7}. The first module comprises five color portions.

Modularized cluster 2: M_2={C3, C4, C13, C16}. The second module comprises five color portions.

Modularized cluster 3: M_3={C8, C9, C10, C11, C12}. The third module comprises six color portions.

Modularized cluster 4: M_4={C14, C15, C17, C18 C19, C20}. The fourth module comprises four color portions.

4.2 DEMATEL calculations

The values that are obtained by the transformation of the reachability matrix of ISM can be substituted into the calculations of DEMATEL. These values enhance the intensities of the factors of various color schemes of ISM and it can serve as the reference data for a design. The procedure is described in the following:

Step 1: Obtain the average influence matrix

The data of the reachability matrix of ISM can be transformed into a direct influence relation of index i on index j, and a 20×20 direct influence matrix $\boldsymbol{A} = [a_{ij}]_{n\times n}$ can be acquired by averaging the results as shown in Table 6.

TABLE 6. Direct influence matrix.

Color	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
C1	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C2	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C3	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C4	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C5	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C6	0	0	1	1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0
C7	0	0	1	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0
C8	0	0	1	1	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0
C9	0	0	1	1	1	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0
C10	0	0	1	1	1	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0
C11	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
C12	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
C13	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C14	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0
C15	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0

C16	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
C17	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0
C18	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0
C19	0	0	1	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	1	0
C20	0	0	1	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	0	1

Step 2: Normalized direct influence matrix

The direct influence matrix can be normalized by Eq. (1) and Eq. (2), and the direct influence matrix $\boldsymbol{D} = [d_{ij}]_{n\times n}$ after normalization, it can be acquired as shown in Table 7.

TABLE 7. Normalized direct relation matrix.

Color	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
C1	0.200	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C2	0.200	0.200	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C3	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C4	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C5	0.000	0.000	0.200	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C6	0.000	0.000	0.200	0.200	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C7	0.000	0.000	0.200	0.200	0.200	0.200	0.200	0.200	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C8	0.000	0.000	0.200	0.200	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C9	0.000	0.000	0.200	0.200	0.200	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C10	0.000	0.000	0.200	0.200	0.200	0.000	0.000	0.200	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C13	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C14	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.200	0.200	0.200	0.200	0.000	0.000	0.000
C15	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.200	0.200	0.200	0.000	0.000	0.000
C16	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.000
C17	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.200	0.000	0.000	0.000
C18	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.200	0.200	0.000	0.000
C19	0.000	0.000	0.200	0.200	0.200	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.200	0.000
C20	0.000	0.000	0.200	0.200	0.200	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.200

Step 3: Obtaining the total influence-relation matrix

The total influence-relation matrix of the network relations can be calculated by Eq. (3) as shown in Table 8.

TABLE 8. Total influence-relation matrix.

Color	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
C1	0.250	0.000	1.250	1.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.250	0.000	0.000	1.250	0.000	0.000	0.000	0.000
C2	0.313	0.250	1.563	1.563	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.563	0.000	0.000	1.563	0.000	0.000	0.000	0.000
C3	0.000	0.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
C4	0.000	0.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
C5	0.000	0.000	1.250	1.250	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.250	0.000	0.000	1.250	0.000	0.000	0.000	0.000
C6	0.000	0.000	1.563	1.563	0.313	0.000	0.000	0.250	0.000	0.000	0.000	0.000	1.563	0.000	0.000	1.563	0.000	0.000	0.000	0.000
C7	0.000	0.000	2.344	2.344	0.469	0.250	0.250	0.375	0.000	0.000	0.000	0.000	2.344	0.000	0.000	2.344	0.000	0.000	0.000	0.000
C8	0.000	0.000	1.563	1.563	0.313	0.000	0.000	0.250	0.000	0.000	0.000	0.000	1.563	0.000	0.000	1.563	0.000	0.000	0.000	0.000
C9	0.000	0.000	1.953	1.953	0.391	0.000	0.000	0.313	0.250	0.000	0.000	0.000	1.953	0.000	0.000	1.953	0.000	0.000	0.000	0.000
C10	0.000	0.000	1.953	1.953	0.391	0.000	0.000	0.313	0.000	0.250	0.000	0.000	1.953	0.000	0.000	1.953	0.000	0.000	0.000	0.000
C11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C13	0.000	0.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
C14	0.000	0.000	1.953	1.953	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.953	0.250	0.313	1.953	0.391	0.000	0.000	0.000
C15	0.000	0.000	1.563	1.563	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.563	0.000	0.250	1.563	0.313	0.000	0.000	0.000
C16	0.000	0.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
C17	0.000	0.000	1.250	1.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.250	0.000	0.000	1.250	0.250	0.000	0.000	0.000
C18	0.000	0.000	1.563	1.563	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.563	0.000	0.000	1.563	0.313	0.250	0.000	0.000
C19	0.000	0.000	2.539	2.539	0.508	0.063	0.313	0.406	0.000	0.000	0.000	0.000	2.539	0.000	0.000	2.539	0.000	0.000	0.250	0.000
C20	0.000	0.000	2.539	2.539	0.508	0.063	0.313	0.406	0.000	0.000	0.000	0.000	2.539	0.000	0.000	2.539	0.000	0.000	0.000	0.250

Step 4: Analysis of results

The fourth step is to calculate the prominence and relation by the summation of each row and column shown in Table 9. Vectors r and c can be obtained, where r represents the index affecting other factors and c represents the index of being affected by other factors. $(r+c)$ is called prominence which represents the relation intensity between indices, and $(r-c)$ is called relation which represents the intensities of indices affecting or being affected by others.

TABLE 9. Calculating and obtaining the summations of prominence and relation.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
r+c	3.31	3.94	30.84	30.84	5.89	3.81	6.53	7.97	5.91	5.91	6.32	6.32	34.50	5.91	6.22	34.50	6.92	5.91	5.91	5.91
r-c	2.19	3.44	26.84	26.84	0.39	3.06	4.78	3.34	5.41	5.41	4.99	4.99	23.19	5.41	5.09	23.19	4.39	5.41	5.41	5.41

4.3 Cluster analysis

Based on the cluster analysis mentioned in Section 3.3, further investigations can be conducted on Fig. 6 which is a case design figure, to understand the interactions between users and color schemes. The PCS market can be segmented by degrees of user preference, and the terms used in SD include beautiful, favorite, natural, pellucid, and delicate can be utilized to represent the color schemes affected by the criteria. By utilizing the cluster analysis data, users in the same group are provided with similar preferences, and users in different groups should have a different preference data.

The results that are acquired by the questionnaire are divided into groups based on their proportions, and the required characteristics of every cluster can be determined then. The resulting scales and weights are obtained and the clusterization results of these four groups are obtained as shown in Table 10.

Table 10. Characteristics of market segmentation and clusterization.

Market segmentation/evaluation criteria	Beautiful (%)	Favorite (%)	Natural (%)	Pellucid (%)	Delicate (%)
Cluster 1 (31.6%)	21.5	18.6	15.3	17.3	27.3
Cluster 2 (28.1%)	21.8	18.8	13.9	19.3	26.2
Cluster 3 (18.2%)	21.9	19.2	16.2	16.9	25.8
Cluster 4 (22.1%)	22.5	13.8	17.4	17.4	28.9

The four color modules classified in Fig. 5 correspond to the four different market segments being divided in Table 10. The four different market segments have then been classified and analyzed by the questionnaire survey, and all of the sample data are calculated to generate the relation matrix for the weight calculations. The results obtained were differentiated between four groups and they further form the standard weights of four modules. Firstly, the average weights of the relation matrix, which correspond to the SD modules in every group, were calculated as shown in Table 11. Then on each cluster module, the averages of standard weights of the evaluation matrix for the SD assessment obtained are shown in Table 12.

TABLE 11. Average weights of the relation matrix between clusters and modules.

Cluster	Weight item/consideration	Module 1	Module 2	Module 3	Module 4
Cluster 1	**Beautiful**	0.185	0.175	0.148	0.213
	Favorite	0.092	0.276	0.142	0.158
	Natural	0.191	0.118	0.071	0.087
	Pellucid	0.237	0.231	0.327	0.216
	Delicate	0.295	0.2	0.312	0.326
Cluster 2	**Beautiful**	0.258	0.139	0.217	0.341
	Favorite	0.068	0.243	0.115	0.081
	Natural	0.211	0.118	0.102	0.182
	Pellucid	0.241	0.231	0.307	0.161
	Delicate	0.222	0.269	0.259	0.235
Cluster 3	**Beautiful**	0.172	0.159	0.159	0.281
	Favorite	0.087	0.228	0.21	0.048
	Natural	0.381	0.249	0.169	0.291
	Pellucid	0.172	0.172	0.238	0.172
	Delicate	0.188	0.192	0.224	0.208
Cluster 4	**Beautiful**	0.251	0.102	0.271	0.281
	Favorite	0.082	0.182	0.108	0.061
	Natural	0.261	0.217	0.126	0.261
	Pellucid	0.272	0.172	0.285	0.168
	Delicate	0.134	0.327	0.21	0.229

The interactions between evaluation standards and component clusters result in complex network relations between various individually segmented markets, and different evaluation standards will lead to different resulting weights. As a result, when every standard is being considered, the weights of varying degrees demands between color schemes of a case study can then be obtained. On the other hand, when the series of every component combinations are taken into consideration, the weights of varying degrees of demands for each assessment standard are also different. In other words, the interaction between evaluation standards and the modules are not only a hierarchical relation but also a relation between networks and feedback. Fig. 7 indicates the network between evaluation standards and modules.

TABLE 12. Average weights of the related evaluation matrix of cluster evaluation.

Market segments	Weight item/ consideration	Beautiful	Favorite	Natural	Pellucid	Delicate
Cluster 1	Module 1	0.261	0.112	0.278	0.391	0.261
	Module 2	0.134	0.241	0.244	0.132	0.182
	Module 3	0.224	0.348	0.16	0.321	0.258
	Module 4	0.381	0.299	0.318	0.156	0.299
Cluster2	Module 1	0.316	0.094	0.392	0.361	0.219
	Module 2	0.281	0.348	0.069	0.072	0.251
	Module 3	0.182	0.309	0.143	0.271	0.179
	Module 4	0.221	0.249	0.396	0.296	0.351
Cluster 3	Module 1	0.218	0.152	0.362	0.361	0.203
	Module 2	0.137	0.247	0.172	0.105	0.261
	Module 3	0.253	0.275	0.132	0.241	0.211
	Module 4	0.392	0.326	0.334	0.293	0.325
Cluster 4	Module 1	0.269	0.139	0.291	0.379	0.269
	Module 2	0.097	0.339	0.176	0.085	0.097
	Module 3	0.273	0.361	0.351	0.326	0.273
	Module 4	0.361	0.161	0.182	0.21	0.361

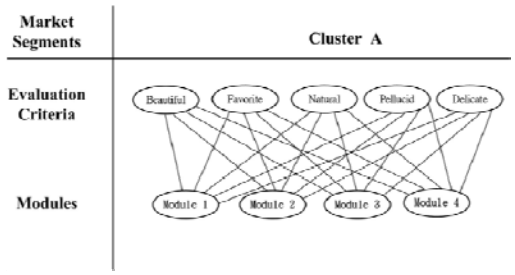


Figure 7. Network between evaluation standards and modules.

4.4 *Processing ANP data obtained*

The analysis technique by ANP, which is described in Section 3.4, is utilized for the product group development of modular designs. Here its operating procedure is explained:

Step 1: Establishing the supermatrix cluster. The supermatrix is a weight matrix which is provided with ten levels. It is determined by a one-level group which is shown in Table 10, and is composed of a five-level evaluation standard which is shown in Table 11 and a four-level modular PCS color scheme which is shown in Table 12. This forms a supermatrix which is shown in Fig. 8.

The weights of the five evaluation standards based on the market segmentation are {W12, W13, W14, W15, W16}; the evaluation criterion A1 (beautiful) is based on major factors of the market segmentation being considered, i.e., {W27, W28, W29, W210}; A2 (favorite) is based on major demands of the market segmentation, i.e., {W37, W38, W39, W310}; A3 (natural) is based on another major factor set of the market segmentation being considered, i.e., {W47, W48, W49, W410}; A4 (pellucid) is based on the major factors of {W57, W58, W59, W510}; A5 (delicate) is based on considering major factor set of the market segmentation, i.e., {W67, W68, W69, W610}. The supply M1 (Component 1) is based on considering major factors of the market segmentation, i.e., {W72, W73, W74, W75, W76}; M2 (Component 2) is based on another major factor set of the market segmentation being considered, i.e., {W82, W83, W84, W85, W86}; M3 (Component 3) is based on the major market segmentation, i.e., {W92, W93, W94, W95, W96}; M4 (Component 4) is based on considering another major factor set of the market segmentation, i.e., {W102, W103, W104, W105, W106}. The summation of all weights along each row must be "1", otherwise the supermatrix will not converge. The value of "0" indicates that two elements do not interact with each other.

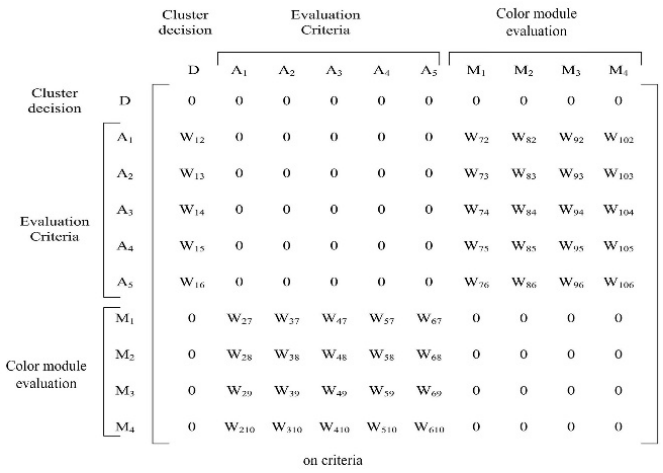
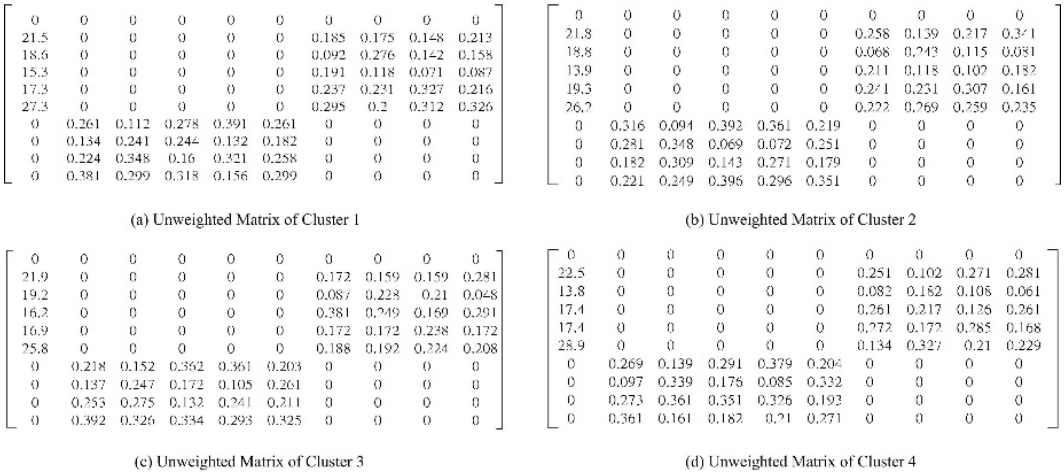


Figure. 8 The super-matrix of the case study.

Step 2: The unweighted matrix of the market group data can then be calculated and the results are shown in Fig. 9. The data from the unweighted matrix obtained in Step 1 are repeatedly calculated until it converges. After its convergence, the summation of each row of the supermatrix is "1", also the weight of each column no longer changes. The super-weighted matrix is shown in Fig.10.

Step 3: The evaluation of development for each product line is proposed and product series based on the weights of color schemes can then be obtained. During this step, the output data of the supermatrix is being integrated. That is, the weight of each column of the supermatrix is combined with the data of market segments that is established during the development of product series. This approach let designers conduct the modular design of various types of color schemes as required.



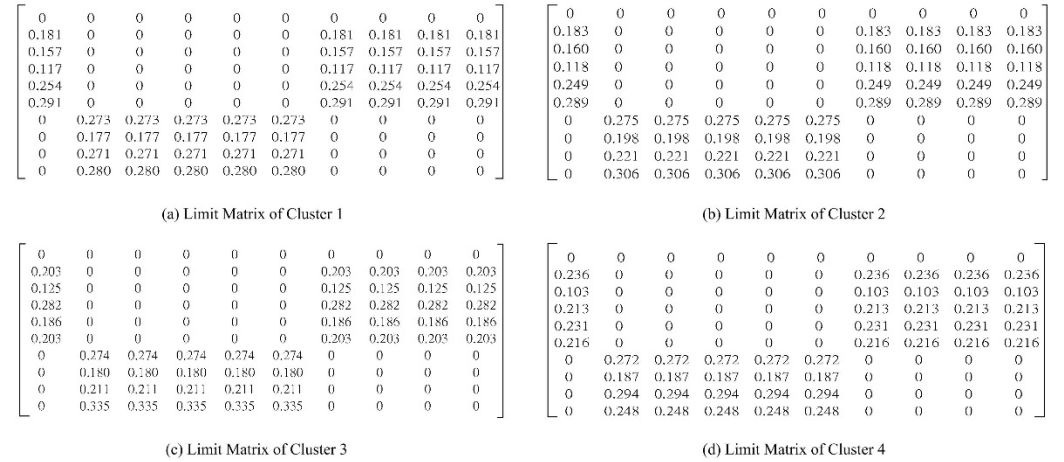
(a) Unweighted Matrix of Cluster 1

(b) Unweighted Matrix of Cluster 2

(c) Unweighted Matrix of Cluster 3

(d) Unweighted Matrix of Cluster 4

Figure 9. Unweighted matrix of the market cluster data.



(a) Limit Matrix of Cluster 1

(b) Limit Matrix of Cluster 2

(c) Limit Matrix of Cluster 3

(d) Limit Matrix of Cluster 4

Figure 10. Super-weighted matrices of clusters.

Based on Step 3, the ANP data is processed by individual operations of four supermatrices as shown in Fig.10. The weight of each market segment is distributed to the optimized components of four color groups for the assessment of weights, and the optimized weight distribution of these four color groups is shown in Table 13.

TABLE 13. Matrices of clusterization.

