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EFFECT OF EXPECTATION ON AFFECTIVE QUALITY PERCEPTION

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ABSTRACT

A user's experience of a product involves a set of transitions from one sensory state to another. In such state transitions, a disconfirmation between prior expectation and posterior experience evokes emotions such as surprise, satisfaction, and disappointment. A noteworthy phenomenon in the perception of expectation disconfirmation is that the expectation affects the perceived experience itself. In this paper, we propose a theoretical model of the expectation effect. We hypothesize that amount of expected information, i.e. entropy, determines the occurrence of the expectation effect and that the amount of gained information is positively correlated with the intensity of the effect. We further hypothesize that a conscious level of expectation discrepancy distinguishes between two types of expectation effect, namely, assimilation and contrast. To verify these hypotheses, we conducted an experiment in which participants responded to the tactile qualities of surface texture. Based on our hypotheses, we analyzed the causes of the visual expectation effect on tactile roughness during a sensory modality transition from vision to touch and found the appropriateness of the proposed model.

Keywords: emotional design, expectation effect, quality perception

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1 INTRODUCTION

In our interactions with a product, we experience its qualities and develop expectations through our senses such as vision, hearing, and touch. To intentionally design such perceived quality, engineering designers need to translate it into engineered properties. Researchers in fields such as *Kansei* engineering (Schutte et al., 2004; Mori, 2002) and affective engineering (Childs et al., 2006) have offered many responses to such translation issues (Yanagisawa, 2010). Most of the studies acquire psychological, behavioral, and/or biological responses from participants who evaluate design alternatives under specific conditions for a given sensory modality. For example, product surface texture, which is one of the important affective qualities, has been investigated under conditions of just touching or looking, as well as conditions under which both modes are combined.

However, in a course of our interaction with a product, we often switch from one sensory modality to another to perceive a target quality. For example, we often see and then touch a surface texture. During such sensory modality transitions, we expect or predict a perceptual experience for a subsequent sensory modality based on a prior modality. For example, we develop expectations for our tactile perception by looking at a surface texture. Our prior expectation, however, does not always correspond to our prior experience. Such disconfirmation between our expectation and our actual experience evokes our attention and evokes certain emotions, such as surprise (Ludden et al., 2012), satisfaction, and disappointment (Oliver, 1977; Oliver 1980; Spreng et al., 1996; Demir et al., 2009; Murakami et al., 2011).

Furthermore, our prior expectations may affect (i.e., change) our posterior experience. Researchers in a broad range of fields have observed this effect, the so-called *expectation effect*, with regard to different cognitive processes such as desire for rewards (Schultz et al., 1997), emotions (Wilson et al., 1989; Geers and Lassiter, 1999), and sensory perceptions (Deliza and MacFie, 1996; Buckingham et al., 2011; Yanagisawa and Yuki, 2011). The present authors previously proposed a method for extracting the visual expectation effect with regard to tactile texture and observed the expectation effect using this method (Yanagisawa and Takatsuji, 2012). The expectation effect changes the disconfirmation between expectation and experience. Thus, the effect is not only a bias based on experience but also a key factor that affects our emotional experience of a product. Although some experimental findings on the expectation effect exist in different disciplines, theoretical models of the effect have been largely ignored.

In this paper, we propose a hypothetical model of the expectation effect. This model is based on information theory and an affective expectation model (AEM). We apply the hypothetical model to analyze the causes of the visual expectation effect with regard to the quality of tactile texture and demonstrate the appropriateness of the proposed model with our experimental results.

