Communicating Kansei Design Concept via Artifacts: A Cognitive Scientific Approach

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Abstract

One aspect of critical failure in design of Kansei-oriented artifacts is that users do not perceive the designed artifacts as the designers intended. When this happens, the designers would want to identify the design elements that might have caused this mismatching, and replace them with the ones that should reduce the degree of mismatching. This paper proposes a cognitive model, "the dual mapping model," that simulates subjective and intuitive processes involved in creating an idea sketch that should convey Kansei design concept, and in evaluating the idea sketch to extract its underlying Kansei concept by users. These processes are represented by using fuzzy theoretical formalism. The dual mapping model was used to build a prototype design support system, which provides designers with an integrated design environment that consists of (1) a unit for measuring Kansei data, (2) a unit for analyzing the data, and (3) a unit for providing useful feedback for enhancing the idea sketch.

1 Introduction

There is a category of artifacts that is called Kansei-oriented products whose design concept is to be communicated to their users via their appearance. Ideally, their designers want to match the Kansei design concept that these artifacts should convey with the one that users perceive when they appreciate or use them. However, there would be a case where this cannot be achieved, which is critical failure in design of Kansei-oriented products. For example, the designers have created a portable device in order to embody a set of Kansei design concept, such as heavy and deep and simple. However, users perceive it as sober and practical. The designers would want to identify the design elements that might have caused this mismatching before a specification for final product is fixed, and replace them with the ones that should reduce the degree of mismatching.

This paper proposes a cognitive model, the dual mapping model, that simulates subjective and intuitive processes involved in creating an idea sketch that should convey Kansei design concept, and in evaluating the idea sketch to extract its underlying Kansei concept by users. These processes are represented by using fuzzy theoretical formalism. This paper describes a prototype design support system that allows the designers to estimate the degree of mismatching based on the dual mapping model and provides useful information for enhancing the current idea sketch.

2 The Dual Mapping Model

The central portion of Figure 1 shows the situation that this paper deals with: Given a set of Kansei design concept C, a designer has constructed an idea sketch S, such as shown in Figure 2, considering how users should perceive it. This process is controlled by his or her mental model of users [4] — designers' mapping. Then the idea sketch was evaluated by intended users in terms of their impression words C' — users' mapping. However, the designers might not obtain a satisfactory result: the ratings of the users were not consistent with those of the designers. The designers had to set a design goal to reduce the degree of mismatching.

We propose a cognitive model that simulates designers' and users' mapping processes, the dual mapping model, which should provide a basis for tools that support such designers' activities. Figure 1 shows the dual mapping model. The model consists of two mapping processes: designers' mapping process that transforms a set of Kansei design concept onto an idea sketch, and users' mapping process that converts the idea sketch to Kansei design concept. Each process consists of three cognitive subprocesses; decomposition, mapping, and aggregation. Both parties perform these same processes, but the order is reverse.

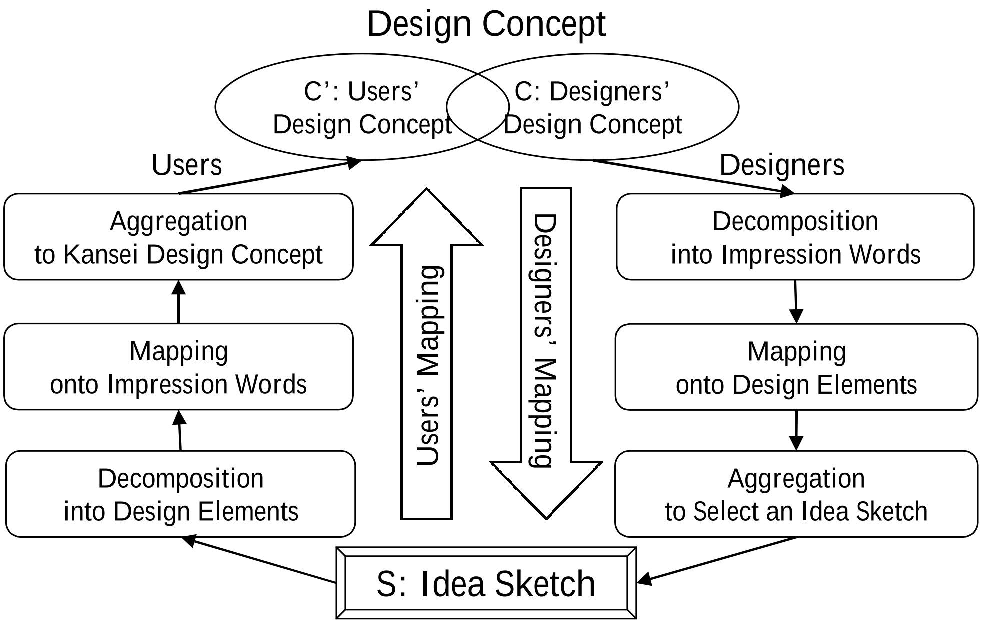

Figure 1. The dual mapping model.

