The Comparison of Iconicity Level of Icon Arrays on Risk Perception

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***Abstract*—The icon array or pictograph has been claimed as the most effective format for health risk information presentation. Some previous study had showed that people with different level of numeracy were differently process the information from icon array, while the effect of iconicity level of icon array remained unclear. Thus, the purpose of this study was to compare the iconicity level of icon array on health risk perception in Thai people with different numeracy level. Total of 112 Thai people participated in this study. The results revealed the differences in risk perception toward different iconicity level of icon array from people with low numeracy. The pattern found in this study could be used as the design guideline and the discussion are provided.**

***Index Terms*—visual aids, iconicity, risk perception, numeracy, decision making, risk information**

I. Introduction

Nowadays, visual displays become a powerful tool to convey health-related statistical information including communication by message, photo, video etc. [1], but not all graphical formats used in those media were equally effective [2], [3]. Previous study had been reported that the graphical forms, such as icon arrays, which used in health risk information might not be intuitively understood and may lead to misused and misrepresent statistical information [4]. Especially the visual display that was used in the society which consists of a wide range of people with differences in their level of perception and cognition ability, the human factors influencing on those design should be concerned.

The icon array or pictograph has been claimed as the most effective format for health risk information presentation [5], [6]. As it could overcome cognitive biases of base-rate neglect and facilitate people to understand the relevant risks [7] which may cause by some numerical format presentation, instead icon array would lead people to process the data with the part-whole relationship in both relative count and relative area. For instance, the health risk information that presented using icon array would show visually depicting both the number of individuals affected by a risk (the numerator) and the overall number of individuals at risk (the denominator). This enhanced the accuracy of people's understanding in risk context [8].

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To understand how people process information from the icon array, Hess, Visschers, and Siegrist used eye-tracking device to examine people information processing from icon array while they were making decisions [8]. They found that people with different level of numeracy were differences in term of information processing from icon array. The high numerate group tend to count icons and draw a relevant meaning, while the low numerate group holistically processed icon array and tended to get confused when they were guided toward counting icons. This showed the individual differences in term of numeracy level in information processing from icon array. Their findings also consistent with the study of Lipkus, and Peters [9] and Reyna *et al.* [10] that people with high numeracy had a better understanding of numeric risk communication formats than people with low numeracy regarding to their greater attention span and precision in interpretation, while people with low numerates always bring their subjective factors to their data processing such as mood, feeling, trust, or experience.

This inspired a number of studies to investigate the influence from the type of the icon used in the icon array or iconicity on the effectiveness of the health risk communication for all numeracy level in the society. In this study, iconicity refers to a relationship of resemblance between the two characteristics of a sign: its form and its meaning [11], [12] that could range by the iconicity level from abstract to concrete as shown in Fig. 1.

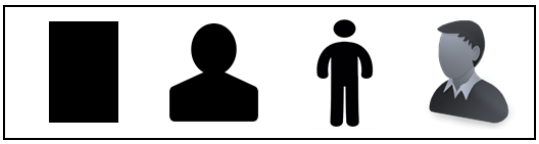

Figure 1. Illustrates the iconicity level represent a man from low (left) level to high (right) level of iconicity.

Zikmund-Fisher and Witteman found that the mental processing of risk information was indeed affected by the iconicity level of icon array [13]. They tested their subjects with 6 types of iconicity level ranging from oval-shape icon to picture of person up-body icon for their perceived risk and recall. The results showed that people with high numeracy perceived more accurate risk (compare perceived risk with presented risk) from the anthropomorphic icon array, although it remained unclear result from people with low numeracy.

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Contradictory, Gaissmaier and Wegwarth had reported from their study that the level of iconicity of the static icon did not effect on people understanding of benefits and side effects of medical interventions [14]. They presented their health-related statistical information with rectangle-shape icon (low iconicity level) to color photographs icon (high iconicity level).

The effect of iconicity level in icon array, especially for people with different numeracy, remained unclear. The inaccurate risk perception would influence people decision making, and may lead to some important behavioural and psychological consequences [15]. This would not limit their implication in health information communication, but also can apply with various industries in designing the presentation format of risk information that compatible to people with differences in their numeracy such as the risk presentation in occupational safety or the risk as a consequence from their actions. To achieve the accident prevention, it would also depend on the processing of cognitions associated with a situation communication and motivation [16].

Thus, the purpose of present study was to compare the iconicity level of icon array on health risk perception in Thai people with different numeracy level. The icon array used in this study would vary from rectangle-shape icon, anthropomorphic icon, and real person photograph up-body icon, respectively. The results from present study could contribute to the visual aid design guideline to promote the design format used to present risk information in public that compatible with individual differences in society.