2 EXPECTATION CONFIRMATION AND EXPECTATION EFFECT

Our experience of a product is a dynamic process. We shift from one sensory state to another in cyclic interactions involving action, sensation, and meaning (Krippendorff, 2005). Between such state transitions, we predict or expect the experience of subsequent states. (e.g., we expect a meal to taste a certain way based on how it looks, the weight of a product before lifting it, the usability of a mouse by looking at it, etc.) According to Helson's adaptive-level theory, perceptual judgments of a stimulus change depending on personal adaptation levels, which correspond to expected levels formed by past experiences (Helson, 1964). In the context of product appraisal, a disconfirmation between expectation and experience evokes certain emotions. In the field of market research, the expectation disconfirmation theory suggests that a customer's satisfaction with a product is influenced by the disconfirmation between prior expectation and perceived quality as well as by the quality itself (Oliver, 1977; Oliver, 1980; Spreng et al., 1996). Expectation confirmation is an appraisal component that evokes emotions such as contentment, satisfaction, disappointment, and dissatisfaction (Demir et al., 2009). Expectation disconfirmation evokes surprise and induces emotions that affect the consumer's overall opinion of a product (Oliver, 1977). Recently, a new research framework called *Expectology* has been proposed to respond to the potential impact of expectation in product design. The aim of *Expectology* is to provide designers with a systematic methodology for designing products in consideration of every possible positive (e.g., expectation, satisfaction, delight) and negative (e.g., anxiety, dissatisfaction, disappointment) emotional response of consumers (Murakami et al., 2011).

Expectation itself often affects our expected experience. This effect, which is known as *expectation effect*, has been observed in multiple disciplines and in different cognitive processes such as emotion and perception. Two patterns of expectation effect are commonly observed. One is *contrast*, and the other is *assimilation*. Contrast is an effect that magnifies the difference between prior expectation and posterior experience. Assimilation is an effect in which the consumer assimilates posterior experience into prior expectation.

The sometimes illusory relationship between size and weight is one example of the expectation effect, as people may perceive a smaller object as heavier than a larger one when the weight of the two objects is identical (Flanagan and Beltzner, 2000). In this situation, people expect a larger object to be heavier than a smaller one but perceive the opposite, even though the weight is actually the same. In other words, the disconfirmation between visual prediction and weight perception works as a contrast effect. This kind of illusion regarding weight occurs with different materials (Buckingham et al., 2011) and surface textures (Yanagisawa and Yuki, 2011). In food science, researchers have investigated the effects of visual expectations with regard to food on its actual taste (Deliza and MacFie, 1996). They have reported that assimilation effects emerge in most cases when there is a disconfirmation between expectations and experience.

The present authors have proposed a method for quantitatively measuring the visual expectation effect with regard to the tactile quality of a product's surface texture and found a contrast effect related to the textural perception of stickiness (Yanagisawa and Takatsuji, 2012). This method reveals the relationships between the expectation effect and different combinations of the visual and tactile properties of a product's surface. The causes of the expectation effect, however, remain largely unexplored. To generalize the conditions of the expectation effect, a theoretical model is needed.

3 HYPOTHETICAL MODEL OF EXPECTATION EFFECT

3.1 Overview of hypothesis

According to information theory (Shannon et al., 1949), the amount of information gained from an event can be quantified using a prior probability of the event. An unexpected event provides us with a greater amount of information than an expected one. The information gained when there is a discrepancy between prior and posterior beliefs represents a measure of the "surprise" experienced, and a certain degree of surprise evokes our sensory attention (Itti and Baldi, 2009). Hence, we hypothesize that the information gain between prior expectation and posterior experience affects the expectation effect, and serves as a measure of the threshold value distinguishing assimilation from contrast.

Furthermore, we hypothesize that the amount of expected information or Shannon's entropy of prior state determines the conditions under which the expectation effect occurs. In a situation of high entropy, in which future events are unpredictable, more weight should be given to bottom-up sensory input than to top-down prediction (Strange et al., 2005). Thus, we predict that the expectation effect occurs when the entropy of our prior subjective probability is lower than a certain value.

Based on the survey in the previous chapter, we assume that the expectation effect consists of two patterns, namely, contrast and assimilation. The contrast effect magnifies the expectation disconfirmation, whereas the assimilation effect assimilates posterior experience into the prior expectation. Another of our interests is the essential causes of these two opposite effects. According to the AEM proposed in social psychology, emotions induced by a stimulus (e.g., watching a movie) is formed with reference to a prior expectation (e.g., the expectation received from a movie review). The AEM suggests that people's affective reactions to a stimulus are generally assimilated with regard to a prior expectation, except in cases in which a discrepancy between the affective expectation and the actual stimulus information exists and this discrepancy is then "noticed" (Wilson et al., 1989; Geers and Lassiter, 1999). Thus, the level of a person's awareness of an expectation discrepancy may be an important factor in distinguishing contrast from assimilation.

