Environment Safety and Visual Communication: An Exploration of Children's Comprehension on Safety Pictograms

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Abstract

According to the statistics on the causes of death from the World Health Organization (WHO) over the years, accidental injuries ranked first among the causes of death for child. Observation of the child safety sign design reveals that there are cartoon characters used in the safety signs both at home and abroad. This study took the sign of "mind your hands", which is commonly seen in public places, as the subject, and explored the environmental dangers, animal characters, and images to identify the problems with children's image recognition. Preschool children aged between 4 and 6 were the subjects of this study, and 67 children were tested through a questionnaire survey and interviews. The results show that: (1) in the image of "mind your hands", the "animal (koala)" was the highest for all children (49.17%), 4-year-old children mainly chose the "animal (koala)" (80.0%), while 6-year-old children mainly chose the "crying face" (54.08%); the results show that there were obvious differences in the "crying face" (P=0.002); (2) 6-year-old children indicated that the combined image of "crying face" and "koala" is clear and simple; the exaggerated painful expression is easily associated with the consequence of hands being pinched; (3) children mentioned that, in the image of the "koala", its hand got pinched, but without any description of the consequences of the pinch injury. Finally, this study suggested that interviews should be conducted with kindergarten teachers, parents, and sign designers, in order to understand children's recognition of safety pictograms and environments from different perspectives.

Keywords: Environment safety, preschool children, safety pictograms, recognition, visual communication

1. Introduction

According to the "World Report on Child Injury Prevention" (2008) from the World Health Organization (WHO), when children reach the age of five years, unintentional injuries are the greatest threat to their survival, and unintentional injuries are also a major cause of disabilities (Branche, C., Ozanne-Smith, J., Oyebite, K., & Hyder, A. A., 2008). The Jing Chuan Child Safety Foundation conducted statistical analysis on the news of child accidental injuries from 2018, and the results showed that children under 6 years old accounted for more than 50% of the deaths and injuries. In particular, "traffic accidents" and "negligence of care" were the main causes of child death and injury (Jing Chuan Child Safety Foundation, Located in Taipei，An organization of promotes child safety education). When children are in a public environment, the issues of how to recognize dangers and prevent the occurrence of accidents, and how to use images to convey safety information, are very important. The sign of "mind your hands" can be seen everywhere in both official and civilian designs of safety signs both at home and abroad. Taipei Metro displays the warning sign of "mind your hands" on various places, such as elevators, escalators, MRT electric doors, and gate machines. However, elevator clearance must allow up to 10mm due to service wear (Public works committee, 2003), thus, when children are exposed to equipment with multiple machine clearances, their tiny fingers might get pinched without enough attention. Preschool children are naturally curious and active, and have weak ability to protect themselves. Without the guidance of parents and teachers, it is not clear how well children perceive these images. Through a survey and interviews, this study helped children recognize safety information with images in the form of course teaching. As a result, the purposes of this study were: (1) to understand preschool children's recognition of "mind your hands"; (2) to compare the recognition of "mind your hands" among children of different ages; (3) to summarize children's recognition and suggestions for the design of safety pictogram information on the basis of the above results.

2. Literature Review

2.1 Children's Recognition of Pictograms

Piaget (1964) observed the knowledge development of children from a cognitive dimension and classified preschool children as being in the "later stage of the preoperational stage" (aged from 4 to 7). The children in this stage have the conception of relationship, time, and sequence, but merely focus on individual cognition. Moreover, they have

consistent capability for classification and the ability to express in a verbal and imaginative way (Papalia, Olds, & Feldman, 1990). Vygotsky believed that children's cognition derived from the process of social learning (Siegler & Booth, 2004) and underlined that "symbol" is a psychological tool for children to express ideas (Vygotsky, 1986) and that children describe what they want to express through some behaviors. Bruner (1966) divided representation into three types: enactive representation, iconic representation, and symbolic representation. Enactive representation means that children under the age of three understand the world through action and practice. Iconic representation indicates that children aged from 3 to 6 can acquire knowledge through pictograms (Papalia et al., 1990). Visual signs convey many messages simultaneously. Before their linguistic competence is fully developed, children think with the help of pictograms (Szechter & Liben, 2004).