Market segment module weight(%)	Weight of optimized Module 1(%)	Weight of optimized Module 2(%)	Weight of optimized Module 3(%)	Weight of optimized Module 4(%)
Segment 1(36.7%)	27.3	17.7	27.1	28.0
Segment 2(16.8%)	27.5	19.8	22.1	30.6
Segment 3(20.8%)	27.4	18.0	21.1	35.5
Segment 4(25.7%)	27.2	18.7	29.4	24.8

4.5 Market analysis of PCS

The purpose color scheme generalization is to save cost, shorten the development time, and eliminate the same colors between common color schemes. Because of the limitation on market segmentation, it is required to break the limit between product series in two product lines. The development of color products requires diversification, which is based on the corresponding market segment. The standardization of some color schemes even requires to consider the establishment of common, independent, and similar color schemes. Under the configuration of a single common color scheme, the independent components assist in the development of color groups. The matrix in Table 14 can be obtained based on Table 13, and the results indicate that the color schemes with a larger differentiation in their weight distribution can be isolated. They are individually developed, i.e., they serve as independent components. The color schemes with a smaller difference in their weight distributions are being combined, and a general-purpose color scheme as shown in Table 15 can be developed.

Based on the distribution of color schemes of various values, the optimization of the distribution of common color schemes and individual color schemes is determined based upon the results obtained. The results indicate a sequence from small to large as: {0.1, 0.2, 0.7, 1.0, 1.1, 1.4, 1.8, 2.1, 2.3, 3.2, 4.9, 5.0, 5.8, 6.0, 7.3, 7.5, 8.3, 10.7}. This sequence is then substituted into every color scheme for calculation. The values of the color schemes, which are listed below, corresponding to a general-purpose color scheme. The values of the independent color schemes are as shown in Table 15.

TABLE 14. Values of the redistribution matrix.

	One				Two				Three				Four			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	0	0.2	0.1	0.1												
2	0.2	0	0.1	0.3												
3	0.1	0.1	0	0.2												
4	0.1	0.3	0.2	0												
1					0	2.1	0.3	1								
2					2.1	0	1.1	1.1								
3					0.3	1.8	0	0.7								
4					1	1.1	0.7	0								
1									0	5	6	2.3				
2									5	0	1	7.3				
3									6	1	0	8.3				
4									2.3	7.3	8.3	0				
1													0	1.4	7.5	3.2

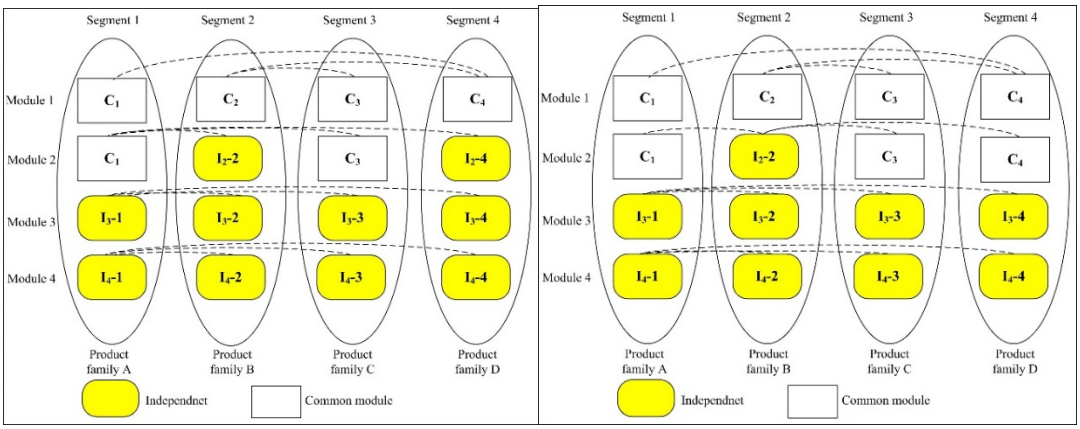
2	1.4	0	4.9	5.8
3	7.5	4.9	0	10.7
4	3.2	5.8	10.7	0

TABLE 15. Sensitivity analysis of module compositions.

	One				Two				Three				Four				
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	
0.1	I-1	I-1	I-1	I-1	I-1	I-2	I-3	I-4	I-1	I-2	I-3	I-4	I-1	I-2	I-3	I-4	◆
0.2	C	C	C	C	I-1	I-2	I-3	I-4	I-1	I-2	I-3	I-4	I-1	I-2	I-3	I-4	◆
0.3	C	C	C	C	I-1	I-2	I-3	I-4	I-1	I-2	I-3	I-4	I-1	I-2	I-3	I-4	◆
0.7	C	C	C	C	C	I-2	C	I-4	I-1	I-2	I-3	I-4	I-1	I-2	I-3	I-4	★
1	C	C	C	C	C	I-2	C	C	I-1	I-2	I-3	I-4	I-1	I-2	I-3	I-4	★
1.1	C	C	C	C	C	I-2	C	C	I-1	C	C	I-4	I-1	I-2	I-3	I-4	◎
1.4	C	C	C	C	C	C	C	C	I-1	C	C	I-4	I-1	I-2	I-3	I-4	◎
1.8	C	C	C	C	C	C	C	C	I-1	C	C	I-4	C	C	I-3	I-4	◎
2.1	C	C	C	C	C	C	C	C	I-1	C	C	I-4	C	C	I-3	I-4	◎
2.3	C	C	C	C	C	C	C	C	I-1	C	C	I-4	C	C	I-3	I-4	◎
3.2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	I-3	I-4	◎
4.9	C	C	C	C	C	C	C	C	C	C	C	C	C	C	I-3	C	◎
5.0	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	◎
5.8	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	◎
6.0	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	◎
7.3	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	◎
7.5	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	◎
8.3	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	◎
10.7	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	◎

◆ independent ★ Qualified ◎ Unqualified

Based on the data shown in Table 15, the optimized color schemes satisfied the demand of the market segmentation can be obtained from values between {0.7, 1.0} as shown in Fig. 11. The number of configurations of color combinations via typical connecting color schemes and individual color schemes is sixteen. Table 15 illustrates the combined configuration of common color schemes and individual color schemes when their values are 0.7 and 1.0 respectively. The results obtained can serve as a reference for those designs with multiple color schemes and those developments with a plurality of PCS, and this module can also vary infinitely between modules in parallel. Based on the market segmentation proposed in this study, and by utilizing color schemes, which are transformed into DIC codes to serve as color layouts, it is suggested that the four color products can be designed with multiplicity and the results can serve as customer references. While corresponding respectively to demands of different segments, this approach can supply cost information and benefits related to modular PCS at the same time. From Table 15, the color schemes with a value of 0.7 can be obtained as shown in Fig. 12(a), and those with a value of 1.0 can be obtained as shown in Fig. 12(b). From the color group information obtained in these figures, the color figures which correspond to each module and market demands between groups, can be obtained. From the color combination in Fig. 12(b) with a value of 1.0, the combined arrangement of Fig. 11 for common color schemes and individual color schemes can be developed through typical connecting color schemes and individual color schemes. Finally, by using a real case study, figures which corresponds to the color groups. In Fig. 13, four kinds of different color products can be developed.



(a) 0.7 module **(b) 1.0 module**

Figure 11. Module composition with the thresholds.

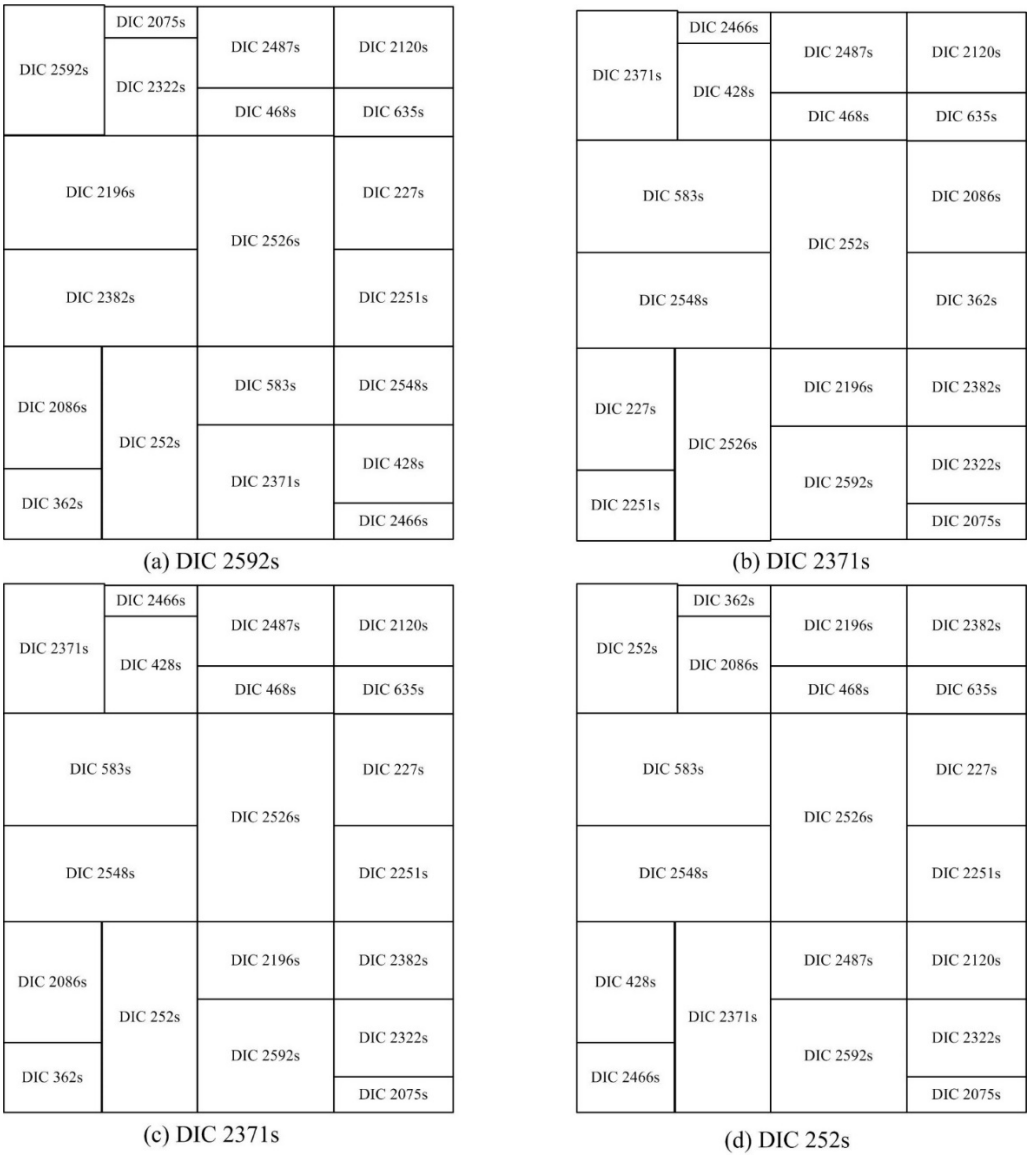


Figure 12. Figures of colors corresponding to variations in clusters.

Figure 13. Real case studies of colors corresponding to clusters.

Several color combinations that were obtained by the application of the SD were applied to reusable bags such as the big handbag and the cloth bag are shown in Figure 13. The results indicated that the color-matching requirements for big

handbags and cloth bags are different. The significance level of the combinations (a) and (b) for the big handbag is low. On the other hand, the combinations (c) and (d) have less number of colors. This result indicates that a minor difference is found from the standpoint of color-matching requirements for handbags and cloth bags. Moreover, the highlight of color-matching for bags is on the color variation and source colors. A higher level of color variation is preferred for cloth bags in order to deliver the color-matching effects. On the contrary, a color scheme can present a greater level of color variation if its colors are generated from those that are obtained by the decomposing approach that is utilized in this study.

5. Conclusions

The approach that is proposed in this study is superior to other similar approaches as it can transform a complex color system into a color module with several color schemes that can be used on reusable bags for environmental sustainability. The color combinations in this study are based on the Mondrian artwork. The DIC system serves as the color coding system for the design of color combinations. Before the colors are modularized, the ISM approach is used to analyze the correlation between different color combinations. After that, the DEMATEL approach is used to determine the significance of the correlation between the resulting matrices. The influence matrix between different color schemes can be obtained. This is followed by the cluster analysis in order to determine the corresponding relationship between different modules and clusters. After the model of color modules has built by the ANP approach, the weight of each module can determine the optimization of the colors. The results of this study indicated that the common color modules for a series of product colors can be determined from the color schemes that are built according to demands of different groups. This approach allows a designer to determine which color schemes to be used on reusable bags according to consumer demands. The creation of common color modules also helps reduce the time and efforts for the development of sustainable products.

Since the current case study is limited to one of the Mondrian artworks, potentially more color modules can be developed from other Mondrian artworks. Follow-up studies are advised to investigate other similar artworks. Since the purpose of this study is to investigate the color schemes that are preferred by consumers on sustainable products, the selection of the source colors to be decomposed by the ISM approach could also affect the results of this study. The range of the source colors can be broadened in further studies for further investigation. Moreover, since the participants in this study are selected among college students, future studies are advised to include participants from other occupations or people from different age brackets. Future applications of this approach should not be limited to colors that are derived from Mondrian artworks. Instead, more color schemes can be included as the source colors for a greater level of color variation. The result of this study indicated that the colors that are generated from the modularized source colors can deliver different effects on reusable bags for different consumer demands. Designers could benefit more from the implementation of this approach when the consumers are allowed to customize a reusable bag with their preferred color schemes. This also allows a designer to have a better understanding of the consumer demands and in turn the effort spent on the development of sustainable products for improving people's lives can then be reduced.

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從彩度、亮度、色相三方面探討記憶色對彩色影像品質之影響前測

解雪瑩

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摘要

隨著經濟的發展，人們對於印刷製品的要求也在不斷提高，促使印刷企業在進行成稿校驗時，會著重檢查圖片色彩的準確性，如色差、色度值等常見色彩問題。本研究透過問卷的方式調查了 15 位接受過專業與色彩相關課程訓練的設計學專業碩博士生，結合單因數變異數分析得到的前測結果顯示，實物的顏色與人們在腦中所記憶的顏色存在較大的色差，多數人對於物體記憶色的偏差主要集中在亮度這一變數上，其次為色相和彩度。本研究在探討實物的顏色與人們在腦中所記憶的顏色色差的具體數值的同時，根據人們對於「喜歡」和「漂亮」的感性定義，分別從彩度、亮度、色相這三個方面得到具體數值，作為研究影響色彩影像品質的最終結果。本研究結果可作為理論依據和參考運用於實際印刷的實踐中。

關鍵詞：記憶色、影響品質、色彩前測

Discussing the Influence of Memory Color on the Quality of Color Image from Saturation, Brightness and Hue

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ABSTRACT

With the development of economy, people's requirements for printing products are also constantly improving; printing enterprises will pay more attention to check the accuracy of picture color, such as color difference, color value and other common color problems. This research through the way of questionnaire survey the 15 master/doctoral student in design degree, combined with the former test results of single factor variance analysis showed that the color of the physical with the color of the people the memory in the brain there is a big color difference, most people in object memory color deviation mainly concentrated on the brightness of this variable, followed by hue and chroma. In this study, while discussing the specific value of the color difference between the object and the color that people remember in their mind, specific values are obtained from the three aspects of chromaticity, brightness and hue respectively according to people's perceptual definitions of "like" and "beautiful", as the final result of the study affecting the quality of color image. The results of this study can be used as theoretical basis and reference for practical printing practice.

***Keywords*:** Memory Color, Influence Quality, Color Pretest

1 緒論

記憶色是人們意識的一部分，在觀察印刷品時人眼對這些顏色比較敏感，如果稍有偏色就會被感覺到。例如，每個人都知道青草的顏色，如果顏色朝著某個不可能的方向變化的話，很快就能識別出來。這是由於人們已經習慣了青草的顏色，並將顏色主觀性的記在了腦海裡，所以當畫面上出現了與印象中不同的色彩，人們便很快的意識到這種偏差。因此，在顏色複製過程中將記憶色準確再現就顯得十分重要。然而在校色中運用記憶色還原影像並非是每個人都擁有的技能，往往是工作人員長時間視覺訓練培養出來的。對於沒有工作經驗或對顏色不敏感的操作人員來說就很難利用記憶色進行顏色校正了。如果有具體的資料作為指引，將這種感覺上的顏色差別量化並作為標準之後，操作人員即使沒有經驗也能根據這些標準值來進行色彩校正，而且這種校正將更加符合人的審美需求。

在實際印刷過程中雖然能透過儀器精確地複製顏色的色度值，即從印刷工藝角度來說達到了很好的印刷品質，但色度值和人們的「記憶色」存在一定的差距，常被人們認為印刷品有色差，即印刷品質是不好的。雖然色度值能通過測量得到相關資料並且通過現代技術精確複製出來，但由於在現實中存在「記憶色」這一現象，使得精准的顏色在人們眼中依然和實物有色差。彩色圖像的色彩增強的確能達到符合大多數人眼視覺「喜愛」的標準，而且不同影像就會有不同的優化處理，所以在印刷前期，工作人員會對色彩圖片進行一定的處理，使顏色更鮮豔明亮或看上去更接近「真實的色彩」。由於對消費者而言印刷品和原稿在時間和空間上是分離的，他們往往通過比較印刷品中某些物體的顏色與記憶中該物體顏色的相似性對印刷品色彩再現品質做出評價，如果兩者之間相似性高，則印刷品質就好，否則就認為印刷品偏色。

由於這種感覺是基於人的主觀意識的主導，所得到的色差是主觀的，不同的人由於評價尺度的差別可能得出不同的評價結果，因此，只有這種感覺上的顏色差別被量化後，它在印刷複製過程中才具有實際應用價值。印刷品的色度值可以用儀器直接測量出來，由於不同的人對於某一種物體的色彩記憶存在些許差距，很難有一個明確且統一的數值，但是如果能獲得記憶色的色度值的普遍色域範圍，就可以直接發現記憶色和印刷品顏色的色差，結合資料值的分析，實際地改善色彩的圖像品質。因此，通過研究人們的視覺觀察得出的資料來檢查影像品質，並討論人眼的視覺與記憶色之間的關係，所得成果具有相當大的實際應用參考價值。

本研究以 15 位亞洲大學設計學碩士班或博士班學生為受測者，探討記憶色與人眼觀察的物件實體顏色的差別。以及記憶色對色彩品質的影響；透過問卷調查的方式，將得到的前測數據以 SPSS 軟體中獨立樣本單因數變異數分析（One-way ANOVA, Independent Samples）的方式，將色差與色彩的影像品質進行量化統計和分析，並得出具體數值作為參考。本研究所選擇的自然實體作為觀察物件的種類偏少，且存在每台印刷機器對於色彩的影響不一等問題。本研究作為前測研究，提供了一個可供思考和參考的研究方向，希望未來研究者可以採取更多物件樣本和受測者進行試驗，以增加實驗的準確性。

