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Children's choice: Color associations in children's safety sign design

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Abstract

Color has been more identified as a key consideration in ergonomics. Color conveys messages and is an important element in safety signs, as it provides extra information to users. However, very limited recent research has focused on children and their color association in the context of safety signs. This study thus examined how children use colors in drawing different safety signs and how they associate colors with different concepts and objects that appear in safety signs. Drawing was used to extract children's use of color and the associations they made between signs and colors. The child participants were given 12 referents of different safety signs and were asked to design and draw the signs using different colored felt-tip pens. They were also asked to give reasons for their choices of colors. Significant associations were found between red and 'don't', orange and 'hands', and blue and 'water'. The child participants were only able to attribute the reasons for the use of yellow, green, blue and black through concrete identification and concrete association, and red through abstract association. The children's use of color quite differs from that shown in the ISO registered signs. There is a need to consider the use of colors carefully when designing signs specifically for children. Sign designers should take children's color associations in consideration and be aware if there are any misunderstandings.

Keywords: Color association; color ergonomics; safety signs; children; warnings; reasoning; participatory ergonomics

1. Introduction

Increasing numbers of researchers and design professionals recognize that color is a key consideration in ergonomics and in the human factors related to sign design. Research has indicated that color plays a more important role than simple decoration and ornamentation (Burkitt, Watling, & Murray, 2011; Jolley, 2010; Luquet, 2001; Zentner, 2001). Color helps people to not only distinguish different objects in two and three dimensions but also to convey messages. For instance, in general, red means 'stop' and yellow means 'danger' on road and traffic signs (Fleyeh, 2004). Different colors represent different meanings, and color also affects display preferences, cognition, behavior and performance (Braun & Silver, 1995). Color stereotypes and color message transfer capability suggest that color is an essential tool that designers can use when the textual message is restricted. Color seems to play an important contextual role in signs, whereas images and pictures serve as the sign's major means of communication. Figure 1 shows two examples of colored signs found in a children's library and in a children's playgrounds.

Figure 1. Colored signs of 'No Playing' in a children's library (left) and 'Keep Clear, Danger' in a children's playground (right)

Safety signs are messages in which the textual information is less important (Ng, Siu, & Chan, 2013). The colors used in signs is thus essential and they may also affect the signs' effectiveness, as the literature (e.g., Braun and Silver, 1995; Young, 1991) suggests that colors affect the noticeability and behavior compliance of signs. Young (1991) suggested that the choice of colors influences the noticeability of signs and found that red warning labels are more noticeable than black signs. Braun and Silver (1995) suggested that color also influences the level of conveyed hazard and compliance behavior. Instead of signs or labels, they used colored words to evaluate the interaction between signal words and colors and behavioral compliance. They found that red and orange were perceived to be significantly more hazardous than black, green and blue and that the perceived level of hazard varied when different colors were used for the same signal word. Behavioral compliance increased for red signal words. However, although the two studies examined the effects of the use of different colors, they only focused on one color in one warning sign or message. The combination of colors on a sign was not considered. Studies have also suggested that appropriate colors should be used to express the different meanings of signs based on findings on color associations (e.g., Ng & Chan, 2008). However, there has been no clear explanation of whether multiple colors are associated with any sign contents.

It should also be noted that the subjects of the above studies were all adults, and it is uncertain whether colored signs and messages have similar effects on children. Children's understanding and choices of color differ from those of adults (Zentner, 2001), particularly in the case of young children who have not received much education and who are not yet restricted by social expectations or requirements (Siu & Kwok, 2004), as they tend not to conform to the prevailing color codes and social stereotypes. Children may have different perceptions concerning the use and choice of colors in safety signs. Kalsher and Wogalther (2007) indicated that warnings designed for children should differ from those for adults and noted that practical research regarding the needs of children is lacking. Currently the literature still lacks information on how children associate colors with safety signs and their contents. Information about how they attribute the color association is still in need. The information obtained from children is worthwhile for designers, engineers, researchers and also policy makers to concern. Children should be included in sign design process to address their needs (Ng, Siu, & Chan, 2012). Although designers and human factors experts are the

final decision makers who determine the design and colors, it is also essential to provide opportunities for children to express their comments and opinions about color association in safety sign designs.

Conducting research with and extracting comments from children is challenging (Waterson & Monk, 2014). Waterson, Pilcher, Evans, and Moore (2012) engaged school children in classroom discussions to obtain their opinions on a number of existing and new safety signs. They had to do careful planning and preparations to guarantee a sensible outcome. Instead of asking children to comment directly, some studies involving children have used drawings to elicit their thoughts (Guha et al., 2005; MacDonald & Gustafson, 2004; MacDonald, Gustafson, & Gentilini, 2007; Kwok, 2002) because children do not have sufficient language skills and cognitive capacity to express their ideas (Lefevre, 2010). Furthermore, drawing with different colored pens or pencils facilitates children's expression of emotions and ideas (Burkitt, 2004; Ehrlen, 2009; Harrison, Clarke, and Ungerer, 2007; Hopperstad, 2008; Jolley, 2010; Jolley, Fenn, and Jones, 2004; Strauss, 2007). Numerous researchers have provided children with different colored pens for drawing to identify their thoughts. For instance, Jolley et al. (2004) provided a pencil and six colored crayons (black, red, yellow, blue, green and brown) for 4, 6, 9, and 12 year-old children to draw pictures about happy and sad topics. Ehrlen (2009) supplied crayons of different colors in a study that asked 6 to 9 year-old children to draw images of the Earth. Hopperstad (2008) arranged shared crayons on a table for 5 to 6 year-old children to use in drawing their thoughts about a story they had been told earlier. Harrison et al. (2007) provided a set of 12 colored felt-tip pens for 6 year-old children to draw themselves and their schoolteachers. In addition, some researchers have advocated using drawing as a tool to initiate conversation with children (Guha et al., 2005; Kwok, 2002; MacDonald et al., 2007; Sanoff, 1994, 2007). Overall, drawing helps children to express their views and preferences.

