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A preliminary surveying of the meaning of colored pictogram instructions for emergency settings in manufacturing

Suopor Hiranchiracheep[a,b*], Atsuko K. Yamazaki[a] and Wichean Foypikul[b]

[a]*Graduated School of Engineering and Science, Shibaura Institute of Technology, 307 Fukasaku, Minuma-ku, Saitama City, Saitama 337-8570, Japan*

[b] *Faculty of Industrial Technology, Nakhon Ratchasima Rajabhat University, 340, Suranaree Rd., Nai Mueang, Nakhon Ratchasima 30000, Thailand*

Abstract

Pictograms are often used for situations where people often do not share the same language. The authors surveyed the comprehension of colored pictograms for emergency situations in manufacturing which can be affected by cultural and educational backgrounds. Colored pictograms for manufacturing setting, such as 'push', 'step' and 'wheel', were designed and presented to workers with different cultural and educational backgrounds in a factory. Their acting behavior scales were examined by conducting a questionnaire survey. Pictograms in different seven colors, such as white, black, red, yellow, green, blue and pink, were used in the survey. The questionnaire was presented to 138 factory workers in Thailand with three different nationalities: Thai, Myanmar and Cambodia. Results indicate that colors have effects on their acting behaviors. The mean values of the acting behavior scales for a group with higher educational backgrounds marked the highest of over 50 % for red. On the other hand, the average value of middle and low educated groups marked the lowest of less than 3 % for red color.

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Keywords: pictogram instructions; colored pictograms; manufacturing settings; swift actions; emergency situations

Corresponding author. Tel.: +08-48-687-5724; fax: +08-48-687-5013.
E-mail address: nb15103@shibaura-it.ac.jp

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1. Introduction

Many manufacturing companies have increased their movement of inventory and overseas production sites with lower labour costs in order to take opportunities for the optimal total cost. Under these circumstances, various languages are used at workplace in manufacturing setting, in particular Southeast Asian countries. Nowadays, many problems associated with language communication gaps in factories, such as delaying deliveries and an increasing in the number of product defects and accident. Eurostat reports 2,487,794 non-fatal and 3,515 fatal accidents involving at least four calendar days of absence from work in the European Union in 2012[1]. These problems may occur from many causes. One of major causes can be a communication problem among workmates from different language backgrounds or among employees at different job ranks. Workers in a factory often have to cooperate with colleagues who have diverse culture and language backgrounds[2]. Therefore, high quality of communication is necessary in order to follow right production procedures to meet manufacturing objectives and to get efficient results for productivity. This is a key to effective manufacturing procedures, in particular emergency situations.

Since pictograms can be used to enhance swift communication without conversing in the same language, necessary measures to be taken for emergency situations can be conveyed to workers with different language backgrounds by using pictograms. Although pictograms are seldom used to show procedures in manufacturing setting, pictograms for manufacturing processes can convey meanings effectively and comprehensibility without relying on language. From the results of a previous study by Yamazaki & Taki indicate that pictograms including an object and an action can be comprehended better than ones including with an action without an object[3]. In this regard, there is an imperative need for the use of pictograms that can represent swift actions for communication among workers with different language backgrounds, especially in emergency situations in manufacturing.

Pictograms are usually used in risk work where necessary actions need to be comprehended correctly. For example, pictograms on pesticide labels indicate pesticide's toxicity and should be interpreted as ''dangerous to pedestrians'' and ''don't walk through pesticides''[4]. Many studies on medical instructions have developed pictogram for low-literacy populations, such as in the cases of glaucoma[5]. Also, pictograms are often used to show actions to be taken in an emergency situation. These pictograms are often colored and principles for colores in safety signs and pictograms are often guided by such organizations as International Organization for Standardization (ISO), Japanese Industrial Standards Committee (JISC) and Industrial Accident Prevention Association. ISO 7010 prescribes design principles including shapes and colors for safety signs. In their principles, red, yellow, blue and green colors are used for prohibitive actions or fire equipments, warning, mandatory and escape routes and safety conditions as first-aid respectively[6, 7]. According to standards determined by JISC, red color in JIS symbols shows 'prohibition' and 'stop'[8]. Although these color standards have been incorporated into sign tandards at organizations and factories, pictograms in various colors such as red, yellow and green are still used for different meanings at many workplaces.