We can summarize our hypotheses as follows:

- Shannon's entropy of prior subjective probability distributions (or the amount of expected information) can be used to identify occurrences of the expectation effect. The intensity of the expectation effect depends on the information gained between one's prior and posterior beliefs affects.

- A person's level of awareness of an expectation discrepancy distinguishes their experience of contrast from that of assimilation.

3.2 Subjective probability, entropy, and expectation effect

Here, we consider a transition from prior event $y \in \mathrm{V}$ to posterior event $x \in \mathrm{U}$, where U and V are sets of events related to posterior and prior states, respectively. Here, *event* represents the sensory state of one's experience with an artifact, e.g. a product, a service, and an environment. An example of an event used in this paper is a person's perception of a product's quality through the sense of touch. We assume that one expects posterior event *x* based on prior event *y*. The error of expectation is defined as the deviation of expected experience s_y from perceived experience without prior expectations s_x, which is expressed as follows:

$$\Delta s_{xy} = s_x - s_y \tag{1}$$

In the transition from expectation to experience, one experiences *x* with a prior expectation s_y. Thus, the expectation effect ε_{xy} is defined as

$$\varepsilon_{xy} = s_{xy} - s_x \tag{2}$$

where s_{xy} is the perceived experience of *x* based on posterior expectation *y*.
In the prior state of a transition, we assume that a person has a belief distribution that is represented as subjective probability distributions $P(X)$ for a random variable of posterior events, *X*. The subjective probability of a posterior event *x*, $\Pr(X = x)$, represents the difference between prior expectation and posterior experience. For example, if $\Pr(X = x)$ is close to 1.0, one experiences an event *x* with a low degree of expectation disconfirmation. On the other hand, if $\Pr(X = x)$ is small, one does not anticipate that event *x* will occur in the way it does, and therefore experiences a high degree expectation disconfirmation, which is felt as surprise. According to information theory, one gains an amount of information $I(x)$ after experiencing an event *x* in a posterior state as follows:

$$I(x) = -\log(\Pr(X = x)) \tag{3}$$

It is known that the amount of gained information $I(x)$ in such state transitions represents the degree of "surprise" induced by the experience of a posterior event. Itti & Baldi validated the fact that information gain, which is a generalized $I(x)$, corresponds to human attention, as determined in an experiment with the attention of people's gaze (Itti and Baldi, 2009). A person's awareness of expectation discrepancy is a factor that distinguishes the contrast effect from assimilation as an expectation effect. We hypothesize that I(*x*) positively affects the intensity of the expectation effect.
Furthermore, the expected uncertainty of an event is an important factor in the balancing of sensory information and prior expectation during perceptual synthesis (Strange et al., 2005). The expected uncertainty of events *X* can be measured using Shannon's entropy $H(X)$ as follows:

$$H(X) = -\sum_{x \in \mathrm{U}} \Pr(X = x) \log \Pr(X = x) = E\left(\{I(x)\}_{x \in \mathrm{U}}\right) \tag{4}$$

where $E(a)$ is an expected value of a. $H(X)$ represents the amount of expected information, and $H(X)$ represents the expected uncertainty. The expectation therefore requires a contextual situation in which H(*X*) is less than a certain value.
Hypothesis 1: Based on the above discussion, we hypothesize that the expectation effect ε_x occurs under a certain level of Shannon's entropy $H(X)$ and that the degree of the effect depends on the amount of gained information $I(x)$ as follows:

$$|\varepsilon_x| = f\left(I(x)\right),\ H(X) > \theta_H, \qquad |\varepsilon_x| \fallingdotseq 0,\ H(X) < \theta_H \tag{5}$$

where $f(x)$ represents a positive function and θ_H represents the threshold value of Shannon's entropy.

3.3 Expectation discrepancy and expectation effect

Two patterns of expectation effect can be defined as conditions of Δs_{xy} and ε_{xy}.
Contrast effect:

$$\varepsilon_{xy} > 0,\ if\, \Delta s_{xy} > 0, \quad \varepsilon_{xy} < 0,\ if\, \Delta s_{xy} < 0 \tag{6}$$

Assimilation effect:

$$\varepsilon_{xy} < 0,\ if\ \Delta s_{xy} > 0, \quad \varepsilon_{xy} > 0,\ if\ \Delta s_{xy} < 0 \tag{7}$$

An expectation discrepancy in the transition is given by $d_{xy} = s_{xy} - s_y$.