Thus, the aim of this study was to understand how children use colors in drawing different safety signs and how they associate colors with different concepts and objects that appear in the signs. Different combinations of colors were also considered in view of the research gap identified in the literature review. The participating children in the study were required to choose different colors and to design and draw certain signs. This approach avoided giving any information or hints about the choice or stereotypical meanings of the colors. Observing and analysing the use of color in children's drawings can help researchers to understand children's thoughts about sign design. The results of this study will provides useful data from children's perspective for sign designers in designing signs for children and also other experts who concern children and their color associations.

2. Method

2.1. Participants

Thirty-two Hong Kong primary school children (16 boys and 16 girls) from P2 to P6 (aged 7–11 years) were randomly selected by their teachers to participate in this study. The boys and girls were evenly distributed among the primary school levels. According to Piaget's stages of cognitive development, children between the ages of about 7 to 11 are in concrete operational stage in which they can solve problems and develop concepts involving objects or other familiar situations (Slavin, 2006). Although the 'stage' theory of Piaget may be controversial, some recent studies involving children still use the theory and the concrete

operational stage to understand children's cognitive development (e.g., Kuscevic, Kardum, & Brajcic, 2014; Shokouhi, Limberg, & Armstrong, 2014). In addition, although the children in this study may have different developmental progresses, the study considers 7–11 year-old children as a group because a majority of children facilities in Hong Kong, for example, playgrounds, is designed for only two age groups: 3–5 years old and 6–12 years old. In other words, only two sets of safety signs are designed for these two age groups. The study conforms to the Piaget's stages of cognitive development, and thus 7–11 year-old children were chosen to be the subjects of the study.

Two boys (12.5%) from P4 and P6 were not able to score full marks on the Ishihara color deficiency test (see Ishihara, 1979). This percentage is relatively high compared with previous research, which showed that about five per cent of Chinese men have color deficiencies (Pickford, 1963; Siu, 2000). Although it is unknown whether the two boys were simply inattentive during the test or had color deficiencies that they and their parents were unaware of, their data and information were omitted from the discussion and analysis of the study.

Although only a small number of children participated in the study, each child had to draw 12 drawings, and a total of 357 drawings were produced. The analysis primarily focuses on the 357 drawings and the colors that appear in them.

2.2. Stimuli

The participating children were given 12 referents chosen from the ISO 7010:2011(E) Graphical symbols – Safety colors and safety signs – Registered safety signs (International Organization for Standardization, 2011). Of the five categories of the safety signs, all of the chosen referents are in the categories of 'Mandatory Action Signs', 'Prohibition Signs', and 'Warning Signs'. They were chosen because among all of the signs in the ISO, the messages conveyed were closest to children's daily life. The signs of the referents can be found in public places such as parks, shopping malls, pedestrian roads and public toilets, and the referents were related to children's daily life activities. Signs in the categories of 'Safe Condition Signs' and 'Fire Equipment Signs', were excluded, as children do not face these situations in daily life. The referents chosen for this study, which were originally in English, were translated into Chinese, the native language of the children, so that they could be easily understood. The 12 referents are:

- R1 Wash your hands
- R2 Warning: Slippery surface
- R3 Use footbridge
- R4 Warning: Drop/fall
- R5 Not drinking water
- R6 No pushing
- R7 No sitting
- R8 Warning: Toxic materials
- R9 Use handrail
- R10 Warning: Floor-level obstacle
- R11 Use this walkway
- R12 Do not touch

(International Organization for Standardization, 2011)

Subsequent interviews and conversations with the children conducted in Chinese confirmed that they were able to understand the referents. The children were able to talk about why they drew the shapes and what they represented. Through the children's explanations and interactions with the researcher, it is concluded that there were no signs of misunderstanding or confusion with respect to the meanings of the referents given to them.

2.3. Instruments

A booklet was designed for the participating children to draw and design 12 pictograms. Each page of the booklet contained a 7 cm square in which the children were to draw. They were required to draw one pictogram only for each referent. An example of how to do the drawing task was shown on the first page of the booklet. The drawing of a referent 'Use facemask' was illustrated as an example. It was in black and white so that no implication of color choice was given to the children.

