Effects of different combinations of text lightness and background colour on the visual comfort, recognition and preference for packaging labels

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Theoretically, the greater the contrast between the colour lightness of the foreground and background, the more helpful it is to recognition, but is the same true for visual comfort and preference on package labels? To more deeply investigate the current status of design, a survey was conducted on the text lightness and background colour of existing five types of packaging. Then performing an experiment that used two independent variables and their levels: background colours (n=18) and foreground text lightness (n=4) to measure dependent variables: Comfort, Recognition and Preference. The data is analysed using repeated measures and correlation coefficients. The results of the study found that Comfort, Recognition, and Preference are all affected by the three colour elements of colousr difference, lightness difference and sum of lightness. In terms of Recognition, the larger the lightness difference, the better. The foreground lightness is *L**=91 (white)> *L**= 84> *L** =74> *L**=65. For both Comfort and Preference, medium lightness difference is perceived as better; the text lightness order is *L**=84> *L**=91(white)> *L**=74> *L**=65. When the lightness difference between the background and foreground is too large or too close, it will decrease the degree of visual comfort, and it is also less preferred. These results are consistent with past research. Both Comfort and Preference are highly correlated with Recognition. Grey and black backgrounds with text of different lightness levels have no significant difference for Comfort or Preference. In terms of Recognition, *L**=91 (white) text on black background is better than on grey background. There is no significant difference between older and younger groups in regard to Comfort, Recognition or Preference.

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Introduction

Packaging design involves almost all commodities in contemporary society [1]. As long as something is a commodity, there is a diverse array of packaging, which shows that packaging design plays a very important role in commercial marketing activities and daily life. For users, colo ur is the first impression from packaging. Singh [2] pointed out that the colo ur of packaging influences about 60%-90% of consumers' shopping decisions.

In recent years, the trend in packaging design has responded to environmental protection requirements, and designs have been honed to be simpler. No matter the packaging of the bag, the outer box or the product container, the design is often expressed purely in words; there is no redundant decorative pattern design. The usual practice is to use a light background with a dark colour text, or dark background with reversed-type text (or text that reveals the background colour of the paper). The latter is especially common on the labels of cartons and bottles. The purpose is to enhance the brand or product impression with strong colours, or to enhance the brand or product name with a strong lightness contrast. The probability of the product name being recognised is enhanced by creating a lively feeling from the combination of two colours. Colours can induce feelings and emotions, produce meanings and associations, and deeply affect people's psychology and behaviours [3-5]. From these observations, it can be seen that even in packaging design that uses a simple background colour and reversed-type text, caution is required.

Regarding research on the correlation between foreground and background colours, many studies focus on whether the information is easy to read and recognise, the speed of the response time, whether the target item is easy to find, or whether the design is visually comfortable. Some research results concerning foreground and background colours show that the higher the lightness contrast between foreground and background colours, the clearer the visual is [6-8]. In research on searching menus for information [9], it is pointed out that when the lightness difference is large, the recognition is the highest and the information is easier to find. Research on the reading effect on LCD screens and tablet computers [10] shows that due to the decline in eyesight among the elderly, the greater the lightness difference between the foreground text and the background colour, the better the recognition and the more comfortable they find it, but younger people think that when the contrast is not so strong, their eyes are more comfortable. Other studies have found that the visual effect of medium lightness is the highest [11-12].

In view of the fact that the stimulus materials used in these abovementioned studies are dots, colour blocks or a paragraph of text displayed on a digital screen, a light background with dark text, or a dark background with reversed-type text, these experiments on reading effect differ from those in packaging design. The packaging design process uses a large area of background colour with reversed-type text for the purpose of highlighting the brand impression, brand name or product name, and making it easier to find products. Therefore, the main research purpose of this paper is to understand: 1. Whether a reversed type product name (brand name) placed on different background colours (including black) printed on paper is the same as reversed-type text placed on a black screen, as investigated by Ou *et al.* [13] and Huang, Ou and Yuan [10], in how it affects the user's visual comfort due to the lightness difference; 2. Whether different combinations of text lightness in the foreground placed on different background colours will result in differences in visual Comfort, Recognition and Preference; and 3. Whether younger and older people will have different visual Comfort, Recognition and Preference for different combinations of text and background lightness.

