PROPOSAL OF "EXPECTOLOGY " AS DESIGN METHODOLOGY

Tamotsu Murakami, Satoshi Nakagawa and Hideyoshi Yanagisawa

ABSTRACT

In the present competitive environment, designers should try to create attractive products to give consumers not just the satisfaction they expect but delight beyond their expectations. For this purpose, the authors propose the concept of "*Expectology*" as a framework to provide designers with a systematic methodology for designing products considering every possible positive (e.g., expectation, satisfaction, delight) and negative (e.g., anxiety, dissatisfaction, disappointment) emotional response of consumers. As a systematic approach to *Expectology*, first the authors enumerate and qualitatively classify relevant emotional states as a combination of two exclusive categories, prior–posterior and positive–neutral–negative, for MECE (mutually exclusive and collectively exhaustive) analysis. Then the authors enumerate all possible transitions from one emotional state to another as a matrix. This classification matrix provides designers with a means of classifying both successful and unsuccessful design case studies as well as relevant design methods and techniques, enabling them to compile design databases (e.g., as web pages) of what they should or should not do in future projects.

Keywords: Emotional design, expectation, disappointment

1 INTRODUCTION

In the present competitive environment, designers should create products attractive to consumers. Although designers usually design products to fulfill consumers' requirements, successful and attractive products seem to give consumers not just satisfaction by meeting their requirements but delight by exceeding them. Since designing products exceeding consumers' requirements requires not only investigation but also designers' foresight and imagination, there is a possibility that the resulting product is not successful because it does not exceed consumers' requirements but it is just different from them. If consumers are generous and considerate of such attempts by designers, such failures may not cause a serious negative response, as in the case of attractive quality in the Kano model [1]. If consumers are not considerate and generous, however, there might be a serious negative response, as in the case of must-be quality in the Kano model [1], which designers and companies want to avoid. Some studies [2][3] have reported that consumers' positive (e.g., delight, satisfaction) and negative (e.g., dissatisfaction, disappointment) emotional responses are determined by positive and negative disconfirmation between their prior expectations toward a product and the (posterior) actual product performance.

Considering this background, the second author, who is an industrial designer, conceived the concept of "*Expectology*" as a systematic framework for understanding emotions relevant to product design, such as expectation, anxiety, delight, and disappointment, and utilizing them in the product design process. *Expectology* is intended to provide designers with a systematic methodology for designing products considering every possible positive (e.g., expectation, satisfaction, delight) and negative (e.g., anxiety, dissatisfaction, disappointment) emotions of consumers in the following manner.

- A design methodology to increase the amount and probability of positive disconfirmation of product performance from consumers' expectations and to obtain a positive emotional response from consumers.
- A design methodology to decrease the amount and probability of negative disconfirmation of product performance from consumers' expectations and to avoid a negative emotional response from consumers.
- A methodology to recover from negative emotional responses of consumers as rapidly as possible as a safety net to enable designers and companies to attempt to produce innovative products.

In this paper, the authors first introduce the concept of *Expectology* and then propose a possible systematic approach to it as a design methodology.

2 PROPOSAL OF "*EXPECTOLOGY*"

2.1 *Expectology*

The quality of a product is generally evaluated on the basis of its aesthetics, functionality, and usability. In product development, which should actively intrigue and involve its users, however, what the users expect of a particular product should equally be examined. To utilize the expectations of users, it is essential to clarify users' thoughts such as “it looks comfortable” and their motives such as “I want it.” *Expectology* is the act of analyzing design from the standpoint of human science. It is also the process of establishing a methodology to evaluate the responses of users to products and environments in advance. Ultimately, our aim is that *Expectology* will be applied as an advanced design engineering technique.

2.2 Basic concept and background

The term *Expectology* is composed of two words, “expect” and “logos.” In *Expectology,* the feeling of anxiety toward products is studied as well as the expectations toward them. This is because these opposing feelings coexist with one another; users are anxious about some parts of a product or the product as a whole because they have sufficiently high expectations toward it. In addition, it is considered that one's sensory organs are at their most sensitive when a person is feeling anxious. Therefore, *Expectology* focuses on the whole mechanism of one's psychological state before using products, services, and environments. In this paper, we present the methodology of design engineering based on *Expectology* and its engineering approach.

