International Journal of Computer Information Systems and Industrial Management Applications.
ISSN 2150-7988 Volume 3 (2011) pp. 399-406

Construction of Graphical Models for Temporary Application of Facial Packs

Junichiro Wakatsuki[1], Takaaki Saito[2], Ali Abrishamian[2], Makiba Sakamoto[2] and Takashi Uozumi[3]

[1] Satellite Venture Business Laboratory, Muroran Institute of Technology
27-1, Mizumoto-cho, Muroran 050-8585, Japan
wakatsuki@mail.svbl.muroran-it.ac.jp

[2] Division of Information and Electronic Engineering, Muroran Institute of Technology
27-1, Mizumoto-cho, Muroran 050-8585, Japan

[3] College of Design and Manufacturing Technology, Muroran Institute of Technology
27-1, Mizumoto-cho, Muroran 050-8585, Japan
uozumi@epsilon2.csse.muroran-it.ac.jp

***Abstract*: We constructed one physiological model and two psychological models for a set of experimental data to investigate the variation of effects among facial pack types of temporary facial pack applications. Using a Bayesian network, a physiological model was built for the transitions of skin moisture and skin surface lipids. The resultant network had direct paths from lipids measured at the forehead to moisture measured at the right cheekbone. This result suggests the existence of some indirect relation among them. Psychological models were constructed to analyze responses of the post-experiment questionnaire using structural equation modeling. One model was built for the impression of the appearance of the packs. We assumed two latent factors—security and likeability—and obtained reasonable fit indices. Another model was built for the overall impression on the experience of temporary pack application. Cronbach's α was consistently large for a subscale that consisted of the observed variables in this model. Although fitness was bad, path coefficients were also consistently large.**

***Keywords*:** Bayesian network, structural equation modeling, cosmetic, epidermal moisture, skin surface lipid**.**

I. Introduction

When general consumers evaluate a cosmetic product, it is said that its physiological effects on the skin are not necessarily evaluated, but a person's feelings during its use influence the evaluation. Senoo et al. reported that when subjects used a washing cream for facial cleansing and applied a lotion and an emulsion in this order, the quantity of their pleasure changed every moment; their recorded spoken words representing their emotions seemed to correspond to the changes (such as "feel refreshed") [1]. Values that must be regarded as added value from the perspective of skin care are probably important [2]. Facial packs used in our experiments contain additives that are intended to relax users during their application.

There is no guarantee that general consumers will think much of a product's quality that its developer regards as important. That applies not only to luxury items such as cosmetics. Everyone will have personal reasons for using a product. If a motive to use a product is influenced by a user's preference, feelings, or environment, then the reason might be unclear even to that person. There are also social factors. We often decide what to buy on reputation or what our friends and acquaintances say. Nowadays, because interaction among consumers in some markets is becoming complicated accompanying development of the internet, the routes of diffusion of products and services is said to be also complicated [3].

As referred above, in the case of cosmetics, psychological effects of product on user seem to be important. In such cases, if producers can know those factors of a product or situations that produce such feelings, they may use the knowledge to develop and market products. In other words, this is a question about whether there is any causal relation between physical features of cosmetics and environments and psychological effects, and, if there is, what it is like.

Bayesian network and structural equation modeling (SE) are graphical modeling methods that have been used to study causality [4]. In models, the relationship that X causes Y is represented by an arrow from X to Y. A Bayesian network is a directed acyclic graph that represents a joint probability distribution. We can judge whether to draw an edge between two nodes in a network from conditional independence relations. We also have used Bayesian networks for prediction of users' demands [5]. A SEM model is built by researcher's hand, and then the researcher evaluates how well the model fit with the covariance matrix of observed data. SEM is used mainly as a method that integrates factor analysis and regression analysis. SEM researchers believe that SEM models cannot infer causality, although SEM was originally designed to do so. Recently, a new Bayesian network method using which we can have latent variables in models like SEM [6]. But, we used simply Bayesian networks and SEM models in this study.