Literature review

Lightness relationship between foreground and background colour

In information design, aside from text, colour is a very important element. Especially in the search for information, the hue, lightness and texture of colour play an important guiding role [14]. In the task of searching for objects, because it is necessary to be able to distinguish the colour of the object, it is necessary to rely on the contrast between the object and the background [15]. It can be seen that

background is a very important factor affecting the appearance of the object [16-17]. When the contrast between the foreground and the background is obvious, sensory stimulation will make the colour of the object distinct from the background colour [18], and when the contrast effect is lower, the colour of the object will stimulate the senses and migrate toward the background colour [19], which will reduce the efficiency of reading the target information in the foreground.

The research of De Vries *et al.* [15] found that search time is the shortest when the luminance of the background colour is between that of the distractor and the target search object. On the contrary, when the luminance of the background colour is lower than that of distractor and target, and it takes the longest time to find the object. In terms of text reading, the greater the difference in lightness between the background and the foreground, the higher the Recognition. Whether it is legibility [7-8], finding information [6], reaction time [20-21], or visual acuity [22], research shows that the higher the lightness contrast, the better the visual effect. In a survey of printed materials, Tinker [23] pointed out that, for printed material in general, when the lightness of the background colour is above 70%, the text is black with low reflectivity, and its lightness is about 3~4%, this is the best condition for reading.

Although many of the above-mentioned papers show that high contrast in lightness has a distinguishing advantage, the visual perception of such samples is sometimes too dazzling. Studies comparing low and high lightness contrast by Zhu and Wu [11], Roufs and Boschman [12] and Boschman and Roufs [24] all show that the visual effect evaluation results for medium lightness contrast are better.

Legibility, readability and visual comfort of text information

To the key to achieving effective communication of information lies in whether the design is legible and readable [25]. Legibility refers to the attributes of being able to identify each individual letter [26]. For example, some characters are designed with letters, some are designed to be very compact and some are very small, all of which may lead to the problem of illegibility. Readability usually involves the pros and cons of text layout. The factors that affect legibility include: font type, font size, kerning and line spacing, column width and layout size, etc. [23]. Easy-to-read arrangements can improve the reading speed and visual comfort.

In addition to the influence of the above factors on Recognition and Comfort in reading text, another other factor is the use of colour, especially the background colour and the suitability of the difference in lightness between the foreground text and the background colour. If they are too close, the text may be difficult to recognise (so this experiment uses the term "Recognition") which will also affect visual Comfort. This paper refers to the research of Ou *et al.* [13], wherein the degree of Comfort is defined as the participant's perception of ease of reading information in response to different stimulus samples during the experiment. The aim is to see whether or not visual Comfort is related to the legibility and readability of the text on backgrounds of varied hues and lightness.

Research on the combination of foreground and background colours and the effect of text on readability shows that certain colour combinations do have significant differences, but the foreground text font is not a significant factor affecting readability [27]. In the ranking of the recognisability of packaging fonts, it is pointed out that the Ming font for Chinese characters is the most recognisable [28], but in research on font and character level of text on menus, Chinese SimHei and Yuan fonts are the most recognisable [29]. These two research results differ because the objects and users of the applications are also different, which shows that there are still many objective limitations and different considerations in packaging design practice.

Methods

This research was divided into two stages. First, a survey was conducted to collect the range of cases of different packaging background colours and reversed-type text. The relationships of the differences in lightness and hues between the background colour and the foreground text were analysed. Then, experiments were designed to explore the effect of the combination of variations text lightness and background colours on visual Comfort, Recognition and Preference.

Survey of existing case

Using the content analysis method, the packaging of 5 types of commodities was analysed, including cosmetics, pharmaceuticals, alcohol, chocolate, and technological products. In each type, 25 examples were selected for a total of 125 packaging cases with background colours and reverse-text type characters. The CIELAB value of the foreground text and the background colour was measured with the X-Rite i1 spectrophotometer colour measuring instrument. After statistical analysis, it was found that the lightness difference between the reversed-type text on the package and the background colours is between L^*=41.3~53.7, on average. The average lightness difference of the five types of products, from high to low, was: cosmetics (M=53.7); pharmaceuticals (M=51.2); alcohol (M=47.8); technology products (M=46.8); chocolate (M=41.3). Only one example of each of the five products is listed in Figure 1.

