A Design Support System Based On Uncertain Evaluation Process In Kansei

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1. INTRODUCTION

One of the major problems in designing interactive systems is that users do not perceive a designed system as designers intended. For example, designers have constructed a system in an effort to embody a set of given top-level design concept, such as *heavy and deep* and *simple*. However, users might conceive the designed system as *sober* and *practical*. Designers want to identify the design elements that cause the mismatching, and replace them with the ones that might reduce the degree of mismatching.

This paper proposes a cognitive model, a dual mapping model, that simulates uncertain evaluation process in kansei by designers and users. There are two mapping processes in the model: the designers' mapping process that transforms a set of top-level design concept onto a system sketch, and the users' mapping process that converts the design sketch to impression words. Based on the dual mapping model, this paper proposes a tool for designers that supports their activities for tuning a design sketch so that users impressions to it should converge to the given top-level design concept. We show an on-going prototype that partly implements the tool proposed in this paper.

2. A DUAL MAPPING MODEL

The central portion of Figure 1 shows schematically the situation that this paper deals with: Given a set of design concept ***C***, designers has constructed their design sketch ***S*** considering their mental models of users [1] — *designers' mappings*. When the design sketch was ready, users evaluated it, which is ***S′***, identical with ***S***, in terms of their impression words ***C′*** — *users' mappings*. However, the ratings of the users were not consistent with those of the designers. The designers' goal for the succeeding design activities includes reducing the degree of the mismatching.

We propose a cognitive model that simulates designers' and users' mapping processes, a *dual mapping model*, which should provide a basis for tools that

