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A Development and Comprehension of Pictograms for Educational Purposes

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ABSTRACT

Many studies of pictograms indicate that they are useful for communication, not only with those who speak different languages. In a multilingual environment, such pictograms as restroom signs in train stations or other public areas and boarding gate signs in airports effectively convey information. These examples show that pictograms can be useful for non-verbal communication among people with different language backgrounds. Pictograms are also often utilized to give instructions to people with low literacy, children and people with language disabilities, and they play an important role in situations where swift and reliable information transfer is critical. This review covers theoretical and experimental studies, psychology of the design and validation, comprehension and usage of pictograms, particularly in educational contexts. The objective of this review is to evaluate the use of pictograms for people with low literacy, such as patients with low health literacy, young children and less-educated immigrant workers in manufacturing settings, and to verify if the use of pictograms could help increase understanding and compliance with instructions and the quality of communication for people with low literacy. The pictograms are often used to enhance the comprehension of critical information about medicines and safety. Through the review of studies on pictograms used in such environments, we found that many studies have pointed out that combining pictograms with brief counseling can increase the health knowledge of people with low literacy and improve their behaviors related to taking medicines and even their awareness of healthy living. On the other hand, not much research has been conducted to investigate the use and effects of pictograms for manufacturing settings where workers with lower literacy and different language backgrounds need to communicate with each other and swift communication is often critical in terms of safety. In this paper, we introduce two studies regarding the development and assessment of pictograms for instructions in manufacturing settings, and discuss the importance of pictogram designs for such purposes.

Keywords: pictograms, education, people with low literacy, workers, manufacturing settings

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Introduction

Pictogramsare believed to originate from prehistoric cave paintings and ancient hieroglyphics. Pictograms are non-verbal communication symbols representing commonly associated concepts. They are prevalently used as a visual communication tool to convey information and messages instantaneously. Such non-verbal communication is very useful, especially in emergency situations or when verbal communication is not possible (Ota 1995; Nakamura and Yuasa 1998; Fujisawa 2001). Icons and marks used in computers and electronic devices are also classified as pictograms. They are sometimes referred to as “signs” or “symbols.” All of them are collectively referred to as “graphical symbols” by the International Organization for Standardization (ISO) and as “pictorial symbols” by the (JISC) (Ota 2005). In addition, symbols called “ideograms” are used to represent a particular idea or concept. In many cases, however, all graphical and pictorial representations that are used to convey information and messages are referred to as “pictograms.”

Pictogram Ideogram Communication (PIC) is the most famous set of communication icons. It was developed by Subhas Maharaj (1980), a Canadian speech therapist, to support communication for people with difficulties in oral and/or written communication. These PIC symbols were also published in Japan in 1995 after they were adapted to communication in Japanese. PIC symbols have been widely used and studied as a communication support tool for children with disabilities. They have also been used in online chatting between children speaking different languages (Fujisawa 2006; Shimizu 2003).Another example of pictograms developed for communication support is a set of approximately 300 symbols created in accordance with the Design Principles of Pictorial Symbols for Communication Support (JIS T0103), established by Japanese Standards Association (JSA) 2005. While most of the JIS T0103-certified symbols represent objects and places, about 15 percent represent actions and movements in Figure 1. Some of them even express emotions. They are among those included in the JIS Design Principles of Pictorial Symbols for Communication Support.

Figure 1. Pictograms for described actions in morning situations: in the morning, wake up, wash a face, and brush teeth.