2.3 Methodologies of *Expectology*

Five senses

The first step in applying *Expectology* to design engineering is to clarify the relationship between products and their users' physiological state. We analyze the sequence of changes in each of the five sensory organs while users interact with products.

Information such as sound and tactility outlines the state of a user’s mind and determines the level of expectation toward the product. As a reference for designing products in a more objective way, such information can be applied to further develop the traditional design process. It has the potential to reveal invisible expectations and latent anxiety that users are not even conscious of (Figure 1).

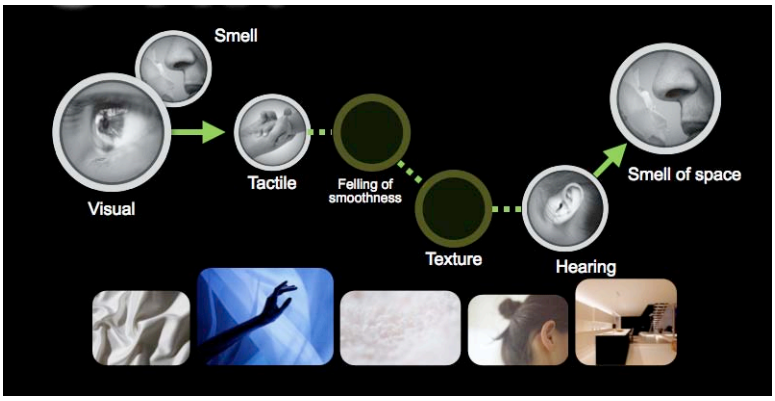

Figure 1. Sequential approach of five senses

Phases of emotional transition

Throughout the course of his/her interaction with a product, the user goes through multiple stages of expectations that continue to change. In Figure 2, the vertical axis shows the level of expectations while the horizontal axis displays the time. The first phase represents the time when s/he first sees a product. The second phase is after trying and experiencing the product. Lastly, the third phase is when the product has changed the user’s way of life.

The chart implies why companies tend to set inappropriate goals for their product development. More than anything, users expect products to possess and fulfill all the basic functions. In other words, the products need to be at least as good as expected. If not, then users are likely to feel disappointed. The

greater the expectation users have toward a product, the more disappointed they will feel. Ultimately, the disappointment leads to a feeling of anxiety.
Without the means to evaluate their underlying feelings, exceeding users' expectations and providing them with excitement may not be taken into consideration.

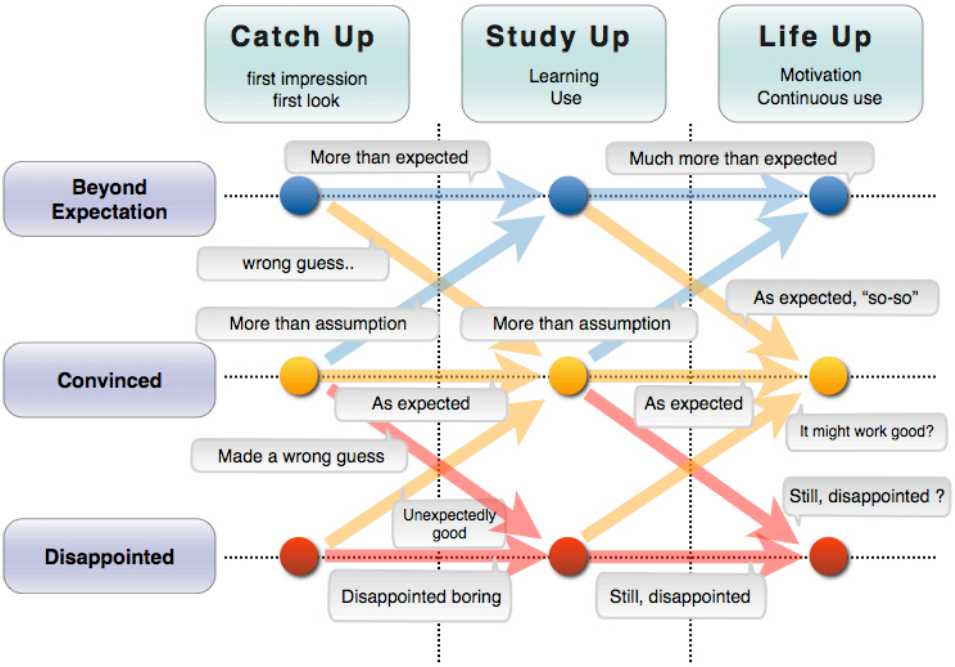

Figure 2. The structure of expectations

3 *EXPECTOLOGY* IN THE DESIGN PROCESS

3.1 Design cycle

In this paper, we consider design as planning attractive objects that enrich people's lives and society both materially and emotionally. To consider how engineering contributes to design, we model the design process as the cycle illustrated in Figure 3.