There has been an increasing number of studies in recent years on preschool children's understanding of pictograms, and research findings show that "pictograms" are helpful for such understanding. For instance, Waterson, Pilcher, Evans, and Moore (2012) conducted a survey on the safety pictograms on trains among children aged from 4 to 10 and found that pictograms could facilitate the conveyance of safety information. Deák and Toney (2013) studied the effect of learning new words with pictograms among children aged from 4 to 5 and noted that pictograms could improve learning. Lin, Chang, and Liu (2015) carried out a survey on warning pictograms among children aged from 4 to 6 and presented that pictograms could help children understand dangerous situations and pictograms should be simple and easy to understand. According to the above studies, pictograms can improve children's learning effectively given that they have little life experience in childhood, and the pictograms should be simple and easy to understand (Waterson et al., 2012; Deák et al., 2013; Lin et al., 2015).

2.2 Child and Safety Pictograms

As far as the design of safety pictograms is concerned, the International Organization for Standardization (ISO) has released the norms for iconic pictograms: (1) pictograms should be simple, clear, distinguishable, logical, and easy to recognize and reduplicate; (2) pictograms should be clear and easy to recognize; (3) pictograms should be free from too many details and show the most recognizable part only; and (4) pictograms can be presented with/without simple written description. Marcus (1992) argued that a good pictogram design should be based on the understanding of users and that it should be simple and clear in meaning and convey the message directly to viewers (Young & Wogalter, 1990). Most users tend to use "pictograms" for communication (Kalsher, Brantley, Wogalter, & Snow-Wolff, 1991). A highly understandable "warning pictogram" is one that can break the limitation of text and convey information in a direct and swift way (Adams, Bochner, & Bilik, 1998). However, according to the suggestions on pictogram designs for children, exclusive pictograms should be made for children due to their strong curiosity, limited perception, and inadequate literacy.

Kalsher and Wogalter (2008) said that some design norms are applicable to children, including (1) warning pictograms must "stand out" and feature bright and comparative colors to catch the attention of children; (2) pictograms are designed to convey a message through images. In the guidelines for the design and evaluation of warning signs, Wogalter et al. (2012) mentioned some visual elements, including (1) pictograms: iconic images are used to enhance safety information; (2) examples: iconic image examples telling "good" behaviors from "bad" ones are used for illustration; (3) symbology: a set of signs that can capture children's attention are adopted; (4) characters: safety role features are used to facilitate the spreading of safety information; and (5) colors: employed to enhance safety information (Wogalter, Conzola, & Smith-Jackson, 2012). According to the above studies, Patrick, and Monk (2013) conducted an interview survey among children and suggested that popular roles, such as those on television, could be adopted rather than those scary images like monsters. Signs should be easy for children to understand. Examples telling "good" behaviors from "bad" ones are suitable for children, but it is also worthy of attention that children may be motivated to imitate some "bad" behaviors. When it comes to the use of color, children's association concerning colors should be taken into consideration. For example, "red" represents "danger" rather than "warning" (Waterson & Monk, 2013).

3. Methods

3.1 Experimental Design

This study conducted surveys on four- to six-year-old preschool school children, and investigated their recognition of warning pictograms. The research process includes two stages: (1) The first phase was the selection and preparation of pictograms: discuss the results of pretests with professionals, modify the survey and choose two to five pictograms (Figures 1 and 2), including: children's recognition of safety pictograms: asking them choose pictograms that best represent danger. (2) The second phase was the questionnaire survey, which investigated preschool children recognition of warning pictograms. (3) Interview of survey：Conduct one-on-one interviews with 10 six-year-old subjects to identify and access images.

3.2 Subjects

Preschool children were the subjects of this study by convenience sampling. Respondents were recruited from a kindergarten in New Taipei City, Taiwan. In total, there were 67 respondents, including 24 children aged 6 years, 23 children aged 5 years, 20 children aged 4 years old, 34 boys and 33 girls. The distribution diagram is shown in Table 1.

Table 1: Class and Number of Subjects

Age	Age	Male	Female	Total
4-years-oldchildren	3 years and 8 months ~ 4 years 7 months	11	9	20
5-years-old children	4 years 8 months ~ 5 years 7 months	11	12	23
6-years-old children	5 years 8 months ～ 6 years and 8 months	12	12	24
Total	Average of 4 to 6 years old	34	33	67

No.A1 Girl | No.A2 Boy | No.A3 Hand Pain | No.A4 Crying Face | No.A5 Koala

Figure 1: Survey Sample

3.3 Materials

Sample selection: Based on the results of pretest and literature, the researchers selects samples from website search and officially used pictograms. Samples were drawn from signs that "Mind your hands", "Keep Hands off the Door" and "Caution! Risk of Pinching Hand". For this study, pictograms for the survey were modified based on the results of the pretests and expert opinions. In total, there were five warning pictograms of each of the one types.