As described herein, we report three graphical models of physiological action and psychological action caused by facial packs as mentioned above, using the experimental data obtained to examine effects attributable to temporary application of the facial packs. Although we conducted the experiments to confirm the effect of relaxation, we were unable to address that effect directly in the models. We measured epidermal moisture, skin surface lipids, and the quantity of melanin along with physiological data that could be useful as indices of relaxation such as electrocardiograms during experiments, and administered questionnaires to elicit various impressions about the packs. The psychological models were constructed to analyze responses to an impression questionnaire using SEM [7]. The physiological model was learned using data of the skin states.

Lastly, we describe some background on the Bayesian network of the skin states. We used data of the epidermal moisture and the skin surface lipids. We can assume some causal relation between quantities of these two types. The skin surface lipids were found to take the form of a film comprising a mixture of the sebum secreted by the sebaceous gland and the epidermal lipids secreted by the keratinocyte [8], [9]. The latter are an important component of the water barrier in human epidermis; they are presumed to play a role in the control of the quantity of the epidermal moisture [10], [11]. Models of skin moisture and skin lipids are thought to be worth constructing because moisturization and regulation of lipids are important functions of packs.

II. Experiment

A. Facial pack samples

Two products for sedation and two products for whitening of Bienargy Color Preserve (CBS Inc.) were used as facial packs. One sedation pack has a color because it contains lavender. The other is colorless and transparent. The main active ingredients are *Aloe barbadensis* leaf extract and bifida ferment lysate. One whitening pack has a color because it contains cranberry and strawberry. The other is almost colorless and transparent (slightly cloudy). The main active ingredients are alpha-Arbutin, placenta extract, L-ascorbic acid, and *Cortex mori* extract.

B. Subjects

In the experiment, 24 female paid volunteers participated. Their ages were 18–53 yr (mean 27.4, S.D. 8.0; except one subject who did not give her age). Of them, 12 were assigned randomly to sedation. The remaining 12 were assigned to whitening. They reported no abnormality of the senses or allergy. After informing them about the purpose and the methods of the experiment sufficiently and telling them that they would be allowed to quit the experiment at any time, we obtained their consent.

C. Experimental environment

Although the experiments were conducted in winter, the air temperature was kept at 20–25°C using heating; the relative humidity was maintained at 40–60% using a humidifier. Lighting was turned off during the experiment except when the subjects needed to write or move.

D. Procedure

Two experiment sets were conducted for each subject with one week interval. For the first set, colored packs were used; for the second set, colorless packs were employed. One set of experiments began with questionnaires administered before the experiment, followed by pack application, leaving a subject alone for 10 min, recording the transition in the state of the skin, and the questionnaire after the experiment. Subjects were requested to cleanse their face at the beginning of the experiment and immediately after taking the pack off. The epidermal moisture was measured: four times at the right cheekbone—once before application of pack and three times after taking the pack off with an interval of 5 min. The skin surface lipids were measured once before application of the pack and once after taking the pack off at two places: the right cheekbone and the hairline over the center of the forehead. Melanin was measured at the right cheekbone once before application of the pack and once after taking the pack off.

After the initial measurement of these data, one experimenter showed the appearance of a pack to a subject and explained the ingredients and the effects before applying the pack with a spatula and covering the subject's eyes with cotton.

The subjects lay face up on a massage chair with the backrest pulled down and under a bath towel during the pack application and during recording of their physical data. Each subject's head and hair were wrapped with a towel to expose the forehead and protect them from the pack. For setting them at ease, partitions were put on the left-hand side and the foot side of the chair.

E. Measurement

Some physiological data that are not explained above were measured (e.g. electrocardiogram). We will address only those data related to the epidermal moisture, skin surface lipids, melanin, and the questionnaire administered after experiments.

1) Skin states

The Multi Probe Adapter System (MPA; Courage+Khazaka Electronic GmbH) was used for measuring skin states.

The Corneometer CM 825 estimates the epidermal moisture by measuring permittivity of the stratum corneum. A diffuse electrical field created by this probe permeates the skin through a thin sheet of glass. This probe presents the merit that no chemical substance or salt contained in cosmetics influences permittivity.

