Effect analysis of the interface design of humanized mobile phones using the structural equation model

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Abstract

Mobile phones interfaces have been developed according to the "people first" principle, which is a consistent development principle that highlights the need for a mobile phone interface that is increasingly humanized in terms of human–computer interaction. The principle also asserts that mobile phone interfaces should be designed such that it considers the general feeling of users. Users are considered principal objects in studies that examine the significant effect of a humanized interface design. However, investigations into this area are statistically limited. Accordingly, the current study distributes a questionnaire survey to different user groups and applies the structural equation model to calculate the influence of each core aspect of the humanized design. Given this background, this study verifies and analyzes the results of the questionnaire survey and calculates the effect of each influence factor with the structural equation. The result of the effect analysis obtained using the structural equation is rigorous and reliable; furthermore, it provides a basic reference direction for the humanized design of mobile phone interfaces in the future.

Keywords: Humanized, structural equation model, mobile phone interface, factor

1 Introduction

The structural equation model (SEM) is a universal, comprehensive statistical analysis technology and model method. It is mainly solved using simultaneous equations [1]. The SEM assumes that a causal relationship exists among a group of hidden variables. These variables can be expressed as a linear combination of several manifest variables [2]. The linear regression model coefficient is estimated to statistically verify whether the assumed model is suitable for the research process based on the covariance among the manifest variables [3]. The assumption of a relationship among the hidden variables is rational if the presumed model is proven appropriate.

The increasing popularity of mobile phone use in daily life heightens people's requirements for their devices [4]. The range of mobile phone types have expanded significantly with the continuous emergence of various types of mobile devices, such as music-based, camera-based, game-based, and commercial mobile phones, as well as mobile phones for the old, for the children, and for females [5]. Nonetheless, mobile phones experience problems apart from multi-polarization. Thus, the numerous special needs of users remain difficult to address although the mobile phone functions have been classified [6]. This scenario reflects the need for a humanized design for mobile phone interface. Aside from satisfying the primary needs of users, the humanized interface design also considers the psychological and physiological needs of users [7]. Moreover, users make direct contact with their mobile phones. Hence, mobile phone interfaces must be aesthetically pleasing for users. Furthermore, users must be able to navigate the mobile phone interface in a fluent and convenient manner [8]. In this case, a humanized design for mobile phone interfaces, along with large and strong mobile phones.

The design of mobile phone interfaces must consider the conventional thinking, physiological structure, and behavioral habits of humans [9]. The humanized design for mobile phone interfaces is defined as the optimization of mobile phone interface functions based on the originally designed functions to provide convenience and comfort to users [10]. Even in the early period of colorless mobile phones, humanistic care (i.e., clear text and simple buttons) can be observed in the interface design of previous black-and-white mobile phones. The subsequent emergence of touch-screen mobile phones has improved humanized design significantly; people can simply and conveniently [11]. Over time, the widely popular smartphone has been designed to meet user demands. The core concept of the humanized design can be categorized into four aspects, namely, physiological, psychological, environmental, and group customization care [12]. These four aspects are important components of humanized design. However, the question of which special design should be perfected or enhanced is significant, and the answer can be determined through user experience and feedback.

Therefore, the effects of the humanized design of mobile phone interfaces must be analyzed. Much research has investigated the effects of humanized design [10]. However, most analysis systems are not rigorous, such that the final results are highly unreliable. Furthermore, such findings may not reflect the true feelings of users. Correspondingly, the current study conducts a sampling survey of different user groups and calculates the regression of the data obtained from the questionnaire results using the structural equation. The equation is also employed to fit with AMOS software. Under the precondition of ensuring a good fitting degree, this study analyzes the influence of each aspect of

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the core of humanized design [2]. SEM is applied because it is a multivariate statistical analysis method for comprehensive verification. It also synthesizes multiple methods, including regression, factor, and path analyses. In addition, SEM is strongly supported theoretically in terms of statistical hypothesis testing [3]. It also allows for measurement errors with respect to the independent and dependent variables. The structural relationship among latent variables can thus be analyzed. Given that this study is a theoretical inspection and that prior theoretical knowledge is sufficient, SEM fits well with the non-diagonal elements used to measure the variable covariance matrix. Therefore, parameter estimation is accurate. In this manner, accurate and reliable analysis results and feedbacks can be obtained based on structural equation theory.

