A. Auinger (Hrsg.): Workshops–Proceedings der 5. fachübergreifenden Konferenz *Mensch und Computer*. Wien: Oesterreichische Computer Gesellschaft, 2005, S. 81-87

Symbol Comprehension in Different Countries: Experience Gained from Medical Device Area

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Abstract

Due to the characteristic of "language-independence", graphical symbols are regarded as one effective way to convey information across countries. This paper present the study results to evaluate 16 symbols used on the ICU (intensive care unit) devices, regarding their comprehensibility in two countries: Germany and China. 20 German and 13 Chinese experienced nurses and doctors working in the ICU area participated in the test. The comprehension test method recommended in ISO 9186 was applied. The test results revealed that the comprehension of the symbols in both countries is generally poor and there is no significant difference between these two countries. The application experience of the users, however, significantly influences the target users' comprehension. It seems that training would be the indispensable way to ensure effectiveness of symbol application on device user interfaces.

1 Introduction

Graphical symbols refer to visually perceptible figures with particular meanings that are used to convey information independently of language. Modern medical devices and their user interfaces apply increasing amount of graphical symbols to convey information. Previous researchers have indicated that the graphical symbols have advantages in conveying information over other ways such as text (Davies et al. 1998, Perry 2003, Wolff & Wogalter 1998) which include:

- high visual impact to transmit information effectively;
- compact information which occupies less space on products;
- information independent of national languages, etc.

For global marketing of complex medical devices, the above mentioned advantages of symbols are becoming more important. For example in European Union, there are 25

official languages. This may make the user interface design using only the language more difficult.

However, symbol application in practice often meets with many problems: symbols might not be able to attract sufficient attention (Davies et al. 1998), symbols can convey a message different or opposite to what was intended (Collins & Lerner 1982), or symbols can be differently comprehended among users in different countries (Piamonte 2000, Shinar et al. 2003). Although standards and technical reports have been issued regarding the application of graphical symbols for use on medical devices (e.g. EN 980:2003 *Graphical symbols for use in the labelling of medical devices*; IEC 60878:2003 (draft) *Graphical symbols for electrical equipment in medical practice*; ISO 15223:*2000 Medical devices - Symbols to be used with medical device labels, labelling, and information to be supplied*), few studies to evaluate these symbols regarding their effectiveness have been published.

In the context of the global market, if safety relevant symbols are not correctly understood by target operators in the foreign countries, use-errors associated with risks for the operator or patient may be provoked. According to the requirements of ISO 14971 and EN IEC60601-1-6, these risks should be analysed and controlled to ensure device use safety.

2 Purpose

Purpose of the study is to evaluate the comprehension of graphical symbols used in the areas of intensive care units (ICU) among users in different countries, to identify potential problems with the application of these symbols in these areas.

3 Method

Liu and Hoelscher (2005) summarized some criteria for evaluating graphical symbols: noticeability, legibility, comprehensibility and suitability for learning. The selection of the main criterion largely depends on the intended use of the symbol. For example, a traffic sign symbol should be evaluated according to its noticeability and legibility (e.g. measured by the legible distance) but these criteria might be uncritical for a symbol used on medical devices. Since few symbols on medical devices can be seen and learned elsewhere, their comprehensibility is the most important one to evaluate their effectiveness.

The comprehension test method recommended by ISO 9186: 2001 "*Graphical symbols - Test methods for judged comprehensibility and for comprehension"* was applied in the study. The participants did the open-ended "free definition" task in the test. They were presented with the symbols and were instructed to write down their own opinion on the

meaning (the response) of the symbols freely. Two rounds of the test were separated: the first round was the comprehension with a *global* context which showed the general product type or the general environment in which the symbol could be found; the second round was conducted with a *fine* context presented additionally, which showed the direct application environment of the symbol, in which possibly other symbols could appear together with the symbol being tested.

Totally 16 symbols used in the intensive care areas and in the operation theatre were tested (see Table 1). 13 of these symbols were chosen from the draft of the IEC 60878 TR Ed. 2.0: 2003 "*Graphical symbols for electrical equipment in medical practice*". The other 3 were taken from products of different manufacturers. Each symbol and its contexts were printed on an A4 sheet of paper. In each round of the test the participant was free to choose the next symbol to be comprehended.