2.1 Designers' mapping process

2.1.1. Decomposition

On the designers side, it is assumed that designers first decompose the top-level Kansei design concept C into a representation in terms of a set of impression words $\{W_i\}$. The model represents C as a fuzzy set:

$$C = \Sigma\, w^{(C)}_i / W_i, \cdots\cdots\cdots\cdots (1)$$

where $w^{(C)}_i$ denotes the degree of consistency of the impression word W_i with the top-level Kansei design concept C.

2.1.2. Mapping

The next process is to map the impression words onto a set of design elements. An example of design elements is shown in Figure 3. This process is simulated by regarding each impression word as a fuzzy set:

$$W_i = \Sigma\, e_i^{(j)}{}_l / E^{(j)}{}_l, \cdots\cdots\cdots\cdots (2)$$

where $e_i^{(j)}{}_l$ represents the degree of consistency of the l-th component of the j-th design element, $E^{(j)}{}_l$, with the impression word W_i.

2.1.3. Aggregation

The aggregation process integrates the knowledge of relationships between W_i and $E^{(j)}$'s into a new definition of W_i on $E^{(1)}\times E^{(2)}\times\ldots\times E^{(N)}$ by using an appropriate aggregation operator, $f_{aggregation}$:

$$W_i = f_{aggregation}(\Sigma\, e_i^{(1)}{}_l / E^{(1)}{}_l, \ldots ,\Sigma\, e_i^{(N)}{}_l / E^{(N)}{}_l) \quad (3)$$

In simple applications, the aggregation operator may take the form of either maximum, minimum, geometric mean, logarithmic mean, or product.

2.1.4. Selection

An idea sketch, S, is defined by selecting one instance from each design element:

$$S \equiv \{E^{(1)}{}_\alpha, E^{(2)}{}_\beta, \ldots ,E^{(N)}{}_\nu\} \cdots\cdots\cdots (4)$$

However, this cannot be done arbitrarily. It is assumed that designers define S in such a way as:

$$s_i = w^{(C)}_i \cdots\cdots\cdots\cdots\cdots\cdots (5)$$

in which s_i denotes the degree of consistency of S with the impression word W_i obtained by (3), and $w^{(C)}_i$ is provided by (1).

2.2 Users' mapping process

Users represent the idea sketch, S, in terms of Kansei design concept using their set of impression words. This process is modeled as three subprocesses, decomposition, mapping, and aggregation.

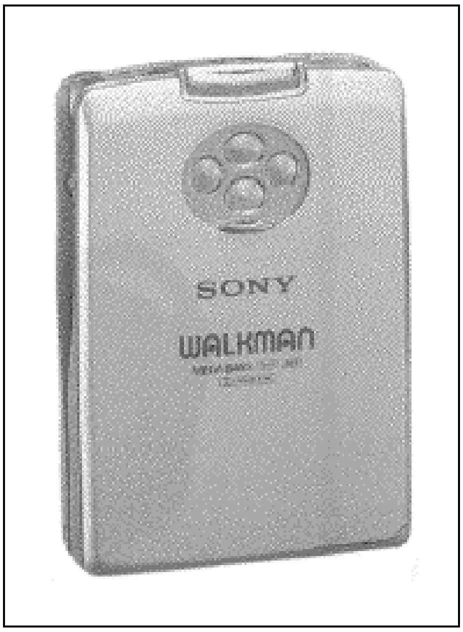

Figure 2. An example of idea sketch.

2.2.1. Decomposition

Users first decompose the idea sketch into instances of design elements, $\{E'^{(1)}_{\alpha}, \ldots, E'^{(k)}_{\kappa}, \ldots, E'^{(N')}_{\nu}\}$. Note that the way users decompose the idea sketch might not be identical with the way designers do.