Hypothesis 2: In an analogy of the AEM assumption [12,13], we hypothesize that there is a threshold value at which the expectation discrepancy θ_s is noticed and that this value distinguishes contrast from assimilation as follows:

$$|d_{xy}| > \theta_s \rightarrow contrast, \quad 0 < |d_{xy}| < \theta_s \rightarrow assimulation \tag{8}$$

4 EXPERIMENT

4.1 Visual expectation effect with texture roughness

To validate the two hypotheses discussed in section 3, we conducted a set of evaluation experiments in which we explored the visual expectation effect in participants who experienced the tactile roughness of plastic textures. The tactile texture of a product's surface is an important factor as regards that product's affective quality. In our previous work (Yanagisawa and Takatsuji, 2012), we determined the visual expectation effects with regard to tactile texture perceptions of a plastic texture using several combinations of visual and tactile stimuli that were synthesized using a half-mirror apparatus, as shown in Figure 1. The causes of the effects, however, remain unknown. Here, we apply our hypotheses regarding possible causes of the visual expectation effect. We focus on tactile roughness perception because roughness is a common property of different kinds of materials and textures (Okamoto et al., 2012).

Thirty one (seventeen male and fourteen female) university students whose ages ranged from 20 to 26 years old (an average age of 22.2 years and a standard deviation of 1.5) participated in the experiment. As evaluation samples, we selected ten HIPS plastic plates with a pearskin finish surface (PS) and one flat surface (FL) from JIDA (Japan Industrial Designers Association) standard samples that are often used in product design. Each pearskin sample had different levels of roughness, ranging from Ra1.56 μm to Ra14.46 μm. The number of a given sample represents its level of roughness, which could range from PS1 to PS10. Based on the result of a pairwise comparison assessment that was conducted for both visual and tactile conditions, we confirmed that the participants could perceive the differences between the roughnesses of samples except between PS7 and PS8. For this reason, we selected the nine pearskin samples except PS8. The experiment consisted of two phases as follows.

4.2 First phase: Assessment of subjective probability distributions

In this phase, the objective was to estimate the subjective probability distributions of the tactile roughness expected by participants in response to the appearance of each sample, i.e., $P(X)$. We prepared two sets of ten samples having different degrees of roughness. In each set, the samples used were identical. We randomly selected one sample from each set and presented the pair of samples to the participants under two different modality conditions: vision-only and touch-only. We asked them to predict the tactile roughness of a visually presented sample and judge whether the expected roughness was identical to that of another sample presented under the touch-only condition. We conducted all possible combinations of the two sets of samples in order to obtain distributions of the tactile samples judged as identical for each visually presented sample. We used these distributions, which were then normalized as a percentage as $P(X)$.

If participants judged that the two cases of roughness were not identical, we asked them which was rougher. We used this judgment as an index of positive and negative in order to obtain the deviation of the expected roughness from the perceived roughness without prior expectations, i.e., Δs_{xy}.

4.3 Second phase: Assessment of expectation effect and expectation discrepancy

In the second phase, we extracted the visual expectation effect ε_{xy} with regard to the roughness perception of samples that were synthesized using the same half-mirror apparatus as in the first phase. We prepared a set of the ten samples for visual inspection and four pearskin samples having different levels of roughness for touch (samples PS1, PS4, PS6, and PS10). We synthesized all the combinations of the visual and tactile samples. We asked the participants to assess the tactile roughness of a tactile sample after they had anticipated the degree of roughness based on a different visual sample. The evaluation method used here is a magnitude estimation (ME) assessment. In our ME assessment, participants compared a target sample and a reference sample and evaluated the roughness of the target sample in terms of a percentage, with the reference sample set as 100%. In addition, participants assessed the roughness of each tactile sample without any visual samples. This assessment represents tactile perception under a touch-only condition. In each trial, we used each tactile sample as a reference sample in the ME assessment in order to eliminate the dependency of the reference sample's roughness. The order of sample presentation was randomized in each trial.