Colored felt-tip pens were provided to the children, who were free to pick the colors they wanted. Felt-tip pens were provided so that the children did not need to spend a lot of time filling colors. Similar to Jolley et al. (2004)'s study, six common colors choices of typical felt-tip pens (red, orange, yellow, green, blue and black) were given to the children. However, instead of providing brown as in the study of Jolley et al. (2004), orange was chosen to replace brown in this study, because it is one of the key colors in safety signs (Braun & Silver, 1995).

2.4. Procedures

The study was conducted with the children individually. In the first part of the study, they were asked to draw and design 12 pictograms in the booklet given to them. Each child was required to draw a pictogram. A researcher experienced in interacting with children acted as a facilitator in the drawing sections.

After the drawing session, the children were asked to explain their drawings and choices of colors. Three standardized questions were asked: 'What is this in your drawing?,' 'Why did you choose this color to draw this part?,' and 'Why did you draw it in this way?.' This took the form of a casual talk between the facilitator and the children so that the children did not feel pressured to explain their color choices. The facilitator did not express any judgements about the children's choice of colors to ensure they felt free to use any colors for their drawings. However, not all of the children were able to give explanations and make sense of what they had chosen. In these cases, the facilitator prompted them to give more details on their choices and asked them follow-up questions if they could not explain themselves clearly. However, the facilitator did not force them to give logical and rational reasons; the children's explanations were accepted as they were.

Through the children's explanations in the interviews, it was confident that all of the children were able to understand the referents. Mayhorn, Wogalter and Mendat (2006) claimed that even younger children (aged 3–6 years) were able to understand the safety messages after completing some learning activities.

3. Results

3.1. Colors Chosen by the Children

3.1.1. Overall

A total of 358 colored and two blank squares were collected from the 30 children. A 10-year-old girl drew nothing in the two squares because she explained that she did not know how to draw the referents given, even she could understand their meanings (R5 and R6). A researcher with an educational background was assigned to read the signs, record the frequency of each color appearing in the drawings of each referent, and count the number of colors used in each drawing. The average number of colors in each drawing was relatively low (Mean = 1.68, SD = 0.99): the children tended to choose only one or two of the six provided colors to draw the signs. The referent for which the children used the highest number of colors was *R5 Not drinking water* (Mean = 2.07, SD = 1.00). The referent with the lowest number of colors used was *R11 Use this walkway* (M = 1.37, SD = 0.76). The Wilcoxon signed-rank test showed that there was a statistically significant difference between *R5 Not drinking water* and *R11 Use this walkway* ($Z = -3.346$, $p < 0.01$). Table 1 shows the statistics for the numbers of colors used in the drawings.

Table 1. The percentage of drawings containing the six colors and the number of colors used for drawing the 12 referents (n = 358)

Referents*	% of drawings containing the color						No. of colors used	
	Red	Orange	Yellow	Green	Blue	Black	Mean	SD
R1 Wash your hands	10.0	43.3	20.0	3.3	66.7	40.0	1.83	0.99
R2 Warning: Slippery surface	20.0	26.7	23.3	13.3	60.0	46.7	1.90	1.06
R3 Use footbridge	10.0	23.3	13.3	13.3	26.7	56.7	1.43	0.90
R4 Warning: Drop/fall	13.3	26.7	16.7	23.3	26.7	53.3	1.60	1.04
R5 Not drinking water	41.4	27.6	17.2	10.3	65.5	44.8	2.07	1.00
R6 No pushing	31.0	17.2	20.7	10.3	27.6	51.7	1.59	0.82
R7 No sitting	40.0	26.7	16.7	20.0	16.7	50.0	1.70	0.84
R8 Warning: Toxic materials	30.0	16.7	13.3	10.0	36.7	60.0	1.67	1.06
R9 Use handrail	16.7	23.3	13.3	10.0	26.7	63.3	1.53	1.14
R10 Warning: Floor-level obstacle	23.3	26.7	30.0	13.3	26.7	60.0	1.80	1.21
R11 Use this walkway	23.3	23.3	13.3	10.0	20.0	46.7	1.37	0.76
R12 Do not touch	36.7	30.0	10.0	16.7	23.3	56.7	1.73	0.98
Total	24.6	26.0	17.0	13.1	35.2	52.2	1.68	0.99

*R1, R3, R9 and 11 are referents of mandatory action signs.
R2, R4, R8 and R10 are referents of warning signs.
R5, R6, R7 and R12 are referents of prohibition signs.

3.1.2. The associations between the referents and the presence of colors in the drawings

Yates' continuity correction was used to examine the associations between the referents and the presence of colors in the drawings (Table 2). It was used instead of other chi-squared tests because some of the frequencies in Table 1 were small. It is more precise than other chi-squared tests that it removes the imprecision of approximation (Siegel & Castellan, 1988; Yates, 1934). The statistical results show that the presence of blue was significantly associated with four referents: *R1 Wash your hands* (Yates' = 12.75, $p < 0.01$, odds ratio = 4.189), *R2 Warning: Slippery surface* (Yates' = 7.656, $p < 0.01$, odds ratio = 3.056), *R5 Not drinking water* (Yates' = 11.32, $p < 0.01$, odds ratio = 3.942) and *R7 No sitting* (Yates' = 4.028, $p < 0.05$, odds ratio = 0.342). Blue was the major color in the drawings of R1, R2 and R5. Similarly, a significant association was found between the presence of red and *R5 Not drinking water* (Yates' = 3.868, $p < 0.05$, odds ratio = 2.350) and between the presence of orange and *R1 Wash your hands* (Yates' = 4.191, $p < 0.05$, odds ratio = 2.371). Red was a major color in the drawings of R5, and orange was also a major color in the drawings of R1.