Furthermore, pictograms are used to communicate medication instructions. These are other examples of using pictograms when verbal communication is not effective (Mansoorand Dowse 2003; De Knegt 2016;) , especially for improving comprehension of people withlow literacy, theelderlyandchildren (Mori 2006; Ito and Hashida 2009; Kheir et al., 2014; Van Beusekom et al. 2017; Ng 2017). The use of pictograms for communication and information provision is prevalent. They are used not only as support tools for people with disabilities and public information, but also to represent varioushazards, such ason labels of agricultural or other chemicals (Chendrashekaran 2017; Eric Boelhouwer et al., 2013; Rother 2008). In addition, the literature contains only a few studies showing procedures in manufacturing settings. Pictograms are often regarded as effective means of communication at companies where many workers from various countries and different cultural backgrounds work, since theycan be used to improve occupational risk prevention at manufacturing sites. Therefore, many health and safety training or educational programs for employees at manufacturing companies include learning about pictograms and signs.Yamazaki and Taki (2010) indicated that well-designed pictograms for an action combined with the object conveyed meaning effectively, where safety and productivity are significant. Hiranchiracheep et al. (2016) examined the effects of educational and cultural backgrounds on colored pictogram instructions in terms of behavioral perception for actions in manufacturing. Theresults showed a significant difference among groups with different educational backgrounds.

There have also been studies conducted on how to use pictograms to show the parameters of special analytical instruments (Piamonte et al. 2001; Pratt 2002; Waichman et al. 2007; Lueder and Rice 2007). As the use of pictograms is spreading, an increasing number of studies are being conducted to review them, not only in terms of their shapes but also in terms of their colors and presentation methods, so that they can be used universally (Yang et al., 2002; Waterson et al. 2012; Korenevsky et al., 2013). In a study by Waterson et al., they gatheredevaluation data from more than 200 young children to evaluate new safety pictograms. Through the summative assessment of the effectiveness of the new pictograms, particularly in an example of formative evaluation, they outlined a useful set of guidelines for designing safety signs for young children (Waterson et al., 2012). As such, the aim of this review is to evaluate the use of pictograms from an educational perspective, e.g., illiterate or low-literate people, the elderlyand children, to verify if these could help increase understanding and compliance with instructions.

Pictograms for Educational Purposes

People with low literacy:

The studies of medication pictograms have focused on elderly patients with low literacy who display declining cognitive abilities and memory. Therefore, the comprehension of pictograms can assist in the care of the elderly in order to establish methods to convey medication instructions. Among the studies on the comprehension of medication pictograms, those conducted by Mansoor and Dowse (2003) and Dowse and Ehlers (2005) are particularlywell known. Both studies assessed the effectiveness of pictograms in showing how to take and store medicines in African countries with low literacy rates. The results suggested that the

US-designed pictograms that had been deemed effective were not interpreted in the same way in South Africa and that medication pictograms would need to be designed with consideration of cultural context. Knapp et al. (2005) examined whether the medication pictograms used in South Africa and the US could be understood by patients in the UK. The results showed that for both the US and South African versions, only three of the 10 pictograms were understood by more than 85 percent of the subjects. Meanwhile, Cho (2009) developed rather complicated pictograms by themselves and showed them to subjects, some US nationals and some Japanese nationals, to analyze the differences in their interpretations. The results indicated that different cultural backgrounds could cause different interpretations of pictograms.

Meanwhile, Shimizu et al. (1995) studied the use of pictograms to convey medication instructions in Japan. Their study examined whether the pictograms of medication instructions added on medicine bags could facilitate the understanding of the information, and found that medicine bags with instructions both in text and pictograms increased comprehension among more than 60percent of the subjects. Patients aged 60 years and over appreciated the pictograms more than younger ones. Based on these studies, the Risk/Benefit Assessment of Drugs – Analysis and Response (RAD-AR) Council, a voluntary association consisting of pharmaceutical companies in Japan, published medication pictograms in 2004. They aimed to explain proper medication use in a way that everyone, including children and elderly people, could understand. The medication pictograms developed by the RAD-AR Council were intended to be displayed on medication instruction sheets provided along with prescriptions. As of 2006, a total of 51 pictograms had been developed. Some pictograms were combined to illustrate medication instructions.

