

An Analytical Study on Product Subjective Sustainability through *Kansei* Engineering Approach

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Abstract: In fact, a sustainable product should be able to last not only objectively but subjectively, as its expected objective and the subjective lifetimes should be in harmony. Aiming to develop a conceptual model clarifying the phenomenon of ‘product subjective sustainability’, this paper presents the process and results of an analytical study on the evolution of users’ *Kansei* toward their mobile phone during its entire lifecycle. As *Kansei* embraces all subjective issues of product, this study is based on *Kansei* Engineering approach. The outcome of this study would be the *Kansei* factors associating with the investigated subjects’ rationale when purchasing, keeping/using and replacing their mobile phones. Considering the changes of each subject’s *Kansei* regarding his/her mobile phone through these three lifecycle stages, the various patterns of *Kansei* evolution and accordingly major trends of subjective sustainability of mobile phone would be extracted.

Key words: *Subjective Sustainability, Product, Kansei, Mobile Phone, Attachment.*

1. Introduction

Sustainability is obviously a vital concern and common interest in simple majority of the fields of science. The three dimensions of sustainability, ie environmental, social and economic, are indeed interrelated and each one included not only objective layers (involving for instance ecological/environmental impacts, eco-industry/technology, energy and natural resources) but also subjective layers such as social, cultural, ethical and behavioral issues and lifestyle. The importance of subjective aspects of sustainability has been emphasized in scientific debates almost from the first stages of emerge of sustainability [1,2]. Some researchers argue “that sustainable development is an inherently subjective concept” [3]. However, most studies about sustainability, especially in the last decade, have focused on its objective side whereas ‘*subjective sustainability*’ (see note 1) has not been observed adequately [4,5].

The key challenge of “subjective environmental aspects of products and processes” has been discussed in design research since the last decade [11]. As design touches human multilaterally, the given importance to the subjective issues of sustainability within the design researches (for example about sustainable lifestyle,

sustainable consumerism and green consumption) is increasing theoretically and empirically. The topic of enhancing sustainability through human-factors design is also receiving growing attention, as the current studies of affective engineering systems, tools and methods, aimed generally at the more effective design of appealing products, would be relevant to design for sustainability [12].

Practically, the main focus of design researches concerning the subjective issues of sustainability is on ‘lifetime optimization of products’ [13]. On the basis of the results of analysis of the factors influencing the users’ decision for product replacement, Nes and Cramer (2005) propose five design strategies for product longevity including: design for reliability and robustness; design for repair and maintenance; design for upgradeability; design for product attachment and design for variability. They emphasize that “the main challenge in design for longevity lies in achieving an enduring satisfaction with the product, rather than only meeting the momentary desires of today” [14].

‘Product attachment’ simply is defined as “the emotional bond experienced with a product” [15]. Many design researchers argue that extending the psychological life span of durables as well as increasing the degree of consumer-product attachment could be instrumental to reduce the demand for scarce resources and the rate of solid waste disposal and may contribute to a more sustainable society; because a stronger emotional bond between a consumer and his/her product will decrease the consumer’s tendency to dispose it and hence may result in a decrease of unnecessary waste and in a decreased use of limited resources of energy and materials [15,16,17,18]. The strategy to enhance product attachment is however the most uncertain in actually enhancing longevity. As this strategy is based on the fact that the disposal of products is made harder when one feels attached to the product, it brings so many questionable points and challenges implying that it should be well considered and applied delicately [14].

In addition to the above mentioned points and challenges, it seems that product attachment is just one of the means for extending the psychological lifespan of products or optimizing product lifetime subjectively (ie affectively/emotionally/aesthetically). A product, even a very personal one like mobile phone device, may be emotionally pleasurable, aesthetically appealing and/or functionally comfortable during its expected short/long lifespan while there may not be any strong user-product-attachment. Moreover, durability of users’ satisfaction and emotional pleasure regarding a product and its appeal may be eventuated to attachment but not necessarily. Therefore, user-product-attachment may be just a part of the product subjective issues including the user’s total attitude, feeling, affection, emotion and/or appreciation, which could be called *Kansei*, about a product [12,19].