2.2.2. Mapping

Each instance is represented as a fuzzy set:

$$E'^{(k)}_{\kappa} = \Sigma\, w'_{kp} / W'_{p} \cdots\cdots\cdots\cdots (6)$$

where w'_{kp} denotes the degree of consistency of the p-th impression word with the instance of design element, $E'^{(k)}_{\kappa}$. Here again, it should be noted that the set of impression words that users use, $\{W'_p\}$, might not be identical with the one that designers have, $\{W_i\}$.

2.2.3. Aggregation

Finally an aggregation operator works on the instances of design elements to generate an overall estimate of the idea sketch:

$$f'_{aggregation}(\Sigma\, w'_{1p} / W'_{p}, \ldots, \Sigma\, w'_{N'p} / W'_{p}) \cdots\cdots (7)$$

This gives us a representation of S in terms of users' impression words, $\{W'_p\}$, that is,

$$C' \equiv S = \Sigma\, w'^{(S)}_{p} / W'_{p}, \cdots\cdots\cdots\cdots (8)$$

showing how users perceive the idea sketch.

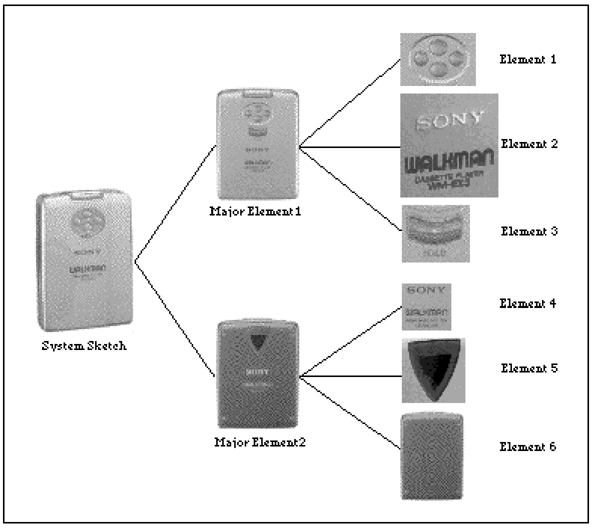

Figure 3. A tree-like representation of design elements.

3 Gap in Design Concept

Conceptual gap is defined by mismatching between C and C', that is, the difference between (1) and (8). When the designers and the users have a common set of impression words, $\{W_i\} = \{W'_p\}$, the gap is defined by a distance between the two fuzzy sets. The following is an example definition of the distance taken from [3] that we adopted for implementing the prototype system:

$$d = 1 - \frac{\|C \cap S\|}{\|C \cup S\|} = 1 - \frac{\sum_{i=1}^{M} \min(\mu_C(w_i), \mu_S(w_i))}{\sum_{i=1}^{M} \max(\mu_C(w_i), \mu_S(w_i))} \cdots\cdots\cdots\cdots\cdots\cdots (9)$$

In this formula, M denotes the number of impression words, and

$$C \equiv \mu_C(w_i); i = 1, \cdots, M \ , \ S \equiv \mu_S(w_i); i = 1, \cdots, M \ ,$$

are alternative representations that correspond to (1) and (8), respectively.

3.1 Eliminating Small Gaps

When the degree of mismatching is small, it can be eliminated by replacing design elements that have least effect on designers' mapping process with the ones that