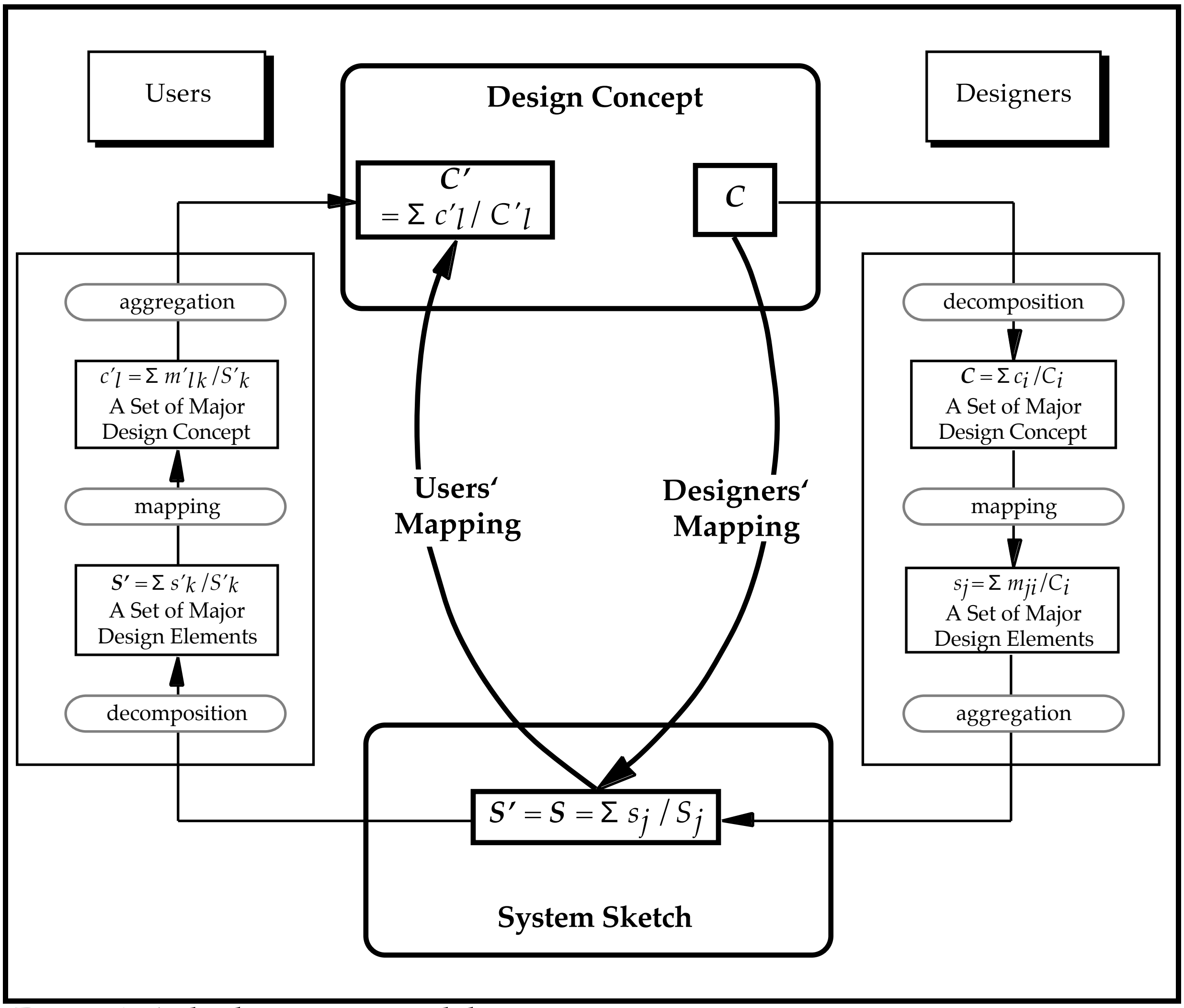

Figure 1. A dual mapping model.

support such designers' activities. In Figure 1, the model is defined by the symbols connected by thin lines; the round rectangles with dotted lines represent cognitive processes, and the rectangles with solid lines represent the representations generated by the cognitive processes that precede.

The entire mapping process is modeled as three separate processes; the decomposition process, the mapping process, and the aggregation process. Both parties perform these same processes, but the order is reverse. On the designers side, they first decompose the top-level design concept $\boldsymbol{C}$ into a representation in terms of a set of major design concept $\{C_i\}$. The model defines $\boldsymbol{C}$ by adopting a fuzzy set like representation: $\boldsymbol{C}=\Sigma c_i/C_i$, where c_i represents the degree of consistency of the major design concept C_i with the top-level design concept $\boldsymbol{C}$.

The next process is to map the design concept onto a set of design elements. We assume that the set of design elements $\{S_j\}$ is given from the outset and that the design sketch is constructed by selecting suitable ones from the set. The representation that is generated by mapping the set of major design concept $\{C_i\}$ to the set of major design elements $\{S_j\}$ is a network with a link m_{ji} that connects