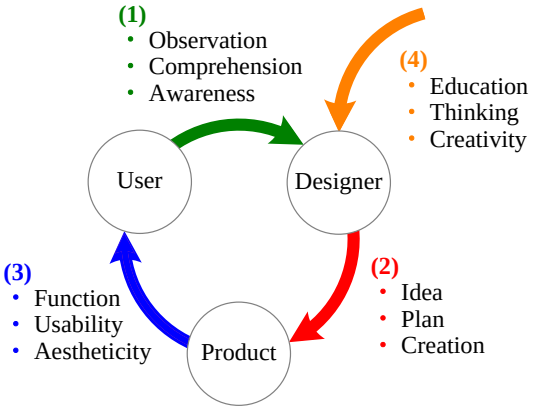

Figure 3. Design cycle

First, a designer observes users and identifies overt or potential needs and problems (arrow (1) in Figure 3). Not only actual observations but also designers' ideas of how things ought to be belong here because such ideas can be regarded as imaginary observations of ideal situations. Then, a designer thinks of original ideas to respond to needs or to solve problems, examines them, and actualizes them as a product (arrow (2)). Finally, the actualized product provides a user with values such as functions, usability, and aestheticity (arrow (3)). Design can be modeled as a cycle consisting of these three processes (arrow (4) in the figure will be discussed later).

According to this model of the design process, there should be three categories of how and where design engineering should contribute to design. The categories are as follows; serving users directly, creating a product, and finding needs and problems.

3.2 Including engineering and science in a product to serve users directly

The most direct and visible way for engineering and science to contribute to design is for their outcomes to be embedded in products and for these products to serve users directly (arrow (3) in Figure 3). Examples are new materials providing new functions and appearances and electronic technologies that enable cellular phones to be made small and highly functional. Engineering in general (not specifically design engineering) has markedly contributed to design in this way. When we classify innovation into product innovation and process innovation, it corresponds more closely to product innovation.

Cross classifies the relationships between science and design into three aspects [4]:

- Scientific design: Modern, industrialized design, as distinct from preindustrial, craft-oriented design.
- Design science: An explicitly organized, rational, and wholly systematic approach to design; not just utilization of the scientific knowledge of artifacts but design as a scientific activity in itself.
- Science of design: A body of work that attempts to improve our understanding of design through scientific (i.e., systematic, reliable) methods of investigation.

In Figure 3, arrow (3) corresponds to scientific design.

3.3 Design engineering to create a product

On the other hand, arrows (1) and (2) in Figure 3 belong to process innovation in which the outcomes of engineering are not equipped in a product but are used to create a product.

Examples of engineering corresponding to arrow (2) are digital engineering technologies (e.g., computer-aided design, computer-aided engineering, computer-aided manufacturing, computer graphics, virtual reality, augmented reality, rapid prototyping), reliability design technologies (e.g., FTA (fault tree analysis), FMEA (failure mode and effect analysis)), and various design theories and methodologies.

3.4 Design engineering to find needs and problems

Arrow (1) in Figure 3 corresponds to the process of identifying needs to be addressed or problems to be solved by design. A portable audio player, which is an example of an innovative product from Japan, was innovative not because innovative technologies were used but because of discovery of people's potential desire to listen to stereo music anywhere and anytime. This fact indicates that engineering corresponding to arrow (1) should be very important in creating attractive products that enrich people's lives and society both materially and emotionally.

According to Cross's classification, arrows (1) and (2) correspond to "design science".

3.5 Design engineering for education

The remaining arrow (4) in Figure 3 represents design education. Current typical creativity education, in which a student carries out a project to design and fabricate a creative product, should be practically effective. However, such creativity education seems mostly to be based not on scientific proof but on empirical rules. Although related research fields such as brain science have not yet obtained sufficient results on how we can nurture creativity [5], it is essential to have an engineering and science based education of creativity and design problem awareness.