Interestingly, although a significant association was found between the presence of blue and *R7 No sitting*, the odds ratio was low (odds ratio = 0.342, see Table 3). This suggests that the association was negative in that non-blue colors were the contributing colors among the drawings of R7 (reciprocal of the odds ratio = 2.924).

Table 2. Matrix of Yates' continuity correction between the referents and the colors used in the drawings

	Red	Orange	Yellow	Green	Blue	Black
R1 Wash your hands	2.946 [a]	4.191 [*]	0.024	1.801	12.75 [**]	1.545
R2 Warning: Slippery surface	0.150	0.000	0.432	0.000	7.656 [**]	0.229
R3 Use footbridge	2.946	0.016	0.123	0.000	0.676	0.081
R4 Warning: Drop/fall	1.612	0.000	0.000	2.273	0.676	0.000
R5 Not drinking water	3.868 [*]	0.000	0.000	0.017	11.32 [**]	0.450
R6 No pushing	0.381	0.807	0.060	0.017	0.479	0.000
R7 No sitting	3.340 [a]	0.000	0.000	0.879	4.082 [*]	0.009
R8 Warning: Toxic materials	0.249	0.995	0.123	0.041	0.000	0.445
R9 Use handrail	0.689	0.016	0.123	0.041	0.676	1.100
R10 Warning: Floor-level obstacle	0.000	0.000	2.774 [a]	0.000	0.676	0.445
R11 Use this walkway	0.000	0.016	0.123	0.041	2.628	0.229
R12 Do not touch	1.917	0.094	0.730	0.135	1.492	0.081

[**] Significant at $p < 0.01$
[*] Significant at $p < 0.05$
[a] Significant at $p < 0.1$

Table 3. Odds ratios between the referents and the colors used in the drawings

	Red	Orange	Yellow	Green	Blue	Black
R1 Wash your hands	0.318	2.371	1.214	0.217	4.189	0.576
R2 Warning: Slippery surface	0.750	1.040	1.511	1.048	3.056	0.774
R3 Use footbridge	0.318	0.856	0.716	1.048	0.647	1.201
R4 Warning: Drop/fall	0.447	1.040	0.951	2.255	0.647	1.037
R5 Not drinking water	2.350	1.094	0.994	0.767	3.942	0.715
R6 No pushing	1.424	0.571	1.272	0.767	0.681	0.966
R7 No sitting	2.211	1.040	0.951	1.800	0.342	0.896
R8 Warning: Toxic materials	1.351	0.545	0.716	0.736	1.072	1.394
R9 Use handrail	0.590	0.856	0.716	0.736	0.647	1.625
R10 Warning: Floor-level obstacle	0.928	1.040	2.224	1.048	0.647	1.394
R11 Use this walkway	0.928	0.856	0.716	0.736	0.433	0.774
R12 Do not touch	1.887	1.245	0.507	1.400	0.535	1.201

As in Table 1, the children tended to choose only one or two of the six provided colors to draw the signs. The associations between the referents and the presence of 2-color combinations in the drawings were then examined. The statistical results show that the red-blue combination was significantly associated with *R5 Not drinking water* (Yates' = 18.01, $p < 0.01$, odds ratio = 6.600). The combination of red and blue was popular in R5. The orange-blue combination was significantly associated with *R1 Wash your hands* (Yates' = 5.959, $p < 0.05$, odds ratio = 3.850). The combination of orange and blue was popular in R1. A significant association was found between the yellow-blue combination and *R2 Warning: Slippery surface* (Yates' = 4.606, $p < 0.05$, odds ratio = 3.315) and between the green-black combination and *R4 Warning: Drop/fall* (Yates' = 4.947, $p < 0.05$, odds ratio = 3.900). Significant numbers of drawings contain both yellow and blue in R2, and both green and black in R4. The blue-black combination was significantly associated with *R1 Wash your hands* (Yates' = 8.903, odds ratio = 3.549) and *R5 Not drinking water* (Yates' = 9.700, odds ratio = 3.760). This combination was popular in R1 and R5.