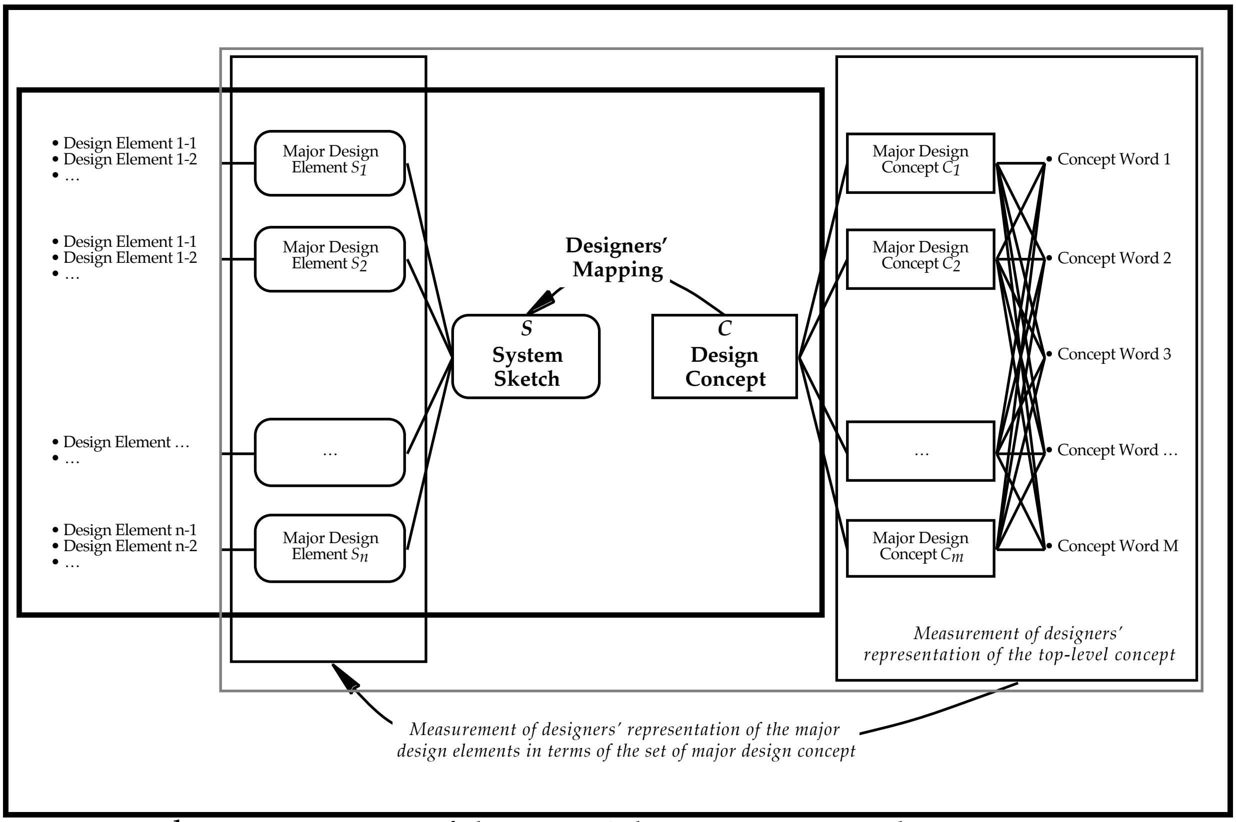

Figure 2. The measurement of designers' decomposition and mapping processes.

each C_i with each S_j. The link strengths represent the degree of consistency of each design element S_j with each of the major design concept C_i. An aggregation process generates a representation of the system sketch $\boldsymbol{S}$ in terms of $\{s_j\}$; $\boldsymbol{S}=\Sigma s_j/S_j$.

On the users side, the mapping processes run in the opposite direction. The users first decompose the system $\boldsymbol{S'}$, then map it onto concept C'_l, then aggregate them into a set of higher concept $\boldsymbol{C'}$. Notice that the bases with which the users' decomposition and aggregation processes are performed, $\{S'_k\}$ and $\{C'_l\}$, respectively, do not necessarily agree with $\{S_j\}$ and $\{C_i\}$, i.e., those of designers', although the designers expect they should be identical.

3. FRAMEWORK OF THE TOOL

Figure 2 is an alternative representation of Figure 1 that focuses only on the part that is relevant when the tool is begun to use, i.e., $\boldsymbol{S}$ has already been constructed according to the given $\boldsymbol{C}$. If designers can know $\boldsymbol{C'}$ — how the tool supports this activity will be described later — the next series of design activities will be to eliminate the gaps between $\boldsymbol{C}$ and $\boldsymbol{C'}$. We assume that $\boldsymbol{S}$ is represented as a hierarchical tree as shown in the left portion of Figure 2 and that designers improve the initial design sketch $\boldsymbol{S}$ by modifying the representation of S_j using alternatives defined by its subordinate design elements so that the modified one should eliminate the gaps.