Figure 1: Samples of background colours and reverse-text type characters. Note: these figures are redrawn by this study

The background colour most frequently used for reversed-type text on the packaging is black; followed by blue. The number of cases using black as a background in the five categories of goods are, from most to fewest: cosmetics (17 cases) > alcohol (11 cases) > technological products (10 cases) > chocolate (3 cases) > pharmaceuticals (2 cases); some pharmaceuticals use blue background (9 cases); grey (2 cases) and yellow (1 case) are the least used.

In terms of colour symbolism, black projects positive images such as professional and high-end. It is used more in cosmetics, alcohol and technology products. It is relatively unsuitable for sweet chocolate and pharmaceuticals, especially the latter. The colours of grey, pink, orange, and yellow are rarely used as the background colours for these five types of products, which is likely due to the lightness contrast not being high enough for easy Recognition of text when reversed type is used. Generally speaking, mature designers will not make such mistakes. Grey is generally not used as a background colour in combination with white text. In addition to the consideration of Recognition, the researchers assume that colour emotion and psychological factors are also involved; grey has negative symbolism such as low-key and pessimistic, which would be unsuitable for at least two of these five types of products, which

are consumer food products. While makeup pays attention to colour and personality [30], pharmaceuticals emphasise efficacy, thus reducing the chance of using a colour such as grey. Based on this, when changing the combination of background and text lightness in packaging practice, Recognition is the first priority, and differences among product categories are seen. The use of background colours also takes colour association factors into consideration.

Experimental design

This experiment was designed with two dependent variables (within-subjects) and their levels: background colours (n=18) and foreground text lightness (n=4), targeting different ages (between-subjects): two groups of 20-40-year olds and 40-60-year olds; dependent variables measured include: visual Comfort, Recognition, and Preference. Data collection was carried out with a seven-point Likert scale; data was analysed by SPSS repeated measures and correlation coefficient analysis.

Stimulus sampling design

The average colour selection distribution was set according to the 11 basic colours mentioned by Berlin and Kay [31] (white, grey, black, red, pink, orange, yellow, green, blue, purple, brown) plus cyan, for a total of 12 colours as the experimental colour samples. Because this research focuses on reversed-type text, white was eliminated, along with brown, because red and brown at low chroma are very similar. Thus, the final selection includes grey, black, red, pink, orange, yellow, green, blue, purple, and cyan, a total of 10 basic colours. Besides grey and black, higher and lower levels for chroma for each basic colour were chosen by adding and subtracting, ultimately yielding 16 colours. Chroma and lightness information were then presented for each basic colour based on the NCS Color Atlas; next, an X-Rite i1 spectrophotometer was used to measure each of their CIELAB values, plus grey and black for a total of 18 colours.

Four Chinese characters appear as the foreground text, representing the virtual brand name (product name); in order to avoid the meaning of the word affecting the judgment of the participants, a phrase devoid of meaning was used. Although it has already been discussed above that the foreground text font is not a significant factor affecting readability [27], in order to highlight the lightness difference and also considering the importance of the brand name (product name) on the packaging, boldface Hei type [29] at the font size of 60pt was used in the sample design. The text design contained four lightness variants, respectively, L1(L^*=91), L2(L^*=84), L3(L^*=74), L4(L^*=65). On the aforementioned 18 background colours, 4 levels of text lightness were applied for a total of 72 printed samples (18*4); the samples were numbered from S1 to S72. The sample design is shown in Figure 2.

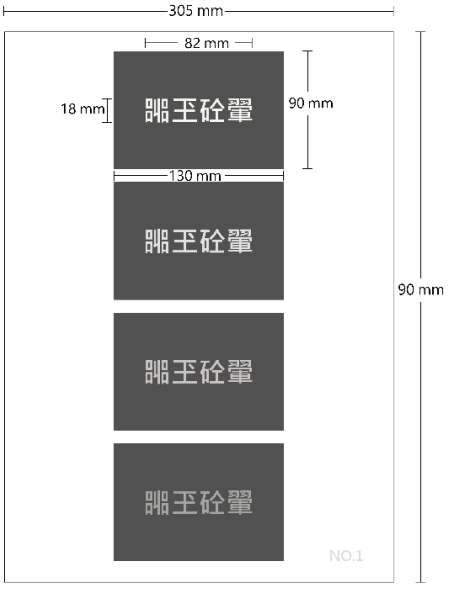

Figure 2: Diagram of experimental sample.

