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TREND OF THE SUBJECTIVE EVALUATION BASED ON VISUAL ANALOG SCALE AND LIKERT SCALE

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Abstract. *This paper relates the distribution trend of the subjective evaluation based on visual analog scale (VAS) and Likert scale (LS). The data are collected from 346 subjects (288 male and 58 female students). 172 subjects were invited to answer VAS questionnaires, and 174 subjects to answer LS questionnaires. To apply the same evaluation criteria, VAS data and LS data are transformed to ratio scales value (i.e., 0.00 to 1.00) and the subjective evaluation distribution based on LS and VAS is calculated. The experiment result shows that there exists unintended bias between LS data and VAS data for the questionnaire of "Are you good at cell-phone operation?", and that there does not exist bias between LS data and VAS data for the questionnaire of "Which one are you good at, cell-phone operation or personal computer operation?".*
Keywords: Subjective evaluation, Distribution, Visual analog scale, Likert scale

1. **Introduction.** Studies on the subjective evaluation based on Likert scale (LS) [1] have been conducted broadly. LS is a simple discrete scale method, but it has some weak points [1-5]: 1) subject's response often becomes complicated; 2) sometimes several bias is introduced by the following factors, such as halo effect, leniency effect and central tendency; 3) LS's results are discrete data. From these points, it is suggested that there exists unintended bias on LS's results.

In order to solve these weak points, visual analog scale (VAS) is investigated on the subjective evaluation [6]. VAS is a ratio scale method, and it is expected that it can solve the weak points of LS as mentioned above. And it is considered that VAS is more flexible than LS. Consequently, studies on trend of distribution based on LS and VAS are important. However, studies on correlation between LS and VAS can be seen [6,7], while studies on comparison of trend of distribution based on LS and VAS cannot be seen.

Therefore, this paper relates the distribution trend of the subjective evaluation based on VAS and LS. As for LS, it employs Likert's simplified method [1,8], which has an equal interval of the scale. To apply the same evaluation criteria, VAS data and LS data are transformed to ratio scales value (i.e., 0.00 to 1.00) and then subjective evaluation distribution is calculated. The experiment result shows that there exists unintended bias between LS data and VAS data for the questionnaire of "Are you good at cell-phone operation?", and that there does not exist bias between LS data and VAS data for the questionnaire of "Which one are you good at, cell-phone operation or personal computer operation?".

First of all, this paper describes subjective evaluation based on VAS and LS. Next, it also describes the materials and methods. Moreover, it refers to the results and discussion on them. Finally, it reaches the conclusions.

2. **Subjective Evaluation Based on VAS and LS.** Recently, VAS has been applied to study on the subjective evaluation such as medical field [9-11], education [6,7]. This paper first introduces VAS in comparison with LS.

Figure 1 shows typical types of LS's questionnaire. This is to ask the information skills. To answer the questionnaire in Figure 1, the response is marked as a discrete value from 1 to 5 on LS (only one place). The same questionnaire in VAS, is shown in Figure 2. To answer Figure 2, the response is marked by a solid dot on the line (Example is shown in Figure 4).

To apply the same evaluation criteria, VAS data and LS data [1,8] are transformed to ratio scales value (i.e., 0.00 to 1.00). Figure 3 shows transformation of LS data. This paper will convert the numbers marked with circle (only one place in 1-5) to the values as

	Poor				Good
Cell-Phone	1	2	3	4	5
Personal Computer	1	2	3	4	5

FIGURE 1. Typical types of LS's questionnaire

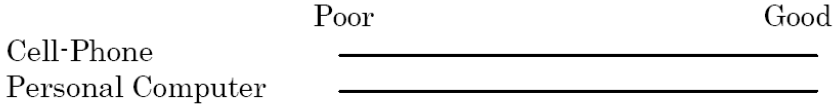


FIGURE 2. Typical types of VAS's questionnaire

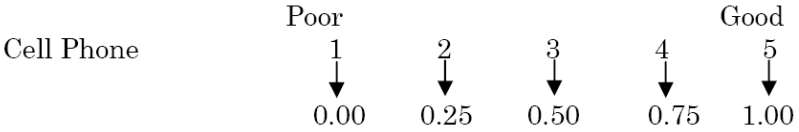
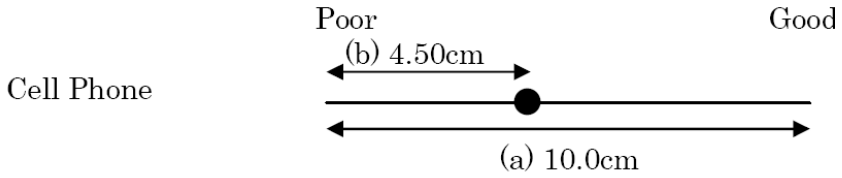