3.6 Contribution of *Expectology* to design process

As mentioned in the introduction, an attractive product exceeding users' expectations should be designed as the result of the design process. Negative disconfirmation between users' prior expectations and actual product performance should be a problem, as the quote "good is not good when better is expected" (Fuller, Thomas) suggests. According to the design process model in Figure 3, such positive disconfirmation of expectations can be achieved when at least one of "needs to be satisfied", "the design idea", and "technologies in a product" exceeds expectation as follows.

- *Expectology* should provide a method of finding not only apparent but also potential needs and expectations that the users themselves are not aware of (arrow (1) in Figure 3). We can achieve

the positive disconfirmation of (conscious) expectations by addressing such potential expectations. In this case, the design idea (arrow (2)) and the technologies in a product (arrow (3)) need not exceed expectations.

- *Expectology* should provide a method of assisting designers to conceive design ideas (of how to satisfy needs) that are beyond users' expectations (arrow (2) in Figure 3). In this case, the needs to be satisfied (arrow (1)) and technologies in a product (arrow (3)) need not exceed expectations.
- *Expectology* may provide a method of suggesting the types of new technologies (e.g., materials with specific properties) that are necessary but presently lacking to make a product exceeding users' expectations.

4 EMOTIONAL STATES AND TRANSITIONS IN *EXPECTOLOGY*

4.1 Qualitative classification of emotional states

For a systematic approach to *Expectology*, first we qualitatively classify relevant emotional states as a combination of the following exclusive categories.

- Prior – posterior: whether an emotional state occurs before or after experiencing a product.
- Positive – neutral – negative: whether an emotional state is positive, negative, or neutral.

As a result, we obtain the classification shown in Table 1 in an MECE (mutually exclusive and collectively exhaustive) [6] manner so that mutual exclusivity avoids the risk of double-counting information, and collective exhaustion avoids the risk of overlooking information [7]. Note that this table is tentative and requires further research for its completion.

Although not included in Table 1, the following categories may also be included in our classification.

- Explicit – implicit: whether or not people are conscious of and able to explain their emotional state. Using this category, we can distinguish "apprehension" (explicit) and "presentiment" (implicit), which are both classified under "prior, negative".
- Reasonable – unreasonable: whether an emotional state (e.g., expectation, disappointment) is adequate and legitimate or excessive and gratuitous. Although reasonable expectations should be promoted, unreasonable and excessive expectations before experiencing a product should be avoided because such gratuitous expectations sometimes lead to gratuitous disappointment after experiencing the product.

Table 1. Qualitative classification of emotional states

		Emotional states
Prior	Positive	expectation, anticipation, fantasy, forefeel
	Neutral	disinterest, forelash
	Negative	anxiety, apprehension, doubt, bias, presentiment
Posterior	Positive	delight, satisfaction, elation, comfort, illusion
	Neutral	detachment, loss of interest
	Negative	disappointment, dissatisfaction, discomfort, backlash, misconception

Table 2. Qualitative classification matrix of transitions between emotional states

From -> / -> To			Prior			Posterior		
			Positive	Neutral	Negative	Positive	Neutral	Negative
			Expectation	Disinterest	Anxiety	Satisfaction	Detachment	Disappointment
Prior	Positive	Expectation	C1*	A1	A2	A7*	A8	A9
	Neutral	Disinterest	A3*	C2	A4	A10*	A11	A12
	Negative	Anxiety	A5*	A6*	C3	A13*	A14*	A15
Posterior	Positive	Satisfaction	B1*	B2	B3	C4*	A16	A17
	Neutral	Detachment	B4*	B5	B6	A18*	C5	A19
	Negative	Disappointment	B7*	B8*	B9	A20*	A21*	C6