Four samples with the same background colour and text at four levels of lightness were printed on the same paper as one set; thus, finally a total of 18 sets of samples were tested. For each set of samples, the colour value of each sample was measured with X-Rite i1 spectrophotometer so as to ensure that the difference between the text lightness and the background colour lightness was maintained above at least L*20. The CIELab values were calculated under CIE D65 and the 1964

standard colour metric observer. The average values of the background colour measurements were sorted as shown in Table 1, with the sample numbers listed from B1 to B18.

In order to maintain the minimum degree of Recognition, the chroma of each colour was adjusted according to the situation. Take yellow as an example, if a high-chroma yellow background colour was used, it would be too close to the lightness of the white characters in the foreground, so the chroma of the yellow background was lower than other hues.

Code	Background colours	Samples	L^*	a^*	b^*	C^*	h
B1	Grey		33.76	0.86	1.01	1.76	308
B2	Black		20.21	0.61	1.02	1.20	58
B3	yellow1		41.94	5.60	30.33	31.28	59
B4	Yellow2		38.73	3.45	16.55	16.91	78
B5	Orange1		43.94	24.63	31.95	40.34	53
B6	Orange2		36.61	16.76	22.68	28.20	54
B7	Red1		38.04	46.14	24.39	48.21	17
B8	Red2		29.91	22.96	7.37	24.16	18
B9	pink1		40.11	44.26	-5.83	44.70	352
B10	Pink2		32.22	44.24	-6.46	33.06	353
B11	Purple1		41.72	32.76	-4.40	37.16	316
B12	Purple2		31.63	17.97	-19.33	26.17	313
B13	Blue1		40.42	-12.30	-22.64	25.77	241
B14	Blue2		34.35	-5.94	-18.68	19.60	252
B15	Cyan1		37.72	-31.29	-9.17	32.61	196
B16	Cyan2		30.52	-19.91	-5.26	20.60	195
B17	Green1		38.92	-38.78	14.82	41.52	159
B18	Green2		31.73	-15.21	7.06	16.77	155

** Note: Numbers behind the background colour names denote chroma level: 1 = high chroma; 2 = low chroma.

Table 1: Eighteen background colour samples.

Participants

A total of 66 participants with normal vision and no colour blindness, of ages ranging from 20 to 65 years old, were recruited for this study. They were divided into two groups, with a total of 39 people from 20-40 years old, M=24.12 years, SD=5.03; 27 people aged 41-60 years old, M= 48.88 years, SD=4.89.

Apparatus

Seventy-two samples printed out on paper were used as experimental materials, and the dependent variables were combined with a seven-point Likert scale to design a printed questionnaire. The scale from 1-7 represented the degree of agreement from low to high, allowing participants to evaluate their visual Comfort, Recognition and Preference.

Procedure

The observers were invited to an office, where windows provided daylight illumination from late morning to mid-afternoon. Measured by a X-Rite i1 spectrophotometer, the colour temperature before the experiment averaged 5500 K. The viewing distance was 45 cm with a 0/45 illuminating/viewing geometry. The colour samples were presented randomly. Participants viewed samples with four different levels of text lightness on the same background colour at a time and scored them based on their subjective judgment. The response time was unlimited to avoid visual fatigue caused by continuous experimental rounds. Participants could take a break at any time and were given a gift upon completion.

Results

Effects of background colour, text lightness, and age on visual Comfort, Recognition and Preference

Three-way mixed ANOVA was used to analyse the effects of background colour, text lightness, and age on visual Comfort, Recognition and Preference. The background colour and text lightness were set as dependent groups (within); age was set as an independent group (between). As shown in Table 2, the results show that the main effect item of background colour does not have a significant difference on the Comfort level while the main effect item of text lightness does have a significant difference on Comfort. According to the results of Scheffe post hoc test: Text lightness L^*=84, (M=5.87, SD=0.08)> L^*=91, (M=5.63, SD=0.09)> L^*=74 (M=4.93, SD=0.12)> L^*=65 (M=3.88, SD=0.14); that is to say, on the 18 background colours, when the foreground text L*=84, most participants felt more comfortable, whereas when the lightness of the text and background was too close, it was visually most uncomfortable.