FIGURE 3. Transformation of LS data: the location with the circle (only one place), converts to the following values (determined to only one value in 0.00∼1.00)



Result = 4.50 / 10.0 = 0.45 (or 45%)

FIGURE 4. Example of calculation of VAS data: it is determined by the ratio of (b) to (a) (only one value in 0.00∼1.00)

shown in Figure 3. Figure 4 shows an example of calculation of VAS data. VAS's results are determined by the ratio of (b) to (a) (in other words, it is determined by the position of the mark on the line).

3. Materials and Methods.

Subjects. The data are collected from 346 subjects (8 classes students; 288 male and 58 female students). 172 subjects (= 49 + 48 + 36 + 39; 4 classes students) were invited to answer VAS questionnaires, and 174 subjects (= 49 + 45 + 39 + 41; 4 classes students) to answer LS questionnaires.

Examination of the distribution trend. It was carried out of the following investigation of subjective evaluation based on VAS or LS.

Question 1. (Q1) Are you good at cell-phone operation?

Question 2. (Q2) Are you good at personal computer operation?

Question 3. (Q3) Which one are you good at, cell-phone operation or personal computer operation?

Questionnaires Q1 and Q2 are shown in Figure 1 (LS) and Figure 2 (VAS). Figure 5 shows questionnaire Q3.

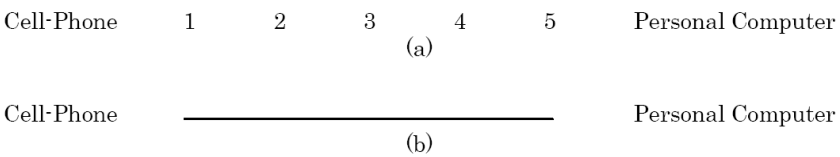


FIGURE 5. Questionnaire Q3: (a) LS, (b) VAS

4. Results and Discussion.

To apply the same evaluation criteria, VAS data and LS data are transformed to ratio scales value (i.e., 0.00 to 1.00). Table 1 shows the results of questionnaire of Q1, Q2 and Q3 (average ± standard deviation and t-test). From F-test's results, they are shown to be equal variances ($p > 0.05$) on the obtained data of Q1