2 Index design

This study conducts a layered analysis of personalized design effects for mobile phone interfaces to confirm the effective indexes in accordance with the four aspects of the core of humanized design.

2.1 PHYSIOLOGICAL CARE INDEX

2.1.1 Ergonomic design

Ergonomic design indicates respect and care for humans. It is highly necessary for studying the characteristics of information perception. For example, the response time of the human auditory sense is 30 ms–50 ms faster than that of the visual sense. Thus, people-oriented concepts heightens the importance of the study on interface design and the harmony of this design with human physiological property (e.g., mobile phone keyboard with phone receiver position).

2.1.2 Human–computer interaction interface

The current human–computer interaction interface includes character, entity, graphical, multi-channel, multimedia, and intelligent network user interfaces.

2.1.3 Function operability

The design of mobile phone interfaces should enable users to master function operations easily by ensuring that each operation complies with logical human thinking and the requirement of sensory organs. Furthermore, the main functions should be fully realized.

2.2 PSYCHOLOGICAL CARE INDEX

2.2.1 Emotional contents

Emotion is the fundamental feedback of user experience. The psychological selection of consumers with different genders, ages, professions, and characteristics should be considered in the design of mobile phone interfaces. Moreover, hardware appearance, material, color, and text must be combined to induce specific emotions from users.

2.2.2 Individualized design

The individualized design of mobile phone interfaces aims to establish a distinct image.

2.3 ENVIRONMENTAL CARE INDEX

Mobile phones are used in a complex and varied environment. For instance, a mobile phone is exposed to strong light. Thus, the mobile phone interface becomes vague and unclear. The color of the mobile phone becomes homogeneous with the interface.

2.4 GROUP CUSTOMIZATION CARE INDEX

2.4.1 Comfort and practicability

The humanized interface design is meticulously developed to consider the needs of the old, disabled, and children. Accordingly, old people with reduced eyesight benefit from the large font size applied in the design. Mobile phone designs for children consider safety and colorful interfaces.

2.4.2 Innovative customization

For many brands, the mobile phone designs for the old should also be improved significantly. Correspondingly, novel, dynamic, and modern interface designs have been developed based on basic customization.

2.5 MARKET COMPETITIVENESS INDEX

Market competitiveness directly feeds design effects back to the interface and fully affirms the humanized design. This process mainly depends on two aspects, namely, the "comprehensive humanized interface design" and the "outstanding individual aspect in humanized interface design".

3 Measuring methods

The detailed estimation mode is expressed as follows:

Measuring equation: $x = \Lambda x \xi + \delta, y = \Lambda y \eta + \varepsilon$

Structural equation: $\eta = B\eta + \Gamma \xi + \zeta$

The various variables are defined as follows: X is the measurement variable matrix of ξ; Λx is the measurement coefficient matrix and indicates the relationship between the latent exogenous variable (the latent independent variable) matrix and measurement variable X; ξ is the matrix of the latent exogenous variable (the latent independent variable); δ is the residual matrix of the measurement equation; Y is the measurement variable matrix of η; Λy is the measurement coefficient matrix and denotes the relationship between the latent endogenous variable (the latent dependent variable) matrix η and its measurement variable Y; ε is the residual matrix of the measurement equation; Γ is the structural coefficient matrix and corresponds to the effects of ξ on the latent dependent variable matrix in the structural model; B is the structural coefficient matrix and connotes the interactions among the component factors of η in the structural model; and ζ is the residual matrix of the structural equation.

4 Analysis of the effect of the SEM-based humanized design of mobile phone interfaces

This study distributed questionnaires and conducted interviews to obtain data from 1000 users. The group was selected based on nationwide census results from 2005. The population that belongs to the 0–14 age range accounted for 20.27% of the total population; that at the 15–59 age range constituted 68.70%; and the population at the age range of 60 or above accounted for 11.03%. The male and female populations constituted 51.27% and 48.73% of the total population, respectively. The number of each group was set according to the proportions of age and gender. Furthermore, the selected objects possessed various characteristics and came from all walks of life. Therefore, interference factors were excluded as much as possible. Hence, the content setting of the questionnaire mainly involved the preceding indices. A three-hierarchy evaluation system was also implemented, i.e., “1-useless”, “2-general”, and “3-useful”. The respondents were required to grade all of the indices. A total of 970 valid questionnaires were collected, and the effectively organized data were statistically analyzed.