It can be seen from Table 2 that there was no significant difference in the visual Comfort response of the two groups of participants, meaning that age had no significant effect. The same is true for Recognition and Preference, so that detail was not repeated.

In terms of Recognition, it can be seen from Table 2 that the main effect item of background colour had a significant difference on Recognition, that is, different background colours had an impact on Recognition. Due to the large number of samples, it is difficult to present the results of Scheffe post hoc tests. The background colours were divided into groups and repeated measures were analysed, which are discussed later in this paper.

Effect Item	*SS*	*df*	*M*	*F*	*p*	η_p^2
Comfort						
A. Background colour, *n*=18	43.11	17	2.53	1.04	.408	.016
Error	2646.03	1088	2.43			
B. Text lightness, *n* = 4	2728.63	3	909.54	92.12	.001***	.590
Error	1895.62	192	9.87			
C. Age, *n* = 2	37.97	1	37.97	1.18	.280	.018
Error	2044.77	64	31.95			
Recognition						
A. Background colour, *n*=18	91.57	17	5.38	2.74	.001***	.041
Error	2133.29	1088	1.96			
B. Text lightness, *n* = 4	6189.04	3	2063.01	392.74	.001***	.681
Error	1008.54	192	5.25			
C. Age, *n* = 2	17.16	1	17.16	0.56	.454	.009
Error	1933.65	64	30.21			
Preference						
A. Background colour *n*=18	92.21	17	5.42	3.11	.001***	.046
Error	1893.02	1088	1.74			
B. Text lightness, *n* = 4	4013.65	3	1337.88	136.73	.001***	.681
Error	1878.61	192	9.78			
C. Age, *n* = 2	0.23	1	0.23	0.008	.931	.001
Error	2044.77	64	31.95			

Table 2: Results of three-way ANOVA for visual Comfort, Recognition and Preference.

The main effect item of text lightness had a significant difference on Recognition, which means that the visual Recognition of participants varied depending on the text lightness differences. According to the results of Scheffe post hoc test, the text lightness was L^*=91, (M=6.39, SD=0.06)> L^*=84, (M=5.87, SD=0.09) >L^*=74, (M=4.54, SD =0.10) >L^*=65, (M=3.42, SD=0.12).

In terms of Preference, it can be seen from Table 2 that the main effect item of background colour had a significant difference on Preference, which means that there was at least one colour among the 18 background colours that significantly differed from the others.

The main effect item of text lightness had a significant difference on Preference, indicating that participants' Preference was different for different text lightness. According to the results of Scheffe post hoc test, the text lightness of L^*=91, (M=5.49, SD=0.11)(p=.27) and L^*=84, (M=5.59, SD=0.09) had no significant difference for Preference, but the two were >L^*=74(M=4.39, SD=0.11) >L^*=65(M=3.29, SD=0.13).

Analysis of three groups of background colours on visual Comfort, Recognition and Preference

The ranking results of background colours on visual Comfort, Recognition and Preference

From the above analysis, it can be seen that background colour has a significant effect on Recognition and Preference. In order to understand the impact of background colour on these factors, this study first employed a ranking method to observe the impact, as shown in Table 3. The ranking results show that the background colour with the highest degree of Comfort is grey, followed by low-chroma pink; the lowest Comfort is high-chroma pink, followed by high-chroma yellow. The background colour with the highest degree of Recognition is black, followed by low-chroma orange, while the lowest degree of Recognition is high-chroma yellow, followed by high-chroma orange. As for Preference, the background

colour with the highest Preference is low-chroma cyan, followed by low-chroma blue, and the background colour with the lowest Preference is high-chroma yellow, followed by low-chroma yellow.

Comfort		Recognition		Preference	
Code	Samples	Code	Samples	Code	Samples
B1		B2		B16	
B10		B6		B14	
B15		B14		B7	
B16		B7		B10	
B12		B15		B8	
B8		B8		B15	
B14		B10		B13	
B2		B16		B18	
B13		B12		B12	
B6		B9		B2	
B7		B13		B11	
B18		B18		B6	
B4		B11		B9	
B11		B17		B1	
B17		B1		B5	
B5		B4		B17	
B3		B5		B4	
B9		B3		B3	

Table 3: Ranking of Background Colours for Visual Comfort, Recognition, and Preference.

