Enhancing the Mobile Phone Usability Questionnaire (MPUQ) with a Multi-criteria Decision Making Method

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Abstract. The goal of this research was to provide greater sensitivity in the response of the MPUQ to support comparative usability evaluations and to determine which usability dimensions and questionnaire items are most critical in selecting the "best" product. The analytic hierarchy process (AHP) was used to develop a decision model to provide composite scores from the responses of MPUQ. Judgments from multiple participants were combined in AHP using a weighted geometric mean method based on the consistency index (*C.I.*) for each participant. Emotional aspects and multimedia capabilities (EAMC) were identified as the least important usability factor for both Minimalists and Voice/Text Fanatics user groups. Efficiency and control (EC) was identified as the most important factor for Minimalists and typical tasks for mobile phones (TTMP) were most important for Voice/Text Fanatics.

Keywords: Usability, mobile user interface, questionnaire, analytic hierarchy process, multi-criteria decision making method.

1 Introduction

Ryu and Smith-Jackson [1, 2] followed a systematic approach to develop the Mobile Phone Usability Questionnaire (MPUQ). The MPUQ consists of 72 questions with a six factor structure; (1) Ease of learning and use (ELU), (2) Assistance with operation and problem solving (AOPS), (3) Emotional aspect and multimedia capabilities (EAMC), (4) Commands and minimal memory load (CMML), (5) Efficiency and control (EC), and (6) Typical tasks for mobile phones (TTMP).

There is a history in psychometrics in weighting items and factors such as using the weights from a factor analysis. However, the usual practice for these types of questionnaires is to simply average the items within a scale to get the scale score. Also, Nunnally [3] pointed out that the effort in developing weights typically does not have much of an effect on a scale's reliability, validity, or sensitivity. However, this

method of simply averaging the item scores is unlikely to reflect the way people make decisions.

Since multiple usability questionnaire items and factor groups are necessary to represent all relevant sub-dimensions of usability in the MPUQ aimed at generating composite scores, assigning relative weights of importance to them relating to a target construct can be regarded as a multi-criteria decision making (MCDM) problem. There are several MCDM methods, including the weighted sum model (WSM), weighted product model (WPM), and analytic hierarchy process (AHP) [4]. Among these, AHP has been known as the most popular across various fields because of superior capability in dealing with complexity and inter-dependency among criteria.

The goal of this research was to provide greater sensitivity in the response of MPUQ to support comparative usability evaluations and to determine which usability dimensions and questionnaire items contribute most regarding selection of the "best" product (as defined by the user). AHP was used to develop normative decision models for various cell phone user groups for use in calculating composite scores for the MPUQ.

2 Method

To develop the AHP models for various user groups, a hierarchical structure was developed first. Based on the international standard for usability (ISO 9241-11) and the factors of MPUQ, a hierarchical structure with multiple levels and nodes of decision criteria was developed (Fig. 1).

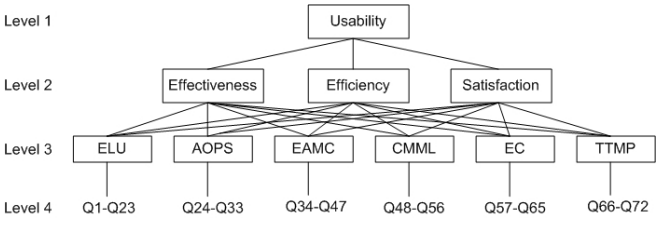

Fig. 1. Illustration of hierarchical structure established

2.1 Participants

To determine the relationship among each of the nodes of the AHP hierarchical structure, the panel of reviewers who participated in Ryu and Smith-Jackson [1] were used. Panel reviewers included two usability experts and four representative users from each user group (Table 1).

2.2 Procedure

After the hierarchy was established, the relative importance of each node at each level in the hierarchy was determined. Priorities were assigned to the nodes, and used as coefficients to calculate the usability score of the MPUQ. A paper-based nine scale format was used for obtaining paired comparison data, as suggested by Saaty [7].

Table 1. Categorization of mobile users [5] quoted by Newman [6]

Label of Users	Description
Display Mavens	Users who primarily use their devices to deliver presentations and fill downtime with entertainment applications to a moderate degree
The Mobile Elites	Users who adopt the latest devices, applications, and solutions, and also uses the broadest number of them
Minimalists	Users who employ just the basics for their mobility needs; the opposite of the Mobile Elite
Voice/Text Fanatics	Users who tend to be focused on text-based data and messaging; a more communications-centric group

Pairwise comparisons were performed by the participants to assign priorities to each node in each level of the hierarchy. For the higher levels, pairwise comparisons were performed among the combinations of Effectiveness, Efficiency, and Satisfaction (level 2) and overall usability (level 1). Each participant's judgment regarding the degree of dominance of one column over the other column on usability was indicated by selecting one cell in each row. If a participant selected a cell to the left of "equal," the column 1 component is dominant over column 2. Similarly, participants performed pairwise comparisons for the next lower level of the hierarchy. Relative importance of the six factors (level 3) on each of three usability dimensions (level 2) was determined.