3.1. Measuring Gaps

The tool supports these activities as the following way based on the dual mapping model. At first, the tool helps the designers elicit designers' own concept $\boldsymbol{C}$ and users' concept $\boldsymbol{C'}$ by providing an measuring environment with a direct manipulation interface (see Figure 5 in the next section). The first approximation we made is that users represent their impressions to the system sketch in terms of the designers major concept, i.e., $\{C_i\}$ — instead of $\{C'_l\}$. Thus the gaps are defined by a distance between the two fuzzy sets. An example definition would be as follows, which is taken from [3];

$$d = 1 - \frac{\|C \cap C'\|}{\|C \quad C'\|} = 1 - \frac{\min(c_1, c'_1) + \ldots + \min(c_n, c'_n)}{\max(c_1, c'_1) + \ldots + \max(c_n, c'_n)}$$

3.2. Eliminating Small Gaps

If $\boldsymbol{d}$ is not significantly large, the designers have to enter into a cycle of repetitive design modification until $\boldsymbol{d}$ becomes smaller values. The tool supports theses activities by first gaining information from the designers and then asking users for further information if necessary. In other words, the tool iteratively elaborates the representations shown in Figure 1. At this stage, the tool helps designers identify their own representations of the system's major design elements S_j in terms of the major design concept C_i, i.e., the tool is used to measure designers' m_{ji}'s.

The tool provides the designers with a visual display for the values for $\boldsymbol{d}$, $\{c_i\}$, $\{c'_l\}$, and $\{m_{ji}\}$, which suggest the major design elements that should contribute to eliminating the gaps.

3.3. Eliminating Large Gaps

If $\boldsymbol{d}$ is significantly large, it is likely that both of or either of the bases for the users' conceptualization, $\{C'_l\}$ and $\{S'_k\}$, do not agree with those for the designers, $\{C_i\}$ and $\{S_j\}$, respectively. In this case, the tool is used to elaborate the representations defining users' mapping processes as shown in the left portion of Figure 1. According to the dual mapping model, the designers need to understand the users' system decomposition first. The tool helps designers perform this activity by applying the same software used for measuring $\boldsymbol{d}$ shown in Figure 5. If $\{S'_k\}$ differs significantly from $\{S_j\}$, designers might want to replace the conflicting design elements with alternatives. An example display of the tool supporting this stage of the designers activity is shown in Figure 6. The detailed knowledge that is gained by the measurement should facilitate this design activity. A new design sketch will be evaluated by users, returning to the process described in Section 3.1.

On the other hand, if designers cannot find any differences between $\{S_j\}$ and $\{S'_k\}$, the cause of the gaps should be found in the representations of major design elements $\{S'_k\}$ in terms of a set of major concept $\{C'_l\}$ that the users defined. Although it is worthwhile to let the designers know the fact that their knowledge about concept 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.

Table 1. The base concept words (47) used for the prototype tool.

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		

4. EXAMPLE

The implementation of the tool is currently under way. Thus this paper describes an outline how the tool might be used. The example design project is to construct a portable device that can play audio tapes. The top-level design concept is *heavy and deep* and *simple*, and the system sketch has been constructed as shown by Figure 3. The design elements are hierarchically structured as shown by Figure 4. The designers are allowed to manipulate the design elements in order to make $\boldsymbol{C}$ and $\boldsymbol{C'}$ identical.

A prototype tool is shown in Figure 5 and Figure 6. The former illustrates how measurement is performed, and the latter, how the results of measurement is back to the designers. The interaction with the tool (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) [2].

The screen shots in Figure 5 illustrate how the tool is used for measuring designers' and users' conceptualization of the design sketch. Table 1 lists the base word set consisting of 47 words that the tool uses to measure $\{c_i\}$ and $\{c'_l\}$. The design sketch is displayed on the window as a digital image, generated by scanning a photographed design sketch. In Figure 5 (a), the subject is asked to select image words (~10) that are relevant to the design sketch. The selection is done by clicking those words in the right scrolling window, where the 47 words listed in Table 1 appear. The selected words are displayed in the left scrolling window. In Figure 5 (b), the subject is asked to identify a few words from the selected word set that most represent the design sketch. Then the subject is asked to sort the word set under the representative words (not shown). In Figure 5 (c), the subject rates the design 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 this version of the tool. Measurement of designers' $\{m_{ji}\}$ and users' $\{m'_{lk}\}$ is also supported by the tool by displaying the design elements in the left display window.