Table 3. Examples of observed phenomena corresponding to cells in Table 2

From		To		Cell	Description
Prior	Positive	Prior	Positive	C1*	Consumers presume the high usability of a product from its attractive appearance.
			Neutral	A1	Consumers' interest in a product does not last from its announcement to its launch.
			Negative	A2	A negative rumor makes consumers skeptical.
	Neutral		Positive	A3*	An advertisement successfully attracts consumers' interest.
			Neutral	C2	An advertisement fails to grab consumers' attention.
			Negative	A4	A negative rumor makes consumers skeptical.
	Negative		Positive	A5*	An advertisement dispels consumers' misunderstanding.
			Neutral	A6*	An advertisement clears consumers' doubt.
			Negative	C3	Consumers presume the poor usability of a product from its unattractive appearance.
	Positive	Posterior	Positive	A7*	A food looks good and actually tastes good.
			Neutral	A8	A food looks good but its taste is so-so.
			Negative	A9	A food looks good but tastes unpleasant.
	Neutral		Positive	A10*	A product is exciting despite its average specifications.
			Neutral	A11	The performance of a product is average, as expected from its specifications.
			Negative	A12	A product is poor and does not even meet its average specifications.
	Negative		Positive	A13*	Contrary to its unattractive appearance, a product is very easy to use.
			Neutral	A14*	Contrary to its appearance, a structure is actually reasonably robust.
			Negative	A15	A product is as poor as consumers feared.
Posterior	Positive	Posterior	Positive	C4*	A product is easy to use throughout its lifetime.
			Neutral	A16	A product is advanced when purchased but becomes obsolete after competing products catch up.
			Negative	A17	A product's step-by-step operation is initially easy to use but becomes bothersome after getting accustomed to it.
	Neutral		Positive	A18*	The usability of a product initially seems average but turns out to be excellent after getting accustomed to it.
			Neutral	C5	The usability of a product is average throughout its lifetime.
			Negative	A19	The initial performance of a product is average and the product frequently malfunctions with use.
	Negative		Positive	A20*	A product is initially difficult to use but becomes easy to use after getting accustomed to it.
			Neutral	A21*	The poor usability of a product can be ignored after getting accustomed to it.
			Negative	C6	A product is difficult to use throughout its lifetime.
	Positive	Prior	Positive	B1*	The good performance of a product makes consumers look forward to the next product.
			Neutral	B2	The performance of a product is not good enough to make consumers look forward to the next product.
			Negative	B3	A product is good but the announced changes to the next product fail to excite consumer interest.
	Neutral		Positive	B4*	A product is average but the announced changes to the next product sound interesting.
			Neutral	B5	A product is average and consumers are not interested in the next product.
			Negative	B6	A product is average but the announced changes to the next product fail to excite consumer interest.
	Negative		Positive	B7*	A product is poor but the announced changes to the next product sound interesting.
			Neutral	B8*	The poor performance of a product causes consumers to lose interest in the next product.
			Negative	B9	The very poor performance of a product makes consumers dislike its product series.

4.2 Qualitative classification of transitions between emotional states

Now that we have classified the emotional states, we can consider transitions from one state to another as shown in Table 2. Although the transitions from "posterior" to "prior" in Table 2 (cells B1–B9) do not appear to make sense, we can interpret them as transitions from "after experiencing a product" to "before experiencing the next product". When we consider customers' emotional transitions as observable phenomena, all cells in Table 2 are meaningful. However, when we consider transitions in design methods used by designers, only cells corresponding to from negative to neutral, negative to positive, neutral to positive, and positive to positive should make sense (cells marked by asterisks in Table 2).

This classification matrix can support designers in the following manner.

- By classifying both successful and unsuccessful design case studies using this table, designers can compile design databases (e.g., as web pages) of what they should or should not do in future projects.
- By systematically classifying existing methods and techniques for achieving the emotional transition corresponding to each cell, we can find necessary but as yet undiscovered methods and techniques to be studied in our *Expectology* project.

Examples of observed phenomena corresponding to each cell in Table 2 are listed in Table 3.

4.3 Differentiation in the same qualitative emotional transition

When we apply Table 2 to actual design problems, a qualitative classification alone cannot represent transitions in sufficient detail. Take the cell marked A7 in Table 2 for example. Although "good but less good than expected", "as good as expected", and "better than expected" all belong to this "prior, positive" to "posterior, positive" cell, the qualitative classification alone cannot differentiate between these three judgements.

A possible approach to this problem is to introduce the qualitative representation of differences as an increase (+), decrease (-), or nochange (0) as in qualitative reasoning [8] as follows.