Number	Symbol	Intended Meaning	Number	Symbol	Intended Meaning
1		Date of manufacture	9		Trend information
2		Person identification	10		Bell cancel
3*		Bellow connection	11		Do not re-use
4		Manual control	12		Nurse
5		Power plug	13*		Infusion status
6		Display transfer	14		Locking (locked status)
7		Type BF applied part	15		Zero-point adjustment
8		Stand-by	16*		Blood pressure measurement

Table 1: Selected symbols and their intended meanings
*Note: the symbols with * are not standard symbols*

The responses of all participants were independently assigned by 3 judges into 7 categories according to the criteria specified in ISO 9186. The final score of a symbol is also obtained by summing and weighting the percentages of responses in the different categories, according to the formula recommended in ISO 9186. It reflects the comprehension of the symbol.

Two groups of participants participated in the test: 20 volunteer German nurses and doctors and 13 volunteer Chinese nurses and doctors working in the intensive care units. The participants had on average 9.9 (in China) and 12.6 (in Germany) years of professional experience at the time of the study.

4 Results

The comprehension scores for the tested symbols are presented in Figure 1. In general, the comprehension scores are low in both countries: In China, the average comprehension scores for global contexts is 32.2 (SD = 30.3) and for fine contexts is 48.2 (SD = 28.9); In Germany, the average comprehension scores for global contexts is 42.7 (SD = 36.3) and for fine contexts is 52.3 (SD = 27.7). Half of the symbols reached a comprehension score higher than 67% (which is specified as the acceptance criterion for safety-relevant symbols by ISO 3864) in Germany but only four symbols reached this level in China. If the criterion of 85% specified by ANSI Z535.3 was considered, only three symbols (both in China and in Germany) would be accepted. Some safety-relevant symbols, for example, the symbols for "Date of manufacturing" and "Don't reuse" (to label e.g. In-Vitro-diagnostics) reached a very low comprehension score in both countries, which suggested that problems might arise when applying these symbols in these application areas.

Further analysis aiming to reveal some differences in symbol comprehension between the two countries was conducted using the SPSS. The ANOVA analysis showed, neither with global context nor with fine context, the comprehension scores were significantly different for participants in Germany and China [$F(1,28)=0.878$, $p=0.357$ for global context, and $F(1,28)=0.186$, $p=0.669$ for fine context]. This result implies that the cultural differences of participants in these two countries have no significant influence on the comprehension of the graphical symbols used on medical devices in ICU area.