Pictogram design process: There were five pictograms used (Figure1). A1(Girl), A4 (Crying Face) is the warning signs used by Taipei Metro. A2 (Boy) is the warning sign used by the mainland subway sign. A3 (Hand Pain) is the warning sign used by Taiwanese learning institutions. A5 (Koala) is the warning sign used by the Taiwan Railway. All the pictograms mentioned above were printed in black and white colors, edited and arranged properly on the paper. Safety pictograms were coded from one to five.

Modified pictograms: The scale of the graphic was drawn according to the norms of safety pictograms. Every pictograms were printed in a 60×60 mm black and white block and drawn on a G8K (21x29.7cm) paper. All pictograms were designed using Adobe Illustrator CS6 and properly printed at high resolutions. Because children have a short attention span, the number of pictogram samples should be minimal. Surveys that require respondents to choose one answer out of five options have been found to be especially suitable for children. Samples from the questionnaire are shown in Figure 2.

The safety pictograms survey included three aspects: instruction, basic information and questionnaire form. The instruction primarily introduces students to the task of completing surveys. Instructions were given orally, asking students to choose safety sign from five pictograms. Basic information includes personal background information, such as gender, age, and class. The researchers assist the children in providing this information prior to the test. The subjects were asked to fill out the survey one at each time, which required them to choose one answer from five options.

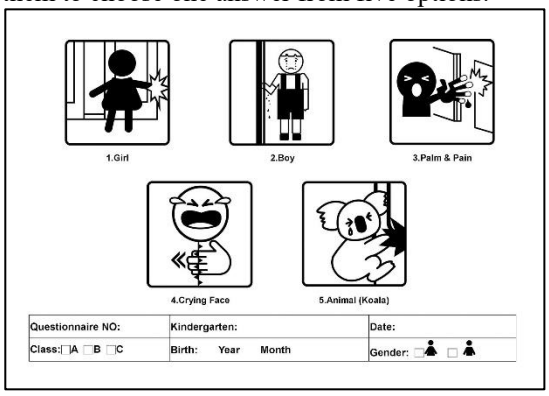

Figure2：Survey Questionnaire Sample

3.4 Procedure

After the researchers used picture book (Emily & Natalie, 2009) taught about the safety of environment and "Mind your hands", groups of children were asked to complete the survey once they fully understood the topic. The survey showed the following title: "Please choose safety sign from five pictograms". The subjects completed their answer sheets around ten minutes in the classroom. The time spent on the surveys was monitored carefully. The purpose of the survey was clearly defined; when a respondent expressed confusion about a question, the researchers explained it to him or her again. The classroom was lit by natural and fluorescent light. The researchers observed the survey process, which was also recorded by digital video. After all surveys were returned, they were properly organized, coded, and analyzed.

3.5 Data Analysis

The raw data derived from the survey was coded and analyzed by SPSS. Different classes of respondents were compared by different statistical

methods, including descriptive statistics, One-way ANOVA and LSD (Least Significant Difference), which were used to explain preschool children's differential recognition of safety pictograms.

4. Results

4.1 Recognition Across Age Groups

As shown in Table 2, recognition of safety pictograms across classes was explained by descriptive statistics. Four-years-old children mainly choose "koala" (80.0%); 5-years-old mainly choose "koala" (43.4%)、"hand & pain"(34.72%), and 4-years-old children mainly choose "crying face" (54.08%). Therefore, 6-years-old children had the highest percentage (80.0%) of respondents that choose "koala"; 5-years-old had the second highest percentage (43.4%) and 4-years-old children had the minimal percentage (29.12%). However, with respect to the recognition of "crying face", 4-years-old children had the highest percentage (54.08%) of respondents that choose "crying face"; 5-years-old had the second highest percentage (21.7%) and 4-years-old children had the minimal percentage (20.0%). Overall speaking, four- to six-year-old preschool children had better recognition of "koala" and worst recognition of "girl", "boy". Four-years-old and 5-years-old children are mainly based on "koala" pictograms, Six-years-old children are mainly "crying face" and "koala", and the choice is more scattered.