II. Methodology

A. Participants

Total of 112 Thai people in Bangkok Metropolis participated in this study. Fifty-eight people are females (51.8%). Their age ranged from 18-29 years old (M = 20.3, SD = 2.54). Majority of participants (91%) had an education level at least a bachelor's degree. They reported their frequency of visiting doctor mostly as 1-2 times per year (75.9%). All participants have no heart attack disease.

B. Scenario

Participants were waiting for the laboratory test of their health at the hospital. After that the doctor recognized their result of laboratory test and told that their blood pressure was higher than the standard. Doctor shows their probability of getting heart attack disease which presented by the icon array.

C. Stimulus Materials

The icon arrays used in this study were varied by their iconicity level from abstract to concrete, as rectangle-shape icon as low iconicity level of icon array (Fig. 2), anthropomorphic icon as medium iconicity created by www.Iconarray.com (Fig. 3), and real Thai up-body photograph icon as high iconicity (Fig. 4).

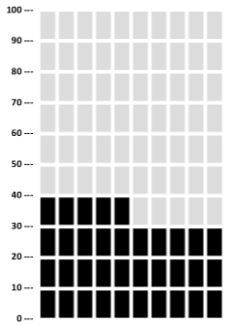

Figure 2. Low iconicity of icon arrays used in this study.

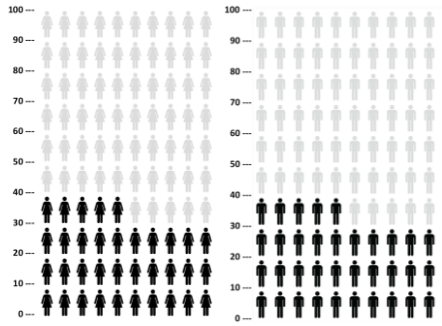

Figure 3. Medium iconicity of icon arrays used in this study.

Figure 4. High iconicity of icon arrays used in this study.

D. Measurement

1) The Berlin Numeracy Test (BNT) is used to distinguish people into low and high level of numeracy [17], [18]. This test consists of seven question-items with free-response. For example, imagine that we flip a fair coin 1,000 times what is your best guess about how many times the coin would come up heads in 1,000 flips? Total sum score was calculated and used for participants level of numeracy separation. The total sum score ranged from 1 to 7. The participants with total sum score from 0 to 3 were low numeracy, while people with 4 to 7 sum scores were those with high numeracy.

2) The Risk perception test was assessed by asking participants to rate the level of their risk perception of getting heart attack disease after viewing the icon array showing the health risk presentation, using five points Likert scale items by ranging from 1 (no chance) to 5 (certain to occur).

3) Preference assessment was examined by asking participants to choose one of three iconicity level which they preferred for presenting of health risk information after they were presented with all iconicity level.

E. Procedure

This experiment was conducted with one person at a time with paper and pencil test. Prior to begin, participants were explained the objective and overview of the study before completed the consent form and the demographic questionnaire. Then, they were asked to complete the Berlin numeracy test to assess their numeracy level.

After, they finished their Berlin numeracy test, Participants were randomly assigned to one condition of iconicity level of icon arrays. They were asked to imagine the scenario of visiting a doctor, which the laboratory test showed their 35% probability of getting disease presented by their condition of iconicity level of icon arrays. Then, they were asked to rate their perception level as "How do you assess your risk of getting a heart attack?" toward the results from laboratory test by rating 5 point-Likert scale ranging from 1 to 5. Finally, they were asked to select their preference format of iconicity level of icon array for presenting the health risk information. They were thanked and dismissed.

III. Result

A. Numeracy Test Score

Numeracy test scores were successfully used to separate all participants into high numeracy (N=58) and low numeracy (N=54). A t-test was computed. There was a statistical significant difference between people with low numeracy and high numeracy on their BNT scores: t (110) = 14.461, $p < 0.001$ (low numerates: M = 2.06, SD = 1.12; high numerates: M = 4.84, SD = 0.91).

B. Risk Perception

The descriptive statistics of numeracy level and the level of iconicity of icon array on their risk perception rating scores were reported in Table I.

TABLE I. A Comparison of Risk Perception Rating Score

Level of iconicity	Level of numeracy			
	Low		High	
	N	Mean *(SD)*	N	Mean *(SD)*
Low	18	1.89 *(0.76)*	19	2.53 *(0.51)*
Medium	18	2.61 *(0.61)*	18	2.56 *(0.51)*
High	18	2.83 *(0.62)*	21	2.62 *(0.50)*

A two-way ANOVA was conducted with level of numeracy and level of iconicity on risk perception rating scale. There was significant main effect of iconicity level (F (2,106) = 7.781, $p < 0.05$), and the interaction effect of iconicity × numeracy (F (2, 106) =5.54, $p < 0.05$).