The Sebumeter SM 815 measures skin surface lipids. The probe, consisting of a plastic tape, is put on a skin region for 30 s. The lipids of the region adhere to the probe. The quantity of lipids is estimated according to the change in transparency of the tape ($\mu g/cm^2$). The lipids were not measured in two sets of experiments because the sebumeter was not available at those times.

The Mexameter MX 18 measures the quantity of melanin. Light of specific wavelengths is emitted from the probe to the skin. The quantities of melanin and erythema are calculated according to the ratio of absorbed light.

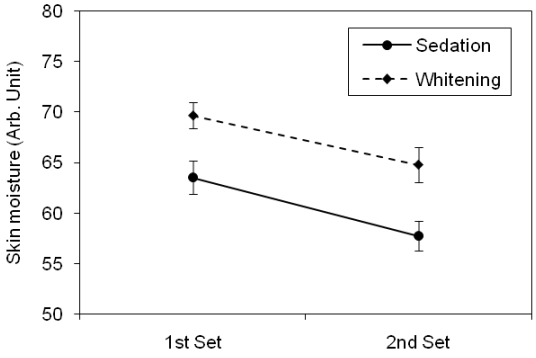

Figure 1. Skin moisture.

In fact, for epidermal moisture and melanin, measurements are repeated seven times at "one measurement". Then their average, as calculated after the maximum and the minimum have been omitted, is regarded as the measured value.

2) The post-experiment questionnaire

The post-experiment questionnaire elicited impressions of many kinds related to the packs using a five-point Likert scale. The questionnaire was improved based on this result; then the impressions were reexamined on another day. In all, 22 subjects answered the latter one (2 subjects of the sedation group could not). The questionnaire consists of 38 items for each of the first set and the second set of experiments, and 1 item for both sets.

III. Experimental Results

A. Epidermal moisture

Analysis of variance (ANOVA) was conducted using three independent variables; the function of pack (sedation/whitening), whether the additive is contained (No/Yes), and the measurement time (four times). The additive was contained in the pack of the second set of the experiment, and not in the pack of the first set. The result indicates that the main effects of the function ($F(1,176) = 17.614$, $p < .001$) and the additive ($F(1,176) = 11.562$, $p < .001$) are significant (Fig. 1). The epidermal moisture of whitening is greater than that of sedation: the first set is greater than the second set. Even the average value of the second set of sedation is greater than 55. The quantity of water seems to have been sufficient overall.

B. Skin surface lipids

The values of lipids were low overall; most were less than 50 μg/cm^2. Although values less than 50 μg/cm^2 that have been measured using the sebumeter are not directly related to the actual quantity of lipids, they are comparable if measured using the same probe. The small amount of lipids might be attributable to facial cleansing that was done immediately before measurement.

ANOVA was conducted also for the values of skin surface lipids after they had been transformed into the natural logarithm because their distribution was close to a log-normal distribution. At the right cheekbone, the main effects of the

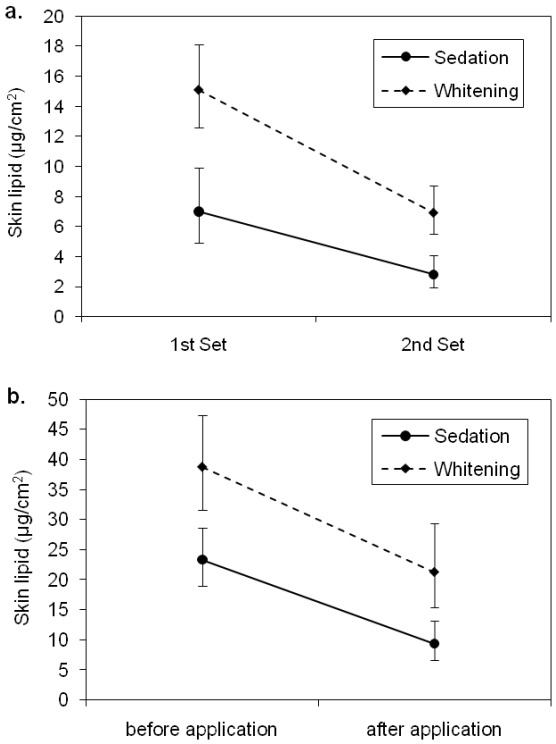

Figure 2. Skin lipids: top, cheekbone; bottom, forehead.