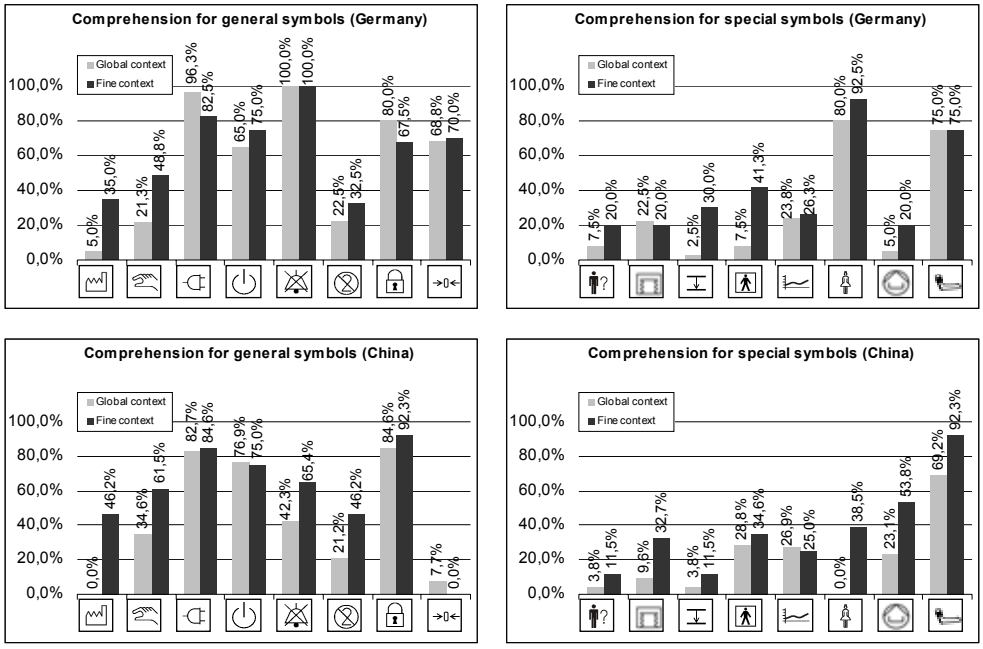

Figure 1: Symbol comprehension among users in Germany and in China

However, for some specific symbols, for example, the symbols for "Nurse" and "Zero-point adjustment", the comprehension between the participants in China and in Germany showed obvious difference. Both symbols were well comprehended in Germany but badly understood in China. The reason for this difference may lay in the fact that the "Nurse" symbol are seldom used on a Chinese ICU patient calling appliance (where a cord instead of a button is used) and fewer settings for medical devices are made by doctors and nurses in China.

It is deduced that the experience with symbol use would significantly influence the comprehension of graphical symbols. Further ANOVA analysis revealed the influence of this factor. In test, we used two types of symbols in the test: The *general* symbols are those used widely in different medical products (not constrained in ICU area); The *special* symbols are those dominantly used in ICU area. The general symbols can be more often experienced by caregivers when they work. The ANOVA analysis showed that either with global contexts or with fine context the comprehension scores of general symbols were significantly better than those of special symbols [$F(1,28)=5.519$, $p=0.026$ for global context, $F(1,28)=5.585$, $p=0.025$ for fine context]. This result implies that the experience with the symbol use may have significant influence on the comprehension of the graphical symbols used on medical devices in ICU area.

Another statistical analysis verified the influence of the experience on symbol comprehension too. In the test the participants were instructed to subjectively rate the occurrence of the symbol being tested in their daily work in a 1 to 5 scale. Both in Germany and in China, the comprehension scores and the occurrence frequency indicated a significant correlation (In Germany: $r_g=0.75$, $p_g<0.001$ for global contexts, $r_f=0.79$, $p_f<0.001$ for fine contexts; In China: $r_g=0.81$, $p_g<0.001$ for global contexts, $r_f=0.72$, $p_f=0.002$ for fine contexts).

The above mentioned results implied that not the cultural background of the users, but their actual experience with the use of the symbols significantly influenced their comprehension. For effective symbol application, beside the good design and selection of relevant symbols to convey specific information, training should be a very effective way. This would be a situation for symbol application in medical area in general.

5 Conclusions

Summarizing the results obtained from the study, the following conclusions can be reached:

- Not only in China, but also in Germany, the comprehension of the graphical symbols tested is very poor. Half of the symbols (in Germany) or four symbols (in China) reached the acceptance criterion of 67% specified by ISO 3864. But only three symbols reached the acceptance criterion of 85% of ANSI Z535.3 in both countries;

- Statistical analysis did not show significant difference in symbol comprehension between participants in these two countries. According to our test results it seems that the cultural difference of the users have no significant influence on the symbol comprehension;
- The professional experience, especially the experience with using of specific symbols may significantly influence the comprehension of these symbols among target users. This means that training would be an effective way to compensate the weakness of symbol comprehension in practice. Symbols should be learned by target users to ensure their application effectiveness.

Based on these conclusions, it is suggested that medical device manufacturers should be careful in applying symbols to convey safety-relevant information on their devices. Special measures should be incorporated in medical device user interface design, such as online prompts to indicate the meaning of the symbols, to reduce the risk of misunderstanding, as well as to encourage users' learning in the use process.

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Acknowledgements

The authors thank Elke Wilken and Rolf Jablonka for their assistance in data collection and open-ended scoring. The research was supported by the Ministry of Science and Research of North Rhine Westphalia, Germany.