2 文獻探討

2.1 記憶色

視知覺的恆常記憶性是指當視知覺的對象在一定範圍內變化時，視知覺映像仍保持相對不變。人們根據自身記憶對事物已有的印象、知識和經驗來感知事物。在眾多知覺中，視知覺的恆常記憶性最為明顯。對於視知覺來說，對象的大小、色彩、形狀等產生的印象與客觀刺激的關聯性並非完全符合物理規律，當外部環境發生一定變化時，人們多次觀察該事物的經驗會對每一個感知器官所接受的不完整的甚至歪曲的信息進行校正，從而使同一事物的知覺印象保持恆定。當人們所觀察的對象是陌生的且周圍沒有熟悉的可參照物時，那麼他們便不具備關於該事物的視知覺恆常性。其中，色彩恆常性（Color Constancy）是指人類

的視覺系統對色彩的感知不會受到環境改變的影響。Jin 與 Shevell（1996）認為恆常性的現象與色彩記憶有關，甚至可透過色彩記憶來觀察。當所觀看的顏色與記憶、經驗中的色彩沒有差別，或是色彩偏移的程度明顯小於實際物理色度的變化，即恆常性發生效用。色彩視覺系統中，色彩恆常性作為其中一個最重要的特質，是一種與光源無關，僅依靠記憶賦予物體色彩的能力（Gegenfurtner & Kiper, 2003），從生理的角度看，這種能力是經過從視網膜直到大腦皮質中一連串的計算而得到的結果（Kraft & Brainard, 1999）。

記憶色（Memory Color）由德國生理學家 Helson（1943）提出，指人類視覺系統獲取的存儲在長遠記憶中的顏色，他認為經歷過的和認識的物體顏色都能在記憶裡找到，是人們熟悉物體在記憶中的顏色。記憶色是源於人類的視知覺具有色彩恆常性這一特質，是對所熟悉的物體顏色在長遠記憶裡的主觀印象，並不是常說的單純紅色、綠色和藍色，而是與具體物體相關的，如草莓的紅色、晴朗天空的藍色、著名珠寶品牌 Tiffany 色等。如果離開了具體物體，顏色就不是記憶色了。

通常我們會無視於環境光源改變，即使光源的變化範圍很大，我們仍然可以對物體的顏色得到相同的結論。這是由於人們的偏好，物體記憶色和實際物體顏色往往存在差別，使它與實際物體顏色並不完全一致。記憶色是人們長期觀察的結果，並不是某一次外出旅遊時見到的某些物體顏色（金洪勇，趙秀萍，2007）。人們對越熟悉的物體進行顏色評價，評價結果越準確。例如，我們會覺得一顆成熟的草莓的顏色是不變的，不論是在白天或夜晚或是使用了特殊的光照，包括使用圖像軟體中的濾鏡功能進行顏色的改變，但若此顆草莓開始變質了，我們卻能判斷出它的顏色變化的能力。例如，圖 1 中的草莓在經過了圖像色彩的處理之後，已經不再是原圖中的紅色，但當人們第一次看到處理過的圖片時，還是會根據自己過往的經驗，將圖中的草莓認定為是紅色，顏色偏差的問題出在圖片而不是草莓本身。

圖 1 草莓在不同光線下呈現出不同色彩

彩色印刷品的內容通常由描述性訊息，如文字和圖等表以及展示性訊息，如自然風景、人物、食品等，後一類資訊往往包含有記憶色。實驗中，變數的控制對於複雜程度高的彩色影像很重要， Fairchild 和 Johnson（2002）指出，使用心理物理法有助於獲取人們主觀的心理感受并進行實驗評量。另外，人們在接受了具有不同的物理屬性的影像刺激後，人的認知會根據感受到刺激強度的不同而給予不同的權重（Weighted Factor）。通常正是根據這些記憶色來評價印刷的品質。在觀察印刷品時，對於缺少專業知識的普通人來說，藍天、白雲、草地等常見事物的記憶色是人們最熟悉的顏色，人眼對這些顏色比較敏感，這些顏色如果在呈現的時候出現偏差，就比較容易被發覺，進而調整（高巧俠、朱鳳萍，2013；楊寶星、景凌雲，2015）。所以根據記憶色來確定標準色樣就會大大減少出現這樣的問題，通過測量色樣中某物體的顏色，並計算該顏色與該物體記憶色標準值的色差，當這種色差在人眼不能分辨的範圍內時，就可以認定該樣張為標準色樣。

2.2 影像品質

影像的成形牽涉到光的呈現與人類視覺感知的層面，因此除了客觀的量測光之物理性外，如何量測人類視覺上對影像品質的主觀判定，成為在評定影像品質的兩個重要面向（黃伊真等人，2008）。Lester（1994）指出，透過視覺進行影像品質的評量主要源於兩個概念，即影像喜好與影像匹配。蔡政旻與管倖生（2009）認為運用科學的實驗對視覺進行評量時，認定實物與複製的影像品質達成匹配的標

準是，達到受測者感覺在影像與實物之間的視覺差異微小或是無法分辨出差異的程度。MacDonald（1999）則將影像品質進一步細分為三個主要方面：亮度、色彩（色相、彩度）和銳利度。Fairchild 等人（2002）認為，影像解析度（Resolution）、雜訊（Noise）、、影像對比（Image Contrast）色彩複製（Color Reproduction）以及影像銳利度（Image Sharpness）等因素都會對人們在進行影像的品質判斷產生影響。Johnson（2005）認為，影像銳利度、色彩以及色調對比度是影像影像品質判斷的關鍵因素。對於影像品質評估而言，目前已經有一些相關研究，大致上從色彩、階調、對比以及銳利度來做評估和分析。

彩色印刷實際上是一個色彩分解、傳遞與合成的過程，所以色彩再現好壞是決定印刷品質的重要因素（金洪勇，趙秀萍，2007）。由於一般評估色彩輸出設備的色彩好壞均是以色差來表示，在商業印刷的過程中，客戶提供的原稿有時會在色相、飽和度、清晰度等基本色彩因素上出現問題，若未經過色彩處理就直接印刷，會導致印刷品質量差的情況，在傳統影像時代，常常存在著色彩“所見非所得”的問題（朱炯，2008）。因此，為了提高數位印刷品的質量，要對原稿進行色差校正、黑白場校正、圖像銳化等處理，並且對於不同質量的原稿，使用的處理方式也不盡相同（劉曉麗等人，2016）。在色彩複製領域，國際色彩聯盟 ICC（International Color Consortium）所建立的色彩管理系統已成為業界標準（ICC，2006）。也有學者通過針對螢幕顯示與印刷複製影像的階調改變所得出的資料進行研究，雖得出了一些色彩管理標準數值（魏裕昌等人，2008），但未必適用於不同材質或物體。透過編輯相機與印表機的 ICC 描述檔，可使螢幕顯示與印刷複製影像的階調改變。不論是影像的物理屬性亦或是品質喜好都是目前影像研究的主題（Vuori et al.，2004），若能將影響品質的因素進行控制，便能確保影像具有較高的品質。

對於影像品質的評估方式主要由主觀評估與客觀評估構成。主觀品質指受測者在受到影像刺激后對影像的喜好程度進行主觀判斷的結果。影像品質的客觀評估主要透過演算法的表現與影響內容進行（Morovic & Luo，2001）。雖然數據能夠快速的得到影像物理數值的高低，但評分高的影像未必會得到人們的好評。對於影像品質的研究而言，得到受測者主觀偏好的分數十分重要。有學者透過心理物理學的實驗得到受測者主觀心理感知程度（Johnson & Fairchild，2002）。視覺感知影像品質（Image Quality Perception）是為了得到人眼直觀的感受，以心理物理方式透過對影像的亮度、彩度、對比度等感知因素測量影像品質的方式。主觀偏好作為影響影響品質的另一個重要因素，有了對偏好的判斷才有選擇的意義。個人對影像的偏好受到環境、經驗、文化等因素的影響，一般來說，很難用數值對某個具體事物的喜歡程度進行評量，但是透過與其他事物做比較，是可以得到哪個是比較喜好的。因此，本研究希望透過對影響色彩影像品質的因素進行實物探究，以便得到最直接的主觀評價以及最適合性的影像品質調整數據。

3 實驗設計

3.1 受測者

雖然主觀性的影像品質之評鑒需經由人眼針對測試影像進行實驗，受測者對於調整參數影像的偏好程度進行評量。偏好是依據觀測者的主觀認定，在不同的色彩影像中選出偏好的影像，並不需要具備任何與影像原稿有關的背景知識（Fairchild & Reniff, 1996）。研究表明，有受過專業色彩相關課程訓練之觀測者其視覺觀測之穩定度較佳，雖然觀測者之背景與其偏好之影響非本研究之主題，但觀測者之穩定度確定可增加評鑒資料的公信力（黃伊真等人，2008）。從接受過專業與色彩相關課程訓練的設計學專業碩博士生中以抽籤的方式，隨機選擇了 15 位作為本次前測研究的受測者，實驗前所有的受測者全部通過了色盲測試。

3.2 實驗設備

Janssen 與 Blommaert（2000）認為，在使用定量的方式進行視覺評量研究時，使用的影像必需具備分辨性（Discriminable）和識別性

（Identifiable）。因此，本實驗選擇的第一組實驗工具是以具有高強度和高純度的色相對比的單色瓷杯（紅色和草綠色）為實驗物件；第二組則以低強度對比和中純度且多種色相的仿真塑膠花束和仿真塑膠紅蘋果組合作為實驗物件。實驗中的兩組實物均以單色為背景，使用經過不同修改的變項（variables）作為色彩影像品質參考，要求受測者對色彩影像品質進行心理判斷（Fernandez et al.，2005）；拍攝工具為「華為 P10 Plus」智慧型手機，此款手機的雙攝鏡頭是與萊卡公司合作版，保障拍攝品質及資料值準確，且拍攝模式設定專業相機相同；使用 Photoshop CS6 版本軟體對拍攝後的圖片進行色彩處理；處理后的圖片選用常見的富士施樂 DocuCentre-IV C2270 彩色複合機進行列印，列印解析度為 1200×2400dpi，標配為 PCL5，PCL6，選配為 PostScript 3。

3.3 實驗環境

為減少產生視覺上的差異，實物和色彩影像印刷參考物放在同一色溫的光源下進行觀察。同時，安靜的實驗環境保障受測者的專心程度。Kurita 與 Saito（2002）的研究發現，人們在處理與視覺有關影像時，其準確度會因外在的環境光源亮度的增加或減少產生喜好的變化。因此，本次實驗是在光源穩定的攝影棚中進行，所有的環境光源予以測量和調整，以確保實物所受光源與觀看影像時的光源色溫一致，以增加實驗的準確度。

3.4 實驗步驟

3.4.1 獲取實驗圖像

實驗中將兩組觀察實物分別放置在放在色溫 4930K、照度 600 lx 的光源下進行拍攝。為了保證圖像顏色與實物顏色一致，拍攝前將手機的拍攝模式設定為數位相機模式并進行色彩矯正：感光度 ISO：100，曝光時間 S：1/43s，光圈 F：1.8。

圖 2 瓷杯組未經處理圖

圖 3 花卉和蘋果組未經處理圖

3.4.2 實驗影像處理

首先，將兩組實驗物品進行分組並將圖片進行編碼：第一組為瓷杯組合，圖片編碼為 A1-A6、B1-B6、C1-C6，花卉和蘋果組合為第二組，圖片編碼為 D1-D6、E1-E6、F1-F6。然後，對彩色圖像的顏色進行處理，處理標準是保證修改後圖像的色相與原圖具有一定的差別，但由於記憶色在不同人的印象中只存在些微不同，所以處理後的圖形與原圖差別不能太大，影響受測者進行正常判斷。

根據上述標準將 A1-A6 保持圖像的亮度（Brightness）和色相（Hue）不變，透過彩度（Saturation）調整使物體看起來更鮮艷或暗淡，加強或減弱觀看圖像的色彩感受。在數值調整時，運用軟體嘗試后，最終將彩度的調整值為減弱 30 單位、減弱 10 單位、增強 10 單位、增強 20 單位、增強 40 單位、增強 60 單位。標記於表格為 S-30、S-10、S+10、S+20、S+40、S+60；B1-B6 保持圖像的色相和彩度不

變，運用軟體對亮度調整進行嘗試之後，最終將亮度的調整值為減弱 20 單位、增強 20 單位、增強 40 單位、增強 60 單位、增強 80 單位、增強 100 單位。標記於表格為 B-20、B+20、B+40、B+60、B+80、B+100；C1-C6 保持圖像的亮度和彩度不變。色相調整傳統的做法是在色環上進行角度調整，但由於本實驗採用的是軟體調整，可直接從數字單位上進行調整，在此基礎上將色相的調整值分別為減弱 20 單位、減弱 10 單位、減弱 5 單位、增強 10 單位、增強 20 單位、增強 30 單位。標記於表格為 H-20、H-10、H-5、H+10、H+20、H+30。第二組圖片編碼的三組 D1-D6、E1-E6、F1-F6 圖像數值的改變將按照第一組圖片編碼的三組 A1-A6、B1-B6、C1-C6 進行相同數值處理。這樣處理的目的是為了在三個變數中控制其中兩個變數不變的前提下，找到第三個變數的數值對於色彩影像品質之影響。兩組一共就得到了 36 張圖片 。

表 1 圖像調整彩度（Saturation）對照表

圖像編碼	A1	A1	A1	A1	A1	A1
	D1	D1	D1	D1	D1	D1
調整數值	S-30	S-30	S-30	S-30	S-30	S-30

表 2 圖像調整亮度（Brightness）對照表

圖像編碼	B1	B1	B1	B1	B1	B1
	E1	E1	E1	E1	E1	E1
調整數值	B-20	B-20	B-20	B-20	B-20	B-20

表 3 圖像調整色相（Hue）對照表

圖像編碼	C1	C1	C1	C1	C1	C1
	F1	F1	F1	F1	F1	F1
調整數值	H-20	H-20	H-20	H-20	H-20	H-20

圖 4 瓷杯組前測所用色彩調整圖，用於檢測記憶色色差

圖 5 瓷杯組前測所用色彩調整圖，用於檢測影像品質「喜歡」和「漂亮」

圖 6 花束組前測所用色彩調整圖，用於檢測記憶色色差

圖 7 花束組前測所用色彩調整圖，用於檢測影像品質「喜歡」和「漂亮」

3.4.3 受測者實驗

為了避免測試物品受到環境色及太陽光的影響下會產生不同的視覺感受，最大限度保證受測者判斷的準確度，本研究實驗選在環境控制嚴格且光源穩定的室內攝影棚進行。將實物擺在色溫 4930K、照度 600lx 的光源下，讓受測者觀看 5 秒後。把觀看物件收起來，10 秒後再讓受測者觀看彩色影印的調整過 RGB 數值的 9 張圖片，並填寫觀察印刷版本圖片的調查問卷。問卷由個人基本資料、圖像偏好、圖像質量三部分組成，以「喜歡」作為評價圖像偏好的詞彙，以「漂亮」作為評價影像品質的詞彙。要求受測者在實驗現場完成問卷的填寫，以減小記憶造成的誤差，并提高問卷結果的可信度。同時，為了避免圖像混淆，採用標號的方式填寫記錄。

問卷中第一個問題要求透過印刷的兩組 36 幅實物圖像的逐一對照，讓觀察者對圖像裡面實物顏色與記憶色進行配對比較，並根據自己的記憶和感覺進行選擇，透過分析 15 位受測者對色彩處理並打亂排序的 36+1（原圖）=37 幅圖像的篩選，找出和記憶色最相似的圖

像。將多數人選擇的和記憶色最相似的圖像與未經處理的原圖進行比較，得到記憶色色值的偏差，採用同樣方法可以得到第二組參照物的記憶色色值偏差。根據問卷中第二和第三個問題，受測者需要根據自己的喜好和審美從處理過顏色的 36 幅圖像中分別從 A1-A6、B1-B6、C1-C6、D1-D6、E1-E6、F1-F6 中選出一張，兩組共 12 張，將 12 幅圖進行兩兩比較，得出喜好與審美對於色彩影像品質之影響資料。

3.4.4 研究方法

在對實驗中提供兩組不同色彩屬性的實物，要求受測者觀察實物 5 秒鐘之後，參照根據實物所拍攝並印刷的原圖和經過 Photoshop 軟體調整資料的圖像填寫問卷。針對彩度、亮度、色相三個數值對於影像品質和選擇人數的影響進行 SPSS 統計和分析，檢驗三項變量之間與影響品質和人眼視覺二者之間是否有顯著性差異。以獨立樣本單因數變異數分析，比較三個(及)以上的平均數的差異。用在三個(及)互為獨立的母群的差異比較。最後，將所有資料進行整合進行描述性統計，分析受測者兩次實驗結果的資料，並分析受測者之記憶色與原圖色彩品質之差異以及個人喜好對色彩圖像品質之影響。實驗結果將依據人們之評量為圖像品質的判斷標準。由於心理量的資料是對不同的人的感知差異進行歸類和比較，並非如物理量能透過儀器測量出絕對的數值，所以其精准度會根據受測者的不同而有偏差。