For each assessment of a synthesized sample, we asked participants the degree of expectation discrepancy they experienced between the visually expected roughness and tactile roughness ($|d_{xy}|$ in 3.2). They expressed this degree of expectation discrepancy by selecting one of the following four categories: "as expected," "somewhat expected," "somewhat different from expectation," and "different from expectation."

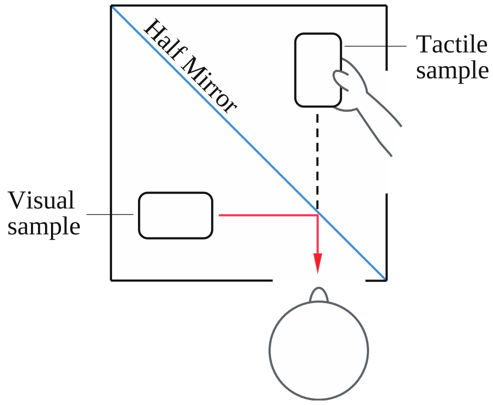


Figure 1. Synthesis of visual and tactile texture using a half mirror.

5 RESULTS AND DISCUSSION

5.1 Shannon's entropy, amount of gained information, and expectation effect

We hypothesized that Shannon's entropy of the subjective probability of expectations explains a condition under which the occurrence of the expectation effect and the amount of information gained from experiencing a posterior event is positively correlated with the intensity of the expectation effect (Hypothesis 1). In the first phase of the experiment, we asked the participants to evaluate the consistency between the visually expected roughness of one sample and the tactually experienced roughness of another sample. Figure 2 shows the frequency rate distributions of participants who responded that the roughness was as expected when visual samples PS1 and PS4 agreed with each tactile sample. We assume that these distributions are subjective probability distributions of roughness predictions for visual samples PS1 and PS4, respectively. If the shape of a distribution is sharply angular, as in the left-hand distribution in Figure 2, the participants expected the roughness with a visual sample with certainty. Conversely, if the shape of a distribution is gentler, as in the right-hand distribution in Figure 2, the participants' expectation was uncertain. Shannon's entropy $H(X)$ of the probability distribution represents such shape features of the distribution. In other words, Shannon's entropy represents the uncertainty of a person's expectation.

We hypothesized that the expectation effect occurs in the context of a certain expectation, i.e., less entropy. Furthermore, the subjective probability of the visually expected roughness was negatively correlated with the amount of information gained from the tactile experience of that roughness. Thus, we hypothesized that the amount of information is positively correlated with the intensity of expectation effect.

Figure 3 shows scatter charts representing the relationship between the expectation effect ε_{xy} and Shannon's entropy $H(X)$ for PS4 and PS6, respectively, as tactile reference samples in the ME assessment. Based on the results of the second phase of the experiment, we calculated the difference between the ME scores for the synthesized sample and the tactile sample under the touch-only condition in order to determine the score for the expectation effect, ε_{xy}. We derived $H(X)$ for each participant to consider individual differences in the expectation of uncertainty. We then derived the subjective probability of tactile sample a as $\Pr(X=a)=\delta_{ay} / \sum_{x\in X}\delta_{xy}$, where y is the degree of roughness visually expected by a participant for a visual sample and δ_{xy} is Kronecker's delta. ε_{xy} is close to zero if $H(X) > 0.7$. ε_{xy} for $H(X) < 0.6$ has some ranges of the score.