Figure 6 illustrates an example output of the tool, showing designers ratings on the design sketch, $\{s_j\}$, and users' ratings $\{s'_k\}$, and their difference $\boldsymbol{d}$ on its main pane. The layout of the ratings is isomorphic to the hierarchical representation of the design elements, shown in Figure 4. A handle is attached to each node window which gives access to the corresponding design element with visual representations. Each node window can be further elaborated; clicking results in appearance of detailed mapping representations of designers' $\{m_{ji}\}$ and users' $\{m'_{lk}\}$ in separate scrolling windows. The number of nodes to be displayed is controlled by a parameter, α-level. The tool displays those nodes whose $\boldsymbol{d}$ is greater than the α-level. Thus the designer easily identify the locations that might cause the gaps. This knowledge will be used to the next stage of design enhancement.

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 hierarchical interactive evaluating tool was developed in the present work to measure the gaps of designers and users, taking advantage of the recent visual and object-oriented programming platform in Oracle Media Object 1.0. But, the tool is partly implemented using the measurement method developed. A full implementation of the tool and its evaluation is currently under way.

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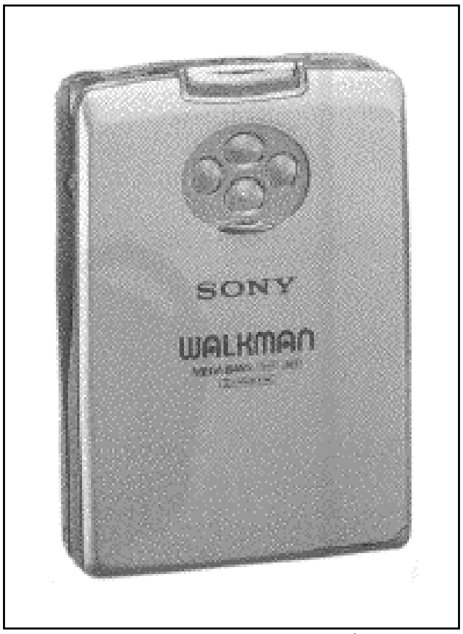


Figure 3. A design sketch constructed according to the design concept.