There is seemingly a room for an open concept or wide expression to comprehensively encompass the product subjective issues influencing product psychological lifetime and pleasurable longevity. In this research “a product’s capability of being pleasing, appealing and satisfyingly lasting during the expected long/short lifetime” is identified as *Product Subjective Sustainability (PSS)*. The word “sustainability” in this concept is to imply not only a fair durability but the imperative application of such durability in terms of product sustainability.

2. Outline

2.1 Approach

Keeping the above-mentioned points as the background, to experientially clarify the phenomenon of *PSS*, this research aims to analyze the evolution of users’ *Kansei* toward a product in its entire lifecycle. To cover all subjective issues, the survey and analysis in this research would be based on *Kansei* Engineering approach [19].

Here, the entire lifecycle of product from user perspective is divided into three main stages including: Purchase (P); Keep/Use (KU); and Replace (R). The specified product type for this analytical study is Mobile Phone, since its subjective issues are more considerable than the other kinds of product due to the users' very close/personal relation with it despite being a short-life product [20,21]. Furthermore, user's emotional attachment to mobile phone – rather than the other kinds of product – is reflected in numerous scholarly works [22,23,24,25].

By doing a survey on subjective sustainability of mobile phone, this analytical study is an initiative phase of a research on PSS. As the major outcome of this study, a conceptual model would be built on the basis of the results of survey. It will be engaged as a solid hypothetical base to be verified, expanded and generalized within the next phase of research. Considering the very individuality and subjectivity of the phenomenon of *Kansei*, to precisely survey the users' *Kansei* about their mobile phones in the three lifecycle stages (ie P, KU and R), initially the close and repeatable touch with the subjects seems necessary. Therefore a limited number of subjects are extensively investigated in this phase. In the next phase, the research will be extended to cover a wider range of users. This phase of research is aimed at finding out and classifying the *Kansei* descriptive words regarding each lifecycle stage of the subjects' mobile phones and thereupon extracting the various patterns of the evolution of the subjects' *Kansei* regarding their mobile phone during its lifecycle.

2.2 Method

To achieve the above mentioned objective and goal, this analytical study has been executed within three main steps. In the first step, as the survey, a group of subjects are investigated through the definite and extensive-descriptive questionnaire. The second step is the process and analysis of the data derived from the questionnaire by using KJ Method, Descriptive Statistics, Quantification Theory Type III (QT3) and Cluster Analysis. Last, the results of analysis are interpreted and put in discussion within the third step.

The subjects are 19 Japanese students of Chiba University investigated about: a brief history of their used/replaced mobile phones; their reasons of replacement of mobile phone; the level of dis/satisfaction of their current mobile phones; and their feeling, emotion or *Kansei* regarding their mobile phones in each of the three lifecycle stages of P, KU and R separately into three different questions.

The *Kansei* descriptive words responded by the subjects are summarized through KJ Method. To determine the important items or *Kansei* descriptive words when shifting from a lifecycle stage to another one, the subjects' responded items in all three lifecycle stages are processed altogether by using QT3. On the basis of the axis dimensions that are the output of QT3, all of the items in the three lifecycle stages are put in a 3-dimensional space. As the following formulation shows, if the distance of an item in two different lifecycle stages, for instance P and R, was higher than the addition of Average and Standard Deviation (Av.+SD), that item is considered important in terms of the shift between those two stages. .

$Dist_{iPR}$ = Item's Distance in P and R lifecycle stages

$$Dist_{iPR} = \sqrt{[(X_{iP} - X_{iR})^2 + (Y_{iP} - Y_{iR})^2 + (Z_{iP} - Z_{iR})^2]}$$

If $Dist_{iPR} > Av.+SD$ then $Importance_{iPR} = 1$

If $Dist_{iPR} < Av.+SD$ then $Importance_{iPR} = 0$

To identify the *Kansei* items' grouping and also the subjects' grouping on the basis of their *Kansei* regarding their mobile phones in the three lifecycle stages, the method of Cluster analysis is used. The various patterns of the subjects' *Kansei* evolution are also extracted from their groupings when considering the lifecycle stages.