ANOVA analysis of three groups of background colours on visual Comfort, Recognition and Preference

Because there were so many samples, it was not easy to group them. In order to understand the detailed differences for the main effect item of background colour, it was divided into achromatic colours, including B1 and B2 (grey and black); warm colours comprising B3~B12 (B3 high-chroma yellow, B4 low-chroma yellow, B5 high-chroma orange, B6 low-chroma orange, B7 high-chroma red, B8 low-chroma red, B9 high-chroma pink, B10 low-chroma pink, B11 high-chroma purple, B12 low-chroma purple, 10 colours in total); and cold colours comprising B13~B18 (B13 high-chroma blue, B14 low-chroma blue, B15 high-chroma cyan, B16 low-chroma cyan, B17 high-chroma green, B18 low-chroma green, a total of 6 colours). The repeated measures test was conducted for the second time on these three groups of data.

It can be seen from Table 4 that there was no significant difference between the three dependent variables for the cold colour backgrounds, while the warm colour backgrounds had a significant difference on Comfort, Recognition and Preference. In terms of Comfort, the results of Scheffe post hoc test showed that B10, B12, B8, B6, B7, B4> B11, B5> B3, B9. In terms of Recognition, the Scheffe post hoc test results are B6, B7, B8, B10, B12, B9, B11> B4, B5, B3. In terms of Preference, Scheffe post hoc test showed that B7, B10, B8, B12> B11, B9, B6> B5, B4, B3. It can be seen that the four background colours B7 high-chroma red, B8 low-chroma, B10 low-chroma pink, and B12 low-chroma purple, were repeatedly present among the top dependent variables, indicating that their Recognition was better, they were more visually comfortable, and easier to be preferred.

Comparing the results in Table 3, it can be seen that B5 high-chroma orange is a background colour that tends to be low for Preference, Recognition and Comfort, while B8 low-chroma red and B10 low-chroma pink are background colours that tend to be high for Preference, Recognition and Comfort. B6 low-chroma orange tends to be high for Recognition as a background colour, but low for Preference and Comfort.

Moreover, achromatic background colours had a significant difference for Recognition, and B1 (grey)(M=4.91, SD=0.13) is significantly smaller than B2(black) (M=5.30, SD=0.09). In other words, the Recognition of white characters on a black background was better than that on a grey background.

Effect Item	*SS*	*df*	*M*	*F*	*p*	η_p^2
Comfort level						
Achromatic colours	4.36	1	4.36	.38	.539	.006
Error	743.38	65	11.43			
Warm colours	29.10	9	3.23	2.40	.011**	.036
Error	787.89	585	1.34			
Cool colours	8.38	5	1.67	1.17	.322	.018
Error	463.99	325	1.42			
Recognition level						
Achromatic colours	16.38	1	16.38	12.41	.001***	.160
Error	85.74	65	1.31			
Warm colours	61.34	9	6.81	2.47	.009**	.037
Error	1614.02	585	2.75			
Cool colours	5.91	5	1.18	1.60	.159	.024
Error	239.87	325	.73			
Preference						
Achromatic colours	1.00	1	1.00	.40	.525	.006
Error	159.62	65	2.45			
Warm colours	56.77	9	6.30	3.65	.001***	.053
Error	1009.22	585	1.72			
Cool colours	17.10	5	3.42	2.22	.051	.033
Error	499.01	325	1.53			

Table 4: ANOVA of the dependent variables on three groups of background colours.

Correlation analysis of visual Comfort, Recognition, Preference and colour elements

According to the ANOVA results, there was no significant difference found between age groups, but there is an interaction between age with background colour and text lightness. Therefore, this research sought to further understand the degree of correlation between the three dependent variables and the colour elements, so researchers further analysed the data using correlation coefficients. The colour parameter used here was the relationship between the foreground text and the background colour, including the difference between the colour attributes of the two chroma for each colour. The colour parameters used here included: ΔE, ΔC^*, ΔL^*, Δa^*, Δb^*, Δh, C*sum, L*sum, and mid h. Among them, ΔE is the colour difference, ΔC^* is the chroma difference, ΔL^* is the lightness difference, Δa^* is the redness-greenness difference, Δb^* is the yellowness-blueness difference, Δh is the hue difference, C*sum is the chroma sum, and L*sum is the sum of lightness, mid h is the middle value of the two hue angles. For the calculation of these parameters, one can refer to Gong and Lee [32].