Kheir et al. (2014) developed and evaluated comprehension of medicine label instructions in a culturally diverse multiethnic population with low literacy skills. Participants were randomized to one of three studygroups: text plus verbal instructions, pictogram-only label, and pictogram with verbal instructions. The results showed that the pictogram with verbal instructions group achieved better comprehension.Van Beusekom (2017) examined 10 pharmaceutical pictograms and identified how the design could be improved for understandability by low-literacy patients in the Netherlands.Thirty adequately literate and 25 low-literate participants (assessed with the Dutch version of the Rapid Estimate of Adult Literacy in Medicine: REALM-D) were asked to verbally explain the meaning of each pictogram. The results of the study indicated that adequately literate participants could more easily understand pictograms than people with low literacy.Five pictograms of the adequately literate group and two pictograms of the low-literacy group reached 67% understanding for the ISO cut-off. Designing pictogram characteristics should focus on familiarity, simplicity, and showing the intake and effect of medicine.

The United States Pharmacopeia Convention (USP) developed 81 pharmaceutical pictograms as 'standardized graphic images that help convey medication instructions, precautions and/or warnings to patients with a lower level reading ability and patients for whom English is a second language. The USP pictograms have been tested for comprehension by Ng et al. (2017). They examined comprehension of USP pictograms for older Hong Kong residents

(65 and above). The first group was presented with text labels and another group with the text labels plus supplementary pharmaceutical pictograms.This study showed that older people favored the addition of pharmaceutical pictograms to written text for conveying medical information. Zargarzadeh and Ahamdi (2017) investigated the understandability of three pictograms selected as most applicable by participants and their recall after educational mini-sessions. The groups with lower levels of literacy had more difficulty interpreting them than those with a high level of literacy.

Young children:

To develop pictograms as an effective communication tool, it is essential to examine whether they are easy for the target group to understand. In particular, children's curiosity and a lack of experience and knowledge is critical to easily understand the pictograms in an instant. Linet al. (2015) investigated four- to six-year-old preschool children and aimed to identify how they understand warning pictograms (signs, frames, and colors). They used a questionnaire to determine children's understanding of warning pictograms and color; and an interview was conducted with the subjects to verify the extent of their comprehension.The results showed thatchildren had stronger recognition of "Palm" among all warning pictograms (Palm, Cross, Oblique Line, Skull, Exclamation Point), stronger recognition of "Triangle Frame" among all warning frames (Triangle Frame, Circular Frame, Diamond Frame, Octagonal Frame, Inverted Triangle Frame), and stronger recognition of the color "Red" among all warning colors (Orange, Red, Green, Blue, Black).In addition, they associated them with familiar objects. Waterson et al. (2012) analyzed various designs for safety signs and accident rate data on board trains for children (aged five-10). The result showed that posters and labels were given a blue background and the colour yellow was used for the background text in order to maximize the contrast between pictures and text as requested by the children. Moreover, to reinforce good behavior and the safety characters, the characters were always put on the "good" circle and never overlapped with pictograms highlighting bad behavior. Korenevsky et al. (2013) recruited adolescents (aged 12-18) from the volunteer organization of the Children's Hospital of Eastern Ontario (CHEO) in Ottawa, Ontario, as well as from a youth organization at the hospital to identify the common graphic elements for defined categories of pictograms and identify the key graphic elements common to all pictograms. For all 21 pictogramcategories, at least 80% of survey respondents agreed that the storyboard conveyed the intended meaning. The result indicated that the context in which pictograms are presented is important to their correct interpretation. Categories had few preferred pictograms such as "take with an empty stomach", "take one tablet", or "do not take if breastfeeding".