3. Results

3.1 General Findings

The subjects are 16 male and 3 female Japanese students ranging from 21 to 24 years. The average number of mobile phones already used by the subjects is 4.2. The subjects have indifferently started using mobile phone from 6.4 years ago. Accordingly, the average lifetime of a mobile phone used by the subjects is 1.54 years. The main reasons of replacement of mobile phone mentioned by the subjects are: Service/Price; Defect; Lost; Oldness; Broken; and Novelty. The percentage of these reasons in the subjects' answers is shown in Figure 1. Besides, 58% of the subjects are satisfied with their current mobile phones.

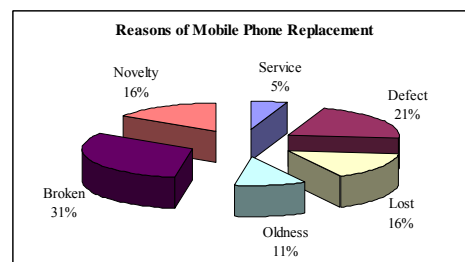


Figure 1. Percentage of replacement reasons in the subjects' response

3.2 Important *Kansei* Descriptive Words

The subjects have totally responded 349 different keywords for their *Kansei*, emotion or feeling about their mobile phone in its different lifecycle stages; 56 ones for R stage, 153 ones for P stage; and 140 ones for KU stage. All these 349 keywords are summarized into 43 *Kansei* items or descriptive words through KJ Method. The subjects' responded *Kansei* keywords regarding all three lifecycle stages are adapted to these 43 *Kansei* items and processed by using QT3. Using the dimensions (X, Y and Z axis) of the *Kansei* items derived from QT3, the distance of an item when shifting from one lifecycle stage to the other one is calculated.

To determine the important *Kansei* items, the highest frequencies and the higher distances than "Av.+SD" relevant to the items are highlighted by color in Table 1. The resulted Average of items' distances, SD and the addition of these two are respectively 2.061, 1.403 and 3.464 ($Av.+SD=2.061+1.403=3.464$).

3.3 *Kansei* Items Groupings

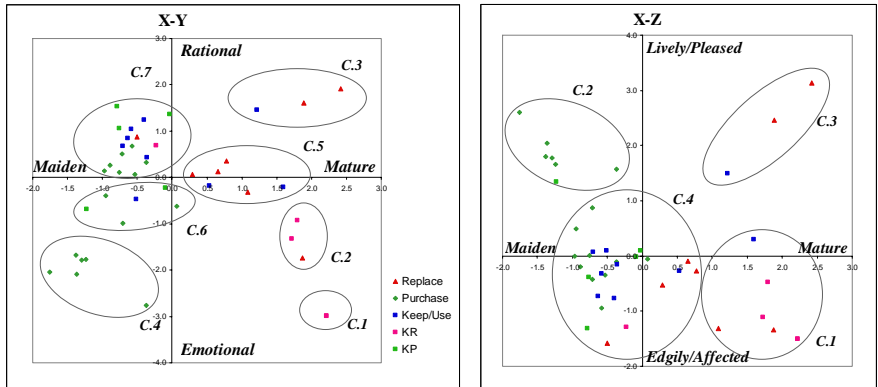
The overall output distribution of the 43 *Kansei* items in the lifecycle stages of mobile phone is shown into two graphs (X-Y and X-Z) in Figures 2 and 3. Using the resulted X, Y and Z dimensions, the chosen cut-off for the clustering algorithm has yielded seven clusters marked from C.1 to C.7 in the X-Y graph and four clusters marked from C.1 to C.4 in the X-Z one. This choice of cut-off is carefully made in order to arrive at the most meaningful groupings for understanding of the relationship between various *Kansei* items or descriptive words associating with the subjects' feeling when purchasing, keep/using and replacing their mobile phones. The items belonging to each cluster are identified in Table 1.

To illustrate the lifecycle stage (P, KU or R) each item associates with rather than the other stages, the different point shapes and colors are used in the graphs. This suggested association is decided in the basis of comparison between the frequencies of each item in the lifecycle stages shown before in Table 1. The directions of the three axis of X, Y and Z are respectively named as *Maiden-Mature (Mai-Mat)*, *Emotional-Rational (Emo-Rat)* and

Edgily/Affected-Lively/Pleased (EdA-LiP). The highlighted clusters (C.1 to C.7) in the X-Y graph can be characterized respectively as Fond, Attached, Ally, Fresh-feel, Valid, Joy, and Bother. Similarly, the ones of the X-Z graph (C.1 to C.4) can be characterized respectively as Attached, Joy/Fresh, Ally and Concerns. These given names are based on the context and distribution of the items in the graphs. As the graphs show, the items having more association with the lifecycle stage of P or R are located respectively in the left or right sides.