3.4.5 實驗流程圖

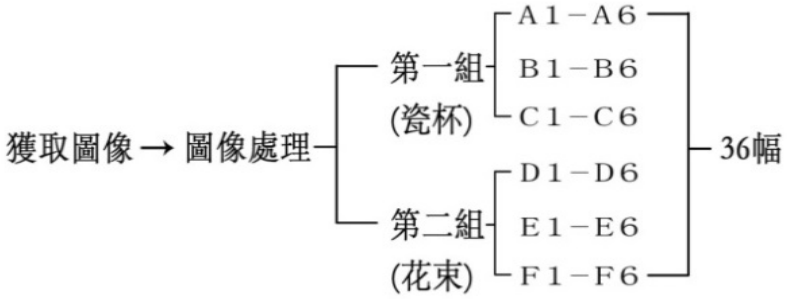

圖 8 圖像獲取

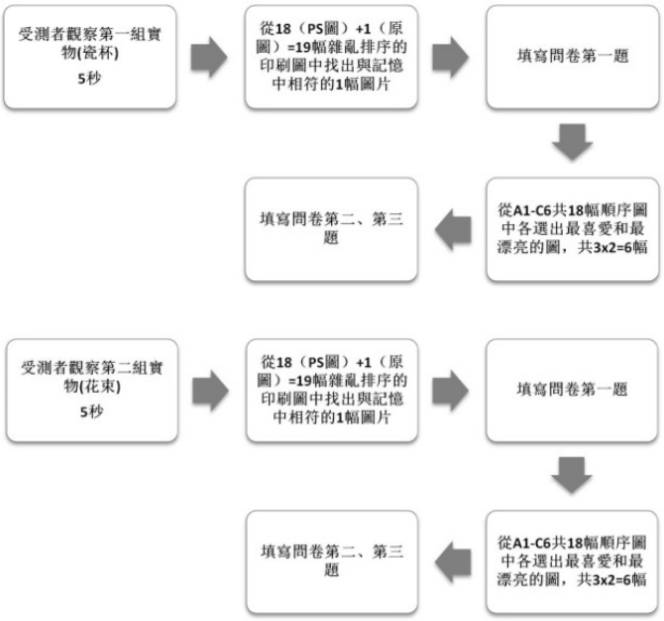

圖 9 實驗步驟

4 分析與討論

4.1 記憶色色值偏差

表 4 記憶色：第一組（瓷杯）受測結果

圖片編碼	選擇人數	占比%	調整數值
12	4	26.67	B+40
10	3	20.00	B+60
11	2	12.33	H+10
3	1	6.67	S+20
5	1	6.67	B+100
6	1	6.67	S+60
7	1	6.67	H+20
9	1	6.67	B+20
13	1	6.67	B+80
4	0	0	原圖

瓷杯組的受測結果顯示，在攝影棚內設定色溫為 4930K、照度 600lx 的光源下，有超過約 60%的受測者選擇了亮度增強的圖片，其中，約 26.67%（4 人）的受測者選擇 12 號圖，即亮度增加 40；約 20%（3 人）的受測者選擇了 10 號圖，即亮度增加 60；其餘受測者分別選擇了色相增強 10、彩度增強 10、亮度增強 100、彩度增強 60、色相增強 20、亮度增強 20 以及亮度增強 80；4 號原圖沒有受測者選擇。

表 5 記憶色：第二組（花束）受測結果

圖片編碼	選擇人數	占比%	調整數值
15	5	33.33	B+60
12	3	20.00	B+40
1	3	20.00	B+80
8	2	12.33	B+20
16	2	12.33	H+10
9	0	0	原圖

花束組的受測結果顯示，超過約 80%的受測者選擇了亮度增強的圖片，其中，有約 33.33%（5 人）選擇了亮度增加 60 的 15 號圖片。約 20%（3 人）的受測者選擇了 12 號圖，即亮度增加 40；另約 20%（3 人）的受測者選擇了 1 號圖，即亮度增加 80；有約 12.33%（2 人）的受測者分別和亮度增加 20 和色相增強 10 的 8 號和 16 號圖片；9 號原圖依然沒有受測者選擇。

在瓷杯組，即顏色對比度較高，色相相對單一且數量較少的第一實物組，影響記憶色色差的因素主要（選取平均值以上資料）為亮度和色相；在花束組，即顏色對比度偏低、數量較多且色相相對複雜的第二實物組，影響記憶色色差的因素（選取平均值以上資料）為亮度。所以在色溫 4930K、照度 600lx 的光源下，影響記憶色最大的因素（選取兩組均值為參考資料）為亮度，根據人眼視覺的差異，亮度的參考數值為增強 40 單位到 60 單位。

實驗結果顯示，在色溫 4930K、照度 600lx 的光源下，實物的顏色與人們在腦中所記憶的顏色存在較大的色差，多數人對於物體記憶色的偏差主要集中在亮度這一變數上，人的認知會傾向於將圖片上的色彩亮度提高，且物品顏色種類越豐富，提高的色彩程度越大；其次為色相和彩度，無論是哪一個變項，受測者都會傾向於認為色彩豐富的圖片才是符合自己所看到的實際物品的顏色，這可能是因為大腦會傾向於對具有鮮艷色彩的物品產生興趣，所以才會下意識的將提高了色彩鮮艷程度的圖片認為是所謂的原圖。

4. 2 彩度、亮度、色相之影響

描述性統計資料

影像品質

	N	平均數	標準偏差	標準錯誤	平均值的 95% 信賴區間		最小值	最大值
					下限	上限		
彩度	19	1.47	.513	.118	1.23	1.72	1	2
亮度	18	1.50	.514	.121	1.24	1.76	1	2
色相	17	1.53	.514	.125	1.26	1.79	1	2
總計	54	1.50	.505	.069	1.36	1.64	1	2

變異數同質性測試

影像品質

Levene 統計資料	df1	df2	顯著性
.027	2	51	.973

變異數分析

影像品質

	平方和	df	平均值平方	F	顯著性
群組之間	.028	2	.014	.053	.949
在群組內	13.472	51	.264		
總計	13.500	53			

表格2-1

圖 10 實驗一 ANOVA 結果

描述性統計資料

人數

	N	平均數	標準偏差	標準錯誤	平均值的 95% 信賴區間		最小值	最大值
					下限	上限		
彩度	19	3.16	2.089	.479	2.15	4.16	1	7
亮度	18	3.33	1.680	.396	2.50	4.17	1	6
色相	17	3.53	2.322	.563	2.34	4.72	1	8
總計	54	3.33	2.009	.273	2.78	3.88	1	8

變異數同質性測試

人數

Levene 統計資料	df1	df2	顯著性
1.410	2	51	.254

變異數分析

人數

	平方和	df	平均值平方	F	顯著性
群組之間	1.238	2	.619	.148	.862
在群組內	212.762	51	4.172		
總計	214.000	53			

表格2-2

圖 11 實驗二 ANOVA 結果

經由 SPSS 軟體 ANOVA 分析後的資料，顯示了選取的變數——彩度、亮度、色相對於色彩品質的影響，將所有受測者針對三個變數的兩次選擇進行綜合統計。結果表明，從影像品質的角度出發，選擇彩度為「喜歡」和「漂亮」有 19 次有效結果，標準差為 0.513；選擇亮度有 18 次，標準差為 0.514；選擇色相有 17 次，標準差為 0.514。其中 P 值為 0.973，即從統計學角度來看三個變量，彩度、亮度、色相之間的任何單項變量對於色彩品質的影響沒有顯著性的差異。根據實驗二的 ANOVA 分析後的資料顯示的結果表明，從選擇的有效人數的角度來看，選擇彩度為 19 人，標準差為 2.089；選擇亮度有 18 次，標準差為 1.680；選擇色相有 17 人，標準差為 3.53。其中 P 值為 0.254，這意味著從統計學角度來看，彩度、亮度、色相三個變量之間的任何單項變量，對選擇的有效人數的影響也沒有顯著性的差異。這兩個實驗結果意味著從影像品質和受測者選擇的結果看，彩度、亮度和色相均不產生任何實質性影響。

4. 3 記憶色對色彩影像品質影響之數值

表 6 記憶色對瓷杯組色彩影像品質之影響（喜歡）

图片编码	选择人数	占比%	调整数值
A5	7	33.33	S+40
A4	5	13.33	S+20

A2	1	6.67	S-10
A3	1	6.67	S+10
A6	1	6.67	S+60
A1	0	0	S-30
B4	6	40.00	B+60
B3	3	20.00	B+40
B5	3	20.00	B+80
B6	2	12.33	B+100
B2	1	6.67	B+20
B1	0	0	B-20
C3	8	53.33	H-5
C4	3	20.00	H+10
C2	2	12.33	H-10
C5	2	12.33	H+20
C1	0	0	H-20
C6	0	0	H+30

表 6 整理了瓷杯組（第一組）在只調整其中一項變數的數值，保持另外兩個變數數值不變的情況下，受測者對於「喜歡」的圖片的選擇。結果顯示，在圖片編碼為 A1-A6 組中，調整彩度（Saturation），保持亮度和色相不變的情況下，有約 46.66%（7 人）的受測者選擇了圖片 A5，即彩度增強 40 單位；圖片 A1 為彩度減弱 30 單位，沒有人選擇；其它分別有約 33.33%（5 人）的受測者選擇圖片 A4，即彩度增強 20 單位；當彩度調整為減弱 10 單位、增強 10 單位和增強 60 單位時，分別只有 1 人選擇，各約占總數的 6.67%。在圖片編碼為 B1-B6 組中，調整亮度（Brightness），保持彩度和色相不變的情況下，有約 40%（6 人）的受測者選擇了圖片 B4，即亮度增強 60 單位；圖片 B3 和 B5 各有約 20%（3 人）的受測者選擇；圖片 B6 和 B2 為亮度增強 100 單位和 20 單位，分別有約 12.33%（2 人）和約 6.67%（1 人）的受測者選擇為「喜歡」；沒有受測者選擇亮度減弱 20 單位的圖片 B1。在圖片編碼為 C1-C6 組中，調整色相（Hue）而保持彩度和亮度不變。結果有超過一半（約 53.33%，8 人）的受測者選擇了 C3，即色相減弱 5 單位；有約 20%（3 人）的受測者選擇了色相增強 10 單位的圖片 C4；圖片 C2 和 C5 都有約 12.33%（2 人）的受測者選擇；當色相減弱 20 單位和增強 30 單位的時候，沒有人「喜歡」。

表 7 記憶色對瓷杯組色彩影像品質之影響（漂亮）

图片编码	选择人数	占比%	调整数值
A6	6	40.00	S+60
A4	5	13.33	S+20
A5	3	20.00	S+40
A2	1	6.67	S-10
A1	0	0	S-30
A3	0	0	S+10
B5	5	13.33	B+80
B4	4	26.67	B+60
B6	4	26.67	B+100
B3	2	12.33	B+40
B1	0	0	B-20
B2	0	0	B+20
C3	8	53.33	H-5
C4	4	26.67	H+10
C5	2	12.33	H+20
C6	1	6.67	H+30
C1	0	0	H-20
C2	0	0	H-10

表 7 是瓷杯組（第一組）在只改變三個變數中的一個變數而保證另外兩個變數不變的情況下，受測者對於「漂亮」的圖片的選擇。結果顯示，圖片編碼為 A1-A6 組中，改變彩度（Saturation），保持亮度和色相不變的情況下，有約 40%（6 人）的受測者選擇了圖片 A6，即彩度增強 60 單位；有約 33.33%（5 人）的受測者選擇了彩度增強 20 的 A4；有約 20%（3 人）的受測者選擇了 A5，約 6.67%（1 人）的受測者選擇了 A1，兩張圖片的色彩調整分別為彩度增強 40 單位和彩度減弱 10 單位；圖片 A1 和 A3 沒有受測者選擇。在圖片編碼為 B1-B6 組中，調整亮度（Brightness），保持彩度和色相不變的情況下，有約 33.33%（5 人）的受測者選擇了 B5，即亮度增強 80 單位；各有約 26.67%（4 人）的受測者選擇了圖片 B4 和 B6，即亮度增強 60 單位和 100 單位；剩下約 12.33%（2 人）的受測者選擇了亮度增強 40 單位的 B3；當亮度增強或減弱 20 單位時，沒有受測者選擇。在圖片編碼為 C1-C6 組中，調整色相（Hue）而保持彩度和亮度不變。結果同樣有超過一半（約 53.33%，8 人）的受測者選擇了 C3，即色相減弱 5 單位；有約 26.67%

（4 人）的受測者選擇了 C4，即色相增強 10 單位；有約 12.33%（2 人）和約 6.67%（1 人）的受測者選擇了 C5 和 C6，兩張圖片色彩調整資料為色相加強 20 單位和 30 單位；沒有受測者選擇色相減弱 20 單位和 10 單位的 C1 和 C2 為「漂亮」圖片。

表 8 記憶色對花束組色彩影像品質之影響（喜歡）

图片编码	选择人数	占比	调整数值
D5	5	13.33	S+40
D3	4	26.67	S-10
D4	4	26.67	S+20
D1	1	6.67	S-30
D2	1	6.67	S-20
D6	0	0	S+50
E4	6	40.00	B+60
E3	5	13.33	B+40
E5	3	20.00	B+80
E2	1	6.67	B+20
E1	0	0	B-20
E6	0	0	B+100
F4	6	40.00	H+10
F3	5	13.33	H-5
F2	3	20.00	H-10
F1	1	6.67	H-15
F5	0	0	H+20
F6	0	0	H+25

表 8 為花束組（第二組）只調整其中一項變數的數值，保持另外兩個變數數值不變的情況下，受測者對於「喜歡」的圖片的選擇。結果顯示，在圖片編碼為 D1-D6 組中，調整彩度（Saturation），保持亮度和色相不變的情況下，有約 33.33%（5 人）的受測者選擇了彩度增強 40 單位的圖片 D5；各有約 26.67%（4 人）的受測者選擇了 D3 和 D4，即圖片的彩度減弱 10 單位和增強 20 單位；各有約 6.67%（1 人）的受測者選擇了 D1 和 D2，即彩度減弱 30 單位和 20 單位；沒有受測者選擇彩度增強 50 的 D6。在圖片編碼為 E1-E6 組中，調整亮度（Brightness），保持彩度和色相不變的情況下，有約 40%（6 人）的受測者選擇了圖片 E4，即亮度增強 60 單位，各有約 33.33%（5 人）和約 20%（3 人）的受測者選擇了亮度增強 40 單位和 80 單位的 E3 和 E5；有約 6.67%（1 人）的受測者選擇了亮度增強 20 單位的 E2；當亮度減弱 20 單位或增強 100 單位時，沒有受測者選擇。在圖片編碼為 F1-F6 組中，調整色相（Hue）而保持彩度和亮度不變。結果有約 40%（6 人）的受測者選擇了圖片 F4，即色相增強 10；分別有約 33.33%（5 人）、20%（3 人）和 6.67%（1 人）的受測者選擇了圖片 F3、F2 和 F1，色相調整數值分別為減弱 5 單位、減弱 10 單位和減弱 15 單位；當色相增強 20 單位或 25 單位時，沒有受測者選擇。

表 9 記憶色對花束組色彩影像品質之影響（漂亮）

图片编码	选择人数	占比	调整数值
D4	5	13.33	S+20
D5	5	13.33	S+40
D3	3	20.00	S-10
D1	1	6.67	S-30
D6	1	6.67	S+50
D2	0	0	S-20
E5	6	40.00	B+80
E4	3	20.00	B+60
E2	2	12.33	B+20
E3	2	12.33	B+40
E6	2	12.33	B+100
E1	0	0	B-20
F4	6	40.00	H+10
F3	4	26.67	H-5
F1	2	12.33	H-15
F5	2	12.33	H+20
F2	1	6.67	H-10
F6	0	0	H25

表 9 為花束組（第二組）只改變三個變數中的一個變數而保證另外兩個變數不變的情況下，受測者對於「漂亮」的圖片的選擇。結果顯示，圖片編碼為 D1-D6 組中，改變彩度（Saturation），保持亮度和色相不變的情況下，各有約 33.33%（5 人）的受測者選擇了彩度增強 20 單位和 40 單位的圖片 D4 和 D5；約 20%（3 人）的受測者選擇了圖片 D3，即彩度減弱 10 單位；另外分別有約 6.67%（1 人）的受測者選擇了 D1 和 D6，即彩度減弱 30 單位

和增加 50 單位；沒有受測者選擇彩度減弱 20 的 D2。在圖片編碼為 E1-E6 組中，調整亮度（Brightness），保持彩度和色相不變的情況下，有約 40%（6 人）的受測者選擇了圖片 E5，即亮度增強 80 單位；有約 20%（3 人）的受測者選擇了圖片 E4，即亮度增強 60 單位；其餘的受測者約 12.33%（2 人）分別選擇了圖片 E2、E3 和 E6，圖片調整數值分別為增強 20 單位、40 單位和 100 單位；圖片的亮度減弱 20 單位時，沒有受測者認為它「漂亮」。在圖片編碼為 F1-F6 組中，調整色相（Hue）而保持彩度和亮度不變。結果同樣有約 40%（6 人）的受測者選擇了圖片 F4，即色相增強 10 單位；有約 26.67%（4 人）的受測者選擇了 F3，即色相減弱 5 單位；分別有約 12.33%（2 人）選擇了圖片 F1 和 F5，圖片調整的數值分別為色相減弱 15 單位和增強 20 單位；只有約 6.67%（1 人）認為色相減弱 10 單位時，圖片是「漂亮」的；當色相增強 25 單位時，沒有受測者選擇。

透過實驗不難發現，人們對於顏色的影像品質在「喜歡」這一關鍵字上存在一定的偏差，但偏差的數值較小。從顏色對比度較高、色相相對單一且數量較少的實物與顏色對比度偏低、數量較多且色相相對複雜的實物的對比上看，兩者的數值偏差不大，基本集中在彩度增強 40 單位、亮度增強 60 單位、色相減弱 5 單位的程度上。其中，在彩度、亮度、色相三個變數中，人們對於亮度的數值偏差大於另外兩個因素，而色相的調整參考數值是以減弱 5 單位為人們「喜歡」的色度。

從彩度、亮度、色相三個變數中，人們對於顏色的影像品質在「漂亮」這一關鍵字上存在的偏差集中在色相上，其中對於顏色對比度較高、數量較少且色相相對單一的實物圖片在調整的時候，色相需要減弱一定數值，減弱的參考值為 5 單位；顏色對比度偏低、數量較多且色相相對複雜的實物圖在調整的時候需要在不改變顏色的前提下增強物體顏色之間對比的差距，即色相需要增強，增強的參考值為 10 單位。另外兩個變數——彩度和亮度在調整時都需要增強，增強的參考值分別為彩度增強 40 單位、亮度增強 60 單位。

另外實驗發現，在調整了亮度和彩度之後，對於被認為是「漂亮」的圖片與「喜歡」的是並非是同一幅，就是說受測者在選擇和判斷時，對圖片的評價和偏好是區分開來的，即「雖然我覺得這張圖是最漂亮的但并非是我最喜歡的」。這一現象也給色彩偏好研究提出了新的且有價值的議題。

5 結論與建議

通過實驗結果發現，人們對於無論是記憶色還是「喜歡」和「漂亮」的印刷品，亮度都會成為比較大的視覺影響：在對於色彩單一、數量較少且對比較大的實物圖進行色彩調整時，不僅要對亮度進行一定的增強，色相要相對減弱，彩度的調整資料介於二者之間。最終，若印刷品傾向於「喜歡」，具體調整參考數值為：亮度增強 60 單位、彩度增強 40 單位、色相減弱 5 單位；若印刷品傾向於「漂亮」，則在進行顏色複雜、數量較多且對比度較小的實物圖片色彩調整時，在不偏離主色調的前提下，儘量加強各個實物之間的色相差距，亮度和彩度的數值也要在一定程度上增強。具體調整參考數值為：亮度增強 60 單位、彩度增強 40 單位、色相增強 10 單位。