- Good but less good than expected: from "prior, positive" to "posterior, positive" (Δ = -),
- As good as expected: from "prior, positive" to "posterior, positive" (Δ = 0),
- Better than expected: from "prior, positive" to "posterior, positive" (Δ = +).

Another possible approach is to introduce a quantitative approach. For example, some studies have revealed that there is a zone of indifference [9] or a zone of tolerance [10], similar to the concept of a dead zone in engineering, in the perceived quality and perceived value of a service. If the service falls within this zone, it is acceptable but merely gives the consumer satisfaction, whereas a service deviating from this zone produces significant delight (on the positive side) or disappointment (on the negative side) [11].

4.4 Additional classification categories

Although we introduced only two categories (prior – posterior, positive – neutral – negative) as examples in section 4, more categories will be needed for the detailed classification of transitions to handle various design problems. If we introduce the category "explicit – implicit" to the classification of emotional states as suggested in section 4.1, we will have a more detailed classification of transitions in Table 2 such as a transition from "posterior, positive, implicit" to "posterior, positive, explicit". Methods or techniques of extracting latent emotional factors that consumers themselves are not conscious of [12] can be classified by this transition. If we introduce the category "reasonable – unreasonable", it should be useful for classifying methods of maximizing reasonable expectations of consumers without inflaming unreasonable expectations (fantasies).

5 EXPECTATION IN EMOTIONAL QUALITIES

In section 4 we proposed a general framework for *Expectology*. In this section, we give examples of possible research.

5.1 Expectation towards emotional qualities

An emotional quality is a quality that evokes specific feelings, impressions, or emotions in a customer towards a product or service (e.g., comfort, luxury, delight) [13]. For example, product sound has been recognized as an emotional quality [12]. To design emotional qualities, designers need to grasp what and how design parameters affect customers' emotional qualities. Several studies have been carried out

to extract quantitative relations between design parameters and emotional qualities [13]. The most conventional approach is to conduct a sensory evaluation in terms of emotional qualities expressed by adjectives using samples having a variety of parameter values and to extract the quantitative relations using statistical methods and AI techniques. In a general sensory evaluation, we ask participants to evaluate specific characteristics of samples (e.g., shape, color, texture, sound) using a certain sense (e.g., vision, touch, hearing).

In reality, however, we dynamically select our senses to perceive a target characteristic while we interact with products and services. For example, we see and smell dishes before we taste them. Thus, we form expectations of the taste of dishes using visual and olfactory information before tasting them. Figure 4 shows a model of expectation and realization in regard to emotional qualities. We expect a mental experience (e.g., a dish to taste good) by performing an event (i.e., eating the dish) on the basis of preliminary information (e.g., the sight and smell of dishes) before we realize the mental experience.

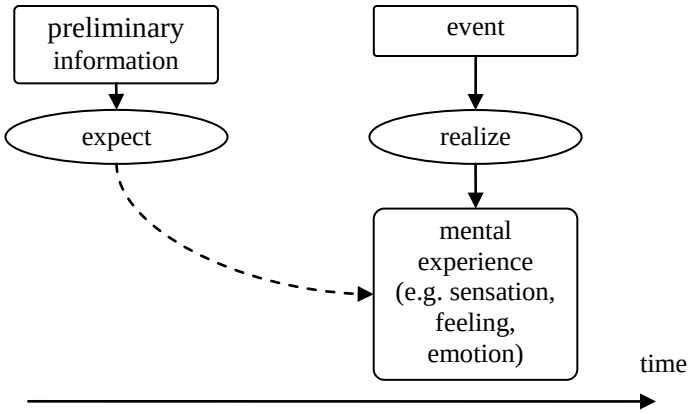

Figure 4. Expectation in regard to emotional qualities

Among the five senses, one sense can be used to predict the response of another sense while we interact with products and services. For example, we predict the tactile sensation of a product surface texture by looking before we experience it by touching. Another example is that we expect a certain engine sound upon the appearance of a sports car. A target of expectations may be a complex combination of the attributes of a product or service. For example, we predict the performance and quality of a machine from its appearance and by listening to its sound, and we may predict the usability of a computer mouse from its shape (i.e., it looks user-friendly) before actually using it.

5.2 Gap between expectation and realization

An expectation based on one sense may differ from an experience obtained using another sense in terms of an emotional quality of the same target. This gap may affect our mental experience, which affects the value of products and services. Thus, a designer needs to consider the interactive effect of expectation and realization between different senses on emotional qualities.