Table 1. Frequency and importance of *Kansei* items in the lifecycle stages of Mobile Phone and their clusters

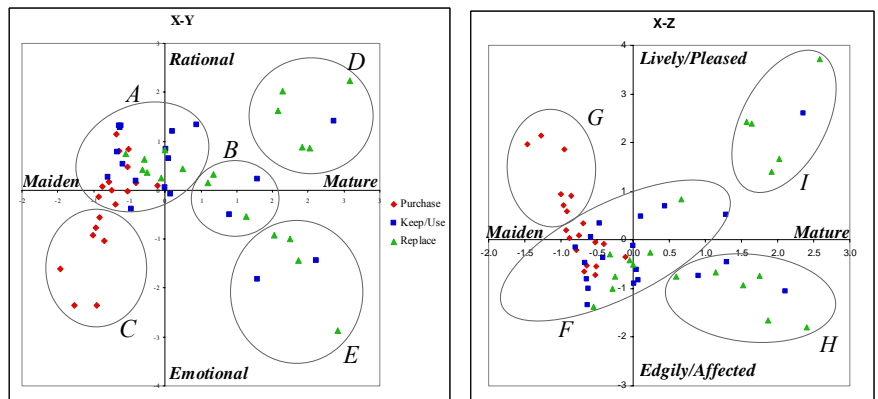
<i>Kansei Descriptive Word</i>	Frequency			(Dist < Av.+SD) = 0			Clusters	
	P	KU	R	P-KU	KU-R	P-R	X-Y	X-Z
Lovely	0	1	1	1	0	1	C.1	C.1
Idol	0	1	1	1	0	1	C.1	C.1
Familiarity	0	3	3	0	0	0	C.2	C.1
Attachment	0	5	5	0	0	0	C.2	C.1
Nostalgic	0	2	4	0	0	0	C.2	C.1
Tattered	0	2	1	0	1	1	C.3	C.3
Partner	0	3	5	0	0	0	C.3	C.3
Appreciation	0	1	5	0	0	0	C.3	C.3
Power Impress	2	1	0	0	1	0	C.4	C.2
Cheap/Childish	1	0	0	0	0	0	C.4	C.2
Surprise	2	0	0	0	0	0	C.4	C.2
Excite	4	0	0	0	0	0	C.4	C.2
Refresh	6	0	0	0	0	0	C.4	C.2
Discovery	3	0	0	0	0	0	C.4	C.2
Cherished	0	5	3	0	0	0	C.5	C.1
Lost	0	1	3	1	1	0	C.5	C.1
Important	3	2	4	0	0	0	C.5	C.4
Regret-Wasteful	0	1	7	0	0	0	C.5	C.4
Longevity	2	2	6	0	0	0	C.5	C.4
Accustom	0	5	0	0	0	0	C.5	C.4
Pleasure	11	2	1	0	1	0	C.6	C.4
Toy	1	1	0	1	1	0	C.6	C.2
Desire	2	3	0	0	0	0	C.6	C.4
Good-look	6	1	1	0	0	0	C.6	C.4
Easy	5	5	0	0	0	0	C.6	C.4
Curiosity	2	0	1	0	0	0	C.6	C.4
Old Style	2	2	1	0	0	1	C.7	C.4
Flaw	1	3	3	1	1	0	C.7	C.4
Boring	0	1	0	1	1	0	C.7	C.4
Dreary	1	1	0	0	1	1	C.7	C.4
Novelty	4	6	0	0	0	0	C.7	C.4
Reasonable	2	3	0	0	0	0	C.7	C.4
Functional	16	10	9	0	0	0	C.7	C.4
Superfluous	2	1	0	0	0	0	C.7	C.4
Complication	10	4	3	0	0	0	C.7	C.4
Complain	5	3	2	0	0	0	C.7	C.4
Anxiety	5	0	1	0	0	0	C.7	C.4
Temporary	2	7	2	1	0	1	C.7	C.4
Anger	0	0	2	0	0	0	C.7	C.4
GUI	5	4	0	0	0	0	C.7	C.4
Puzzled	7	1	0	0	0	0	C.7	C.4
Dislike	1	1	0	1	0	1	C.7	C.4
Uniqueness	0	2	1	0	0	0	C.7	C.4