It is important to have all staff members at an organization comprehend the meaning of a colored sign to prevent injury or be well aware of possible dangers. In the same token, the meaning of a colored pictogram to show a necessary action in an emergency situation at a factory should be well understood by all workers and managers who often have different linguistic or cultural or educational backgrounds. The colors of pictograms have to be designed for matching their perceptions with actions. In this study, the authors developed new pictograms which can perceptively convey the meanings of operations necessary for an emergency situation in manufacturing settings. We focused on colored pictograms and investigated whether different literacy levels and cultural differences of staff members at a manufacturing company can affect their acting behaviour in terms of their perception for the operations.

2. Methodology

2.1 Colored Pictograms

In this study, we focused on common actions used in manufacturing procedures to be taken for an emergency situation in factories. We chose three typical actions: 'push' a button, 'step' on a pedal and 'wheel' a handle. We designed three pictograms for these common actions for guiding workers to take these manufacturing steps. Pictograms for taking actions are often represented by using black colors or black lines, but we used various colors for the part of the pictograms that represent verbs for these step actions consists of a hand and an arrow for 'push', a foot and an arrow for 'step' and a hand and an arm and an arrow for 'wheel'. We chose seven colors for the action parts of the pictograms, such as white, black, red, yellow, green, blue and pink. Other parts of the pictograms were drawn in black color. We created a set of seven differently colored pictograms for each action. Figure 1 shows the pictograms in seven different colors for the actions to be taken in an emergency situation at factory.

2.2 Acting Scale Questionnaire and Subjects

In order to examine how colored pictograms can effectively convey the importance of an action represented by each pictogram, we created a questionnaire to ask how important a subject feels for an action represented by a differently colored pictogram when they encounter an emergency situation. A part of the questionnaire is shown in Figure 1. The questionnaire was presented to 138 staff members at a factory in three different groups: a group of high-literate worker subjects who had an undergraduate or graduate degree, two groups of medium-literate worker subjects who held a secondary school or vocational diploma, and a group of low-literate worker subjects who received education up to the primary school level. All respondents to the questionnaire worked at factories of a cosmetic company (LF Beauty Company) in Thailand. The ages of respondents ranged from 19 to 51 years, and they had three different nationalities: Thai, Burmese (people from Myanmar) and Cambodian (58 Thai subjects, 40 Myanmar subjects and 40 Cambodian subjects) as shown in Table 1. They responded to the questionnaire in which the instructions were expressed in their native languages. Table 1 also summarizes the gender, age range and educational level of the subjects.

Table 1. Personal background data of the subjects in this study: gender, age range, nationality and educational level

		Thai	Burmese	Cambodian
Gender	Male	23	26	19
	Female	17	14	21
Age	12-17	0	0	
	18-27	11	22	24
	28-37	28	14	14
	38-47	9	4	2
	48 or above	10	0	0
Education level	Primary School	0	40	40
	Secondary School	38	0	0
	Vocational Diploma	2	0	0
	Graduate/undergraduate degree	18	0	0