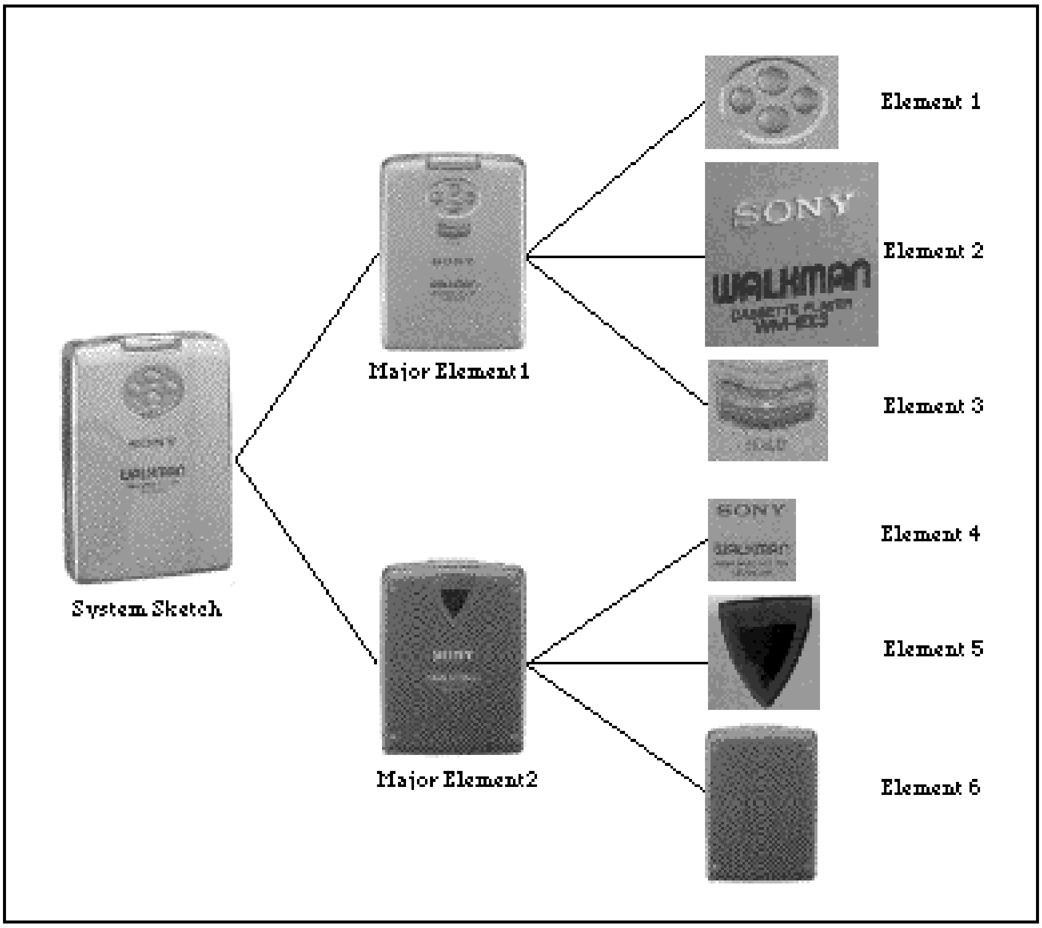
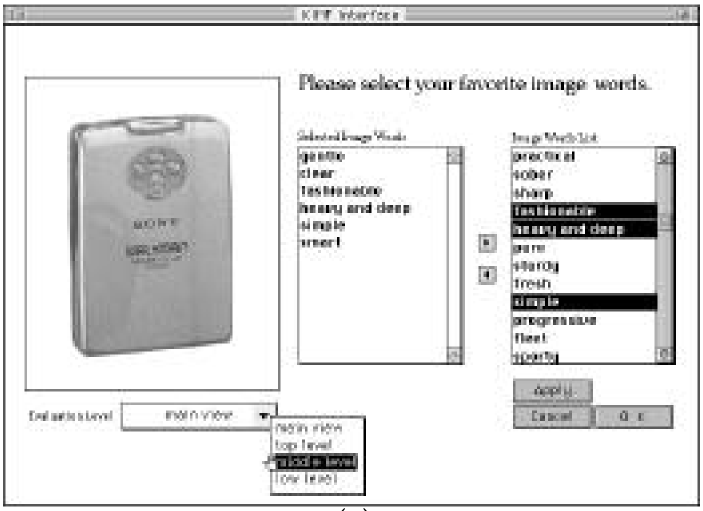
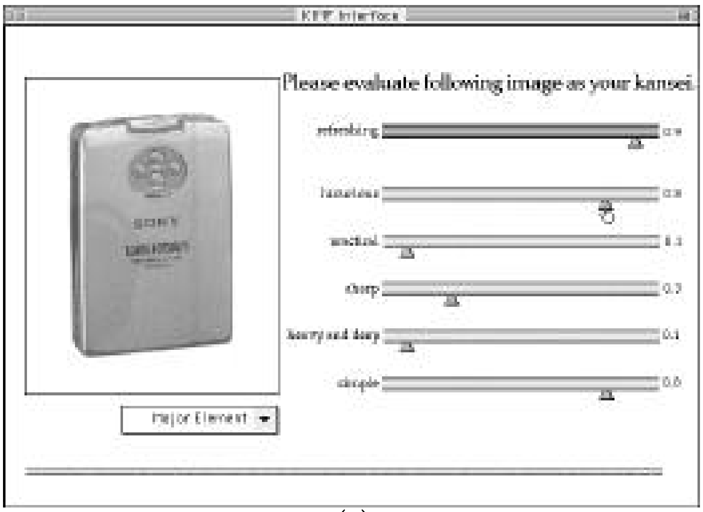


Figure 4. A tree-like representation of the design elements.