Figures 2 and 3. Distribution graphs (X-Y and X-Z) and groupings of the *Kansei* items

3.4 Subjects *Kansei* Evolution

This part of the analysis is to delineate the changes of the subjects' *Kansei* toward their mobile phone during its P, KU and R lifecycle stages. The resulted graphs of distribution of the subjects in X-Y and X-Z axis are shown in Figures 4 and 5. These distribution graphs and the ones of *Kansei* items grouping (shown before in Figures 2 and 3) are built on the basis of the "sample score" and "category score" of the same output of QT3 analysis on the same input data, and hence can be overlapped. The same names are therefore given to the directions of X, Y and Z axis in both sets of distribution graphs. The purposely chosen cut-off lines for clustering within the resulted X-Y and X-Z dimensions have yielded respectively five clusters marked from A to E and four clusters marked from F to I in the graphs. Accordingly, the highlighted clusters (A to E) in the X-Y graph can be characterized respectively as Bother, Valid, Joy/Fresh, Ally, and Attached. Similarly, the ones of the X-Z graph (F to I) can be characterized respectively as Concerns, Joy/Fresh, Attached and Ally.



Figures 4 and 5. Distributions (X-Y and X-Z) and groupings of the subjects' *Kansei* in the lifecycle stages

Table 2. The subjects' belonging clusters of *Kansei* statuses in each lifecycle stage of their mobile phones

	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈	S ₉	S ₁₀	S ₁₁	S ₁₂	S ₁₃	S ₁₄	S ₁₅	S ₁₆	S ₁₇	S ₁₈	S ₁₉
P	CG	CG	AF	CG	CG	CG	AF	AF	AF	CG	AF	AF	CG	AF	AF	AF	AF	AF	AF
KU	EH	AF	AF	BH	AF	EH	AF	AF	AF	AF	AF	DI	AF	AF	AF	AF	AF	BF	AF
R	EH	AF	BH	DI	DI	EH	AF	AF	EH	DI	AF	DI	AF	EH	AF	DI	AF	BH	BF

These graphs (Figures 4 and 5) show the evolution of the subjects' *Kansei* statuses during the entire lifecycle of their mobile phones. Each point represents a subject's *Kansei* status in each of the three lifecycle stages, which

are discernible by three different colors and shapes in the graphs. The subjects' *Kansei* statuses in P stage are almost located in the left side of the graphs. To extract the various patterns of subjects' *Kansei* evolution, the clusters, in which each subject (S_i) is laid during each stage (P, KU or R), are listed in Table 2.

Considering the changes of the subjects' *Kansei* statuses in the three lifecycle stages, the subjects can be set into various types. The resulted clusters (Figures 4 and 5) indicate each subject's *Kansei* statuses in the three lifecycle stages. According to the subjects' belonging clusters in each lifecycle stage (Table 2), 10 various patterns of *Kansei* evolution are extracted and shown in Figure 6. The given title to each pattern corresponds with the marks of the clusters, in which the respective subjects are laid sequentially in P, KU and R stages. Half of these patterns associates with mobile phone's longevity, well-ending and hence *PSS*. As the figure shows, the patterns associating with shortening mobile phone's lifetime and subjective un-sustainability can be improved and evolved into their close subjective sustainable patterns by using some means such as aesthetical, functional, software and/or hardware solutions.