The post hoc analysis (LSD) of main effect of iconicity level revealed that participants perceived lower risk from low iconicity level of icon array than medium ($p < 0.05$) and high ($p < 0.001$) iconicity level of icon array. While, there was no significant difference of the risk perception between icon arrays with medium and high iconicity level.

The post hoc analysis (LSD) of iconicity × numeracy interaction effect showed that there was no significant difference of people with high numeracy group on their risk perception toward all iconicity level of icon array, as shown in Fig. 5. On the other hand, people with low numeracy showed some differences toward different iconicity level of icon array. The results showed that low numeracy group had significant lower risk perception score toward low iconicity level of icon array than those with medium ($p < 0.05$) and high ($p < 0.05$) iconicity level of icon array.

C. Iconicity Preference

Participants selected their preferences of iconicity level for presenting of health risk information as using anthropomorphic icon which is medium iconicity level of icon array (79.5%), real Thai up-body photograph icon which is high iconicity level of icon array (4.4%), and square shape icon which is low iconicity level of icon array (16.1%), respectively.

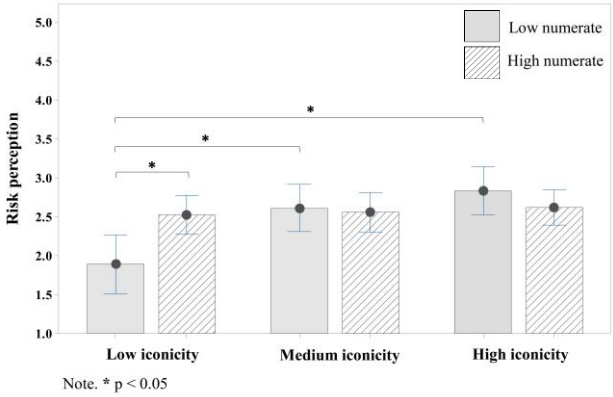

Figure 5. Effects of iconicity level on risk perception of each numerate group.

IV. Discussion & Conclusion

This study aimed to compare the influence of iconicity level of icon arrays on risk perception of health information from people with different numeracy level. The results revealed some differences of people with different numeracy level on their risk perception toward various type of iconicity level of icon array.

People with high numeracy had no effect in their risk perception whether the information was presented with either low, medium, or high iconicity level of icon array. While another population to be concerned was the people with low numeracy, since they perceived risk differently when the same information was presented with different level of icon array. This may be able to explained these results with the previous study of Lipkus, and Peters [9] and Reyna *et al.* [10] that people with high numeracy had a better understanding of numeric risk communication formats due to their greater attention span and precision in interpretation so that no matter of iconicity level was

used to present the information, the high numeracy could accurately access the risk perception. While, people with low numerates always bring their subjective factors to their data processing such as mood, feeling, trust, or experience, so that they were easily influenced by the type of the information presentation.

The risk information should be carefully designed the presentation form since the risk perception would influence people decision making, and may lead to some important behavioral and psychological consequences [15]. Although the results of participants' preference showed that they preferred the anthropomorphic icon (medium iconicity), this may be caused by their familiarity with in the icon normally used in society. The result of the present study could provide some design guidelines regarding the result of the use of iconicity level of icon array presenting the risk information as follows:

- *Low iconicity*: The use of low iconicity level of icon array in presenting the risk information may not appropriate to the public place that normally consists of people with different level of numeracy. Due to the differences in their perception toward the same information between people with high numeracy and low numeracy, this would create some gap difference between receivers in their risk perception which may cause some quality issue in information communication.
- *Medium iconicity*: The use of medium iconicity level of icon array in presenting the risk information may be the most appropriate and accurate format for people with all level of numeracy. This format could be used for risk information that need an accurate perception from the information such as the health risk information used in medical. Since people with low and high numeracy could perceive the same amount of risk perception toward the medium level of iconicity.
- *High iconicity*: The use of high iconicity level of icon array in presenting the risk information may appropriate in some condition such as the risk information with the objective to promote the risk awareness or want people to perceive risk and shape their behavior to prevent an accident. Since the low numerate people showed even higher in their risk perception toward the real person photographs up-body icon than people with high numeracy, even though the result is not statistically significances.

Moreover, individual difference should be even more concerned if the format presentation would be used in the public or for people in general. Since the result of this study showed that the iconicity level of icon array had an influence on people with low numeracy. Thus, it need to carefully design risk information while it has to be used with low numeracy people to avoid potentially misleading which may lead to wrong decision respectively.

There were limitations regarding to the scope of this study. The participants were limited to only young adults from Bangkok metropolis and the scenario-based is limited only in health context about heart attack disease. For further studies should include more range of people regarding to age, culture, and the context of use as well as investigate other indicator of the effectiveness of communication such as comprehension, attention or recall since it may affect to the effectiveness of communication through the visual design format.

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