As the last step of assigning priorities for the lowest level of the hierarchy (level 4), participants were asked to categorize each item's importance into three different grades (i.e., A [very important], B [somewhat important], and C [less important]) relating to the factor group in which the item belonged.

A weighted geometric mean based on the consistency index (*C.I.*) was used to combine the judgments. The weight was calculated based on the *C.I.* of the decision matrix of each decision maker. In other words, the judgment by a participant that shows higher consistency contributed more to the synthesis of group judgments. This concept can provide a consistent philosophy of AHP by considering relative priorities on the decision makers' judgment and may follow user-centered design concept by incorporating data from all the participants, some of which could be discarded as unsound judgments or outliers.

3 Result and Discussion

All pairwise comparison matrices for Level 2 on Level 1 and Level 3 on Level 2 were combined using weighted geometric means, in which the weight was calculated based on the *C.I.* values. It was inferred that efficiency was most important to Minimalists and effectiveness was most important to Voice/Text Fanatics (Fig. 2).

Three normalized vectors were obtained for Level 3, because each vector combined six factors for each of the three dimensions in Level 2. The values of the vectors are charted with regard to the two user groups, respectively (Fig. 3 and Fig. 4). No notable variations in the relative importance of each factor with regard to

the dimensions of Level 2 were found for either group. This trend is more obvious in all factors for the Voice/Text Fanatics (Fig. 4). However, some level of variation was observed regarding EC and TTMP for the Minimalist (Fig. 3).

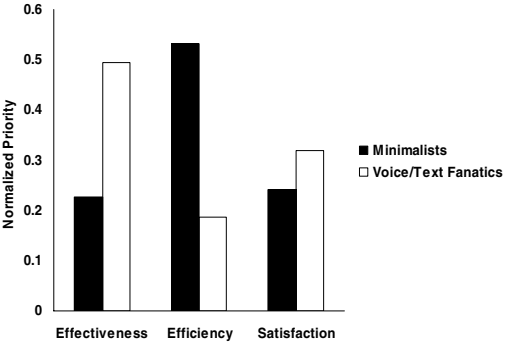

Fig. 2. Normalized priorities of Level 2 on Level 1

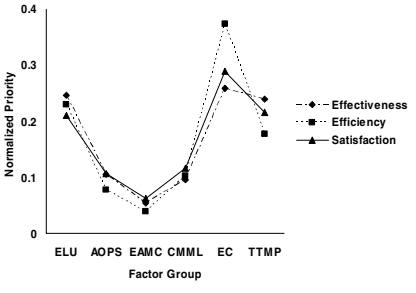

Fig. 3. Normalized priorities of Level 3 on Level 2 for Minimalist

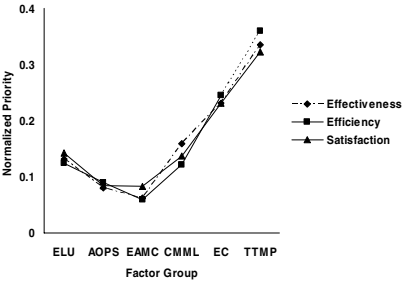

Fig. 4. Normalized priorities of Level 3 on Level 2 for Voice/Text Fanatics

Normalized priority vectors for each level were obtained, as well as the priority vectors for the lowest level (Level 4) were from the absolute measurement AHP. By combining normalized priority vectors for higher levels into priority vectors for the lowest level, final relative weights for each questionnaire item was obtained. Two sets of models reflect the final relative weights since the two of the four groups were investigated.

Based on the result of the normalized vectors of Level 3 nodes on Level 2, EAMC was identified as the least important factor group for both user groups. EC was identified as the most important factor for Minimalists and factor TTMP was most important for Voice/Text Fanatics.

4 Conclusion

The analytic hierarchy process (AHP) was used to develop decision models to provide composite scores from the responses of MPUQ. To combine the sets of judgments from multiple participants in the use of AHP, a weighted geometric mean method based on the consistency index (*C.I.*) for each participant was suggested in this study. According to the result, Emotional aspect and multimedia capabilities (EAMC) was identified as the least important factor for both Minimalists and Voice/Text Fanatics user groups. Efficiency and control (EC) was identified as the most important factor for Minimalists and typical tasks for mobile phones (TTMP) were most important for Voice/Text Fanatics.

Future research is needed to show whether using AHP decision models for computing MPUQ composite scores provides a measurable advantage of an unweighted scoring mechanism. In order to achieve the goal, a case study of comparative usability evaluation will be performed to select a best mobile phone in terms of usability among multiple numbers of competing phones.

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