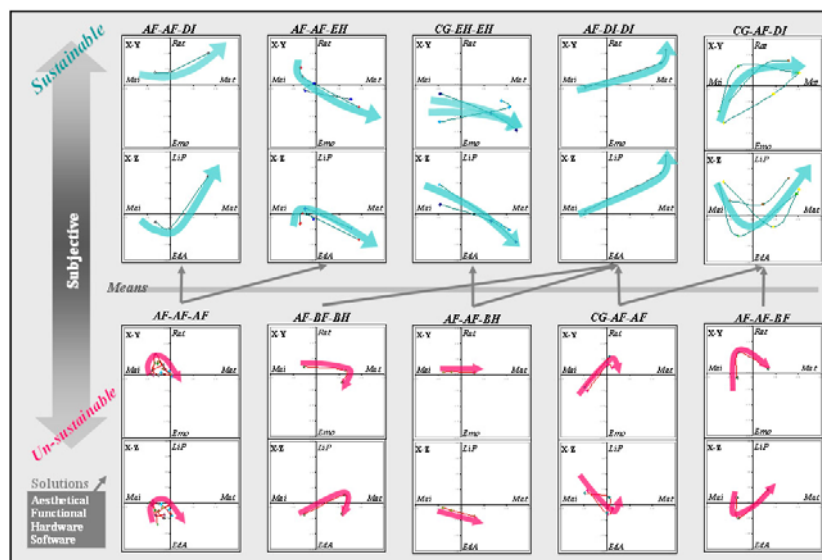


Figure 6. The extracted patterns of subjects' *Kansei* evolution during the lifecycle stages of their mobile phones

4. Interpretation and Discussion

The resulted average lifetime of a mobile phone confirms that mobile phone is a short-life product. Most of the subjects (totally 68%) have replaced their mobile phones because of the basic and objective problems such as break-down, lose and techno-functional defect. However, as 32% of the subjects' reasons of mobile phone replacement are subjective (such as oldness and novelty), this kind of reasons also deserves attention. Dissatisfaction, as the concern of a considerable percentage (42%) of the subjects, is also an observable issue.

Among the *Kansei* items, the only one that has the highest frequency in all three lifecycle stages (P, KU and R) at the same time is "Functional". Therefore, the subjects common *Kansei*, feelings and emotions about their mobile phone in its three lifecycle stages have changed. In terms of shifting from one lifecycle stage to the other one, as Figure 7 shows, the highlighted important *Kansei* items in Table 1 can be set into three groups named as Good Feel, Displeasure and Bad Feel. The first group, Good Feel, seems to associate with the extending psychological lifetime of mobile phone and hence with its subjective sustainability. But the second and third groups, on the contrary, associate with shortening its psychological lifetime and hence subjective un-sustainability.

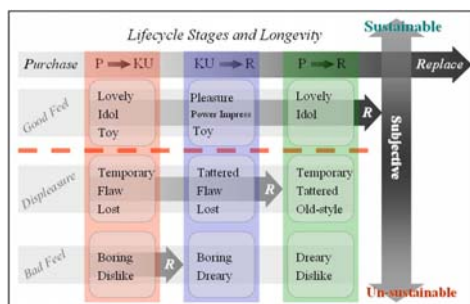


Figure 7. Association of important *Kansei* items with *PSS* when shifting between two lifecycle stages

The positions of the resulted clusters of the *Kansei* items beside the axis directions in the respective graphs (Figures 2 and 3) depict the various types of emotional concerns in each lifecycle stage of mobile phone. The located clusters in the *Mai-Emo-LiP* area are much concerned with the lifecycle stage of P or the beginnings of use. The *Kansei* items that are mainly concerned with the lifecycle stage of KU are almost intermediate in the middle area. Few *Kansei* items, which are mainly concerned with the lifecycle stage of R, are located near the *Mai* or close to *EdA* directions. These few items associate with a situation in which a subject tends to replace his/her mobile phone due to some rational concerns before the end of its expected lifetime or after a short while using it, namely with subjective un-sustainability.

But the *Kansei* items being positioned near *Mat* direction are emotionally concerned with a well-ended lifecycle. Those items which are laid in the characterized clusters as “Ally” tending to *Rat-LiP* direction associate with the subjects’ satisfyingly appreciation because of a good partnership and pleasant utility of their mobile phones. Those ones which are laid in the characterized clusters as “Fond” and “Attached” tending to *Emo-EdA* direction associate with the subjects’ close relation, interest and affective attachment to their mobile phones. And the ones laid in the borderline and the characterized cluster as “Valid” somehow associate with the subjects’ ecological concerns and environmental awareness while they are prizing their mobile phone (as an important, valuable or useful object deserving prevention from wasting) and caring its longevity. These three set of characterized clusters (Ally, Attached and Valid) indicate three different *Kansei* means or ongoing trends associating with *PSS*.