As shown in Table 5, it can be seen that the correlation coefficients of Comfort, Recognition, and Preference were significantly positively correlated with ΔE, ΔL, and L^*sum, indicating that they were all affected by colour difference, lightness difference and the sum of lightness. The Recognition of the three colour elements reflects the highest correlation compared to Comfort and Preference.

In terms of colour difference (ΔE), the correlation coefficients with Comfort, Recognition, and Preference were 0.68, 0.79 and 0.73, respectively, which indicates that the greater the correlation with ΔE, the greater the influence, that is, the greater the colour difference, the more visually comfortable it was to viewers; the clearer it was for Recognition; the better liked it was in Preference.

The same was true for the lightness difference (ΔL^*). The correlation coefficients with Comfort, Recognition, and Preference were 0.76, 0.80 and 0.77, respectively. That is to say, the greater the difference in luminance between the text and the background, the more visually comfortable it was to viewers; the clearer it was for Recognition; the better liked it was in Preference.

The correlation coefficients between the lightness sum (L^*sum) and Comfort, Recognition, and Preference were 0.65, 0.73 and 0.70, respectively, which means that in terms of the sum of lightness, the larger the sum of the background and foreground lightness, the more comfortable it was visually; the clearer the Recognition; the higher Preference it had.

Meanwhile, it is also found that Recognition and Preference had a high degree of positive correlation, r(64)=.96, p<.001; degree of Comfort and Preference had a high degree of positive correlation, r(64)=.97, p<.001; degree of Recognition and Comfort were highly positively correlated, r(64)=.93, p<.001.

	ΔE	ΔC^*	ΔL^*	Δa^*	Δb^*	Δh	C^*sum	L^*sum	a^*sum	b^*sum	mid h
Comfort	0.68**	-0.12	0.76**	-0.05	-0.08	-0.04	-0.06	0.65**	-0.05	-0.05	0.02
Recognition	0.79**	-0.03	0.80**	0.02	-0.06	0.00	-0.01	0.73**	0.01	-0.04	0.01
Preference	0.73**	-0.04	0.77**	0.04	-0.08	-0.04	0.00	0.70**	0.02	-0.04	0.03

** Indicates significant medium to high positive correlation

Table 5: Correlation analysis of Comfort, Recognition, Preference and colour elements.

Average ranking of visual Comfort, Recognition and Preference

Sorting the data of Preference, Recognition, Comfort by the average from high to low, the top 10 and the bottom 10 were listed. From Figure 3, it can be seen that some of the top 10 samples were repeated between Comfort and Preference; that is to say, the combination of text lightness and background colour with good visual Comfort was more likely to be favored, such as background colours S62, 58, 26, 50, 70, which were low- and high-chroma cyan, high-chroma red, high-chroma blue, and low-chroma green, with lightness L^*=84. In terms of Recognition, the text lightness of the samples ranked earlier were all at L^*=91, except for S22 (low- chroma orange, L^*=84), with background colours of black, high-chroma blue, red and green. On the contrary, background colours such as low-chroma orange (S20) and yellow (S12) with low-lightness foreground texts were weaker in terms of Comfort, Recognition, and Preference. Just as for the correlation coefficient analysis result for lightness, the greater the difference or the greater the sum of lightness, the higher the Recognition.

	Comfort	Recognition	Preference
High	S62	S22	S 62
	S58	S5	S 58
	S50	S49	S 38
	S22	S25	S57
	S46	S65	S26
	S70	S45	S70
	S3	S57	S18
	S26	S53	S30
▲	S38	S33	S50
	S30	S29	S49
▼	S24	S72	S44
	S60	S44	S52
	S48	S4	S60
	S44	S36	S72
	S52	S52	S16
	S72	S24	S24
	S36	S68	S36
	S68	S16	S68
	S12	S20	S20
Low	S20	S12	S12

Table 5: Better and poorer performance of different background colour and foreground lightness combinations.