實驗的過程是要探討實物的顏色與人們在腦中所記憶的顏色色差的具體數值，同時，根據人們對於「喜歡」和「漂亮」的感性定義，從調整數值不同的圖片中進行選擇，最後分別從彩度、亮度、色相這三個方面得到具體數值，作為研究影響色彩影像品質的最終結果，並將結果運用於實際印刷的實踐中，作為理論依據和參考。由於本研究僅為探討記憶色對彩色影像品質之影響小規模的前測研究，故僅選擇兩組日常物品作為樣本，未來可以採取更多樣本和受測者進行試驗，增加實驗的準確性，找到更多的角度對於影像品質進行研究，如對比度、銳利度、曝光度等；或可以在改變色溫和照度的光源下（建議選擇冷色光）重新進行實驗，並將兩次的結果進行比對。本次研究的結果發現，被認為是「漂亮」的圖片未必是最「喜歡」的圖片這一現象，未來也可在此次結果的基礎之上，針對不同的目標受眾，分別就「喜歡」與「漂亮」做專門的主題研究。在受

測者的選擇上，也可以將「設計專業人員」與「非設計專業人員」分別進行研究，將兩次結果進行比較，從而判斷「專業知識」是否會是成為色差判別的影響因子，進一步豐富有關色彩的認知差異與記憶色之間關係的領域研究。

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附錄 1：（前測所用的調查問卷）

調查問卷	
性別：男 \ 女	班級：碩士班 \ 博士班
1，哪張圖的顏色與您之前看到的原物最相符？	
瓷杯組：	花束組：
2，請分別從兩張圖的三個分類中分別挑選出一張你認為最「喜歡」的圖。	
A：	D:
B：	E:
C：	F:
3，請分別從兩張圖的三個分類中分別挑選出一張你認為最「漂亮」的圖。	
A：	D:
B：	E:
C：	F:

空間文化創意研究—以高雄市老屋再利用之餐廳個案調查為例

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摘要

高雄市近年發展文化創意，興起許多老屋再利用成商業餐廳的之個案，在延續歷史與經濟發展雙重考慮下，其儀式內涵與外在形式的創意，常左右老屋核心價值的定位與規劃設計。本研究先透過老屋再利用文獻進行探討，形成論述依據；再者，針對高雄市具有 40 年以上歷史老屋再利用成餐廳的 14 個案進行調查提出研究發現。主要具體成果為：一、餐廳作為老屋再利用的載體，對原有老屋結構硬體更變影響較小，也增加空間停留時間體驗。二、案例中商業經營與文化教育觀念的取徑差異，造成再利用呈現真實體驗、過度商業化與虛構氛圍的不同。三、老屋餐廳空間文創可分舊有為主、新舊共融、虛構歷史三種方式，而舊元素修護與新舊元素對比的設計手法最為普遍。

關鍵詞：室內設計、老屋再利用、文化創意

Cultural Creativity Strategy – Case Study in Restaurants Converted from Old Houses in Kaohsiung City

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ABSTRACT

The development of cultural creativity in Kaohsiung has encouraged the conversion of many old houses and buildings into commercial restaurants in recent years. With the consideration of the continuation of cultural values and the development business and economy, the cultural creativity strategy of internal rituals and external appearance often dictates the position of core values for old houses and the operation of planning and design. The theoretical foundation of this study was established by reviewing literatures of old house reuse. A field survey focusing on characteristics and current status was conducted on 14 cases of converting old houses of 40 years or older into restaurants in Kaohsiung City. The following are the findings: 1. The use of restaurants as the carrier for old house reuse has little impact on the changes in the old houses in terms of structure, and adds the ambience of time experience and spatial perception; 2. The gap between the property ownership and the concepts and values of cultural education allows the development of old house reuse to present the true ambience, over-commercialization and a fictional atmosphere as it is; 3. The cultural creativity strategy of old house restaurants comes in three categories, nostalgia, fusion of old and new, and fictional history, where the most common practice is to incorporate the contrast of old and new elements and the association with historic presentation, indicating the popularity of the fusion of old and new.

***Keywords*:** Interior design, Old House Reuse, Cultural Creativity

1 前言

空間文化創意，是建立在多年社區總體營造的基礎上，目的是將文化產值化，達到厚植國家經濟與地方收入與環境改造，提升在地生活品質與文化保存。然而，近年台灣面臨全球金融景氣低迷、中美貿易談判等國際情勢，以及少子化、高齡社會的國內困境，政府與民間如何創造經濟發展與環境創生，成為重要的課題。室內設計扮演日常創意與建築硬體整合的工作，融入美感與機能來建構良善的生活環境。文化創意與室內設計皆是認識歷史與記憶情感的重要媒介，兩者是感性兼具理性的認識，而老屋再利用就是這樣的認識，確切的說，更含括一切概念的認識，是屬一種傳達在地文化與生活真實的認識。

餐廳是集合空間文化創意與室內設計重要的場域，身處在歷史感與記憶的空間用餐是一種理解，也是一種存有方式。餐廳空間是抽象概念，它不似民居受到地方性與文化歷史的制約，更不像教堂廟會儀式與象徵界域的規範，它始終附依日常飲食活動，承載物資滿足消費需求，同時也經營與反映文化。文化創意的餐廳空間因文化工業繁榮而產生異化，這概念包含同質社群聚集與跨文化界域的表達，也是消費主義被推展的常見，透過飲食活動由現代過渡到後現代，其特徵也由國族國家概念過渡到資本消費時代與分眾的可能。有歷史文化的餐廳、有文化創意的餐廳、有年代老房子的餐廳在全球與在地蔓延開來，高雄市也在此風潮下產生許多老屋再利用的實例，透過在地文化與情感，再利用成為歷史與記憶的場域。

老屋再利用最佳途徑是維持它被持續使用，因為在使用中，當時生活景觀與日常氛圍能清楚呈現，讓現代人可理解與體會。雖然被繼續使用這詞很籠統，也無精確性，但無論如何，這樣的名稱可保持一種屬於過程存在整體的要求或者是回歸的可能，因此維持原來用途乃是最佳的保存方式。其中，使用中的維護成本必需考量，因此再利用手法，必然涵蓋經濟收與支的規劃，也需留意因應現代生活方式所帶來的微調與修正。

舊房子隨著時間會變得陳舊與殘破，但其蘊藏的記憶與故事卻是新造房子所創造不出的，改造是將老房子注入活力與新鮮，同時是保存記憶最好的方式，再利用是一個不斷被建構、實踐、詮釋、集體性的參與過程，背後都有未見之指向，通過再利用本身之暗示與明示，指向利用不能真及之存在理想的終極。高雄市老屋再利用，很多都是進行商業空間的餐廳改造，除延續房子本身的效益與價值外，另外在改造同時，注入在地文化特色與空間記憶，成為都市與社區的休閒風景，有的也兼具文化活動，進一步凝聚社區居民意識，對建物、居民、遊客與社區有種積極正面的效益。

高雄作為台灣南部海洋城市，在面臨政治政黨治理變化，庶民經濟成為重要的議題，在既有民以食為天觀念中，商業空間餐廳是經濟活動最能夠察覺的載體。因此，本研究以高雄市 40 年以上的老屋作為研究樣本，聚焦在老屋再利用為餐廳的空間個案，經過聯絡與意願的受訪，共進行 14 個實際案例的訪查，包含三民區 2 棟、左營區 1 棟、前金區 2 棟、前鎮區 1 棟、苓雅區 2 棟、鼓山區 3 棟、鹽埕區 3 棟。主要研究目的為探討高雄市老屋再利用成為餐廳的空間創意情形？文化記憶與歷史情感的文化創意手法為何？再利用的空間設計為何？希望透過本研究的發現，提出面對高屋齡的老房子，在從事餐廳商業空間環境改造時，可供參照的初步認識。

2 文獻探討

2.1 生活與記憶的創生

羅蘭巴特在其符號學論述曾經描述摔角是種景觀，是一發不可收拾的景觀。「現場實境中每一個姿態都能使人全盤瞭解某種單獨爆發的熱情，每一動作符號都被賦與絕對清晰，…因此摔角是種種景觀的總和」（Barthes，1972：115）。而老屋再利用的場景也確為是一種姿態，猶如巴特論述的摔角姿態，其目標不全是讓老屋獲得以往的既有功用，而是確實完成所謂的預期動作，這動作旨在傳達空間的魅力與感染力，對於老屋中每一空間符號都被賦予絕對的清晰，企圖讓所有體驗老屋的人，必須自始至終當下理解每一件與空間記憶有關的事與物，或是新的可能在既有的舊空間。

所謂「老屋」有四項評斷：「一、老屋為民眾私人所有，意即非屬公共性質建築，與民眾生活相關。二、老屋是被使用過程之中長時間被閒置或呈現遺棄狀態，失去原有機能，大多數再利用契機都是建築本身具有潛力。三、空間特色之留存與利用是體現老屋具體價值與展現其獨特、稀有意涵。四、老屋工藝技術與材料具有當代意義，無形技術轉換成有形藝術，替歷史做紀錄。」（林雅君，2012：46）。

老屋再利用，則將一個老舊建築適應現代為目的之情況下，透過重組使其獲得全新機能，並使之能延續文化並在現代生存。「老屋整理後，便是在建築生命週期中透過用途的改變，或是重組建築物來延續機能，適當的調適這個過程便是「再利用」」（李清泉，1993：85）。

老屋經整理後便是透過手法來改善建築物並延長生命週期，而手法是須要強化原有空間特性，但並非完整地保留，應該是要賦予時間感在其中，讓觀賞人能從中感受時間的流逝性（王惠君，2001：6）。再利用的方式，約略可分成以下四大種類：「一、展示為主之再利用經營；。二、藝文活動使用之再利用經營。三、休閒遊憩結合之再利用經營。四、餐飲消費之再利用經營。」，不同老屋空間所適合再利用策略，常因客觀條件因素各有差異，選擇最適當方式是兼顧營利與維護老屋原有文化（洪慦璜，2001：31）。不論是古蹟、歷史建築、閒置空間，再利用都應建立在結構安全上，使之兼具史實並延續建築生命週期，並獲得相當程度的經濟條件，因此應有三點考量：一、建築物生命週期在循環與機能持續使用。二、結構安全與經濟存活兼顧的保存方法。三、史實性與現代性兼顧的保存」（傅朝卿，2001：1.8）。

老屋再利用是場域活化的開端，台灣現階段進入老年化、少子化及經濟遲緩的困境下，地方創生與空間改造成為振興當地、提高地方發展與創造地方就業的良策。徐彥婷就國家與地方創生發展政策議題，介紹日本尾道市、英格蘭利物浦市、基隆太平國小基地、台北萬華新富町市場四個典範案例。日本尾道市的 2008 年空屋再生計畫中，北村洋品店搖身一變為兒童服裝雜貨店，三軒家由舊公寓改造成咖啡店、有機食堂等，並舉辦文化活動，此案例獲得日本地域再生大獎。英格蘭利物浦市在去工業化變成蕭條城市甚至是治安的死角，在 2014 年啟動「十屋計畫」、「四街角計畫」，當地居民以當地材料自行裝飾美化，於 2015 年獲英國透納獎，社區定期舉辦市集並凝聚社區意識。台灣北部廢校的基隆太平國小，在基隆市政府與元智大學攜手合作再生，獲得 2017 國發會「空間活化場域指標獎」。台北萬華沒落老舊街區的「新富町食料品小賣市場」被市政府指定為古蹟後，由忠泰基金會進行活化利用，將新生命注入老舊市場，於 2017 年獲得「老屋新生大獎」。（徐彥婷，2019：105）

在這些典範案例中，新舊手法設計包含複製、過度、對比、聯想與襯托等規劃概念，並根據社區、居民與參與者，在共同目標進行議題的改造與利用。再利用能否成功關鍵乃是取決於居民、參與老屋者、公部門、規劃者們共同觀察，發覺現存築物之潛力，並利用其記憶與魅力，開發出空間新生命。老屋的空間文創模式，常見歷史與虛構的修飾原則，手法旨揭歷史情感與在地記憶。文化注入空間創意的設定，使老屋再利用設計手法包含有修飾的歷史、保存的歷史、再塑的歷史與虛構的歷史。高雄市的老屋再利用成餐廳，常見生活住宅所進行的再利用，意謂在業主與者設計規劃者巧思下，將老屋歷史文化記憶保留，並增加消費者親身體驗，所以餐廳用途的置入，常成為經濟收入與保留體驗兼顧的普遍策略。

2.2 魅力與美學的創意

魅力是種吸引，日本的感性工學，將魅力工學編入其中，由消費者選擇消費商品的方式與產品設計的成功經驗，便可捕捉魅力特質。陳怡芳等就魅力因素進行台南老屋咖啡店空間進行探討，發現消費者對於咖啡館魅力，提及最多的抽象因素是建築美感。建築美感因素評價的構造圖，以建築風格的多元（閩式、日式、巴洛克式）、採光良好（天井、落地窗、窗戶多、復古窗、格狀拉門）、復古建材（紅磚牆、洗石子、榻榻米座位）。一棟吸引人的老屋擁有風格美感、良好採光與復古建材是魅力主要的因子（陳怡芳、馬敏元，2015：4）。

另外在老屋本身的魅力屬性評價上，簡慧錘等以台南五條港的「老屋欣力」為對象進行研究，透過專家問卷挑出 9 項空間感屬性以及 22 個情感認知的評價項目，運用上述的評價進行 40 位專家與 220 位一般相費者進行 31 個影響消費者的問卷評估。結果專家認為「獨特風格」與「室內保留原本風貌」是最重要的，而一般消費者則認為「新生命感」與「創意的」才是重要的。其中的「新生命感」是專家與一般消費者相交疊的重要評價項目（簡慧錘、吳連賞，2017：11）。這研究顯示老屋進行改造再利用，必須思考人與環境的「新關係」，這透露出創意的空間遠比復原的空間更讓人期待與接受，也使老屋再利用的魅力評價不只是所謂的古歷史與文物的保存。

只有當我們能夠居住，我們然後才能建築，只有我們理解居住，才能體會生活美學。生活美學是透過審美感受日常的所有並滿足於當下。知覺是人一般認知，僅就事實認定無關情感，而審美是知覺與快感的結合，並對事物本質做直接把握，海德格就曾針對居住，進行哲學論述，在他的〈築・思・居〉一文中，提到棲居概念，所謂棲居就是讓居住，而他所談論的建築本性是讓居住（Heidegger，1971：146）。黑森林農舍在兩百多年前由農民的居住所建造，這裡使天地人神四元合一整體，建立了住宅。他描述著農場安置在草地中間，靠近泉水向南避風的山坡，給住宅寬闊的懸垂屋頂蓋板，蓋板恰好斜撐著屋面上雪的重壓，深深地向下延伸，保護著房屋渡過那漫漫冬夜的風暴。聖壇在房間裡為搖籃留下神聖之地，以此方式它為幾代人在同一屋頂下經歷不同時代。

「場所」聚集天地神人四元，通過這個場所，構成空間的「所在」和方式得以確定。作為「所在」，提供了場所的物，我們叫做「建築」。建築師面對時代，勇敢地用新建築實踐新生活，回到建築的原點，不斷探問過去。建築別於「建築物」（building）或「構造物」（construction），因建築具有生活美學意義或特徵。一種由居住產生的，仍然使用作為物的工具構架的工藝，建造農舍。黑森林的農場，並不意味著我們應該或者能夠回到這種住房的建築。不如說，它代表我們過去一個（已經存在的居住）如何能夠去建築（王應棠，2009：28）。

文化再創意的本質在講求文化厚度、感動的深度與產業接受的廣度。文化內度需要關懷生活的主張、品味與型態；創意感動深度需要尋求象徵意義、消費符號與創意商品；產業的接受廣度則形成品牌、行銷策略與創意注入的推動（林榮泰，2011：Ⅱ）。在融合文化與美學的操作下，文化創意設計所產生的新興產業，其務實做法包含了科技加持設計、文化即生活風格、全民參與美學及經濟是生活型態。上述是新興產業推動文化創意的關鍵，也是文化創意注入老屋再利用的參照因素（林榮泰、林伯賢，2009：99）。空間文化創意針對具有在地歷史老屋進行利用，使用科技與設計力建構在地生活風格的場景，並結合社區文藝活動、開發特色文創商品，產生餐飲咖啡論壇，成就民眾參與的生活美學。

老建築本身就是文化，就是生活。在哲學實踐中，將建築所在辨識出為已經是特別，形式決定這種直接結果，將變成無意義。文化是種自明，這樣的自明性成為思想，而非自明性的假定。自明性的語用論不曾被排除，其需要的是作為問題之自明性的回歸。建築不是一種封閉的專業，而是一種生活的方式，無論我們到那裡旅行，最容易感受到的當地文化便是建築，尤其是具有時間感與歷史感的老房子，它呈現的是迷人獨特的地景、風景與視野，更訴說從前的生活方式與日常價值。這也是老屋魅力與美感的地方。

2.3 歷史與文化的創價

建築空間是對自然外界的抵禦與營造，產生「裡」、「外」分別，在生活社交彼此產生連結，建構起社會文化組織，這空間構築與社會組織息息相關，老屋透過活動、組織、形體與視覺形象，形成社會文化的認知（徐明福，1990：9）。地方的歷史即是地方的文化資產，如何運用地分的歷史感常是民間空間文創慣用的主要手法。對於老屋必須有歷史脈絡解析與思維，透過時代與時俱進，構想出延續老屋壽命的計畫，使之能繼續在新時代生存且持續被使用是重要的原則。「周遭環境、歷史沿革、關係人、建築主體空間組織、造形、構造、裝修樣式、物理環境系統等」、「老屋的再利用對於干預等級以及新舊共存的手法這兩件事情，是必須被注意且執行，而所謂的干預等級分成：1.衰敗防治 2.保養 3.原貌保存 4.穩定 5.補強 6.修繕 7.歸位 8.置換 9.修復 10.複製」，新舊共存的設計層級分成：「1.歷史古蹟 2.歷史為鄰 3.歷史成長 4.歷史軀殼 5.歷史點綴」（傅朝卿，2010：224）。干預是保存修繕的手段，再利用是活化創生的良方。