Table 4. Matrix of Yates' continuity correction between the referents and the 2-color combinations used in the drawings (R – Red, O – Orange, Y – Yellow, G – Green, B – Blue, K – Black)

	RO	RY	RG	RB	RK	OY	OG	OB	OK	YG	YB	YK	GB	GK	BK
R1	0.044	0.000	0.361	0.000	1.011	1.400	0.000	5.959 *	0.004	0.153	2.094	0.000	0.153	1.046	8.903**
R2	0.044	0.012	0.000	1.869	0.215	1.400	0.000	2.911 a	0.004	0.000	4.606 *	0.077	0.000	1.046	3.768 a
R3	0.044	0.361	0.361	0.487	1.011	0.519	0.000	0.249	0.000	0.000	0.000	0.000	0.000	0.000	0.443
R4	1.046	0.361	0.175	0.487	0.215	0.000	0.000	1.522	0.004	3.701 a	0.000	1.013	0.587	4.947 *	0.443
R5	0.000	0.028	0.328	18.01**	0.501	0.478	0.025	3.193 a	0.000	0.133	0.000	0.758	0.658	0.027	9.700**
R6	0.000	0.028	0.328	0.000	0.501	0.478	0.000	1.437	0.003	0.133	0.363	0.000	0.133	0.000	1.257
R7	0.361	0.000	2.069	0.487	0.382	0.000	0.017	0.000	0.554	0.153	0.423	0.000	0.153	0.000	1.409
R8	0.044	0.216	0.000	0.000	0.382	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
R9	0.000	0.000	0.000	0.000	0.215	0.054	0.017	0.000	1.664	0.000	0.000	0.077	0.000	0.044	0.021
R10	0.000	0.672	2.069	0.487	0.006	1.400	0.017	0.249	0.374	0.587	0.559	2.718 a	0.000	0.361	0.443
R11	0.000	0.361	0.361	0.487	0.215	0.519	0.000	1.522	0.004	0.000	0.423	0.077	0.000	0.044	2.918 a
R12	1.995	0.012	0.175	0.000	1.345	0.000	0.017	0.000	0.000	0.153	0.423	0.077	0.153	0.000	0.443

** Significant at $p < 0.01$
* Significant at $p < 0.05$
a Significant at $p < 0.1$

Table 5. Odds ratios between the referents and the 2-color combinations used in the drawings

	RO	RY	RG	RB	RK	OY	OG	OB	OK	YG	YB	YK	GB	GK	BK
R1	0.531	0.830	-	0.765	0.397	2.926	-	3.850	0.736	-	2.533	1.028	-	-	3.549
R2	0.531	1.347	0.908	2.424	0.633	2.926	-	2.924	0.736	1.222	3.315	0.639	1.222	-	2.500
R3	0.531	0.384	-	0.356	0.397	-	-	0.418	1.190	1.222	0.796	1.028	1.222	1.162	0.564
R4	-	0.384	2.058	0.356	0.633	0.773	-	-	0.736	5.095	0.796	1.987	2.857	3.900	0.564
R5	1.209	1.403	-	6.600	1.605	-	2.902	3.056	1.240	-	0.829	0.310	2.972	0.552	3.760
R6	1.209	1.403	-	0.796	1.605	-	-	-	0.766	-	0.384	1.071	-	1.209	0.369
R7	1.914	0.830	3.533	0.356	1.533	0.773	2.793	0.905	0.343	-	0.369	1.028	-	1.162	0.355
R8	0.531	1.347	0.908	1.239	1.533	0.773	-	0.905	0.736	1.222	0.796	1.028	1.222	1.162	1.062
R9	1.162	0.830	0.908	0.765	0.633	1.731	2.793	0.905	2.323	1.222	0.796	0.639	1.222	0.531	0.798
R10	1.162	1.949	3.533	0.356	1.196	2.926	2.793	0.418	1.715	2.857	1.865	2.578	1.222	1.914	0.564
R11	1.162	0.384	-	0.356	0.633	-	-	-	0.736	1.222	0.369	0.639	1.222	0.531	0.167
R12	2.814	1.347	2.058	0.765	1.914	0.773	2.793	0.905	1.190	-	0.369	0.639	-	1.162	0.564

3.2. Reasons for Children's Choices

Of the 358 drawings, only 217 were explained by the children in terms of their color choices; 32% of these were by boys. Although the children were asked to explain their choices of colors after the drawing session, not all of them gave explanations. The reasons for choosing a color may be none or more than one for some drawings. The children's explanations for their choices of colors were recorded.

The children's reasons for their color choices were coded after the individual interviews using qualitative content analysis (see Elo et al., 2014). Whenever the child mentioned a color, its corresponding reasons were spot. Both the color and the reasons were coded. All of the reasons were then reviewed, and reasons with the same rationale were grouped into the same category. Five major codes were identified. Table 5 shows the children's reasons for the color choices in their drawings.

Table 6. Children's reasons for the color choices in their drawings

Reasons	Explanation	Example
Concept	Children chose the color based on their understanding of a particular concept or idea.	'Red represents being frightened and warning.'
Object	Children chose the color based on their understanding of a particular object.	'The floor at [my] home is green in color.'
Constraints	Children chose the color to replace a desired color that was not available.	'Orange is the most similar color to beige.'
Design	Children chose the color based on their aesthetic judgement and drawing clarity.	'Green, because [it is] beautiful.' 'Black, for better contrast.'
Preference	Children chose the color based on their own preference or without specific reasons.	'Black was randomly selected.' '[I used] orange because I do not want to use red.'