Workers with lower education in manufacturing settings:

Migrant workers in a factory often have to cooperate with colleagues who have diverse culture and language backgrounds. Therefore, pictograms can be used to enhance swift communication without conversing in the same language, where safety and productivity are critical. Yamazakiand Taki (2009) investigated the comprehension of pictograms in manufacturing settingsfor actions such as 'cut', 'push' and 'measure'. Their comprehensibilitywas examined

by Questionnaires A and B. Questionnaire Acontained pictograms with objects of intended actions, and Questionnaire Bhad pictograms without objects. The results indicate that well-designed pictograms for an action combined with an illustration of an object can be used effectively in manufacturing settings. In addition, pictograms showing use of a tool for actions such as cutting and measuring tended to be comprehended more correctly and spontaneously. Hiranchiracheep et al. (2016) examined the effects of educational and cultural backgrounds on colored pictogram instructions (push, step and wheel) in terms of behavioral perception. Pictograms in seven different colors (White, Black, Red, Yellow, Green, Blue and Pink) were used in the survey with three different countries (Thailand, Myanmar and Cambodia). Results showed significant difference among groups with different educational backgrounds. This suggests that educational background may have more effect on the interpretation of colors used in pictograms than cultural background.

Discussion

The first advantage of pictograms is that a graphical representation focused only on the necessary information can be understood intuitively and instantly; however, there may also be a disadvantage. Excessive filtering of information and oversimplified representations may cause confusion (Ota, 2005). Another advantage of pictogram communication is that information can be easily understood by anyone, regardless of language, culture, or age. Neither prior knowledge nor education is required to understand pictograms. This is why graphical symbols are usedfor the public. However, pictorial symbols often vary across countries and societies. This is because cultural context and individual cognitive performance affect the interpretation of symbols and icons (Mansoor and Dowse, 2003; Dowse and Ehlers 2005; Knapp et al. 2005; Cho, 2009). Moreover, some pictograms can be used only in certain cultural spheres (Mori, 2006). For example, the International Federation of Red Cross and Red Crescent Societies (IFRC) has two different emblems, one for Christian societies and one for Muslim societies.United States Pharmacopeial Convention (USP) pictograms are the most widely used and studied pictograms in the healthcare domain, but eventually they turned out to be slightly different from those used in other countries. These examples indicate that it is difficult to create a truly universal icon that can be used regardless of cultural context (Ota, 2005).

The American National Standards Institute (ANSI) as the American standard and the International Organization for Standardization (ISO) as the European standard have been developed to mitigate this issue. They have laid a foundation for the JIS-certified public information symbols. However, these ANSI, ISO and JIS standards cannot be applied to many pictograms. The uniform design principles set for public information symbols by the ISO Technical Committee on Graphical Symbols cannot eliminate regional differences (Ota, 2005). The study conducted by Kostelnick (1995) on the influence of cultural context on the comprehension of pictograms and pictographs indicated that the proper selection of information signs would depend on the familiarity of the symbols included in the signs to people in that culture as well as the complexity of cultural backgrounds of the target group, particularly when applying pictograms to children.

Tzeng et al. (1990) also assessed the recognition of pictograms from a psychological perspective. The results suggested that the test subjects preferred pictogram designs similar to those traditionally used in their home countries. Many other studies also showed that people's comprehension of pictograms could be greatly affected by their familiarity with the symbols and symbolic elements included in the pictograms (Preece et al., 1994; Quiye, 2000; Ng and Chan, 2007; Lin et al., 2015). Therefore, it is thought that each pictogram should be carefully examined as to whether it will be easily understood by the target group in the intended situation (Foster 1994; Matsuda et al. 2007).

Conclusion

The use of pictograms enhances illiterate populations' comprehension, including people with low health literacy, children and workers with lower education. Some of the reviewed studies about the use of pictograms for health education point out that pictograms can be very effective when they are used in combination with written or oralinstructions.In this review, we found only a few articles on the use of pictograms in manufacturing settings, compared to the existence of many studies on the use of pictograms to educate people for health and medical purposes. This gap in the literature underlinesthe need for more research in this area to provide a more comprehensive approach to pictograms in manufacturing settings, in particular situations where swift and reliable information transfer is needed, such as in dealing with an accident.

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