建築本身歷史價值影響著修繕保存與再利用的程度，重要歷史建築富含文化性，修繕方式著重完善保存，以利文化延續與傳承。另外，民間歷史建築若非含有重要文化意義，其設計手法則著重於再利用，使之能在新世代被持續使用而非棄置或拆除。歷史是記憶、是文化，更是地方創價的基礎。建築的設計歷史作為老屋利用的理論建構，有西方保存修復概念、再利用設計層級的分析與「設計歷史」為老屋再利用的觀念（林雅君，2012：39-48）。

優質的老屋再利用有三點認知：一、真實性為核心，可適性改造而非過度更新與破壞歷史文化特色，更不創造虛構歷史。二、發展在地文化價值，推廣並使之成為城市價值。三、柔性融入社區成為日常生活的據點，不過份強調商業利益，而是以在地為主（張玉璜，2014：48）。

因此，老屋再利用的空間創意，是立基於歷史的真實性，並兼顧經濟發展與在地文化，注入一股歷史情感與文化記憶。老屋建築形式與文化對於外來觀光客而言，時代性以及在地性的歷史都能傳達深層的文化內涵，成功的利用老屋歷史感並結合現代技術及創新思維，能使空間設計產生截然不同的文化層次，也使社區經濟發展與在地價值，獲得更正面的推動與肯定。

西方的傳統修復代表著「超越」，亦即復原至未曾存在過的完整狀態，然而也引起許多反對不實描述過度的批判，這兩股力量引起正視歷史的正確性，亦即是修復應該顯示歷史性建築完整的歷程。另外，再利用的層級應該以積極活化態度來看待，是重要的核心價值如何再創價。因此，應視建築歷史重要性，評估保存與再利用。例如國家級的歷史建物，其存在有重要意義，限制與干預就越強，而舊建築與老屋再利用的自由與可能就相對的彈性。設計歷史作為老屋再利用的觀念，需伴以城市景觀

作為整體思考，因為城市重要組成即是住宅，變遷是老屋歷程與調適，在新生活與舊日常的對話下，老屋循著歷史開展成為今昔對話與連結。台灣高雄的老屋，在都市紋裡的變遷下，有其地方性特色，在去工業化的今日，如何與時俱進的發展與再利用，以創意、創價的空間處理手法，連結既有歷史與今日對話，儼然成為再利用的最佳方式。

2.4 干預與活化的分析

干預與活化都是老屋再利用的手法，依其老屋建築對於歷史的重要與價值。本研究審視研究樣本個案現況，依其干預與活化的程度，初步提出老屋再利用手法的分類（表 1）。

依其程度，分為舊有為主、新舊共融與虛構歷史三者。在舊有為主，又分為舊屋完整保存、舊有元素修護、新舊元素比對三種操作。在新舊共融手法分為文化型態再塑、機能結構改善、改變使用型態三項操作。在虛構歷史操作手法，主要是歷史樣貌與仿造關連性的操作。在每個操作中，以綱要文字敘述空間再利用操作手法的原則與樣態，增進在個案分析、分類再利用程度的歸納與說明。

表 1 老屋再利用手法分類表

A 舊有為主		B 新舊共融		C 虛構歷史
A1 舊屋完整保存	**空間文化策略：** 將舊有事物完整保存或部分保存，留在老屋再利用空間。 **室內設計手法：** 如保留老舊竹夾泥牆，使文化意義透過老牆的空間元素傳遞。給參觀者最直接視覺感受，空間氛圍的感覺也是真實的。	**B1 文化型態再塑**	**空間文化策略：** 透過歷史痕跡來顯露與現代環境共構，形成文化再塑形，新與舊共存。 **室內設計手法：** 例如將包覆的水泥牆面拆開，顯露出原有紅磚牆樣貌，將隱藏不顯眼的歷史文化顯露出來，讓參觀者有更多文化體驗與歷史認知。	**歷史樣貌與仿造關聯性** **空間文化策略：** 將虛構的歷史風貌，重新呈現在空間中。 **室內設計手法：** 製作不屬於該建築歷史傳統的元素，如磨石子地面或木造傳統櫃等，雖然對於這個空間是完全不相關的，但也能透過設計者本身的創意想法，呈現各種風格的室內空間，使人聯想舊歷史文化。
A2 舊有元素修護	**空間文化策略：** 將損壞或以安全為考量進行，去修繕舊有空間。 **室內設計手法：** 修復破損的屋瓦或磨石子地面，在還原該元素原始樣貌，以傳達真實的歷史訊息。	**B2 機能結構改善**	**空間文化策略：** 舊文化進入新世代，為適應現代環境而做的更動與修繕。 **室內設計手法：** 強化舊有建築結構材料，使之能適應現代並兼顧安全性，以不過分破壞舊文化前提方式去改造。	
A3 新舊元素對比	**空間文化策略：** 透過接近原始樣貌空間或物件作為背景，加入現代化的物件與元素。 **室內設計手法：**在紅磚牆掛上現代畫作，透過新舊之間所產生的對比對照，來製造不同文化視覺感受。	**B3 改變使用型態**	**空間文化策略：** 將舊有的器具、物件做為新的用途、新的改變機能作法。 **室內設計手法：**將老舊木屋頂桁架，轉為掛物架使用，轉換用途使之有新的價值。	

本研究歸納整理

3 研究範圍內容與方法流程

3.1 研究範圍與內容

本研究以高雄市一般老屋為研究對象，樣本選定為再利用成為餐廳的個案，排除政府公部門所認定重要性的古蹟、高歷史價值的文化資產，著重在民眾日常現代生活關連度高的老屋住宅，進行空間改造再利用的餐廳。選擇老屋再利用成為餐廳的考量，是餐廳普遍反映在地日常生活，亦是消費者喜歡聚集的場所。另外，對於空間體驗時間的停留，餐廳比一般零售業較久，也較能體驗建築美感與空間創意。

選取研究樣本時間的考量，一、為參考國內法規認定 1989 年之前所興建的建物為「舊有建築物」，並參酌國內常見的鋼筋混凝土建築構造，使用週期為 50 年。二、參考台南「老屋欣力」對於老屋的定義：「老屋：至少有 30 年以上歷史的老房子，且獲得妥善保存」（陳怡芳等，2015：2）。綜合兩者在本研究研究對象的老屋，定義為超過 40 年以上的建築。

另外，也考量老屋再利用的真實性改造、結合在地價值性融入社區的原則進行初步篩選後有 21 個案（三民區 2 棟、左營區 1 棟、前金區 2 棟、前鎮區 1 棟、苓雅區 2 棟、鼓山區 3 棟、鹽埕 4 棟、鳳山區 1 棟、新興區 1 棟、小港區 1 棟、鳥松區 1 棟、苓雅區 2 棟）。經過訪查後，意願受訪的為 14 棟。

本研究之樣本個案分布於高雄市三民、左營、前金、前鎮、苓雅、鼓山與鹽埕七個行政區，總計有 14 個研究對象，茲將研究案例的編號、名稱、建造年代、用途與地址，整理成個案資本資料表（表 2）。

表 2 本研究之老屋再利用餐廳個案 基本資料表

編號	個案餐廳名稱	西元建造年代	個案主要用途	研究個案地址
01	起家厝	1916	餐廳、文創商品	三民區三鳳中街 28 巷 9 號
02	逃咖啡	1971	餐廳、文創咖啡	三民區義德路 3 號
03	鬲离	1976	餐廳	左營區新上街 253 號
04	織織人 67 號	1941	餐廳、文創空間	前金區前金二街 67 號
05	公寓咖啡	1976	餐廳、文創咖啡	前金區仁義街 227 號
06	鄭江號緩食茶二店	1966	餐廳	前鎮區林森三路 52 號
07	高師大美學角落	1966	餐廳、展覽空間	苓雅區四維二路 88 號
08	鄭江號緩食茶	1966	餐廳	苓雅區和平一路 144 巷 33 之 3 號
09	樓梯腳	1956	餐廳	鼓山區登山街 34-1 號
10	一二三亭	1916	餐廳、文創商品	鼓山區鼓元街 4 號
11	叁食壹	1917	餐廳	鼓山區麗雄街 13 號
12	柒壹喫堂	1971	餐廳	鹽埕區大公路 71 號
13	好雙咖 2ins : H Cafe	1956	餐廳、文創咖啡	鹽埕區大成街 73 號
14	元啡驢派	1951	餐廳、文創咖啡	鹽埕區建國四路 276 號

本研究整理

3.2 研究方法與流程

本研究首先進行文獻回顧，透過用歷史文獻回顧法（Documentary Historical method），系統蒐集文獻，進行老建築在生活記憶的討論、建築美感魅力的生活美學及老屋對於歷史文化的影響。再利用的干預與利用呈現兩種不同空間營造方向思維，皆與建築的價值重要性及歷史文化有重要的關係。再者，整理文獻對於老屋再利用操作方法的原則，作為本研究理論基礎與空間改造手法的分析基礎。

本研究將相關設計手法與再利用的操作手法分類，將研究對象分為舊有為主、新舊共融與虛構歷史三種主要的老屋再利用策略，並檢視每件個案的空間現況，包含建築外觀、室內設計、裝修手法與裝飾展示，作為案例分析之依據。於 2016 年 2 月至 3 月，進行為期兩個月的實地訪查，紀錄高雄市 7 個行政區 14 間老屋再利用為餐廳個案，透過現況特色與設計手法，探討其空間規劃，提出具體研究成果。

本研究將再利用的原則分為：A 舊有為主、B 新舊共融、C 虛構歷史三者（圖 1）。並將三項原細分其中的再利用操作手法，分成 A1 舊屋完整保存、A2 舊元素修護、A3 新舊元素對比、B1 文化型態再塑、B2 機能結構改善、B3 改變使用型態、C 虛構歷史：歷史樣貌與仿造之關聯性七項設計手法，以上述進行個案的綜合分析（表 3）。

圖 1 老屋個案再利用的三種概念

另外，進行代表性個案的詳細分析。先說明配置設計原則及空間表情操作，包含平面規劃範圍的界定、建築立面的歷史或記憶營造。再者，進行老屋空間裝修部位的設計，例如：天花板形式的修復或創新、牆面開口門窗的運用、地板鋪面與選材等。最後進行細節的描述，例如：洗石子、馬賽克、花磚、紅磚、裝修細節、復古窗花等獨特的細部設計。綜述老屋氛圍的營造，並輔以訪查現場進行比對，盡可能完整描述老屋再利用成為餐廳的空間文化創意與保存意義。

表 3.本研究個案老屋之再利用設計手法分析

個案編號	研究個案名稱	原用途 / 結構 / 規模	設計手法 (●主要手法 / ○次要手法)						
			A-舊有為主			B-新舊共融			C
			A1	A2	A3	B1	B2	B3	虛構的歷史
			舊屋完整保存	舊有元素修復	新舊元素對比	文化型態再塑	機能結構改善	改變使用型態	
01	起家厝	日本軍官宿舍/R.C 結構/ 3F		○	○	●	○	○	
02	逃咖啡	舊街屋住商/ 磚木結構/ 2F			●	○	○		
03	鬲离	舊街屋住商/ R.C 結構/ 2F		●	○	○	○	○	
04	織織人 67 號	舊街屋住商/ R.C 結構/ 2F		○	●	○		○	
05	公寓咖啡	舊街屋住商/ R.C 結構/ 3F		○	●	○		○	
06	鄭江號緩食茶二店	舊街屋住商/ R.C 結構/ 3F		●	○	○		○	
07	高師大美學角落	師大學校宿舍 / R.C 結構/ 2F		●	○	○	○		
08	鄭江號緩食茶	舊街屋住商/ R.C 結構/ 4F		○	○	○		○	●
09	樓梯腳	住宅、倉庫 / 磚木結構/ 2F		○	○	○	●		
10	一二三亭	日治時期料理亭、茶館 / 磚木結構/ 3F	●	○	○		○		
11	叁食壹	日治時期診療所 / R.C 結構/ 3F	●	○	○	○	○		
12	柒壹喫堂	舊街屋住商 / 磚木結構/ 2F	●	○	○				
13	好雙咖啡 2ins : H Café	住家、商空 KTV / R.C 結構/ 3F		○	●	○	○	○	
14	元啡驢派	舊街屋住商/ 磚木結構/ 2F		○	○	○	○	●	

本研究分析與整理

4 研究分析與結果

4.1 以「舊有文化」為主的老屋再利用

4.1.1 舊屋完整保存：「叁食壹」個案

該個案老屋位於高雄市鼓山區，建於 1917 年，過去用途為診療所。老屋在荒廢幾年後，由業者承租下來經營「叁食壹」餐廳，外牆洗石子與鐵窗花，道出日據時期建築氛圍，與周遭建築能有所區別，部分破損牆面是不刻意修復而顯露，直接讓人了解營造的方式與結構，外觀完整，保留既有建築形式，所營造的空間氛圍盡可能保留真實的歷史。

個案目前用途為餐飲空間，日後將開放文創與小型工作室。進入到室內便能清楚看到當初老屋完整的木結構，承租人以鋼構補強來補強結構安全。建築外觀與大部分結構都完整地保存與修繕。室內空間導入懷舊元素，例如彈珠台、儲藏空間的木櫃，彼此呼應襯托，創造老屋的獨特韻味。「叁食壹」外牆為大量洗石子壁面，窗戶的鐵窗花、地面磨石子地磚也增添歷史感，破損部分不刻意維修。時間感的老屋風格相當吸引人，建築與室內設計立面幾乎看不到現代元素，推開近百年歷史的木門進入到室內，眼見的戶外磨石子地磚，延伸進來室內，進入抬頭就能看原始的木結構，室內設計利用繽紛色彩的鋼構來強化木結構，呈現特別的歷史視覺體驗。

4.1.2 舊有元素修護：「鬲离」個案

「鬲离」位於高雄市左營區，由 40 多年屋齡的老街屋改造。建築立面的洗石子牆，使龐大量體中維持統一的視覺風格，地處寧靜巷道，自遠方觀看老屋整體，沉穩地坐落並透露出樸實內斂。室內保留許多原始鐵窗花，另外，在施工過程中所標註的記號、柱位等痕跡也一併保留下來，其痕跡的新舊軌跡清晰可見，目前功能為餐飲空間與閱讀空間，但營業部分僅以一樓為主。

老屋留下許多老物件，利用舊時門柱與紅磚堆砌，將用餐區與街道隔開。木棧道改造成用餐區，後方保留過去木門與壓花紋，重新上色後貼上春聯，意指老屋新生再出發的意象。地面水泥不刻意掩飾，是大方地展示出來，僅以打磨處理，上頭的施工紀錄圖、打磨痕跡等，一概被保留下來，消費者可以透過這些痕跡，來瞭解這棟老建築再利用的生命過程，是新鮮有趣的視覺體驗。出入口部分使用大面透明落地窗，內、外空間有所區隔但又能聯繫視覺性，遊客能看見內部的空間，可吸引人進來。

店內用餐區域原屬於騎樓型態，將部分重新隔成室內空間。包廂與吧台部分則屬於原本建築的內部區域，僅將特定牆面再利用，留下結構柱。吧台前的柱子側邊並無修飾，拆除痕跡仍然保留，可由側邊觀察柱子結構，牆面上掛著展覽性畫作，顯出文藝氛圍。室內用餐區家具以木料為主，周遭洗石子完整保留。客席包廂以水泥牆面為主，顯示簡潔。天花板有天井的設計，增加室內的採光度，局部種植綠色植物，使室內空間增添生氣。

4.1.3 新舊元素對比：「公寓咖啡」個案

個案「公寓咖啡」由屋齡 40 年老屋改造，一樓是用餐區與廚房，二樓全為用餐區。老屋外牆以馬賽克磚鋪貼，是過去年代常使用的建材款式，一眼就能看出具有一定的屋齡與歷史。外觀與外圍鐵窗花圍籬，是完整保留，大面落地窗設計讓遊客輕易地看到室內，增加新穎感，夜晚時也因落地窗的設計，讓室內光線往外照射，成為吸引人目光的空間。

室內空間使用現代設計手法，但細觀察仍有許多老元素的部分隱藏在其中，如斑駁牆面、原有鐵件扶手、磨石子牆面等，藉用歷史感小細節呈現整體氛圍。打開落地玻璃門，進入室內，首先映入眼簾的是為修護與耐用目的所採用的仿木紋地板，在吧台與座椅選擇上，以木質為主，其空間氛圍調性較讓人感到溫暖放鬆與休閒。往二樓的樓梯間，牆面可看到斑駁油漆痕跡，藏在油漆下面的是過去使用的磨石子壁面，一旁鐵件扶手，本來是黑色油漆重新上色，後因時間剝落顯露出以前的紅色油漆，這樣諸多小細節都藏在許多地方，等著被發現。二樓的角落空間擺放著許多老物件，包含轉盤式電話、原始老屋牆壁磁磚。整體空間性質採用新舊元素對比的方式設計，顯現日常的休閒逸趣。此隱藏在熱鬧百貨公司旁的巷弄老屋，在舊軀殼中藏著一間現代咖啡廳，然在現代空間又呈現老物件、老元素的歷史，對於一般民眾而言是相當有趣的文化消費體驗。

4.2 以「新舊共融」為主的老屋再利用

4.2.1 文化型態再塑：「起家厝」個案

「起家厝」位於三鳳中街的巷弄內，過去曾是日本軍官的住所，有近百年歷史，幾經轉手後由現在的業主陳先生所承租改做為餐飲空間。一樓現況為用餐區與備料區，二樓為用餐區，三樓為社區教室與用餐區。屋外的洗石子牆面保留完整相當懷舊與完整，其餘如紅色的鐵圍籬、淡綠色鐵窗花等，都是現代許多老屋再利用會保留的特色元素與細部。屋外與中街連結出入口的壁面，有著彩繪裝飾，可提升週遭環境的美觀與活力。

室內地面保留原始屋內的磨石子地板，還有舊鐵窗花、木窗框以及罕見的架高木地板。雖然也陳列許多現代化設備，但在選擇上都能新舊搭配，相當和諧。一樓是較為現代化空間，置放冰箱、木製吧台與烤箱等，在搭配上，並沒有搶走老屋氛圍，戶外陽光透過老舊鐵窗花灑落在室內空間。窗外有悠久歷史的老房子，將現實抽離於市區。沿著鮮紅色漆皮的鐵扶手往二樓的樓梯間，能看到過去刻意往牆壁內挖鑿的倉儲空間，是該老屋案例的特色。