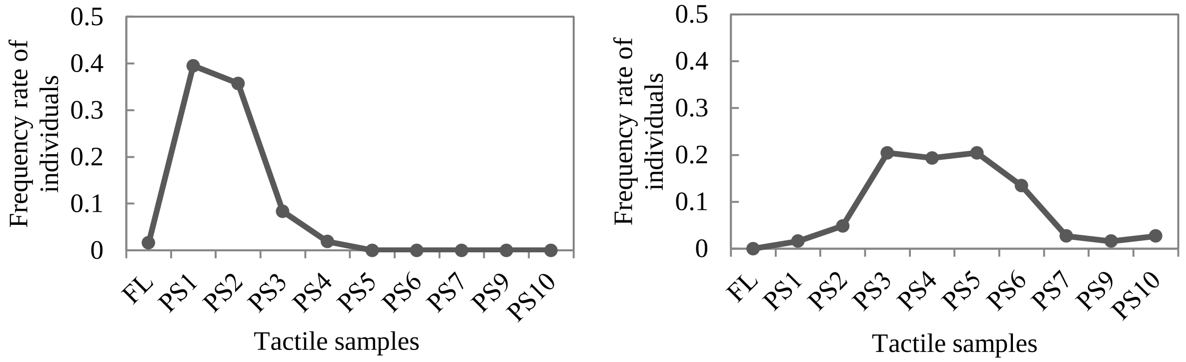
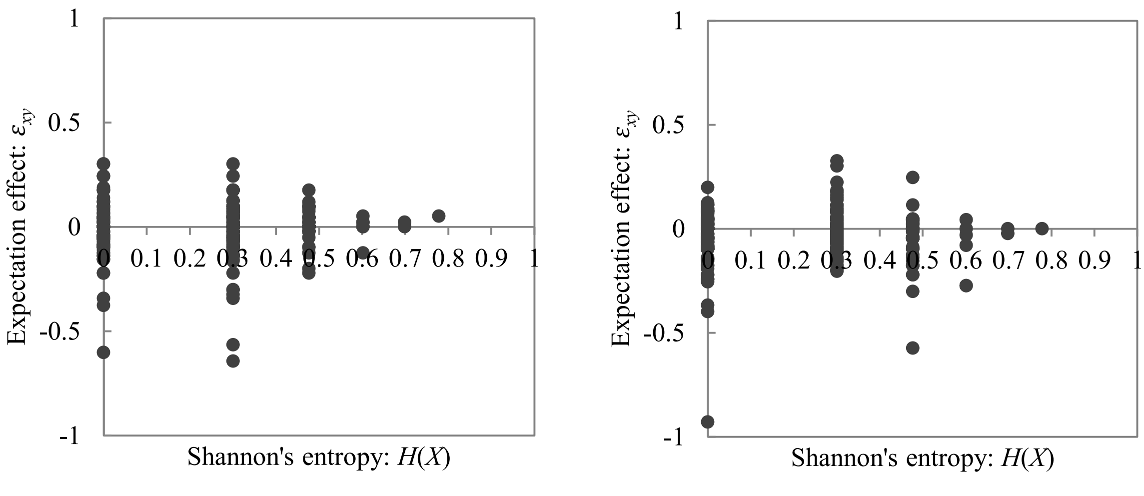


Figure 2. Examples of frequency rate distributions of participants who responded that visually expected roughness agreed with tactually experienced one for each tactile sample

These results suggest that Shannon's entropy for subjective probability distributions works as a condition for the occurrence of the expectation effect and that when this is the case, around $H(X) = 0.7$ is the threshold value. The range of ε_{xy} radually increases as the $H(X)$ decreases similarly. This unexpected result suggests that the Shannon's entropy negatively affects the intensity of the expectation effect, especially around the threshold value.

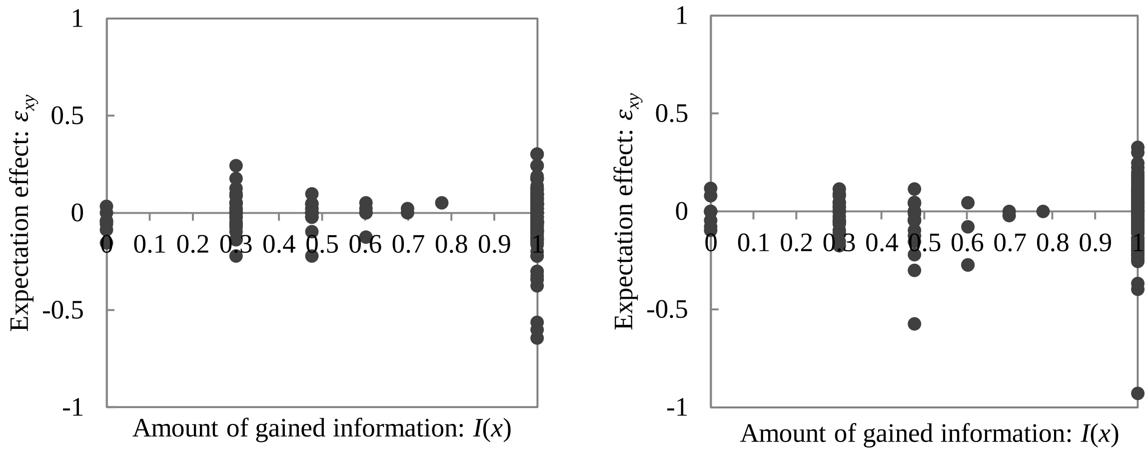
Figure 4 shows scatter plots representing the relationship between the expectation effect ε_{xy} and the amount of gained information $I(x)$ for PS4 and PS6, respectively, as tactile reference samples in the ME assessment. It is common that the range of ε_{xy} is the largest when $I(x)$ is infinite. Conversely, the range of ε_{xy} is small at $\mathrm{I}(x) = 0$. The range of ε_{xy} increases until a certain $I(x)$; for example, $I(x) = 0.3$ for PS4 and $\mathrm{I}(x) = 0.48$ for PS6. These results corroborate hypothesis 1; that is, the amount of gained information $\mathrm{I}(x)$ is positively correlated with the intensity of the expectation effect.