In order to understand how the children used colors to express ideas in the drawings, the drawing contents related to 'Concept' and 'Object' were chosen for investigation (see Tables 7 and 8). Red was popular for 'Don't' in *R5 Not drinking water* (20.7% of the drawings), *R6 No pushing* (10.3%), *R7 No sitting* (13.3%), *R10 Warning: Floor-level obstacle* (6.7%), and *R12 Do not touch* (6.7%). 'Beware' and 'warning' in R10 and R12 (both 6.7%) were the other two concepts represented by red. Yellow was popular for 'signage' in *R2 Warning: Slippery surface* (13.3%). Green was popular for 'toxic' (6.7%) in R8 *Warning: Toxic materials* and for 'hill' (10%) in *R4 Warning: Drop/fall*. Blue was highly popular for 'water' in *R1 Wash your hands* (50%), *R2 Warning: Slipper surface* (43.3%), and *R5 Not drinking water* (37.9%). It was also used to represent 'footbridge' (6.7%) in *R3 Use footbridge* and 'bottle' (6.7%) in *R8 Warning: Toxic materials*. Black was used for 'dirty' (6.7%) in *R1 Wash your hands*, 'toxic' (10%) in *R8 Warning: toxic materials* and 'handrail' (10%) in *R9 Use handrail*. Orange was not popular to represent any concepts and objects in particular in this study.

Table 7. Children's drawing contents (concepts) and the corresponding colors in the referents (with the percentages of drawings attributed to the reasons), based on the children's verbal explanations

	Red	Orange	Yellow	Green	Blue	Black
R1	-	Comfortable	-	Routine	-	Dirty (6.7%)
R2	Attention, danger	-	-	-	-	Dirty

R3	-	-	-	Safe	Comfortable	-
R4	Don't	-	-	Careless, routine	-	-
R5	Don't (20.7%), beware, mark deducted	-	-	-	-	Dirty
R6	Don't (10.3%), temptation	Don't	Painful, severe	Correct	Bad, pity	Committing crime
R7	Don't (13.3%)	-	Warning	Fresher, tired	Disobeying rules	Committing crime
R8	Don't	Related to red	Warning	Toxic (6.7%)	Bad	Dirty, toxic (10%), wrong
R9	Danger, warning, wrong	-	-	-	Important	Wrong
R10	Beware (6.7%), don't (6.7%)	Collision	Problematic	Stable	Boys, rubbish bin, standing position	Don't
R11	Beware, judgement	-	-	-	Boys, car, human figure	Very dark
R12	Don't (13.3%), beware, warning (6.7%), wrong	-	-	-	Reminder	Committing crime

*Percentage value of less than 2 counts is not shown in the table.

Table 8. Children's drawing contents (objects) and the corresponding colors in the referents (with the percentages of drawings attributed to the reasons), based on the children's verbal explanations

	Red	Orange	Yellow	Green	Blue	Black
R1	Flower, germs	-	Bubbles, flower	-	Soap, water (50%)	Water tap
R2	Clothes, signage	-	Shining surface, signage (13.3%)	Floor	Twinkling features, water (43.3%)	-
R3	Taxi	Human	Footbridge, human, taxi	-	Footbridge (6.7%)	Building, footbridge, rock, signage, waste gas
R4	Blood	Bleeding, human	Banana skin, human	Car road, hill (10%)	Sea, staircases	Building, car road, human, rock
R5	Signage	Bottle, sand, seashore	Human	Mud water	Water (37.9%)	Cross
R6	Blood	-	Explosion, stuffs	Signage	Boys, tuck shop	-
R7	Cross sign	Bus	Electricity, gold, handrail (on bus), signage	Bench, sofa	Boys, signage	Chair
R8	Cross sign	-	Signage	Bubbles	Bleach,	Clothes

					bottle (6.7%), correction pen, pills, signage	
R9	-	Floor, human	Human	-	Boys, signage	Clothes, handrail (10%)
R10	Carpet	Racing lane	Banana skin, electricity, signage	Construction board, watermelon	-	Fence, small nails
R11	Blood, notice board	-	Human	-	-	Car road
R12	-	Fire, human hand, wet paint	Golden human	Crocodile	Clothes, twinkling features	Cross, glass box, hair, railing

*Percentage value of less than 2 counts is not shown in the table.

4. Discussion

4.1. Red, Orange, and Yellow for Prohibition and Warning Messages

By combining the statistical results in Table 2 and the children's verbal explanations in Tables 7 and 8, it is possible to identify the key objects or concepts which lead to the statistical significance. The statistical significance in the associations between red and *R5 Not drinking water* and between the red-blue combination and R5 (see Tables 2 and 4) was due to the frequent use of red for 'Don't' (see Table 7). Frequent use of red for 'don't' was observed in other prohibition signs such as *R6 No pushing*, *R7 No sitting*, and *R12 Do not touch*, despite the absence of statistical significance. It is interesting to note that red was also used for 'don't' in some warning signs (R4 Warning: Drop/fall and R10 Warning: Floor-level obstacle), and it was also used for concepts related to warning, such as 'attention', 'danger', and 'beware', in both prohibition (*R5 Not drinking water*) and warning signs (*R2 Warning: Slippery surface*, *R10 Warning: Floor-level obstacle*, and *R12 Do not touch*). Orange and yellow, which were also used to attract attention and to indicate hazard level (Laughery, 2006; Luximon, Chung, & Goonetilleke, 1998; Wogalter, Mayhorn, & Zielinska, 2015), were not found to significantly associate to any prohibition or warning messages. Orange and the orange-blue combination were significantly associated with *R1 Wash your hands* probably because the children used orange to replace beige for 'hands' (16.7% of the drawings). Although no significant association was found between yellow and the referents, significant association was found between the yellow-blue combination and *R2 Warning: Slippery surface* (see Table 4). The significant association was probably due to the use of yellow for 'signage' in R2 (see Table 8). The children in this study used red to represent all kinds of prohibition and warning message, and they used yellow for 'signage' just because of their observation of slippery signage in daily life as reported by some of the children. The linkage between yellow and prohibition and warning message was weak.