二樓在室內空間上分成左側獨立小空間，其隔牆考慮通風並沒有封到頂部，家具是業主自各處蒐集，包含老舊皮椅、牆面內崁書櫃與後方的鐵窗花，顯得寧靜懷舊。另一側是兩間架高木地板房間，可看到許多收納空間，所有結構、面材都完整保留下來，不做翻新或整個拆除淘汰，保留接近原汁原味的懷舊空間。三樓可看到魚鱗板與木屋頂的原始結構，為了結構安全及克服室內漏水問題，僅使用的鋼板將頂部遮蓋。另外，附近老房子高度較矮小，案例本身建築體有三層樓高，周圍老房子與合院等懷舊氛圍盡收眼底，讓消費者能以不同視點、角度來體驗老屋與週周遭社區地景。

4.2.2 機能結構改善：「樓梯腳」個案

「樓梯腳」位於鼓山，最初是作為住宅與倉庫用途，現今老屋再利用為餐飲空間，屋齡

有 60 年的歷史。個案位於鼓山區武德殿週遭，所以一眼望去大都是日式風格的建築形式，這更強化個案老房子氛圍。整體空間分為一樓的用餐與備料區，及二樓小閣樓用餐空間，建築立面整體在外觀部分並無太大改變，只在外牆重新上色，屋頂石瓦以及若隱若現的木屋頂結構都是能辨識老房子之要素。為避免室內漏水與結構安全都有做局部補強，另一側增加機能的鐵皮屋廚房，以因應現代化商業用途的機能使用。

推開室外木門進入，一旁白馬賽克牆面與崁牆老舊書櫃，在暖色系中引人注目，配合牆上的黑膠唱片機，讓空間有倒流時光之覺。室內牆壁有許多拆除木樑的痕跡，留下部分做為二樓的閣樓用餐區使用。上到閣樓可清楚看到本案原始木屋頂結構，保有過去的透氣窗花圖樣，空間中使用許多老物件、裝飾增加懷舊氛圍，包含木窗框的圍籬、映像管電視、老舊唱片機等。室內用餐空間面積不大，暖色系的配色以及擺放懷舊海報、老舊物件等，顯得獨特溫暖，有如回家感覺貼近生活。

4.2.3 改變使用型態：「元啡驢派」個案

「元啡驢派」是由舊街屋住宅改造為現代的咖啡廳，位於高雄鹽埕區，與一旁街屋連貫，接近附近老屋舊氛圍，一側外牆在戶外進行彩繪，提升印象活力與空間生氣，而原有的石雕紋路與新彩繪融合，在入口處能引起體驗消費者對當時的風格想像。老屋至今已近 70 年，建築立面可看到早期鹽埕區常見的雕塑紋路裝飾圖騰，在空間機能上，一樓為用餐區與備餐區，二樓為工作室與用餐區。

在室內設計與裝飾，進行許多老物件轉換使用型態的設計手法。例如：木窗框被創意改為點餐目錄板，或是使用原本建築大量的木窗框組合，製作成具有開放與界定空間的隔間系統。進入室內空間，使用常出現的木窗框，改變用途成為點餐目錄板，消費者在看價格同時，也產生歷史感與復古空間的感受，有別於其他空間經驗。

二樓用途作為文化創意工作室，頂部的天井將光導入室內增加空間光照。一旁是以大量的木窗框，群體疊加組合而成的隔間系統，創造空間界定並保有光亮與減少空間封閉的程度。室內空間天花板運用大量復古工業燈泡，採用高低不一的懸吊方式，增加創意的特性，也增進照明。室內設計也由於許多物件改變原來的機能用途，顯得活潑有創意。

4.3 以「虛構歷史」為主的老屋再利用

「鄭江號緩食茶」由業者自宅改建，已有 50 年屋齡，是由街屋改造為餐飲空間，老屋位於巷弄街邊，一旁就是公園，整體氛圍寧靜舒適，外部鐵窗花刷上紅色油漆引人注目，大面透明落地窗讓戶外看到內部空間，進而吸引消費者。整體設計由業者一手包辦，店內所有陳列物與擺設均是業者長年來的嗜好蒐集，在空間氛圍上有這些老舊家具顯得懷舊獨特，但部分老物件的歷史與此案例屋子本身並無任何關聯與脈絡。

室內空間以大量老物件營造懷舊氛圍，企圖營造懷舊用餐氛圍。多數物件都是由老闆業者本身多年來的嗜好蒐集，雖然部分是屬於原本建築所保留下來，並經過整理修復後再拿出來使用，但在外觀與形式上已有所改變，這改變為型態與機能。「鄭江號緩食茶」因為業主本身嗜好與收藏，內部空間蘊含著相當大量的老物件，雖然數量很多，但與時代歷史並無關係。例如復古鐵盒、老舊紡織裁縫車、復古的皮椅與懷舊小物等，都是老闆透過室內空間的展示與擺設，呈現自己歷年來的蒐集。也因為物件的多元與樣態差異，導致視覺歷史感的複雜與層次，表現出強烈懷舊物件與形式，虛構的場景伴隨多元歷史物件，也成了無名特質。

上述案例的老屋再利用成為餐廳，其設計手法多注重於氛圍營造，可發現建築立面是呈現老屋的重要場域，除了彰顯自明性外，再善用此主要造形基礎，來進行室內空間的改造。安全與結構是老屋再利用的首要因素，結構補強與修復是為適應現代生活與用途所必須的基礎工作。另外，室內設計與裝修部分，選用懷舊物件的擺設與空間設計創意，在於延續老屋復古情懷勾起回憶，或者對當時代能有所聯想的，再開發成為新的創意；而部分案例則選用全新現代化的手法，造成與原始懷舊對比的美感，也是一種設計操作手法。

老屋再利用案例的手法細節多元，但其本質不外乎藉由歷史與文化的價值，經由創意設計力的營造，創造餐廳用餐的趣味、視覺性與體驗，達到營運經濟的收支。或者成為社區的創生基地，或是扮演知識傳播場域，在當今現代社會發展中，作為延續在地精神與社區文化記憶的節點。

5 結語

本研究以高雄市 40 年以上歷史的老屋，進行其再利用的訪查 14 個案，透過舊有為主、新舊共融與虛構歷史三項原則與七項操作手法（舊屋完整保存、舊有元素修護、新舊元素比、文化型態再塑、機能結構改善、改變使用型態、歷史樣貌與仿造關連性的引用），再

利用的彈性與積極，一在顯示老屋的活力與再生。消費者在餐廳、咖啡廳進行消費，除增加體驗歷史感的空間設計，亦增加文創商品販賣的機會，並適時發展柔性日常生活文化意識，對整體社區人文景觀有著重要的影響。個案的再利用策略與設計操作手法，大都同時圍繞舊屋歷史為主軸，除了喚醒人們對該時代精神與生活提出理解的方向，亦即向大眾展現該時代的生活空間形式與景觀。在此氛圍，老空間是當時生活的呈現；而再利用則成為現代性的作為，一來一往的聯繫，空間經驗有了超越。

文化歷史與今昔連接的有趣性，餐廳商業經濟創價為載體，一來因應現代生活，二來延續記憶。老屋再利用，重點在於定義空間價值與文化深淺而進行的干預與活化。餐廳做為老屋再利用議題，有其彈性與多元，在注入商業營運後，後續能發展成文化創意平台，提供展示藝文、休憩與販賣活動，抑或是成立文創工作室連結社區，舉辦社區活動。在研究個案中，可由普遍咖啡廳的營運嗅出端倪。空間文化創意中的歷史體會與記憶喚醒，是文化創意空間設計的核心，這從案例理解，即便是虛構的歷史，也都在進行歷史、記憶、符號重組與呈現，那怕只有一點關連也都是再利用手法。

高雄市老屋餐廳的文化創意，在新舊歷史間呈現空化創意的可能，即產生美感、價值與故事。美感來自過去美好生活記憶與獨特的建築風格；價值源於建築美感魅力與生活美學日常的連結，故事是歷史或文化歷程重新詮釋與創造的形式，真實的來自於居民歷程與社區共生，老屋再利用個案中，常看到廣泛的歷史故事性的運用，舊器具老物件常以主角形式出現，似乎以第一人稱來訴說屬於那個時代的故事。這也意味著我們對於經濟與文化兩者的關連，需要有一個深切且具建設性、規範性的理解與作為，而架構在文化創意觀念下的老屋空間再利用，正是如此適用的作為。

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高齡者面對網路謠言困境之探討

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摘要

高齡者常因不熟悉智慧型手機使用方式，造成操作失誤或資料刪除等問題。除了使用行為的的困境之外，高齡者也要面對大量網路訊息。資訊內容是否影響高齡者行為，他們的角色是參與討論還是轉換成傳播者，這些都是是值得探討的問題。本研究透過內容分析法，由高齡者 Line 群組各式訊息中過濾出謠言，進行內容編碼與找出訊息頻率與群組內成員互動情形。經過分析，高齡者對於政治議題，健康問題和勵志故事的比例最高，很容易被轉傳和引起關注。大量傳遞特定訊息的行為也造成了群組織內的爭端，群組成員甚至會選擇退出群組表示抗議，少數的成員會直接的反駁與爭執，呈現個人不同的喜好差異與反應行為。多數高齡者以直覺或感覺的方式看待謠言，並不會進行內容的檢驗，也不太在乎訊息的真偽。證明高齡者行容易被操縱，謠言經過變形，利用高齡者所關心的議題，透過人為改寫增加可信度，達到傳播謠言的目的。

關鍵詞： 網路謠言、謠言傳播、Line群組、高齡者、資訊困境

The Preliminary Study on the Information Processing Dilemma of Internet Rumor in Elderly Person

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ABSTRACT

Elderly people often frustrated to use smartphones, causing problems such as operational errors or data deletion as the information dilemmas. In addition to the predicament of using behaviors, elderly people also have to deal with a large number of online messages. Whether these online messages affect the behavior of elderly people, whether their role is to participate in the discussion or resend the message becomes a broadcaster is a question worth exploring. Through the content analysis methodology, this search finds out the rumors from elderly people's Line chatting groups and encodes content than finds the frequency of messages and the interaction of elderly members in the group. After analysis of these messages, elderly people will have a highly emotional response and transfer the issues of health information, and politically related topics. Such behaviors have also caused disputes within the line groups, and some elderly members may even choose to withdraw from the line group to protest. A small number of members will directly refute and argue for the different opinion, their behavior shows presenting different preferences and reactions of individuals. To increase credibility many of the internet rumors have been rewritten by the participant in the specific topics such as political or commercial campaign. Therefore the internet rumors have been transformed in different pattern and in audio and video format appear in the groups of the elderly person.

***Keywords*:** Internet rumors, rumors transmit, Line groups, elderly people, information dilemmas

1. 前言

2018 年 4 月由內政部公布的數據顯示台灣 65 歲以上人口佔總人口數的 14%，正式宣告進入「高齡社會」時代的來臨(內政部統計處, 2018)。台灣人口老化程度嚴重的程度，高過鄰近的日本與韓國，日本從「高齡化社會」進入到「高齡社會」用了 24 年，南韓花 17 年，而台灣只花了 15 年就達標。這些 65 歲以上的高齡者生活在電腦與網路科技重鎮的台灣，透過社群網站與即時通訊 App 獲取與傳遞資訊，已成為他們使用網路主要活動之一。財團法人台灣網路資訊中心所公布之調查指出，65 歲以上受訪者使用超過 9 成以上使用過 Line App，主要希望透過使用社群網路和即時通訊軟體服務來增加「與親友間聯繫」(財團法人台灣網路資訊中心, 2016)。

這些高齡者使用智慧型手機與 App 主要目的除了與親友聯繫之外，也接觸到許多流竄的訊息。實際生活上，高齡者族的 Line 群組群，所找看到的訊息多數是問安式圖文「長輩圖」或來路不明的網路消息。顯示網路調查所得到結果，希望透過這些網路服務可以得到與家人朋友聯繫的作用，但是從這些網路服務當中卻傳遞著許多資訊，這樣的行為是否有達到聯繫的目的，對於接受訊息的另一方，卻造成了某種程度的干擾和壓力。因此網路上也流傳「十年前長輩叫年輕人不要沉迷網路和電腦，十年後長輩不管看到甚麼都相信還會叫你一定要看」的笑話。更何況高齡者的 Line 或臉書群組當中，流傳各式各樣議題，從健康、立志到政治文宣無所不包。這些夾雜著真偽的訊息，經過轉寄與分享，流竄各個高齡者的手機或平板電腦之中。

高齡者面對這樣大量訊息，很多時候沒有能力進行查證，甚至無法辨別訊息的真偽，只能依直覺或過去經驗判斷。從他們的行為來看，這些訊息的傳遞並沒有中斷，高齡者的角色由訊息接受者轉變為傳遞者，訊息就被再次轉傳更加地擴散。因此高齡者如何面對如此大量訊息，這些問題的長者面對謠言的困境，對於訊息所採取的行為又是如何，為何促成散布，處理資訊與裝置操作能力、網路訊息判讀以及使用心態等困境等，是值得探討的問題。

2. 文獻回顧

2.1. 資訊傳遞與內容

網路環境的蓬勃發展，帶動人與人之間的溝通與遠距活動，因此對於各項資訊的接收與傳遞活動非常頻繁。網路媒體的興起，加速使用者雙向傳遞訊息的機會。

傳播研究對於訊息的傳遞關係，如電腦中介傳播 (Computer-mediated Communication, CMC)，包括訊息的傳遞者、接收者、傳送的方式與回饋(Walther, 1996)。其中特別注意的是，在人手一機的時代，智慧型手機與行動裝置讓訊息的傳遞，如透過不同的社群網站、APP 增加許多選擇。另一方面，訊息內容格式與多樣性，內容早已不限於文字與圖形，大量的影音與直播的形式，讓傳播的內容更加的刺激與聳動。

透過行動裝置讓資訊快速傳遞，使用者可獲得即時訊息的便利，從另一角度來看，傳播者為了收視率或訂閱率，急需填補吸引閱聽者訊息需求，在內容上添加許多聳動的詞彙或者加入各種利益考量，如新聞工作者報導愛滋病議題，多以煽情與衝突導向影響大眾健康認知，沒有表現在理性的角度或者是傳遞正確訊息(徐美苓 & 黃淑貞, 1998)。國外學者的研究更發現，網路留言板(Message Board)的訊息，對於股價影響更有顯著的影響(Antweiler & Frank, 2004; Tumarkin & Whitelaw, 2001)。

這些人不僅扮演著資訊接收者的角色，由網路與行動裝置等媒體特性的特性，接收的同時可立即的轉換成為傳播者。這樣的媒體特性，助長了訊息傳播速度與資訊量的增加，看似多樣性得訊息，卻產生另一個問題，訊息的內容包含許多訊息(Message)與消息/新聞(News)，混雜著許多八卦(Gossip)，如謠言、假消息、假新聞、廣告文案等(Bordia, DiFonzo, Haines, & Chaseling, 2005)。考驗著不同族群、學經歷背景甚至是各年齡層的訊息接收者，如何判斷與思考網路訊息內容的真偽。

2.2. 謠言與網路

社群網路加速訊息流竄的速度，尤其是 Line 群組與臉書 Facebook，每日產生大量訊息，包含了謠言、八卦、假新聞、廣告等等。Kapferer 指出謠言在社會中出現和流傳，被視為的未經正式公開證實或者已經被正式闢謠的訊息，無論是訊息的真確與否，謠言的存在最主要的因素有著相信它的人(Kapferer, 1992)。而 Allpon 和 Postman 創造了一個衡量謠言強度的公式，指出「重要性」和「模糊性」這兩個因素與謠言存在的強度有正向的關係。

謠言強度的公式：$R \approx i \times a$

R 代表謠言的強度、i 代表內容的重要性，a 代表含糊不清。也就是說意味著謠言的強度，會隨著謠言訊息對接受者的重要性而有所變化，也與謠言訊息模糊性有關。謠言的強度公式中，訊息重要性和模糊性之間的關係，不是

相加而是相乘的，重要性或不確定性若是為零，就沒有謠言。因此，訊息的模糊性(ambiguity)與訊息的重要性(importance)最常被用以解釋謠言是否被產生與被流傳(Allport & Postman, 1945)。

由 Koenig 研究中指出，構成謠言有三個要件，第一是目標或意圖（The target）在背後想達到的目的，第二是指控或訴求（The charge or allegation），透過謠言中的訊息讓受眾覺得情緒受到波動，最後是消息來源（The source）是一個有權威的或者是類似官方的機構，讓受眾覺得消息是可靠的(Koenig, 1985)。

謠言由口語傳播開始、經歷文字書寫傳遞，再透過大眾媒介如電視、廣播等加入，傳播速度與影響力遽增。最著名的莫過於 1938 年美國哥倫比亞廣播公司的廣播劇「火星人入侵」，在廣播節目之中插入緊急新聞，讓觀眾誤以為火星人攻打地球，造成紐約市民不小的恐慌。而網際網路(Internet)的發明，開啟人類傳播與科技的另一個新頁。網路傳播的特性，除了傳遞訊息快速之外，更具有雙向的溝通與個人傳播的能力，影響力與傳播速度都大過於傳統或電子媒體。雖然科技進步，但謠言這古老的人類訊息活動並沒有消失，反而隨著網路的興起加快了傳播的速度與影響力。李欣穎等(2003)認為電子郵件中的轉寄功能，已使得電子郵件成為謠言傳播的溫床。透過按鍵送出的轉寄方便謠言的散布，電子郵件轉寄的功能提高謠言的影響範圍。而在轉寄的行為之中，郵件內容在也可能經過轉寄修改或加註過 (李欣穎, 汪志堅, 駱少康, & 方文昌, 2003)。

2016 財團法人台灣網路資訊中心的調查報告指出，台灣 60 歲以上網民使用即時通訊軟體比例高達 76.7%，而使用網路社群的比例則高達 55.4%(財團法人台灣網路資訊中心, 2016)。而高齡者多數使用 Line 即時通訊 App，這個免費的即時通訊 Line，由韓國 Naver 集團開發的 App，於 2011 年 6 月發表後在台灣大受歡迎，用戶間可以連接網路後使用 Line App 以文字、貼圖、聲音等進行溝通聯繫。由於簡單易用，還有貼圖增加趣味。這樣簡單有趣與即時互動特性，吸引許多高齡者使用 Line 來傳遞訊息與打發時間。