function ($F(1,84) = 8.599$, $p = .004$) and the additive ($F(1,84) = 8.744$, $p = .004$) were found to be significant; at the forehead, the main effects of the function ($F(1,84) = 5.694$, $p = .019$) and application ($F(1,84) = 7.174$, $p = .009$) are significant (Fig. 2). Results for skin surface lipids at the cheekbone resemble results of epidermal moisture. For the function of the pack, the result of the forehead is also similar to the result for moisture. The result also suggests that application of packs accompanies a decrease in skin surface lipids at the forehead, although it is difficult to imagine a direct relation between them. Some indirect relation might exist.

C. Melanin

Regarding the quantity of melanin, the main effect of the function of pack was significant ($F(1,88) = 15.374$, $p < .001$). The value of sedation is greater than that of whitening, which

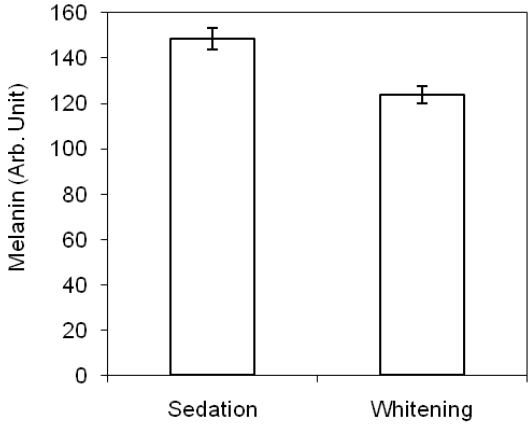

Figure 3. Melanin.

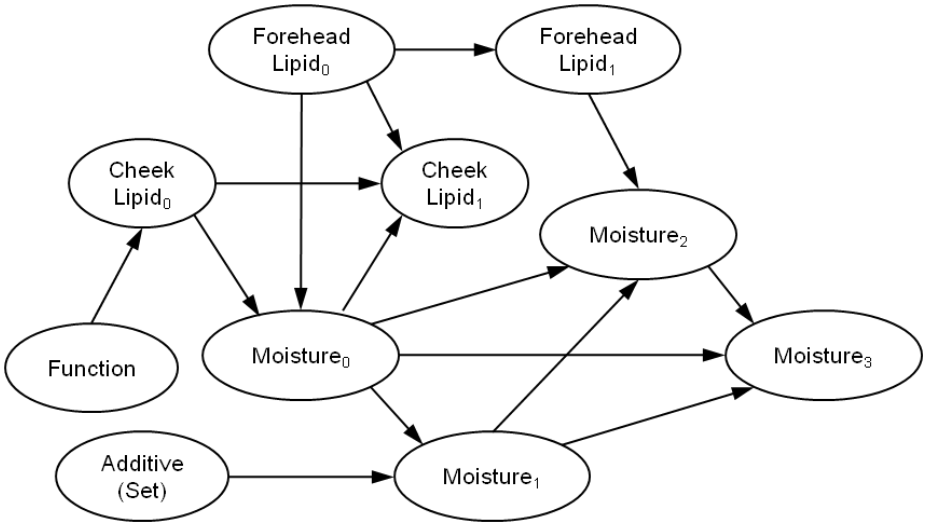

Figure 4. Bayesian network of change in skin states.

is contrary to the results obtained for moisture and lipids (Fig. 3), which suggests that some bias exists between these two groups of subjects because the quantity of melanin must not be changed during the period of experiments.

IV. Modeling the Skin State

We built a model to search for a causal structure among the physiological variables related to the skin. A Bayesian network—a directed acyclic graph representing a joint probability distribution—was used for modeling. We used software (GeNIe 2.0; Decision Systems Laboratory, University of Pittsburgh; http://genie.sis.pitt.edu/) to build and learn networks.