Table2: Descriptive Statistics of Safety Pictograms, Number of People (percentage)

Subjects	Pictograms	Name	4-years-old children N=20	5-years-old children N=23	6-years-old Children N=24	Percentage of all N=67
A1		Girl	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
A2		Boy	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
A3		Hand Pain	0 (0.0%)	8 (34.72%)	4 (16.64%)	12 (17.88%)
A4		Crying Face	4 (20.0%)	5 (21.7%)	13 (54.08%)	22 (32.78%)
A5		Koala	16 (80.0%)	10 (43.4%)	7 (29.12%)	33 (49.17%)

4.2 Recognition Differences Across Age Groups

Table 3 (A3, A4, A5) demonstrates that preschool children's recognition of "crying face" (p=.004**) and "koala" (p=.003**) showed very significant differences. Their recognition of "hand pain" (p=.44*) exhibited significant differences. After the data were found to be statistically different using a one-way ANOVA, the data were further analyzed using LSD to ensure that the differences across classes would be clearly shown. As shown in Table 4 (A3, A4, A5) with respect to recognition of "hand pain", there are statistically significant differences between 4- and 5-yearold children (p=.014*). More than 34.72% of the 5-year-old children and 6-year-old children (16.64%) indicated that "hand pain" expresses warning messages clearly. However, the 4-year-old children (0%) never chose this pictogram.

Table3: ANOVA Test of Safety Pictograms

Factor：GROUP			Sum of Squares	df	Mean Square	F	Sig.
A1.Girl		Between Groups	.000	2	.000	.	.
		Within Groups	.000	64	.000		
		Total	.000	66			
A2.Boy		Between Groups	.000	2	.000	.	.
		Within Groups	.000	64	.000		
		Total	.000	66			
A3.Hand Pain		Between Groups	.977	2	.488	3.290	.044*
		Within Groups	9.501	64	.148		
		Total	10.478	66			
A4.Crying Face		Between Groups	2.217	2	1.109	6.006	.004**
		Within Groups	11.813	64	.185		
		Total	14.030	66			
A5.Koala		Between Groups	2.849	2	1.424	6.560	.003**
		Within Groups	13.897	64	.217		
		Total	16.746	66			

Note : 1.(*Significant Difference), p≤.05 ; (**Very Significant Difference) p≤.01

In terms of the recognition of "crying face", there are statistically significant differences between 5- and 6-year old children (p=.002**) and between 4- and 6-year-old children (p=.008**). Six-year-old children (54.08%) had the highest recognition of safety pictograms, compared with 4-year-old children (20.0%) and 5-year-old children (21.7%) with lower recognition. Most 6-year-old

children indicated that "crying face" signs most clearly express messages of warning and that "koala" signs exhibit warning messages only moderately well. With respect to "koala", there are statistically significant differences between 5- and 4-yearold children (p=.027*) and between 4- and 6-year-old children (p=.001*), compared with 29.12% of the 6-year-old respondents who believed that this pictogram expressed a warning message.

Table 4: LSD Multiple Comparisons of Safety Pictograms

Subjects	**A3. Hand Pain** 			**A4：Crying Face** 			**A5：Koala** 		
Age	4-years-old	5-years-old	6-years-old	4-years-old	5-years-old	6-years-old	4-years-old	5-years-old	6-years-old
4-years-old children	—	.014*	.321	—	.680	.008**	—	.027*	.001**
5-years-old children	.014*	—	.112	.680	—	.002**	.027*	—	.075
6-years-old children	.321	.112	—	.008**	.002**	—	.001**	.175	—

Note : 1.(*Significant Difference), p≤.05 ; (**Very Significant Difference) p≤.01
2.A3:5-years-old children＞6-years-old children＞4-years-old children; 4:6-years-old children＞5-years-old children＞4-years-old children; A5: 4-years-old children＞5-years-old children＞6-years-old children.

5. Discussion

According to the statistical analysis, among all warning pictograms, the preschool children's answers indicate that "koala" expressed warning most clearly and that "girl" and "boy" was the weakest expression of warning. With respect to age, 4-year-old children and 5-year-old children thought that "koala" expressed warning most strongly, whereas 6-year-old children thought that "crying face" expressed warning most strongly and that "koala" expressed warning only moderately. According to the above experiments and interviews, 6-year-old subjects stated that they had seen a pictogram of a "crying face" on a subway and sometimes a pictogram of a "girl" on an elevator, but most subjects were deeply impressed by the pictogram of a "crying face". This pictogram included a crying child whose palm touched the automatic door and whose fingers became fractured. This sign warns that fingers may be squeezed in the crack between the door and its frame. In a comparison between the "crying face" and the "koala", the subjects believed that the former pictogram indicated more pain, because it featured two closed eyes, a wide-open mouth, two teardrops, and four fractured fingers - all of which imply "great pain and danger". In contrast, "koala" showed just one teardrop after touching the door. The 4-year-old subjects said that the animal was cute and deserved sympathy. The 6-year-old subjects said that they were more familiar with the combination of "crying face" and "palm", because they had seen it. They added that the pictogram was clear and simple and easy to recognize and associate with something. Some 6-year-old subjects said that the facial expression and swollen fingers of "hand pain" indicated severe pain, and that the pictogram could also be used to convey the message of "mind your hands".