However, ε_{xy} decreases as $I(x)$ increases after a certain value of $I(x)$, except when $I(x)$ is infinite. Except when $I(x)$ is zero or infinite, $I(x)$ corresponds to the expected amount of information, namely, the entropy $H(X)$, in the case of an individual's data. Thus, this phenomenon may represent the influence of $H(X)$. In other words, high entropy, i.e., a context with uncertain expectation, decreases the intensity of the expectation effect.



(a) Tactile sample PS4 as reference in ME (b) Tactile sample PS6 as reference in ME

Figure 3. Expectation effect and Shannon's entropy of subjective distributions



(a) Tactile sample PS4 (b) Tactile sample PS6

Figure 4. Expectation effect and amount of gained information

5.2 Expectation effect and expectation discrepancy

We hypothesized that the occurrence of assimilation or contrast as expectation effects depends on the level of a person's awareness of an expectation discrepancy. We determined whether an expectation effect is contrast or assimilation based on formulas 6 and 7, using a participant's judgments in the first phase of the experiment if he/she judged that the visually expected roughness was not identical to his/her touch perception. In the first phase of the experiment, we categorized a synthesized sample as assimilation in case a participant judged that the visually expected roughness was identical to his/her touch perception. Figure 5 shows percentages of the synthesized samples that were categorized as assimilation, contrast, and no expectation effect for each category of expectation discrepancy evaluated in the second phase. The numbers in the different bar segments represent the number of responses.

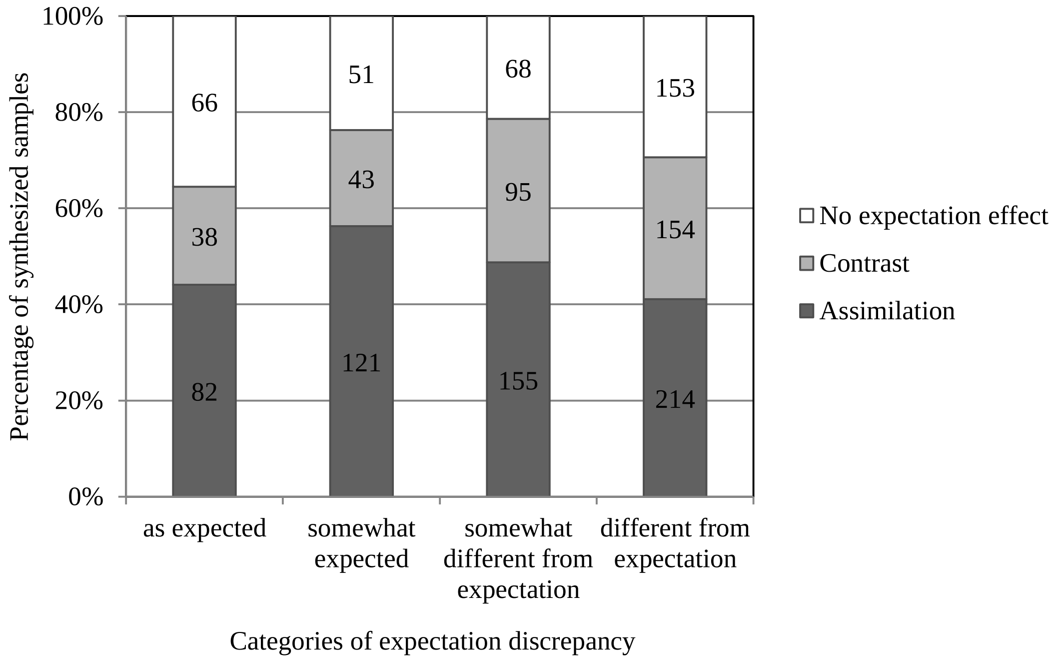


Figure 5. Percentages of synthesized samples categorized as assimilation, contrast, and no expectation effect for each category of expectation discrepancy