We have investigated the interactive effect between product color and sound in terms of the product emotional quality [14]. In this work, we conducted two sensory experiments based on the semantic differential (SD) method. First, to extract evaluation factors related to the impression of colors, we showed participants the same vacuum cleaner body with 11 different colors and asked them to evaluate the factors using 12 word pairs with seven levels. We called the result the "color SD score". After a short break, we conducted a second SD-method-based test using 33 combinations of color and sound. In the test, we showed the participants the color before the sound. We called the result of this experiment the "multimodal SD score".

From the result of factor analysis using the multimodal SD scores, we extracted the first factor as an evaluation factor and found that the "harmonized" contributed to the first factor. In other words, the harmony of color and sound affected the goodness of the multimodal emotional quality.

As shown in Figure 5, we found that the sense of harmony between colors and sounds depends on the sharpness of the sound. Different colors harmonize with different levels of sound sharpness. In addition, we found that harmonized sharpness is positively related to color factors that affect impressions such as the "lightness" and "brightness" of colors. We were able to show that the lightness and brightness of colors can be explained using CIE L*C*h.

The above result suggests that minimizing the gap between visual expectation and auditory realization positively affects the emotional quality (i.e., the first factor of the multimodal SD scores). The participants unconsciously formed an expectation of the sound by looking at the color and were satisfied if the expectation fitted their impression of the actual sound.

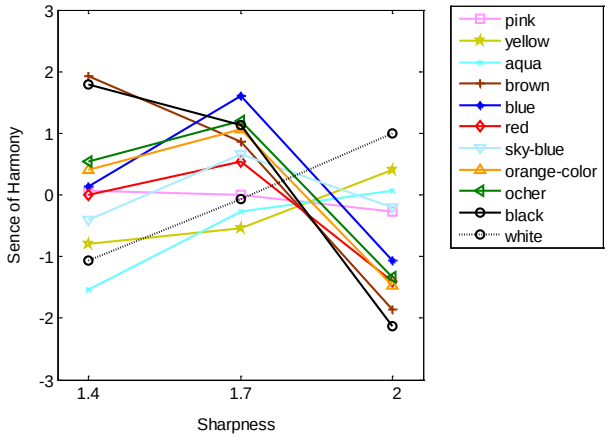

Figure 5. Effects of sharpness and color on sense of harmony

Although minimizing the gap between expectations and realizations is one of the strategies to provide a positive experience for customers, it is also possible for realizations to unexpectedly exceed their expectations as discussed in section 4. In future work, it is necessary to investigate how the gap between expectations and realizations affects positive emotional qualities. Such knowledge will provide us with a way of applying the expectation gap in design to realize emotional qualities.

5.3 Actions induced by expectations

Our expectations affect our external actions as well as our internal mental experiences. It is well known that we perceive the smaller of two objects of equal weight to be heavier when lifted. This illusion is called the size-weight illusion. In this case, we predict the weight of each object using visual information such as its size. The expectation of weight affects our approach to how to lift the object.

We have investigated the effect of visual surface characteristics on the fingertip force (horizontal grip force) when lifting an object [15]. We prepared eight cylindrical objects having different surface characteristics, i.e., the brightness of the gray surface, dots with different gloss and thickness (Figure 6(a)). The size and weight of all samples were the same.

We showed five participants each object and asked them to evaluate their impressions of the surface using adjectives and onomatopoeias (Figure 6(b)). After the evaluation, we asked them to lift and keep holding each object with the tips of the thumb and index finger three times (Figure 6(c)). We recorded the grip force using a sheetlike force torque sensor embedded in the surface of the objects while the participants held the object. To cancel the effect of the friction force, we estimated the minimum grip force required to keep holding the object and defined the difference between the applied force and the grip force as ΔF.

As a result, for all participants, we found significant differences between the values of ΔF for the samples (p<0.01). This result indicates that the participants changed their grip force depending on prior visual information obtained from the surface characteristics. We conducted three-way ANOVA using the surface characteristics as factors and ΔF as the response. As a result, we found that the effects of the brightness and thickness of the dots on the surface on ΔF were significant (p<0.01).