Discussion

Participants' responses to Recognition, Comfort, and Preference were measured for the combination of 18 background colours and four levels of text lightness. The results of the three-way mixed ANOVA show that, aside from Recognition, the visual response of the two groups was in response to the changes of Comfort and Preference for changes in the foreground, the text lightness of the two, in order, is L^*=84> L^*=91> L^*= 74> L^*=65. The more comfortable combined lightness was not a combination of strong contrast between text and background colour, but a combination of slightly lower lightness, which was also more preferred. This result is consistent with the correlation analysis results and previous research findings of Ou *et al.* [13], Huang, Ou and Yuan [10], Zhu and Wuj [11], and Roufs and Bochman [12]. On the contrary, when the lightness of the text and the background was too close, when Comfort and Recognition were not high, Preference was not expressed either. The results for these samples printed on paper did not differ from those viewed on a screen investigated by Ou *et al.* [13], nor for the single row of large characters in this study compared to a paragraph of text reported by Ou *et al.* [13].

There was no significant difference in visual Comfort, Recognition, or Preference between the older and younger groups. A possible reason is that 40 years old is the boundary, an age at which visual acuity has not been significantly altered. The differences are likely evened out among people between 30-50 years old. Furthermore, because the tested samples were printed on paper, the reversed-type text does not possess the strong light contrast that it would on 3C products (Ou *et al.* [13]; Huang, Ou and Yuan [10]), so this result does not reflect the visual advantages or disadvantages of differing ages very clearly. However, judging from the average scores, younger people had a slightly better response to Recognition and Comfort than older people. In terms of text lightness L^*=91, younger people (M=6.61, SD=0.08)>older people (M=6.18, SD=0.10); for Comfort of text lightness L^*=91, younger people (M=5.82, SD=0.12)>older people (M=5.44, SD=0.14), that is, when comparing the younger group to the older, they were slightly more able to accept combinations with a large difference in lightness.

For the grey background with the reversed-type text at lightness combinations of L^*=91, L^*=84, L^*= 74, the participants' response on Comfort and Preference was better than that for the black background with reversed-type text (L^*=91, L^*=84), which is consistent with Ou *et al.* [13] and Huang, Ou and Yuan [10]'s research results, showing that grey background with reversed-type characters is the first choice for Comfort, both on paper and electronic screens. However, it was found in the survey that reversed-type text on a grey background is not as widespread as black text on the packaging labels of cosmetics, alcohol, technology products, chocolate and pharmaceuticals. Perhaps reversed-type text on a grey background is not suitable for some specific products' packaging, but it may be suitable for PowerPoint presentations and posters, or other graphic design applications. Warm colours that elicit Comfort, Recognition and Preference centered on orange, pink, and red backgrounds with L^*=84, especially in terms of Comfort and Preference; Recognition enhanced with reversed-type text at L^*=91. Moreover, high-chroma orange with L^*=81 had the best Recognition, better than the combination of black and white, which deserves further confirmation.

Comfort and Preference are respectively highly correlated with the degree of Recognition. It can be seen that any design with a background colour and reversed-type characters was the first to be recognised, because if Recognition was lacking and participants felt that reading that label is strenuous, it naturally would not make people feel comfortable and, of course, not be preferred. As for which type of packaging label is suitable for strong contrast reversed-type text or downgraded light grey, that would be any label that can maintain Recognition and elevate Comfort and Preference. This is worthy of in-depth follow-up, because different product categories have been observed in the leading research. The

use of background colour has its own considerations, whether it can reflect the characteristics of the product or brand, as well as the psychological aspects of colour.

Conclusion and recommendations

According to the results of this research, in packaging practice, it is recommended that the combinations of background and text lightness can be changed. If Recognition is to be emphasised, then of course the greater the sum of lightness, the better; so text lightness L^*=91 or more can be considered, for example, applied to the small print description on pharmaceutical packaging. When the lightness difference between the foreground text and the background colour is at least 40, if the goal is for people to feel that it does not affect the Recognition visually, and feel the most Comfort, L^*=84 can be considered for the reversed-type lightness of the packaging text design. Visual Comfort will be better and it is easier to attain higher Preference. However, due to different product characteristics, the lightness of the foreground text on the packaging and the choice of background colour may also have different considerations, which can be extended to follow-up research studies. The results of this phase of research will help designers extend their application to other related designs, such as packaging paper bags, posters, advertising billboards, and logo design as a reference for print designs.

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