The percentages of the expectation effect, i.e., assimilation and contrast, for the ambiguous judgments of "somewhat expected" and "somewhat different from expectation" are larger than those for the clear judgments of "as expected" and 'different from expectation." The percentage of "no expectation effect" is the largest in the judgment category "as expected." This result suggests that the expectation

discrepancy is an important factor affecting the occurrence of the effect itself. On the other hand, the percentage of "no expectation effect" increases for "different from expectation." In the experiment, we observed that participants tended to rely only on tactile perception if the difference between their expected and experienced roughness was large. In short, the dominance of touch over vision increases the expectation discrepancy. These results suggest that the expectation effect occurs more frequently if the expectation discrepancy is in the gray area between conscious and unconscious awareness.
As regards the contrast effect, its percentages for "somewhat different from expectation" (29.9%) and "different from expectation" (29.6%) are larger than those for "somewhat expected" (20.4%) and "as expected" (20.0%). This tendency corresponds to the assumption of the AEM. in which a person's noticing an expectation discrepancy produces a contrast effect in his/her affective response. As regards the assimilation effect, the percentage peaks at "somewhat expected" (56.3%) and decreases as the certainty of the expectation discrepancy increases. Under a condition of uncertain expectation discrepancy for the judgment "somewhat," the ratio of assimilation and contrast is reversed.
Based on the above discussion, we confirmed a tendency that corresponds to hypothesis 2. However, we newly discovered that (1) the uncertainty of the expectation discrepancy expressed as "somewhat" significantly affects the occurrence of the expectation effect, and (2) both assimilation and contrast occur regardless of the degree of expectation discrepancy, although the ratio of their occurrence follows hypothesis 2.

6 CONCLUSIONS

Expectation disconfirmation is an important factor in the design of a satisfactory product. A person's perception of expectation disconfirmation depends on the expectation effect, in which one's prior expectation affects one's subsequent experience. An understanding of the mechanism of the expectation effect can facilitate the design of the affective qualities of a product by making use of the consumer's expectation disconfirmation, producing delight by exceeding expectations, for example, and thus preventing their disappointment. In this paper, we proposed a hypothetical model of the expectation effect based on information theory and the AEM. The model consists of two hypotheses. One regards the effects of the expected amount of information, i.e., Shannon's entropy of the subjective probability distributions, and the influence of the amount of gained information on the expectation effect in terms of its occurrence and intensity. The other hypothesis regards the relationship between the level of a person's awareness of an expectation discrepancy and the type of expectation effect, i.e., contrast versus assimilation.
We validated these hypotheses in an experiment in which texture quality was perceived through both vision and touch. We found that the entropy negatively affected both the probability that there would be an expectation effect as well as its intensity. In this case, the entropy represents the uncertainty of an expected set of events. Thus, a certain expectation, which is dependent on prior information and an individual's knowledge, is a contributory factor in the expectation effect. The amount of gained information is positively correlated with the intensity of expectation effect. The amount of gained information represents the "surprise" one experiences when one's sensory attention is evoked (Itti and Baldi, 2009). Hence, the "surprise" evoked by the perception of an expectation discrepancy induces the expectation effect. Furthermore, we found that the level of awareness of the expectation discrepancy was what distinguished assimilation from contrast. The probability of an event of expectation effect was prominent in the gray area between a conscious and unconscious level of expectation discrepancy.
The experimental results suggest that our hypothetical model of the expectation effect is appropriate, although validations obtained by applying it to a variety of cases would be desirable to further refine it. The model estimates the conditions of the expectation effect based on information theory that is not application-dependent. Therefore, we believe that the model can be applicable to the design of a large variety of artifacts.

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