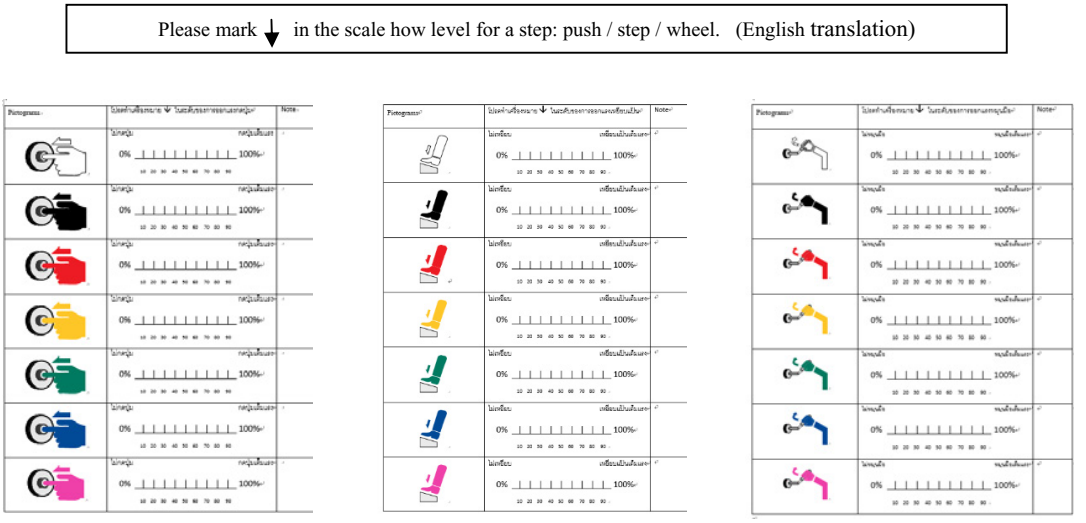


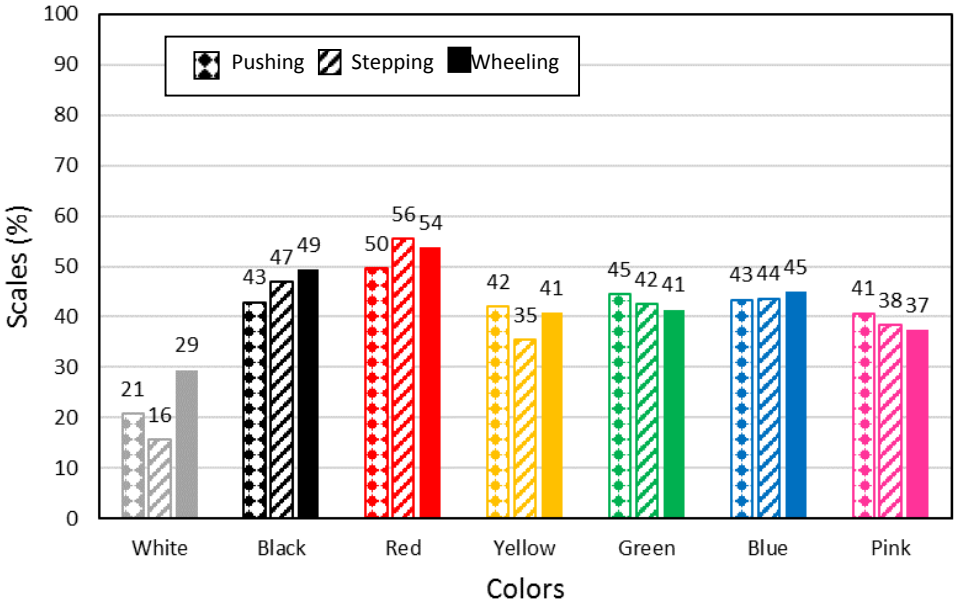
Fig. 1. Part of the questionnaire in Thai language: the action pictograms in different seven colors

3. Results And Discussion

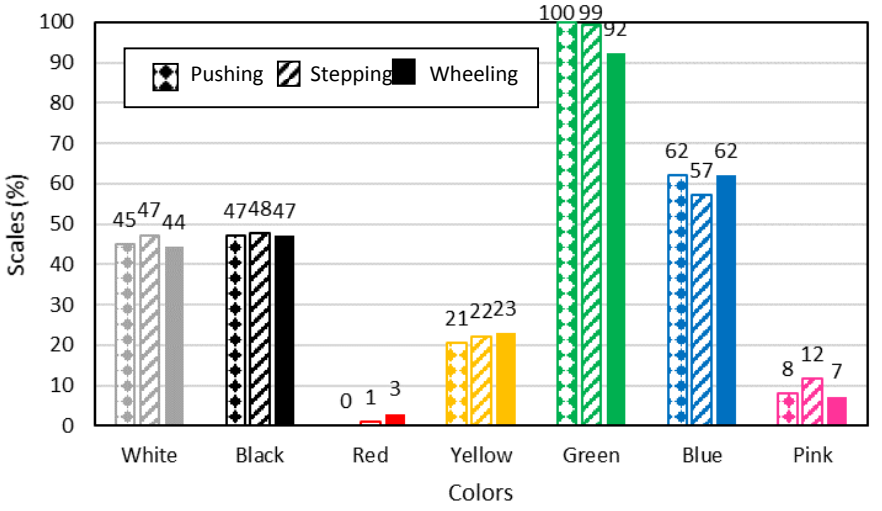
The authors collected 138 responses from the respondents who were working for factories in Thailand. Figures 2 (a) through (c) presents the average values of the acting behavior scales obtained from the respondents. We divided the results into three graphs by education; (a) group of respondents with an undergraduate or graduate degree, (b) group of respondents with secondary school education or a vocational diploma, and (c) group of respondents with education up to the primary school level. Each graph shows the average values for even color categories; white, black, red, yellow, green, blue and pink. For the subjects with undergraduate or graduate education, we found that the red color marked the highest value of over 50 % of the scale for all types of pictograms. In contrast, the white color marked the lowest average value, which was less than 30 % for the high-educated group. On the other hand, results for the colored pictograms from workers with lower education, including Thai, Myanmar and Cambodian nationalities, showed very different tendencies from the results for the high-educated subjects. The lowest average value for the low-educated subjects was marked 0% for the red pictograms and it was the lowest average value among the seven colors. However, the green pictograms had the highest average value of over 99% for the low-educated subjects. The average values for all yellow pictograms were also low for both low-educated groups: the low-educated Thai subjects (from 21 to 23%) and the subjects from Myanmar and Cambodia (12 and 13%), while the average values for the high-educated Thai subjects were more than 35% for the yellow pictograms.