First, some variables were discretized. The set of variables consists of two properties of pack (function and additive), four measurements of moisture (each measured time), two measurements of cheek lipids (similarly), and two measurements of forehead lipids (similarly). We defined the values of each variable as shown below:

- *Function* = {*sedation*, *whitening*},
- *Additive* = {*contained*, *not*} (or *Set* = {*first*, *second*}),
- $Moisture_i$ = {(0, 50), (50, 70), (70, ∞)} (where i = 0, 1, 2, 3),
- $CheekLipid_j$ = {(0, 6), (6, 20), (20, ∞)}, and
- $ForeheadLipid_j$ = {(0, 16), (16, 50), (50, ∞)} (where j = 0, 1).

The discretization criteria were determined by consulting the user's guide of the probes so that the resultant distribution satisfied normality. Then, a new network was learned using the PC algorithm (5% significance level) [12]. Here, 22 of 24 samples were used because the skin lipids could not be measured in two sets of experiments, as described above. Some restrictions were given to avoid disturbing the temporal order of the skin state variables.

Figure 4 presents the network that was constructed. First, the dependence between *Function* and $CheekLipid_0$ draws attention because they are presumed to be independent, which suggests some bias between the Sedation and the Whitening groups of the subjects, as described in the subsection of the result of melanin. Next, *Additive* (*Set*) has an influence only on $Moisture_1$. Nevertheless, it is impossible to divide the influence of the additives and the influence of the experimental orders: the influence appears after application of the packs.

It can be expected that the cheek lipid influences cheek moisture. However, in this model, not only the cheek lipid but the forehead lipid influences the cheek moisture. Regarding after application of the packs, only the forehead lipid influences the cheek moisture, and that not immediately but slowly. It is not plausible that the forehead lipid directly regulates the cheek moisture. Therefore, there is presumed to be some indirect path of causality between them.

V. Results of the Post-experiment Questionnaire

We used PASW Statistics (SPSS Inc.) for statistical analyses.

Paired *t* tests were performed for the difference between the first set (no additive) and the second set (additive contained) for each group of sedation and whitening (Table 1). For the sedation group, significant results were found for Q01 (i.e. the first item of the questionnaire), Q07, Q12, Q13, Q14, and Q15 (5% significant level). In fact, Q01 is an item indicating either

Table 1. Differences of the responses of the questionnaire between the first set and the second set

	Item	mean	*s.e.*	*t*	*p*
Sedation (df = 9)	Q01	–2.600	0.600	–4.333	.002
	Q07	–0.700	0.213	–3.280	.010
	Q12	–1.900	0.433	–4.385	.002
	Q13	–1.100	0.314	–3.498	.007
	Q14	–0.900	0.348	–2.586	.029
	Q15	–1.100	0.233	–4.714	.001
Whitening (df = 11)	Q01	–1.417	0.529	–2.679	.021
	Q11	–0.667	0.284	–2.345	.039
	Q12	–1.083	0.358	–3.026	.012
	Q26	–1.250	0.411	–3.045	.011

colored or colorless; Q07 reflects comfort to the touch; Q12 signifies scented or odorless; Q13 is related to preference for the odor; Q14 shows whether the pack has triggered nostalgia; Q15 is about the soothingness of the odor. All of these items had larger scores for the second set (additive contained). Results for the color and the odor are as expected because the sedation pack with the additive contains lavender. For the whitening group, significant results were found for Q01, Q11, Q12, and Q26. Of those, Q11 is an item related to the gentleness on the skin; Q26 is related to whether sweetness was sensed. All of these items had larger scores for the second set again. The results for the color and the odor are expected to be higher because the whitening pack with the additives contains cranberry and strawberry. The result for the taste is also attributable to the berries. However, causes of the results for the touch of the pack (Q07 and Q11) remain unclear.

VI. SEM of the Impression Questionnaire

We built some models of directed graph for the relations among the observed variables of the impression questionnaire and latent variables using structural equation modeling. We used AMOS 18 (SPSS Inc.) for modeling and analyses. As described in this paper, we present two models; a model of the impression of the appearance of packs and a model of the overall impression.