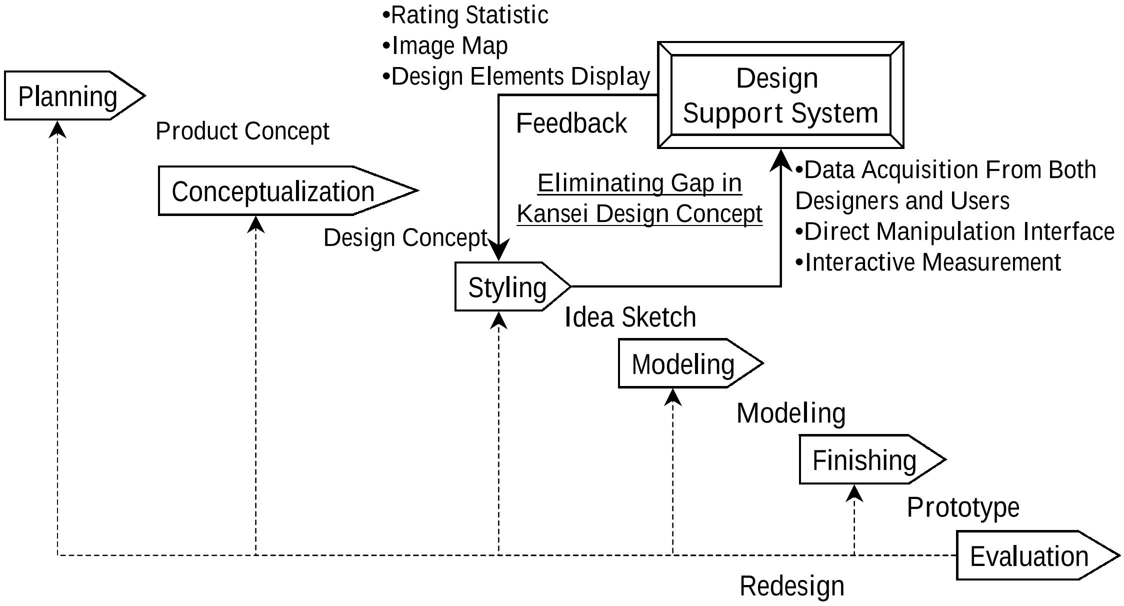

Figure 4. Outline of the entire design process and the role of the design support system.

yield desired effect. This strategy would work when there are alternative combinations of instances of design elements that satisfy the requirement that an idea sketch should satisfy, represented by (5).

3.2 Eliminating Large Gaps

If d is significantly large, it is likely that both of or either of the bases for the users' conceptualization, $\{W'_p\}$ and $\{E'^{(k)}\}$, do not agree with those for the designers, $\{W_i\}$ and $\{E^{(j)}\}$, respectively. According to the dual mapping model, the designers need to understand the users' system decomposition first.

If $\{E'^{(k)}\}$ differs significantly from $\{E^{(j)}\}$, designers might want to replace the conflicting design elements with their alternatives. The detailed knowledge that is gained by measurement should facilitate this design activity. A new idea sketch will be evaluated by users.

On the other hand, if designers cannot find any differences between $\{E'^{(k)}\}$ and $\{E^{(j)}\}$, the cause of the gap should be found in the representations of design elements $\{E'^{(k)}\}$ in terms of a set of impression words $\{W'_p\}$. Although it is worthwhile to let the designers know the fact that their knowledge about impression words is different from that of users, the tool is not as helpful, because this should be considered as a sign of serious problem of the project itself. The designers should have to start learning the users again.

4 A Prototype Design Support System

A prototype design support system was built that assists designers to enhance idea sketches by reducing conceptual mismatching during the styling stage of the whole product design process. Figure 4 illustrates the role of the design support system with respect to the whole design process. The system supports interactive measurement of both users' and designers' mapping processes, and provides immediate feedback about the results of the measurement including design gaps. See [2] for more detailed description about the prototype system.

4.1 Measurement Unit

Figure 5 illustrates how the system is used for measuring users' evaluation of the idea sketch. The interaction with the system (by the designers and the users) is supported by direct manipulation interfaces that have been applied for a Kansei measuring system developed by one of the authors (KDH) [1]. Table 1 lists the base word set, $\{W_i\}$, consisting of 47 impression words. The idea sketch is displayed on the window as a digital image. In Figure 5 (a), the subject is asked to select (~10) impression words that are relevant to the idea sketch. The selection is done by clicking

Table 1. The base impression words (47) used for the prototype system.

Alluring	Balanced	Bold
Brilliant	Casual	Charming
Chic	Child like	Classic
Clean	Clean and fresh	Clear
Colorful	Compact	Dandy
Dapper	Decorative	Dignified
Disliking	Dressy	Dynamic
Elegant	Enjoyable	Extravagant
Familiar	Fashionable	Feminine
Fleet	Formal	Fresh
Friendly	Gentle	Gorgeous
Graceful	Hard	Harmony
heavy and deep	Intense	Interesting
Liking	Luxurious	Metallic
Mild	Modern	Natural
Noble	Nostalgic	Old-fashioned
Placid	Plain	Polished
Practical	Precise	Pretty
Progressive	Provocative	Pure
Refined	Refreshing	Repetition
Restful	Romantic	Sharp
Showy	Simple	Simple and appealing
Smart	Smooth	Sober
Soft	Speedy	Sporty
Sturdy	Symmetry	Traditional
Trifling	Urbane	Vigorous
Vivid	Western	Wild
Youthful		

appropriate words in the right scrolling window. The selected words are displayed in the middle scrolling window. In Figure 5 (b), the subject is asked to identify a few words from the selected word set that best represent the idea sketch. Then the subject is asked to sort the word set under the representative words. In Figure 5 (c), the subject rates the idea sketch by using each representative word first. This rating is used as an anchor for subsequent ratings for non-representative words of the same category. Direct manipulation sliders are used for entering ratings. The same interface is used to measure designers' mapping processes.