(a)

(b)



(c)

Figure 5. An illustration of the tool.

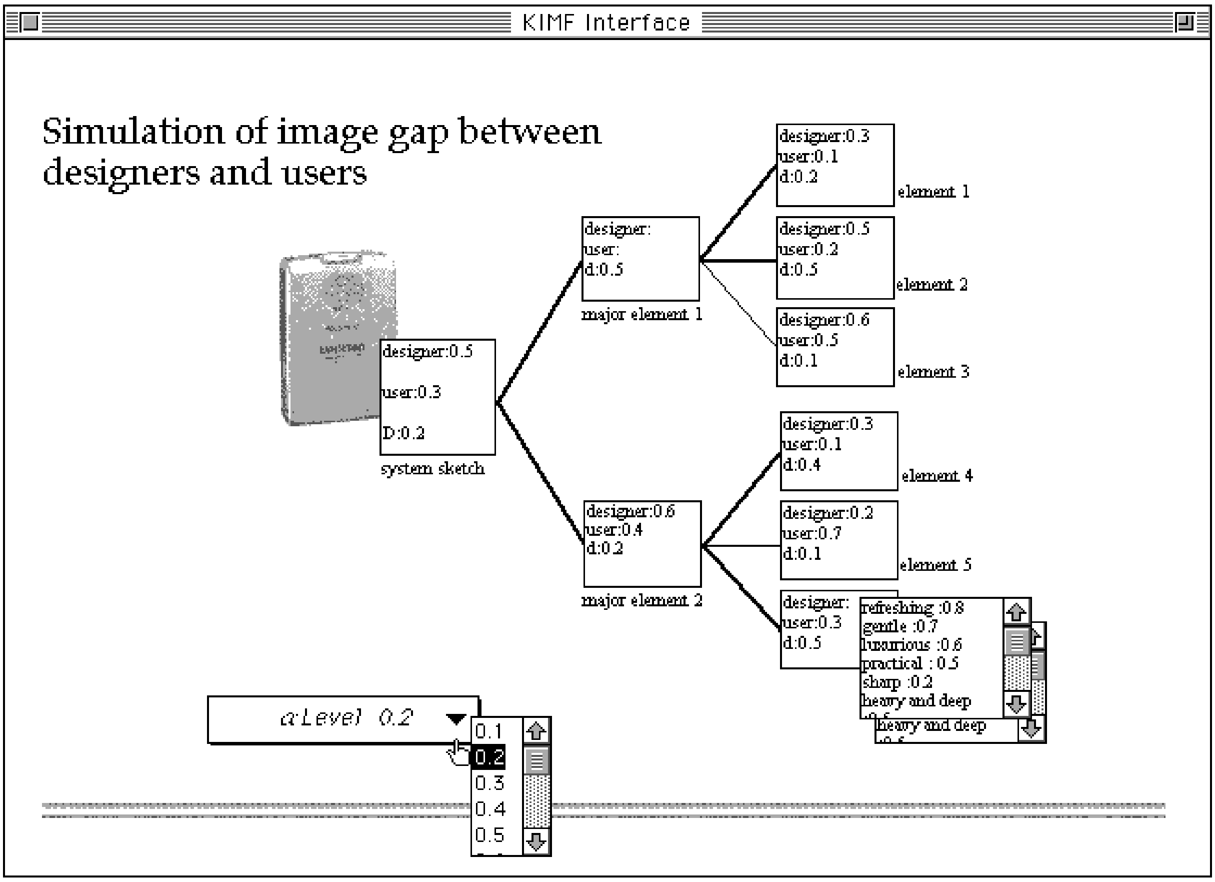


Figure 6. An example output of the tool showing the results of measurement of ***C*** and ***C′***.