A. Model of the impression of the appearance of packs

Items 1–5 of the questionnaire are related to the pack appearance. However, because item 1 was weekly correlated to the other items and fit indices increased without it, this model was built for items 2–5 (Fig. 5):

- Q02. Did the pack look safe? (Safety)
- Q03. Did the pack look cute? (Cuteness)
- Q04. Do you like the pack's appearance? (Preference)
- Q05. Did the pack look easy to use? (Usability)

This model includes the assumption that a latent variable (F1) between Q02 and Q05, another latent variable (F2) between Q03 and Q04, and correlation between these latent variables. We named F1 "Security" because Q02 questioned whether the pack appearance reassured the subject and Q05 indicated whether the pack appearance was easily used. We named F2 "Likeability" because Q03 reflected whether the pack appearance looked cute and Q04 reflected whether subject liked the pack appearance. Answers to the questionnaire were grouped into four groups by the functions of pack and the experimental order; then a multiple group confirmatory factor analysis was performed for these groups with the constraint that the error terms had the same value for every group.

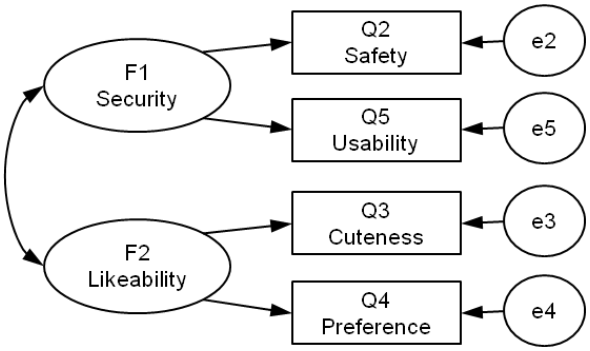

Figure 5. Model of the impression of the appearance of packs for SEM.

Table 2 shows standard estimates for each group. The chi-square test result was $\chi^2 = 24.188$ ($df = 16$, $p = .085$), so that the null hypothesis, "the model is correct", was not rejected. Fit indices were GFI = .801, AGFI = .503, and RMSEA = 0.113. Although the fitness is not good, it is also not bad. First, it is noteworthy that the path coefficient from the factor "Likeability" (F2) to "Cuteness" (Q3) for the first set of the sedation group (no additive) is smaller than that in any other group (not significant with 5% significant level). Considering the transparent pack of whitening is, in fact, slightly cloudy, this is the only pack that is truly colorless and transparent. This fact might be responsible for this result. Next, the correlation coefficient between two latent factors in the whitening groups is greater than that in the sedation groups (not significant). It remains unclear whether the strong link between the impressions of "Security" and "Likeability" is attributable to the ingredients of the whitening packs.

B. Model of the overall impression

The correlation coefficient was rather large for items 30–36. These items are related to the overall impression of the experience of pack application:

- Q30. Were you comfortable during application of the pack? (Comfort)
- Q31. Were you relaxed all over during application of the pack? (Relaxation)
- Q32. Did you feel anxiety about the pack's influence on the skin? (Anxiety for Influence)
- Q33. Do you think the pack had a favorable influence on your skin? (Goodness of Influence)
- Q34. Do you think this pack is effective? (Effectiveness)
- Q35. Do you think this pack is a good product? (Quality)

Table 2. Standard Estimates of the Path Coefficients for the Model of the Pack Appearance

	Sedation first Set		Sedation second Set		Whitening first Set		Whitening second Set	
	path coeff.	R^2	path coeff.	R^2	path coeff.	R^2	path coeff.	R^2
Q02 ← F1	.950	.659	.957	.342	.888	.479	.946	.485
Q05 ← F1	.812	.968	.585	.957	.692	.949	.696	.952
Q03 ← F2	.302	.091	.808	.653	.790	.624	.769	.592
Q04 ← F2	.984	.903	.978	.915	.974	.789	.976	.895
F1 ↔ F2	.548		.504		.982		.921	