The results obtained from two groups with different cultural backgrounds and similar educational backgrounds showed similar characteristics. The results of the average values for low-educated respondents from Cambodia and Myanmar were very similar to the results obtained from Thai workers, who did not have an undergraduate or graduate degree. On the other hand, the results from the high-educated Thai respondents were very different from ones obtained from the low-educated Thai workers although both groups share the same cultural background. According to some previous studies, cultural differences affect the interpretation of colors and signs. Cho examined cross-cultural differences in pictogram interpretations by people from United States and Japan and suggested that cultural difference in pictogram interpretations could be used as an agent construction basis[9]. Piamontea *et al*. evaluated cultural differences in the interpretation of graphical symbols. Their results obtained from American and Swedish subjects

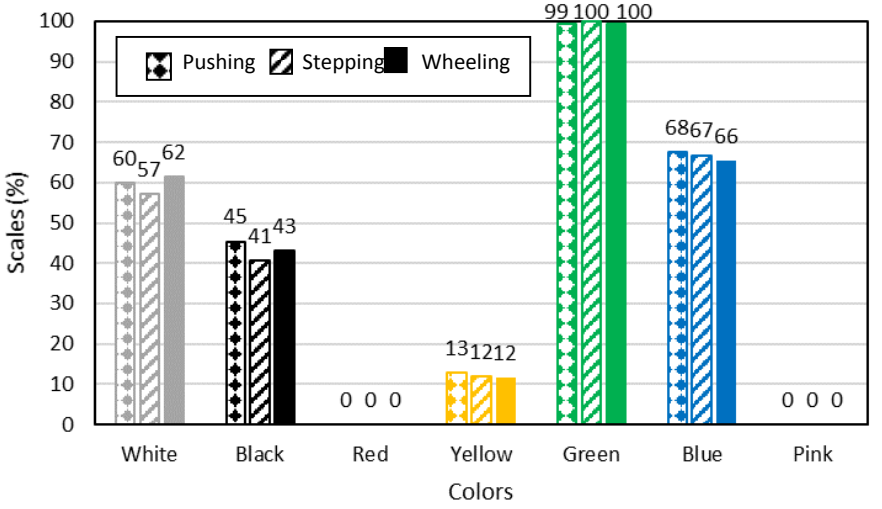
indicate that there were differences in pattern ratings between two nationality groups and the differences may be culturally linked[10]. However, the results in this study show that differences in the interpretation of the colored pictogram meanings were more affected by educational backgrounds than cultural differences. The results of average values of the acting behavior scale for colored pictogram in Figure 2 showed that there were opposite tendencies between the highest and lowest educated groups. These two groups may have interpreted the meaning of colored pictograms differently based on their previous experience. For the highest educated group of Thai nationalities, red color can be interpreted to have various meanings from prohibition to encouragement. In contrast, both low and middle educated groups, including Thai, Myanmar and Cambodian nationalities, interpreted red pictograms as actions that should not be taken. They may have interpreted that red and pink pictograms had the meaning of prohibition. The workers usually learn the meaning of pictogram and colors through training with safety and work instructions whose details often depend on their job ranks. Thus, they may have interpreted the meaning of pictograms in a different way from that of high-educated subjects.



(a) Thai subjects who had a undergraduate or graduate degree



(b) Thai subjects who had a secondary school and vocational diploma



(c) Myanmar and Cambodian nationalities with education up to the primary school education level

Fig. 2. Average values of the acting behavior scales obtained from three groups with different educational backgrounds for each pictogram color

4. Conclusions and Future Work

In conclusion, we examined the effects of educational and cultural backgrounds on colored pictogram instructions in terms of behavioral perception for actions in manufacturing settings, in particular emergency situations, by using a questionnaire. Questionnaire results showed a significant difference among groups with

different educational backgrounds. This suggests that educational backgrounds may affect more on the interpretation of colors used in pictograms than cultural backgrounds. Although we obtained the results that indicate the factors to affect the interpretation of colored pictograms, we need to get more data for detailed analyses for factors affecting their perception. Further studies should be conducted to examine what influences a person's ability to perceive the meaning of a pictogram when it is used in manufacturing settings. We plan to conduct perception reaction experiments with people with different backgrounds, such as nationalities, educational levels and industry business types, in addition to cultural backgrounds.

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