The ISO registered signs use red to convey prohibition messages and yellow to convey warning messages. Apparently, the results in this study were different from what have been adopted by the ISO registered signs. The children were unable to distinguish between different hazardous levels of the referents, or to relate orange and yellow to lower hazardous levels such as warning, as they also used red in some warning signs. In studying color and

psychological functioning, Elliot and Maier (2007) suggested that color association is established based on either learning or biological proclivities. People sometimes learn the association from 'repeated parings of colors with particular messages, concepts, or experiences', or relate color to a behavior because of biological inherence. As it is unlikely that the red-prohibition and other associations connecting orange and yellow to prohibition and warning are kinds of biological inherence, it can be argued that the children in the study learnt the associations but did not develop a clear concept to distinguish among red, orange, and yellow in a safety context. They perceived red as a color to convey meanings of both prohibition and warning.

4.2. Blue for 'Water'

The statistical significance in the associations of blue and *R1 Wash your hands*, *R2 Warning: Slippery surface*, and *R5 Not drinking water* (see Tables 2 and 4) was due to the frequent use of blue for 'water' (see Table 8). The use of blue for 'water' was not observed in other referents, as among all referents, R1, R2 and R5 were pertinent to 'water'. The color was also found in expressing other objects such as footbridge and bottle but no statistical significance could be found correspondingly. The use of blue was not associated with any concepts significantly (see Tables 2 and 8).

The children in the study used blue in a straightforward fashion that blue was used to represent 'water'. In the ISO registered signs, blue was used in mandatory signs. None of the children had used blue in the way that the ISO registered signs do. The most similar use of blue could be found in *R12 Do not touch*, where blue was used for the concept of 'reminder' (see Table 7), despite the low count. However, R12 was not a mandatory sign but a prohibition sign. In addition, other mandatory signs, i.e., *R3 Use footbridge*, *R9 Use handrail*, and *R11 use this walkway*, were not associated with blue (see Table 2) or related to concepts illustrating by blue (see Table 7). The discrepancy between the use of blue in the ISO registered signs and among the children suggests that the use of blue in the registered signs is unable to convey the message of mandatory or be unintended to convey any messages to children. The ISO registered signs convey the safety messages primarily by their forms. For example, the ISO registered sign of *R1 Wash your hands* is 'to signify that hands must be washed' (International Organization for Standardization, 2011, p. 47). The image content includes two hands, three lines of four dots representing water, and a tap. Yet, the blue background color of the sign conveys unknown message. Blue, from the perspective of sign categorization, is used to differentiate the mandatory signs from other signs.

4.3. The Combinations of Green-Black and Blue-Black

Six combinations of colors show statistical significance in Table 4: red-blue, orange-blue, yellow-blue, green-black, and blue-black. Some combinations containing red, orange, yellow or blue are discussed in the previous sessions. The green-black and blue-black combinations are the focus in this section. Three statistical significances were found in the two combinations.

The two blue-black significant associations (to *R1 Wash your hands* and *R5 Not Drinking Water*) were probably due to the significant association between blue and the referents and the meaning of black among the children. The children had used black for 'dirty' or without

special reasons. It is clear from Table 7 that the children used black for 'dirty' in R1 and R5, though the percentages of explanations of the color were relatively low. Among all explanations of using black in all drawings, about 35.6% indicated that black was used without specific reasons. It is argued that black is a general color for children, and it can be used in most circumstances. This study shows that if it possesses a meaning, the best meaning is 'dirty'. The use of black as a general color is similar to that in the ISO registered signs, where black is used as the color of the objects appeared among the prohibitions signs and as a contrasting color and the triangular frame among the warning signs.

Apart from the blue-black combination, significance was found between the combination of green-black and *R4 Warning: Drop/fall*. This result was exceptional, because neither green nor black was significantly associated with any referents. While black was used because of its generality, green was used for 'hill' as explained by the children (see Table 8). Although it is unknown whether 'hill' was a significant object used in the drawings of R4, green was a good fit for 'hill' from the children's perspective. In the ISO registered signs, green is the major color for safe condition signs (not included in this study). Comparatively, the children in this study used green in a more physical way.

4.4. The Children's Color Association from a Theoretical Approach

The children's reasons (Table 6) is mapped to the color association framework constructed by Osgood, May and Miron (1975) (Figure 2). Osgood et al. suggested that there are four types of color association: concrete identification, concrete association, abstract association and abstract symbolism. The first two types refer to the associations related to tangible objects, which have a typical given color (concrete identification) and a culturally assigned color (concrete association). The last two types refer to associations related to abstract ideas or concepts that are metaphorical (abstract association) and culturally significant (abstract symbolism). This categorization is comparable to the reasons given by the children in this study.