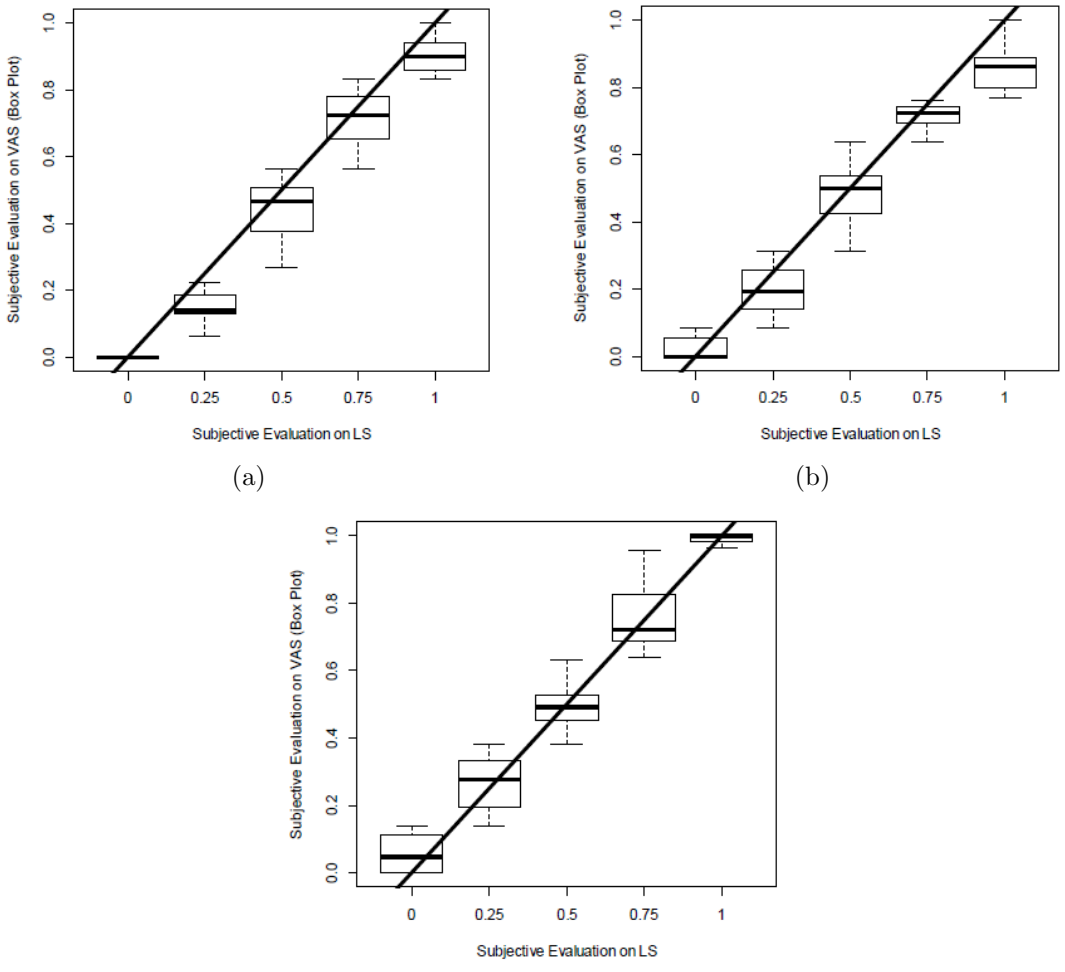
TABLE 1. Results of questionnaire

	Q1	Q2	Q3
LS	$0.61 \pm 0.24^{\#}$	0.49 ± 0.28	0.41 ± 0.23
VAS	0.55 ± 0.25	0.45 ± 0.26	0.41 ± 0.22
t-test	*	not significant	not significant

#: average $\pm$ standard deviation,
*: t-value $t(344) = 2.41$, $p < 0.05$

($F(171, 173) = 1.05$), Q2 ($F(173, 171) = 1.17$), and Q3 ($F(173, 171) = 1.11$). Therefore, it is considered that individual difference will not bring influence to the results of the questionnaire. Furthermore, the results show that there is a significant difference in Q1, between LS and VAS, from t-test's results. However, there is no significant difference in Q2 and Q3.

From these results, the subjective evaluation distribution is calculated. And in order to visualize, it is supposed that the subjective evaluation distribution on VAS follows the subjective evaluation distribution on LS. First, the box-and-whisker plot [12] of subjective



(a) (b)

(c)

FIGURE 6. Subjective evaluation distribution on LS *vs.* box-and-whisker plots [12] of subjective evaluation distribution on VAS: (a) Q1, (b) Q2, (c) Q3. Function $y = x$ is expressed by the solid line in each of these plots.

evaluation distribution on VAS is shown. Next, they are plotted *vs.* subjective evaluation distribution on LS. These plots are summarized in Figure 6.

Two facts can be observed from Figure 6: 1) Figures 6(a) and 6(b) show that there exists unintended bias between LS data and VAS data for the questionnaire such as Q1 or Q2. 2) Figure 6(c) shows that there does not exist bias between LS data and VAS data for the questionnaire of Q3. These differences are supported from the results in Table 1 and published articles [13].

To obtain reliable conclusions, it is necessary to try this method on the results such as [6] and do more measurements and discussion.

5. **Conclusions.** This paper relates the distribution trend of the subjective evaluation based on visual analog scale (VAS) and Likert scale (LS). The data are collected from 346 subjects (288 male and 58 female students). 172 subjects were invited to answer VAS questionnaires, and 174 subjects to answer LS questionnaires. To apply the same evaluation criteria, VAS data and LS data are transformed to ratio scales value (i.e., 0.00 to 1.00) and the subjective evaluation distribution is calculated.

The experiment result shows that there exists unintended bias between LS data and VAS data for the questionnaire such as Q1 or Q2, and that there does not exist bias between LS data and VAS data for the questionnaire of "Which one are you good at, cell-phone operation or personal computer operation?". These differences are supported from the results in Table 1 and published articles [13].

To obtain reliable conclusions, it is necessary to try this method on the results such as [6] and do more measurements and discussion.

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