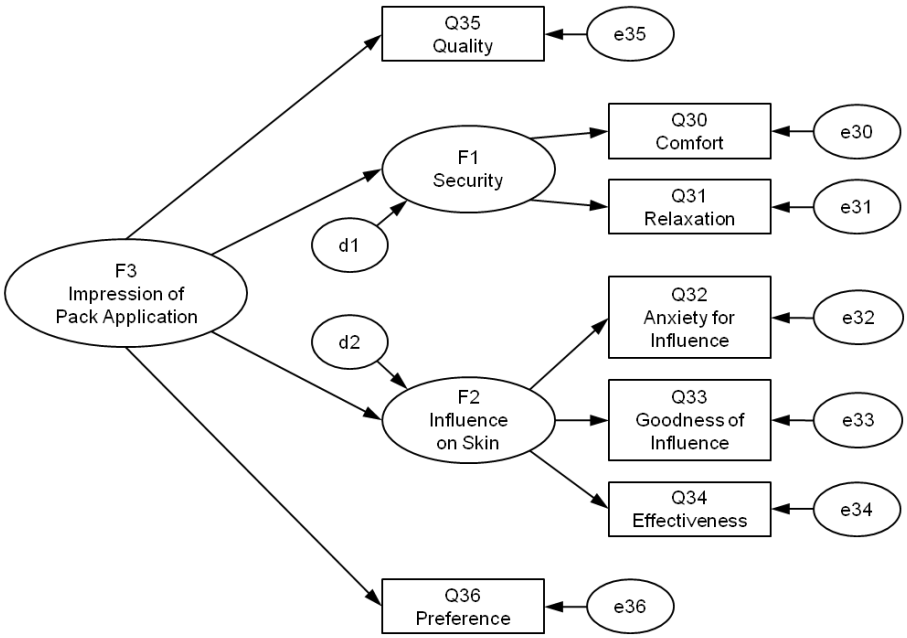

Figure 6. Model of the overall impression.

- Q36. Do you like this pack? (Preference)

Cronbach's α was calculated for each group: the first set of the sedation group, .876; the second set of the sedation group, .779; the first set of the whitening group, .935; the second set of the whitening group, .954. Because these results showed large values, it seemed appropriate to deal with these items as a subscale. Figure 6 shows a model built for this subscale. We assumed a latent variable (F1) between items 30–31, a latent variable (F2) between items 32–34, and another latent variable (F3) between items 35–36. We designated F1 as "Security", F2 as "Influence on Skin", and F3 as "Impression of Pack Application". A multiple group confirmatory factor analysis was performed using this model with the constraints that the error term of F2 (d2) was fixed to zero and the other error terms had the same value for every group.

Table 3 shows standard estimates for each group. The chi-square test result was $\chi^2 = 146.896$ ($df = 76$, $p < .001$), so that the null hypothesis that the model was correct was rejected. Fit indices were GFI = .591, AGFI = .398, RMSEA = 0.153: the fitness is bad. The path coefficients have consistently high values, but they tend to have smaller values for the second set of the sedation group (no significant difference with 5% significant level). A common factor might exist for these items, but it may not be related to the frequency of use (Q37) or the desire to buy (Q38).

VII. Discussion

As described herein, to estimate effects of the facial packs, we conducted these experiments for assessment of relaxation, measurement of skin states, and for administration of the post-experiment questionnaire. We also constructed graphical models using the experimental data. For the skin state, significant main effects of such as the experimental order (whether the additives are contained) were found using ANOVA. A Bayesian network was learned using measured data of the epidermal moisture and the skin surface lipids. We obtained some knowledge from this model such as (unintended) dependence between the subject grouping and

Table 3. Standard Estimates of the Path Coefficients for the Model of the Overall Impression