4.1 ESTABLISHMENT OF THE ANALYSIS MODEL

First, a statistical analysis was conducted on the data. This study considered only a few factors; hence, variables need not be screened by explanatory factor analysis. The mean value and the standard deviation of each sample index were calculated for the direct and simple verification analysis (Table 1). If indices with scores exceeding 1.5 are effective, then interface design effect on the preset manifest variable factors is sufficiently effective as well. Most of the respondents consistently considered “ergonomic design” to be necessary at the physiological care level, and its standard deviation is small. In general, users validated the effectiveness of physiological and psychological care. Moreover, the standard deviation of “innovative customization” was highest sat the group customization care level. Thus, “innovative customization” is evaluated in extremes; some respondents believe that “innovative customization” was useful, whereas others considered it to be completely useless. Nonetheless, the feedback was good on average.

TABLE 1 Statistics of the survey results for all indices

Core content	Detailed index	Mean value	Standard deviation
Physiological care	Ergonomic design	2.4205	0.3890
	Human–computer interaction interface	2.2649	0.3904
	Functional operability	1.8636	0.4873
Psychological care	Emotional content	1.9532	0.5651
	Individualized design	2.0043	0.7432
Environmental care	Environmental adaptation	1.9760	0.6549
Group customization care	Comfort and practicability	1.8598	0.5428
	Innovation customization	1.8167	1.1583

The relationship among the manifest variables was mutually independent. Hence, regression was calculated for the corresponding latent variables based on the preceding indices [5]. Five latent and 10 observational variables were designed based on structural equation theory. The names and definitions of each variable are presented in Table 2. Four exogenous latent variables (i.e., physiological, psychological, environmental, and group customization care) and one endogenous latent variable (i.e., market competitiveness) comprised the structural model. The relationship among the variables is also illustrated in Fig. 1.

TABLE 2 Latent and observational variables in the structure

Type of latent variable	Latent variable	Type of observational variable	Observational variable
	Physiological care		U11: ergonomic design U12: human–computer interaction interface U13: functional operability
Exogenous latent variable (ξ)	Psychological care	Exogenous observational variable	U21: emotional content U22: individualized design
	Environmental care		U31: environmental adaptation
	Group customization care		U41: comfort and practicability U42: innovative customization
Endogenous latent variable (η)	Market competitiveness	Endogenous observational variable	U51: comprehensive humanized interface design U52: outstanding individual aspect in humanized interface design

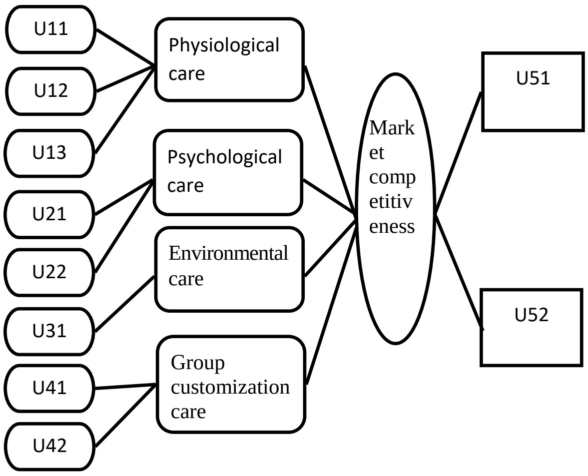

FIGURE 1 Diagram of variable relations

According to Table 2 and Fig. 1, the parameters (t) that must be estimated include 10 path coefficients $\lambda(x)$ and $\lambda(y)$ derived from the latent variables to manifest variables; 10 residuals δ and ε of the manifest variables, 4 path coefficients λ (ξ) and λ (η) among latent variables, 8 exogenous manifest variables, and 2 endogenous manifest variables (q). The degree of freedom of the model path diagram was written as $df = [(p+q)(p+q+1)/2] - t = 45 > 0$ for model recognition.

4.2 CALCULATION OF THE ANALYSIS MODEL

This study selects the specific value of chi-square and degree of freedom (CMIN/DF), the root mean square error of approximation (RMSEA), the goodness-of-fit index (GFI) of the model, the adjusted GFI (AGFI), and the normative fit index (NFI) as evaluation indices. It also calculates the degree of fitting [7]. The calculation results are listed in Table 3.