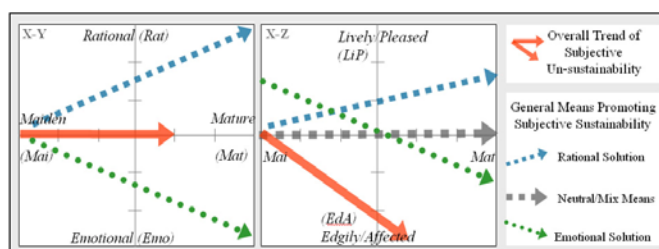


Figure 8. The rough trends of subjective un-sustainability of mobile phone and the solutions promoting its *PSS*

Comparing the extracted patterns of the subjects’ *Kansei* evolution (Figure 6), the overall trends of product subjective un-sustainability and general means or solutions promoting *PSS* are condensed into a conceptual model shown in Figure 8. Normally, product subjective un-sustainability is due to the highly increase of users’ displeasure or drastically verging of their *Kansei* to *EdA* direction before becoming *Mature* enough in terms of using the product. The tip of arrow in the model indicates the end of the product lifetime, namely the lifecycle stage of R. To extend the product lifetime into *Mat* area, roughly the possible trends of solution may be rational, emotional or neutral meaning borderline or mix of rational and emotional. These three trends correspond with

the above-mentioned three trends of *Kansei* means (Ally, Attached and Valid). It should be mentioned that the subjects' *Kansei* in the stage of R is indeed about their last mobile phones, which are replaced, and is chronologically happened before P and KU stages. However, the derived trends hypothetically depict the probable trends of evolution of user's *Kansei* toward a mobile phone in its lifecycle stages.

5. Conclusion

Longevity or lifetime optimization of durables is the main concern of many design researches dealing with product sustainability. Regarding the subjective issues in terms product sustainability, most design researchers have focused on product attachment as the only means for extending the psychological lifespan of products. However, as the results of this analytical study show, there are some other effective means in this regard. To comprehend all such means, here the concept of *PSS* is proposed to imply "a product's capability of being pleasing, appealing and satisfyingly lasting during its expected long/short lifetime".

As the user-product-attachment is seemingly stronger in mobile phone than the other personal electronic devices, using *Kansei* Engineering approach, subjective sustainability of mobile phone is analyzed in this study. On the basis of the results derived from investigation of the subjects' *Kansei* in the three lifecycle stages of their mobile phones, 10 various patterns of *Kansei* evolution during the lifecycle of mobile phone are extracted. Half of those patterns associating with subjective un-sustainability can evolve into the subjective sustainable patterns through some aesthetical, functional, software and/or hardware means.

Overall, *PSS* of mobile phone has three different trends or circumstances that can be characterized as Ally, Attached and Valid. The first one is the issue of user's good partnership relation with and pleasant utility of mobile phone. The means for shifting from a subjective un-sustainable circumstance to this trend, Ally, could be the integrated functional hardware/software encouraging/facilitating the perfect partnership relation between user and mobile phone. The second one is the issue of users' close affective relation with and attachment to their mobile phones. Emotional attraction of software or appearance, durable aesthetics and/or durable hardware could be used as the means or solutions for evolving to this circumstance. The third one is the issue of user's prizing his/her mobile phone as a valuable and still useful object deserving to be kept for a longer time. The effective means for improving or evolving to this circumstance could be functional or software upgradeability, durable hardware and durable aesthetics. To generalize such results, much more subjects with a wider age range should be investigated within the next phase of this research.

Note:

1. The term 'subjective sustainability' seems to be a versatile and wide concept. It has been used in the literatures of various fields, such as Public Policy [6], Forest Management [7] Urban Planning [4,5,8] and Social Sciences [9]. 'Subjective sustainability' in terms of Social Sciences generally is the matter of the social and cultural issues of sustainable development [9] and in Urban Studies specifically is about "rising real incomes, adjusted market frameworks and changing consumer preferences interact to moderate resource inputs while raising GNP" [4,5]. According to Haie (2006), subjective sustainability criteria should be approached through subjective judgments, subjective classifications and subjective conclusions [10]. Nevertheless, the definite territory of 'subjective sustainability' has not been clearly identified and expanded well within the literatures.

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