The children's reasons for using colors conform to the first three types of associations. The children were not expected to have any difficulty performing concrete identification and concrete association, as children at ages 7 to 11 should have the ability to perform these associations (see Slavin, 2006). For example, the children were able to associate blue with water (concrete identification) and yellow with signage (concrete association). Surprisingly, the children were also capable of attributing their reasons by abstract association, i.e., red with 'don't'. It is argued that among the six colors, red was the only color that the children were able to make abstract association.

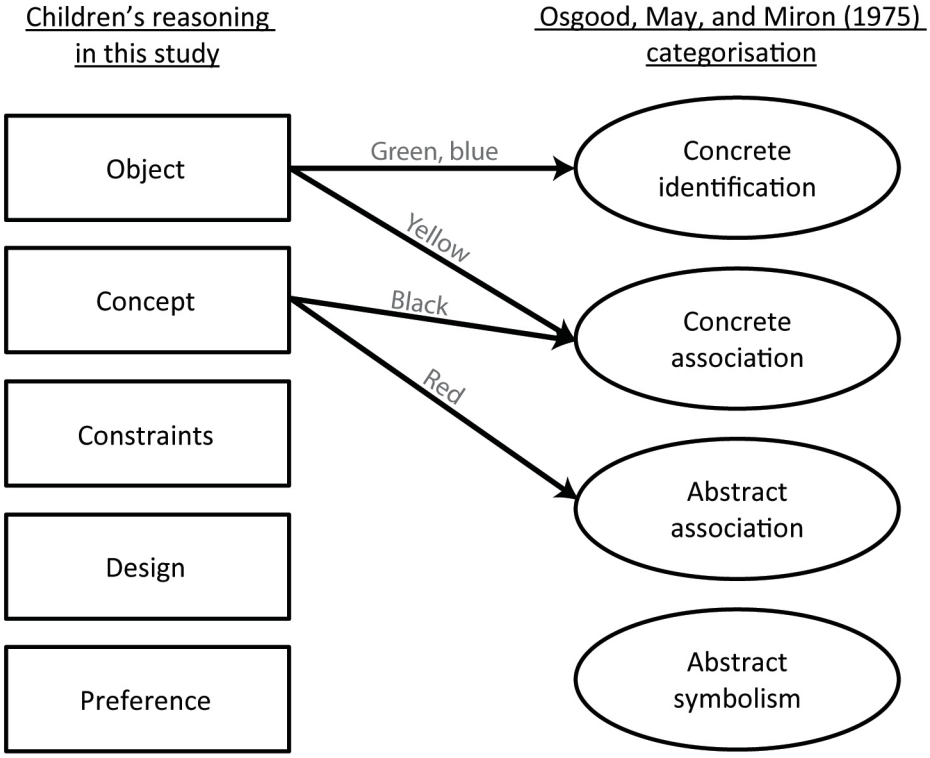

Figure 2. Mapping the children's reasoning in this study to the categorization of Osgood, May and Miron (1975)

The discussion here raises a question: should designers retain the conventional ways of using colors, or conform to children's color association found in this study? If the latter approach will be adopted, orange and yellow will be not used for hazardous meanings, as the children failed to associate orange and yellow by abstract association but only concrete identification or concrete association. This may violate some of the usual practices, and some educated adults who are familiar with the stereotyped color associations may be confused. This becomes a dilemma whether sign designers should align to the conventional practices and urge children to learn the stereotype, or generate a new set of signage from children's perspectives and understanding. Nevertheless, the results in this paper provide references for sign designers before making decisions.

5. Conclusions

Recent studies have identified that the use of color is an important topic in human factor research as well as professional practice. Based on the results discussed above, the children's use of color quite differs from that shown in the ISO registered signs. In the context of safety signs, this is especially important, as color provides additional information about the nature of the hazard (Industrial Accident Prevention Association, 2007). It is possible that this additional information can be misunderstood if users associate the color with unintended concepts or objects. It is thus necessary to understand children's color associations before designing signs for them. The quantitative data and verbal explanations given by the children in this study provide information on this topic. In addition, the method used in this study has methodological implication to research involving children that drawing is also an effective method to obtain feedback from children.

The results of this study showed that, first, the children were only able to make abstract association between red and 'don't'. Other hazardous colors such as orange and yellow did not have a similar meaning for the children. Second, blue and green had distinctive meanings, and they were used for blue and green substances in the reality. Last but not least, black was used for general objects. If it had a specific meaning, it was related to 'dirty'.

This study has several limitations necessary for further research and discussion. First, the cultural issue of color association has not been addressed. It is unknown whether studying children in other cultures would yield similar findings, and no comparisons have been made with children from different cultures. Thus, it is difficult to determine the extent to which culture influenced the findings of this study. Second, statistical tests were conducted on the association between the signs and colors but not the elements in the signs and the colors used for these elements. Studying the latter association statistically will be able to suggest results that are not limited to safety signs.

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