4.2 Feedback Unit

Figure 6 (a) illustrates an example output of the system, showing designers' and users' ratings, and their total difference on its main pane. In Figure 6 (b), the data are shown as two-dimensional image map. In Figure 6 (c), a handle is attached to each node window which gives access to the corresponding design element with visual representation. Each node window can be further elaborated by clicking. The number of nodes to be displayed is controlled by a parameter, α-level. The system displays only those design elements whose gap is greater than the α-level. Thus designers easily identify the locations that might have caused mismatching. This knowledge suggests effective strategies for revision of the idea sketch.

5 Conclusions

This paper proposed a dual mapping model that serves as the basis for constructing a tool that is used by designers for the purpose of converging the users' conceptualization of the system sketch with that of designers. A new interactive design support tool with direct manipulation interfaces was developed, taking advantage of the recent visual and object-oriented programming platform in Oracle Media Object 1.1.

The proposed design support system provides designers with an integrated design environment, consisting of a unit for measuring Kansei data, a unit for analyzing the acquired data based on the dual mapping model, and a unit for providing useful feedback for design enhancement. This allows designers to perform iterative design revisions smoothly, and to select consistent strategies for converging the concept that the users perceive from the idea sketch at the intended Kansei design concept that the idea sketch should convey.

References

[1] Kim Don-Han, Harada, A., and Matsuda, N. (1997). Interactive image evaluation based on the prototype theory. Journal of art and design, No.1, 65-72. University of Tsukuba. (in Japanese).

[2] Kim Don-Han, Kitajima, M., and Harada, A. (1998). A design support system for Kansei-oriented products based on mental model measurement. Bulletin of JSSD, 44, 21-30.

[3] Murakami, J. (1993). Model designs for expressing attraction emotions. Journal of Japan Society for Fuzzy Theory and Systems, 5 (6), 1383-1392. (in Japanese).

[4] Norman, D. A. (1986). Cognitive engineering. In D. A. Norman & S. W. Draper (Eds.), User centered system design: New perspectives on human–computer interaction. Hillsdale, NJ: Erlbaum Associates.