2.3. 資訊困境

高齡者所面臨的資訊困境，從數位落差(Digital Divide)到資訊安全(Information security)都是處於弱勢的一方。隨著世界資訊潮流以及電腦網路產業的興起，具備數位能力成為人們競爭力的一種表現，各國也開始注意並提升資訊素養(Information Literacy)，如傳統素養(traditional literacy)、媒體素養(media literacy)、電腦素養(computer literacy)、與網路素養(Network literacy) (McClure, 1994)。已進入高齡社會的台灣，估計 65 歲以上人口約有 330 萬人。這些高齡者處於所謂的資訊社會，需要面對的能力與技能都嫌不足。台灣 1994 年開始推動「國家資訊基礎建設」計畫，到 1998 年將資訊教育列入各級學校課綱中。雖然當時教育部推動「推動終身教育及資訊網路教育」行動方案，但是這些高齡者在當年者正是青壯期，負起養家活口的責任，加城鄉差異的因素，也就不難得知現在高齡者的數位落差的情形會有多麼嚴重。

由媒體的開放管制到科技的進步，讓各種媒體的數量與種類不斷的增加，如平面媒體、電子媒體到網路媒體等，現代人生活在各種資訊傳播之中，在行為上很容易引起不安、焦躁、甚至手機不離身的情形。國外研究學者認為資訊焦慮是資訊尋求過程中，自然產生的情緒反應，焦慮的情緒反應會推動資訊搜尋去探索。更進一步指出，那種焦慮通常與缺乏對信息來源和技術的了解有關(Kuhlthau, 1991)。

高齡者除了數位落差之外，對於 APP、智慧型手機與平板電腦等行動裝置有著操作上有一定程度的心理負擔。這樣的困境是否會影響資訊判讀、參與討論甚至是轉換成傳播者，資訊內容是否影響高齡者行為，是本研究欲了解的課題。

3. 研究方法

網路訊息內容複雜與多樣性，本研究欲利用「內容分析法」，探討高齡者與網路謠言之間的關係，是否存在著數位落差、使用困境以及內容判讀等認知問題。內容分析法（Content Analysis、Textual Analysis），起源於 18 世紀瑞典，利用定量分析為了平息教派之間的爭論，開啟了內容分析的方法。於 1930 年代應用於傳播學的興起，開始進行宣傳分析和傳播研究。利用內容分析法研究德國公開的報紙，甚至幫助美國政府破獲了許多德國的機密情報，這種研究方法因此受到世人的矚目。許多學者利用內容分析法進行研究，讓研究方法更加的成熟，現代學者利用電腦與軟體加速統計，讓內容分析法更容易地運用於其他的社會科學領域，成為一種重要的研究方法。

Berelson 認為內容分析法是一種對溝通內容的表示，可以進行客觀、有系統以及量化觀察的研究方法(Berelson, 1952)。Berelson 的貢獻更研究 1935-1950 間 17 種內容分析應用類型，於定量之外進行質性的方法，致力於內容分析的單元和類別，完整的提出抽樣，可靠

性，表述和推論模型與結論等。由此可知，內容分析法是一種將定性的資料轉換成定量資料的研究方法，客觀的態度加以分析、解釋文件與訊息內容的一種技術(王玉民, 1994)。

本研究透過內容分析法，由高齡者所接收的訊息找出謠言，選擇不同的高齡者使用 Line 群組，提取其中訊息，建構分析內容並透過內容編碼，找出訊息內容出現頻率、轉發程度與群組內成員互動情形，找出其中的相關性並進行資料分析、討論與解釋。

3.1 研究步驟

研究者加入許多高齡者的 Line 族群中，經過三個月左右的觀察，以便了解群組的成員背景的同質性或差異性，同時觀察群組成員互動狀況，再這些群組中挑選欲研究的群體。經過挑選出合適的研究群組，對於每個群組中的內容對話，再進行三個月的觀察與紀錄。各群組對話的內容，包括時間標記、成員名稱以及對話內容。由各群組得到的對話內容進行數量統計，接著把各群組的訊息進行分類與編碼。

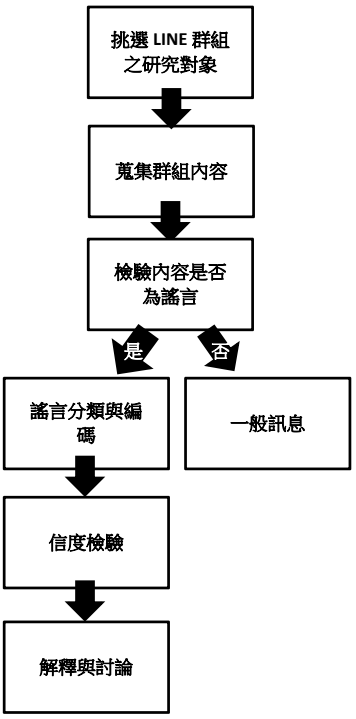

圖 1. 本研究之步驟

這些經過分類與編碼的訊息，得到許多不同型態的訊息，即可在各群組當中進一步的比對與分析。透過上述步驟，各群組的內容有更清晰的輪廓，各類別有多少數量，內容型態為何，有多少相同的訊息在不同群組出現，與當時的環境有無關聯，成員發布訊息後有無進一步的互動等，經過量化與分析後進行討論。

3.2 研究範圍

本研究範圍集中在 2018 年 10 月至 12 月三個月期間，高齡者 Line 群組的留言與互動訊息，觀察與紀錄 Line 群組之訊息與成員的對話與反應。

3.3 研究對象

本研究對象為會使用智慧型手機基本功能與 Line 的高齡族群，此次的研究對象群組共有 4 個，每個族群中由 22-49 人不等。這些群組為「樂齡」學習族群、「長青學苑」學員或里活動中心的里民，成員主要符合聯合國老年 65 歲之標準，每組 65 歲以上人數超過六成。抽樣的選取以立意抽樣法。

3.4 信度檢驗

本研究邀請三位編碼員進行信度檢驗，挑選兩位男性 A(22 歲)、B(50 歲)及一位女性 C(38 歲)，學歷分別為大學與研究所以上，皆熟悉網路生態。三位編碼員以不同年齡層與性別，熟悉網路生態，經過分類與編碼原則說明，進行內容編碼分類。對於內容分析法在信度的看法不一因此採用「相互同意度」進行信度檢驗(王石番, 1992)。

本研究的信度計算方式為編碼員交叉同意度再平均值後計算。編碼員之相互同意度為：A 與 B 相互同意度為 68%、A 與 C 為 77%、B 與 C 為 70%，經計算後平均同意度為 71%。本研究之信度檢驗計算，所獲得的信度為 88%，，已超過 Gerbner 之文化指標立意標準(80%)，因此推斷本研究編碼已達信度水準。

$$信度 = \frac{N \times (平均相互同意度)}{1 + (N-1) \times (平均相互同意度)}$$

圖 2. 信度計算公式

3.5 研究限制

本研究於資料蒐集與編碼程序之執行過程，仍有相當之限制，本研究囿於時間與人力之限制，在蒐集資料的時間上只能採取片斷或某一定時點之觀察描述，無法做到長期的觀察與紀錄，因此限制了資料的完整性。雖然編目與分類參照文獻研究，但對於訊息的複雜與謠言的型態變化，原先所定義的類目可能會面臨不同的解釋與分類，這將會造成研究結果的差異，所得之資料重點在於「量」的差異，而未能深入分析、量測「質」的差異。

4. 分析與討論

本研究參考 Allport & Postman 的謠言公式兩個重要因素，訊息的模糊性(ambiguity)與訊息的重要性(importance)來進行編碼與大分類 (Allport & Postman, 1945)，再參考 Koenig 所述的謠言組成要素，進行細項分類，將目標或意圖（The target）在背後想達到的目的，指控或訴求（The charge or allegation）與消息來源（The source），區分為「健康類」、「政治類」、「感性故事」、「威脅恐嚇」、「有趣遊戲」，整理後如表 1 ：

表 1. 本研究謠言分類與相關特徵

傳播謠言要素	目標或意圖（The target）	指控或訴求（The charge or allegation）	消息來源（The source）	內容分類與編碼
重要性 (importance)	養生健康	做法與服用	醫師或公部門	健康類 H1
	影響輿論	揭開真相	知情人士	政治類 P1
模糊性 (ambiguity)	心靈雞湯	激勵立志	名人代言	感性故事 S1
	行為影響	罰則或官司	權威人士或公部門	威脅恐嚇 T1
	控制行為	轉寄或分享	親友	有趣遊戲 F1

總訊息則數為 1967 則，謠言相關的訊息有 166 則，如同本研究所論，網路上充斥著許多訊息，真的與假訊息夾雜形成許多雜訊，一般人不易辨認訊息真假，更何況是不熟悉網路生態的高齡族群。經過觀察多數網路謠言，會在傳遞過程當中加工與變形，例如簡體字轉繁體字，加上威脅警語等。

以群組內的健康類謠言為例：「李麗眼科醫師語重心長的特別告知大家，熄燈後千萬不要看手機，會直接傷害眼睛的黃斑部，黃斑病變如同眼癌，無法醫治患者只能等待失明…等等」如下圖 3。

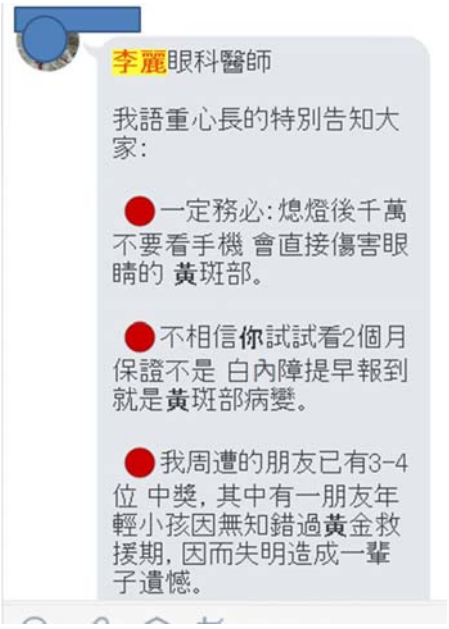

圖 3. 群組內容顯示健康類 H1 之訊息。

經過以「李麗眼科醫師」關鍵字，透過 Google 搜尋約有 97,100 項結果，搜尋結果第一頁即有「【假知識】李麗眼科醫師，我語重心長的特別告知大家？黃斑部病變跟眼癌 ..」標示著假知識拆解真相與流言揭密 4 則，其中揭開真相的有簡體字解放日報 1 則，顯示「李麗-解放軍第 254 醫院眼科中心醫師-華人百科」1 則，其他的 4 則即是網路謠言的網頁，包括 1 則眼科醫生變成教授。

除了不存在的專家掛名之外，內容添加與變形也是高齡者群組散步謠言常見的型態。例如「林靜芸-吃肉到底好不好」在群組中屬於 H1 類的的訊息，文中除了探討吃肉之外，還夾雜「夜尿與心肌梗塞」的內容。經查證後是一篇「健康遠見」雜誌的網路文章 (https://health.gvm.com.tw/webonly_content_17691.html)。這篇文章經過群組與網路轉發之後，成為一篇由專家掛名，但是原本的內容遭到添加的網路謠言。

這種網路謠言型態，常見於 Line 或其他社群媒體，在傳播的過程當中被竄改、加工與變形，讓讀者分不清楚內容真偽。由於使用智慧型手機和 Line App 的高齡者，沒有生活與經濟的壓力。因此對於健康的訊息特別的關注，在各群組中所獲得的健康類謠言總數達 45 則。把生活常見的健康觀念經過層層的改寫和包裝，變成一個頗具權威或者是警語式的謠言。透過這樣的方式，謠言還不斷的循環加工，再經過高齡者群組不斷的轉傳發送，謠言不但成為廣為流傳的網路謠言，更讓內容真偽更加的難以辨認。

因此由文字的謠言漸漸地轉換成為圖片與影音，這樣的改變趨勢與傳播的型態，更讓容易讓高齡者接受，若是這些高齡者在其他群組與親友間也看到同樣的訊息，可能能產生深

信不疑的印象而，例如圖 2 的文字或影音，「吃柿子和優酪乳會中毒往生」、「筷子和淋巴腺瘤」(https://youtu.be/bsUJ0jJYeY0)的關係，也是流傳已久的謠言之一。

整體類別來看，共有 166 則網路謠言，其中政治類 P1 的最多達到 79 則，占整體的 48%，其次是健康 H1 類佔 27%居次、威脅恐嚇 T1 類佔 17%、感性故事 S1 類佔 5%，最少的是有趣遊戲 F1 佔 3%。由於研究資料蒐集期間 10-12 月，為 2018 年台灣縣市長及議員選舉和公投活動前期，因此這段期間可以看到大量且密集的各式訊息，夾雜著許多網路謠言，紛紛出現在各高齡者群組間，例如特定政黨名稱有在 A 群 18 則、B 群有 24 則、C 群有 25 則，同性戀相關的在 A 群有 3 則、B 群有 1 則、C 群有 4 則、D 群 2 則。其中包括某特定政治人物，A 群 1 則、B 群 8 則、C 群 2 則、D 群 0 則，而這些訊息內容包括，相同訊息被不同人轉發，並且同樣訊息出現在不同群組等現象。

本研究各群組之「政治類」謠言，第一順位的有 A、B、C 三個群組，第二順位則是「健康類」、「威脅恐嚇類」謠言。原因就是網路訊息本身容易被加工、改寫，甚至製作成圖片影音等，高齡族群不容易檢驗訊息內容。有研究指出台灣民眾對於談話性節目「偶爾」或「經常」收看的比例達到 58% (盛治仁, 2005)，加上談話節目名嘴的加油添醋，很容易引起高齡族群的注意，引起 Line 群組中轉發的動機。

同時也反映出，高齡者對於自身所關心的議題，加上權威人士所掛名的較有興趣，卻不關心內容是否真實。這也給了謠言製造者很大的機會，有較大的空間可以添加與變形。如各群組中見到相同內容但掛不同作者的訊息，如掛名「美國紐約楊偉林醫師」、「台南一中校長蔡勇」發表老人健康要點，內容幾乎一樣。

除了高齡者關心的程度之外，更可推論網路訊息的擴散量非常大，不同群組和不同人都發布相同訊息。本研究顯示，更可以觀察到各群組都有一至兩位主要發布者，發布訊息的數量與密度高於其他群組成員非常多，A 群單人最高發布 228 則、B 群單人最高發布 183 則、C 群單人最高發布 93 則、D 群單人最高發布 153 則。少數人持續發布各項訊息，群組中卻沒有明顯的得到贊同與附和，反而讓群組的成員感到厭惡。B 群原本人數有 22 人，經過組內成員的大量政治謠言，紛紛退出群組至資料蒐集時的 10 人。由這個現象可以知道，這些高齡者在某些狀況去干擾她的生活，可能就選擇離開群組眼不見為淨。

高齡者轉發謠言的原因，除了主題重要性與關心程度之外，訊息內容多數再透過關鍵字如「重要」、「傳出去」、「請轉發」，達到謠言散布的目的。在另一層次的觀察，高齡者在退休之後，無法保持原有社經地位，體力與心理落差產生相對的落寞感。因此由本研究可以理解，大量發送自己覺得有用的訊息，卻不在乎訊息的真偽，除了助長謠言的傳遞之外，行為背後的目的，無非是提高自己的存在感，表示自己還有能力參與社會議題與社團活動。

表 3. 各群組與謠言分類編碼則數表

Line群組代號別	人數	訊息總數	內容分類與編碼	則數
A	49	382	健康類 H1	5
			政治類 P1	18
			感性故事 S1	3
			威脅恐嚇 T1	3
			有趣遊戲 F1	0
B	22	325	健康類 H1	14
			政治類 P1	34
			感性故事 S1	0
			威脅恐嚇 T1	7
			有趣遊戲 F1	2
C	31	843	健康類 H1	4
			政治類 P1	25
			感性故事 S1	0
			威脅恐嚇 T1	8
			有趣遊戲 F1	1
D	40	417	健康類 H1	22
			政治類 P1	2

			感性故事 S1	6
			威脅恐嚇 T1	10
			有趣遊戲 F1	2

5. 結論

本研究探討高齡者面對謠言的困境，如何面對如此大量的網路訊息。由高齡者的使用和互動行為觀察，雖然這些高齡者已習慣使用智慧型手機和即時通訊軟體如 Line App，但是多數是以直覺或感覺的方式看待那些謠言，並不會進一步的進行內容的檢驗，甚至也不太在乎訊息的真偽。

群組當中少數人發送大量特定議題，滿足高齡者在群體中的存在感。透過這些媒介或載體，進行訊息的再次傳播，如 Line App 的設計簡單轉傳功能，讓高齡者很輕鬆的轉傳到群組或者親友的 Line 當中。

高齡者 Line 群組中以「政治類謠言」的比例最高，顯示政治議題如年金改革，關係到自身利益，群組當中的特定政黨或政治人物謠言數量比起「健康類」與「感性故事類」高出許多。這樣的行為造成了群組織內的爭端，由本研究觀察，少數的高齡者會針對政治議題直接的反駁，另有些高齡者會選擇退出群組表示抗議，呈現議題類別偏好差異與互動行為。

本研究的貢獻即在於證明，在謠言與訊息的傳遞過程中，高齡者的行為容易被操縱。謠言經過變形，利用高齡者所關心的議題，透過人為改寫增加可信度，達到傳播謠言的目的。智慧型手機與 App 又成為傳遞大量的載體。未來更可以進一步研究，更多圖像式和影音型態的謠言，對於高齡者的認知與接受的影響程度。

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Initial review: The Editor-in-Chief evaluates all manuscripts to determine if a manuscript is appropriate for consideration by International Journal of Digital Media Design. Manuscripts that do not meet the minimum criteria are returned to the authors within one week of receipt. This is in the best interest of the authors who could then decide to fix the problem or to submit the manuscript to a more appropriate venue, avoiding delay caused by a lengthy review process that would nonetheless lead to rejection.

Peer review: Manuscripts passing the initial review are assigned to a Guest Editor, who selects several referees based on their expertise in the particular field. A manuscript is reviewed by at least two referees under a double-blind peer review process, where both the referees and the authors are kept anonymous. Referees are asked to evaluate the manuscript based on its originality, soundness of methodology, impact to design research, and relevance to design practices. To facilitate timely publication, referees are asked to complete their reviews within one month. After collecting the referees' reports, the Guest Editor makes a recommendation on the acceptability of the manuscript to the Editor-in-Chief.

Recommendation: Based on the referees' comments and the Guest Editor's recommendation, the Editor-in-Chief makes a final decision on the acceptability of the manuscript, and communicates to the authors the decisions, along with referees' reports. The final decision can be "accept as is", "minor revision", "major revision", or "reject". A revised manuscript should be re-submitted within six months of the decision. It will usually be returned to the original referees for evaluation.

Manuscript Submission

Authors are invited to submit their manuscripts. For further information, please contact **dmd@dmd.org.tw**

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