(a) Texture sample *(b) Sensory test by observation* *(c) Lifting and holding*

Figure 6. Experimental material and procedure

We found a relationship between the sensory score for "looks heavy" and ΔF for each participant. This result implies that the participants predicted the sample's weight from the surface characteristics, which caused them to change the value of ΔF even though the actual weight of all samples was the same. In other words, the visual expectation affected the grip force, i.e., the action. Although the grip force affected the tactile perception, the surface characteristics were the same. Thus, we need to consider such action changes caused by visual expectations when designing surface textures.

6 CONCLUDING REMARKS

Consumers expect various purposes and usages from a product, and when such expectations differ from reality, some negative emotions regarding the product may occur as well as some practical problems related to poor usability [16]. In contrast, a product that generates positive emotions in consumers should be attractive and commercially successful [17]. In this paper, we propose the concept of *Expectology* as a systematic framework for understanding emotions relevant to product design and utilizing them in the product design process. *Expectology* is intended to provide designers with a systematic methodology for designing products while considering every possibility of consumers' positive and negative emotions such as expectation and disappointment. What is described in this paper is simply an outline, and actual design cases and methods for product design will be studied to complete our classification table.

REFERENCES

[1] Kano, N., Seraku, N., Takahashi, F. and Tsuji, S. Attractive Quality and Must-be Quality, *Journal of the Japanese Society for Quality Control*, 1984, 14(2), 147-156 (in Japanese).

[2] Oliver, R.L. A Cognitive Model of the Antecedents and Consequences of Satisfaction Decisions, Journal of Marketing Research, 1980, 17(4), 460-469.

[3] Nevo, D. and Wade, M.R. How to Avoid Disappointment by Design, *Communications of the ACM*, 2007, 50(4), 43-48.

[4] Cross, N. Designerly Ways of Knowing: Design Discipline versus Design Science, *Design Issues*, 2001, 17(3), 49-55.

[5] Andreasen, N.C. *The Creating Brain: the Neuroscience of Genius*, 2007 (Japanese Translation) (Seidosha, Inc.).

[6] Rasiel, E. and Friga, P. *The McKinsey Mind*, 2006 (Japanese Translation) (Softbank Creative Corp).

[7] http://en.wikipedia.org/wiki/MECE_principle (5 Jan. 2011).

[8] Kuipers, B. Qualitative Reasoning: Modeling and Simulation with Incomplete Knowledge, *Automatica*, 1989, 25(4), 571-585.

[9] Woodruff, R.B, Cadotte, E.R. and Jenkins, R.L. Modeling Consumer Satisfaction Processes Using Experience-Based Norms, Journal of Marketing Research, 1983, 20(3), 296-304.

[10] Liljander, V. and Strandvik, T. Estimating Zones of Tolerance in Perceived Service Quality and Perceived Service Value, *International Journal of Service Industry Management*, 1993, 4(2), 6-28.

[11] Estelami, H. Competitive and Procedural Determinants of Delight and Disappointment in Consumer Complaint Outcomes, *Journal of Service Research*, 2000, 2(3), 285-300.

[12] Yanagisawa, H., Kataoka, A., Murakami, T., Ohtomi, K. and Hosaka, R. Extraction of Latent Emotional Factors by Analyzing Human Sensitivity towards Unexplored Design: Application to Product Sound Design, *International Conference on Engineering Design*, 2009.

[13] Yanagisawa, H. Kansei Quality in Product Design. In Fukuda, S. (Ed.) *Emotional Engineering : Service Development*, 2010, 289-310 (Springer).

[14] Yanagisawa, H., Yoshinaga, R., Murakami, T., Ohtomi, K. and Hosaka, R. Sense of Harmony between Product Sound Quality and Color Sensation: A Case Study of Vacuum Cleaner, *Internoise*, 2010.

[15] Yuuki, H., Yanagisawa, H. and Nakagawa, S. A Framework for Evaluating Kansei Quality of Product Texture Considering with Multi-modal Sensations, *JSME 20th Design and Systems Conference*, 2010 (in Japanese).

[16] Norman, D.A. *The Psychology of Everyday Things*, 1988 (Japanese Translation) (Shin-yo-sha Publishing Ltd.).

[17] Norman, D.A. *Emotional Design*, 2004 (Japanese Translation) (Shin-yo-sha Publishing Ltd.).