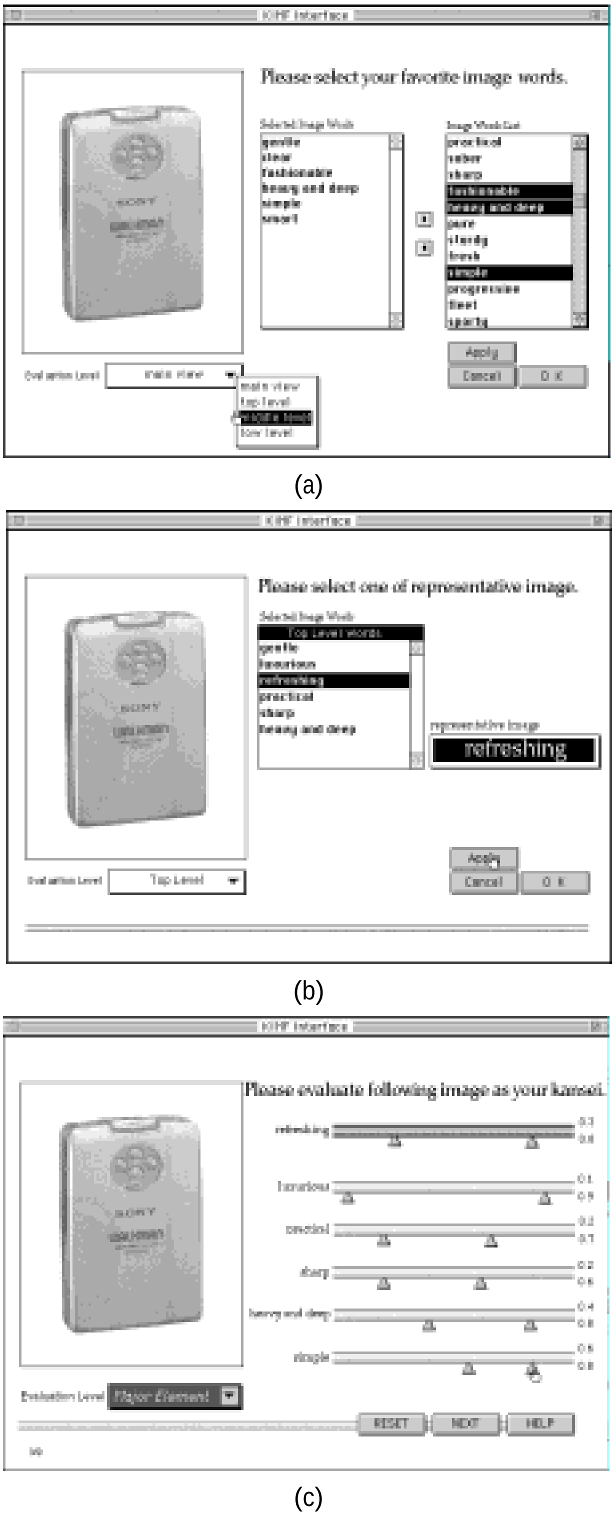

Figure 5. Direct manipulation user interfaces used to measure mapping processes. See text for explanation of each display.

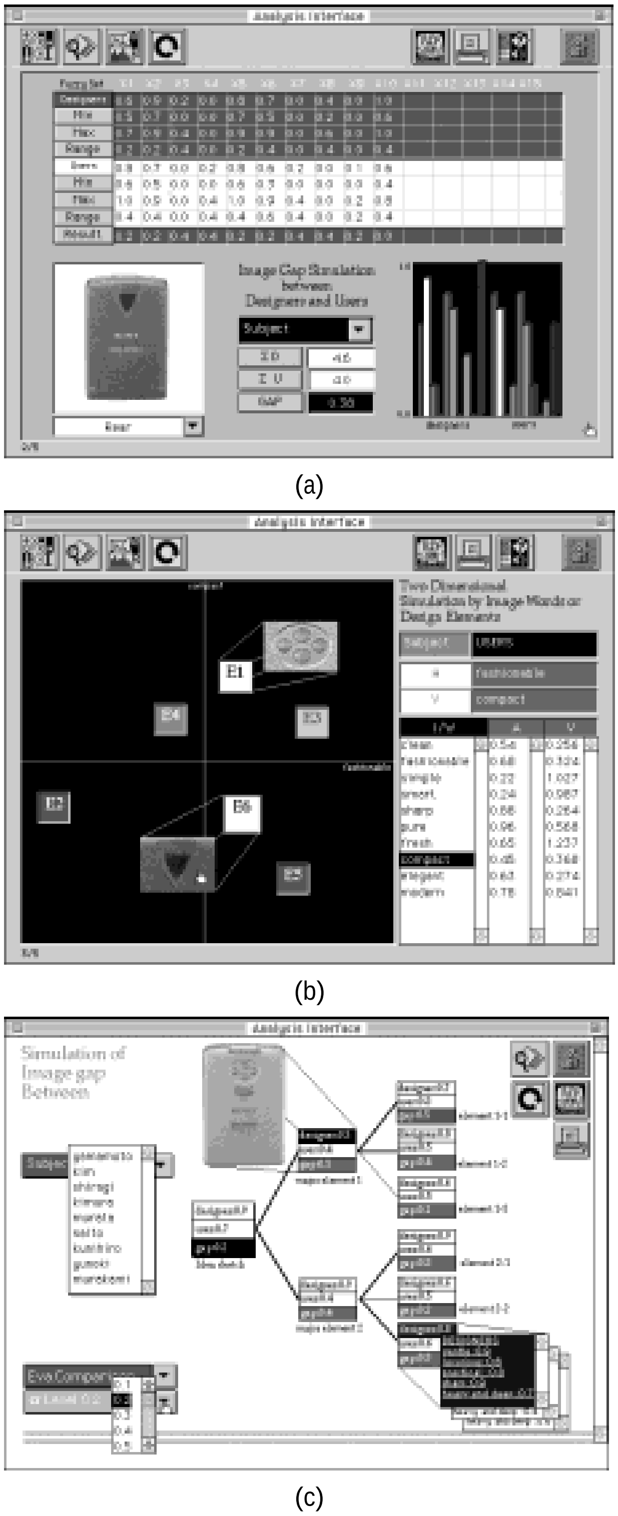

Figure 6. Designers can have access to the data in several forms. Display (a) shows statistics of the data. Display (b) represents the data as a two-dimensional image map. Display (c) relates the data with the design elements, helping the designers discover alternative design solutions.