TABLE 3 Fitting coefficients

Index	CMIN/DF	RMSEA	GFI	AGFI	NFI
Data	2.514	0.069	0.817	0.872	0.846

Accordingly, Bain et al. suggested that CMIN/DF < 3 indicates the favorability of the overall effect of this model. Moreover, Lell et al. asserted that the GFI, AGFI, and NFI values were between 0.8 and 0.9 when RMSEA < 0.08. This observation suggests that the fitting effect is good. In accordance with the results depicted in Table 3, the analysis findings related to the effect of humanized design for mobile phone interfaces fitted well the relationship among the latent variables. The results obtained using SEM can explain the causal relationship effectively.

4.3 PARAMETER ESTIMATION AND TEST

This study employed the maximum likelihood method, applied the AMOS software to analyze the factor loading and path coefficient of each manifest variable, conducted normalization processing, and obtained the normalized factor loading and path coefficient.

TABLE 4 Normalized factor loading

Manifest variable	Normalized factor loading	Manifest variable	Normalized factor loading
$X_1(\xi_1)$	0.6295	$X_6(\xi_3)$	0.5917
$X_2(\xi_1)$	0.6013	$X_7(\xi_4)$	0.4982
$X_3(\xi_1)$	0.5744	$X_8(\xi_4)$	0.4021
$X_4(\xi_2)$	0.6402	$Y_1(\eta)$	0.6358
$X_5(\xi_2)$	0.4836	$Y_2(\eta)$	0.5890

The principle of the maximum likelihood method states that the model has good explanatory power when the factor loading was > 0.4. The normalized factor loading of the manifest variables above exceeded 0.4, thereby indicating the strong explanatory power of each factor for the measurement model. The loading of the observable variable X_1 ("ergonomic design") was maximal for the first exogenous latent variable "physiological care ξ_1". Therefore, X_1 the contributed the most to ξ_1, followed by X_2 and X_3. Similarly, manifest variable X_4 ("emotional content") contributed the most to the second exogenous latent variable ("psychological care"). Manifest variable X_6 ("environmental adaptation") alone acted on the third exogenous latent variable ("environmental care"). The manifest variable X_7 ("comfort and practicability") mostly contributed to the fourth exogenous latent variable ("group customization care"). Manifest variable Y_1 ("comprehensive humanized interface design") mostly contributed to the endogenous latent variable "market competitiveness".

TABLE 5 Normalized path coefficient

Latent variable path	Normalized path coefficient	Significance at the 0.0001 level	Hypothesis verification result
$\xi_1 \cdots\to \eta$	0.7982	Significant	Support H_1
$\xi_2 \cdots\to \eta$	0.8316	Significant	Support H_2
$\xi_3 \cdots\to \eta$	0.7540	Significant	Support H_3
$\xi_4 \cdots\to \eta$	0.7794	Significant	Support H_4

The path coefficients of the latent variables are shown in Table 5. The overall effect values of the exogenous latent variables (i.e., ξ_1, ξ_2, ξ_3, and ξ_4) on the endogenous latent variable (i.e., η) were 0.7982, 0.8316, 0.7540, and 0.7794, respectively. Correspondingly, market competitiveness improves by 0.7982, 0.8316, 0.7540, and 0.7794 standard units when physiological, psychological, environmental, and group customization care are enhanced by one standard unit.

5 Results and analysis

Physiological, psychological, environmental, and group customization care significantly affect the market competitiveness index. Hence, they are utilized as the indices to analyze the effect of humanized design. The manifest variables X_1, X_4, X_7, and Y_1 contribute the most to each latent variable. Nonetheless, the contribution of each manifest variable varies significantly.

The present study establishes an analysis model based on previous research to form a reliable and valid scale of quantitative measurement. In the process, the weight coefficient can be obtained. The present result can be a significant reference for the humanized design of mobile phone interfaces in the future. The present study results indicate that mobile phone users support the humanized design of mobile phone interfaces. The aspect of psychological care in humanized design earned the best response among all of the aspects. The designers can therefore analyze the emotional tendencies of different groups during the design process.

Therefore, a comprehensive fusion of multiple humanized designs should be considered in designing a humanized mobile phone interface instead of designing a certain aspect excellently. "Comprehensive strength" is emphasized in the field of humanized interface design. In general, this study is basically complete and is rigorous. The indices listed in this paper can reflect the actual effects of the humanized design effectively and can provide a reference for future studies and development.

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