These five pictograms all have a main character that touches the door with hands, has a facial expression, and is in a dangerous place. As far as the pictogram of the main character is concerned, the pictogram of "girl" does not show any emotion on her face, and her facial expression was presented with a color silhouette. The pictogram of "boy" shows a crying face with drooping eyes and a twitched mouth. The pictogram of "hand pain" displays closed eyes and an open mouth. The pictogram of "crying face" presents closed eyes and a crying mouth. In terms of the description of a dangerous consequence, the pictogram of "girl" merely tells that the crack between the door and its frame should not be touched, but does not show potential dangerous consequences, which are described in such pictograms as "boy", "hand pain", and "crying face". The pictogram of "boy" has bleeding fingers; the pictogram of "hand pain" has swollen and bleeding fingers; the pictogram of "crying face" has fractured fingers (there are swollen fingers in a colorful pictogram). It can be deduced that the message to be conveyed in the pictogram of "crying face" is strong and complete, while the pictograms of "girl" and "koala" merely show the action of touching, but do not reveal the consequence of "being squeezed".

As for children's understanding of pictograms, Piaget (1964) said that children aged from 2 to 7 (in the preoperational stage) could express their understanding of the world through a single word and sign and would make a judgment through "intuition". Their thinking featured "direct reasoning", and they tended to personify all objects (Papalia et al., 1990). Take the pictogram of "crying face" for an example. The painful facial expression is adopted to convey the message of danger, which is supported by an action. This pictogram is understandable and acceptable to preschool children aged from 4 to 6. In addition, the pictogram of

"koala" was widely accepted by the subjects, as they showed special preference for animals. According to the interviews, only a few children had their fingers squeezed in a public place. Most of the children believed that "a squeezed finger" was like a touched, patted, or pressed finger, and they did not have the experience of having their fingers squeezed. Therefore, children aged from 4 to 5 interpreted the pictogram as "I should touch the crack carefully and my fingers would be pressed and cause pain"; they did not regard it as a warning of "being squeezed" or a prediction of an accident that would lead to a fractured finger.

6. Conclusions

According to the research results, children aged from 4 to 6 showed the highest level of recognition of "koala" for the pictogram of "mind your hands". There was a significant difference in "hand pain" and a highly significant difference in "crying face" and "koala". As for the comparison between children of different ages, older children prefer "figures" while younger children prefer "animals". The 6-year-old children showed a preference for the pictograms like "crying face" on the subway in Taipei, while the 4-year-old children showed a preference for animals like koalas. As far as the whole survey is concerned, 6-year-old children were more prone to accidents and had stronger abilities to express ideas and describe things; moreover, they showed more interaction and feedback to the pictogram of "mind your hands". In comparison, children aged 4 to 5 showed weaker abilities to express ideas and to interact, and they had a lower level of understanding of a dangerous place in the environment. However, the individual interviews with the teachers and parents showed that younger children who had an accident of having their fingers squeezed were unable to express ideas and showed the problem of communication. Hence, the research results of this study are the same as those of other studies: Warning pictograms should be more attuned with children's lives, and objects should be concrete to ensure that they will not conflict with children's cognitive development or cause confusion with other symbols (Lin et al., 2015).

According to the research results, this study proposed some suggestions on the design of safety pictograms: (1) safety pictograms should be educational and popularized so that children can recognize the pictograms with the help of parents and teachers, enhance their understanding of dangerous places, and pay more attention to personal safety and avoid accidents; (2) pictograms should be designed according to the age, cognition, and behavioral experience of users; and (3) "warning" and "consequence" should be taken into consideration in the design of pictograms to remind viewers of potential harm. According to the above findings, pictograms are closely related to the life experiences, familiarity and preferences of users. To design a pictogram about environmental safety, a designer should consider children's cognition development, and governments and schools should cooperate with each other to plan the measures for safety popularization and education, so as to effectively convey the message of warning pictograms.

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