	Sedation first Set		Sedation second Set		Whitening first Set		Whitening second Set	
	path coeff.	R^2	path coeff.	R^2	path coeff.	R^2	path coeff.	R^2
F1 ← F3	.933	1.000	.472	1.000	.878	1.000	.922	1.000
F2 ← F3	1.000	.870	1.000	.222	1.000	.770	1.000	.850
Q30 ← F1	.965	.542	.831	.472	.940	.687	.959	.680
Q31 ← F1	.893	.782	.516	.777	.625	.872	.791	.902
Q32 ← F2	.767	.344	.782	.383	.754	.765	.736	.807
Q33 ← F2	.874	.763	.608	.369	.866	.750	.907	.822
Q34 ← F2	.586	.589	.619	.612	.875	.568	.898	.541
Q35 ← F3	.884	.798	.881	.266	.934	.391	.950	.625
Q36 ← F3	.737	.930	.687	.691	.829	.883	.824	.920

the initial value of the skin states, and the possibility of some indirect relation between the epidermal moisture and the skin surface lipids. Two models were also constructed to analyze the responses of the post-experiment questionnaire using SEM: a model of the impression of the appearance of packs, and a model of the overall impression. Regarding the impression on the appearances of packs, the analysis results suggest that two latent variables—the sense of security and the sense of likability—existed, and that the correlations among variables varied with the type of pack. Regarding the overall impression about the experience of pack application, a subscale with large Cronbach's α was found and path coefficients of the model had consistent large values.

Some of this knowledge was obtained as a result of construction of graphical models. The possibility of a causal relation from the forehead lipid to the cheek moisture was not found until the network was learned. The possibility that the cuteness of the appearance of packs reflected the actual appearance was also revealed by virtue of modeling. Although dependence between the subject grouping and the initial value of the skin surface lipids is an unintended result, the model suggests concrete areas demanding caution when the experimental data are examined. This is one advantage of causal models [4].

As described in the Introduction, when general consumers evaluate cosmetic products, their emotions during their use of the products might be important [1]. However, we were unable to infer or construct any model suggesting which physical factor of cosmetics is related to which impression. We aim at predicting user's demands related to a person's senses, emotions, or feelings using models in which physiological models and psychological models are integrated. However, it is difficult to construct such models that are convincing compared with scientific knowledge because so many links are missing. This method might represent a means to draw paths from physical variables to psychological variables by force and obtain some hints. We have already tried to learn some Bayesian network of the kind using data obtained from this experiment [13].

Acknowledgment

This study was supported by the Subvention for Supporting Product Development by Small Enterprises of Manufacturing for the Fiscal Year Heisei 21 (*Heisei 21 nendo monozukuri chu-sho kigyou seihin kaihatsu shien hojokin*). We are grateful to CBS Inc. for providing facial packs used in this research.

References

[1] M. Senoo, Y. Takemoto, I. Iida, Y. Sugaya, H. Jingu. "Emotional Change Caused by the Use of Skin Care Products", *Journal of the Society of Cosmetic Chemists of Japan*, 34 (3), pp. 267-272, 2000. (*Article in Japanese with English abstract*)

[2] M. Senoo. "Kansei-value of Cosmetics and Kansei-engineering", *Fragrance Journal*, 37 (3), pp. 33-38, 2009. (*Article in Japanese with English abstract*)

[3] K. Fujita, T. Takenaka, N. Nishino, K. Ueda. "Service Diffusion in a Market Considering Consumers' Subjective Valuation", *International Journal of Computer Information Systems and Industrial Management Applications*, 1, pp. 83-91, 2009.

[4] J. Pearl. *Causality: Models, Reasoning, and Inference (Second Edition)*, Cambridge University Press, Cambridge, 2009.

[5] K. Fukuta, T. Uozumi. "Kansei Modeling Based on a Bayesian Network and Ontology", *Transactions of the Japan Society of Kansei Engineering*, 8 (3), pp. 499-508, 2009. (*Article in Japanese with English abstract*)

[6] Z.E. Zheng, P.A. Pavlou. "Toward a Causal Interpretation from Observational Data: A New Bayesian Networks Method for Structural Models with Latent Variables", *Information Systems Research*, 21, pp. 365-391, 2010.

[7] M. Senoo. "Evaluation Methods for Cosmetic Emotional Benefit in Kansei Engineering", *Fragrance Journal*, 38 (6), pp. 53-58, 2010. (*Article in Japanese with English abstract*)

[8] H.D. Onken, C.A. Moyer. "The Water Barrier in Human Epidermis", *Archives of Dermatology*, 87, pp. 584-590, 1963.

[9] P.M. Elias, D.S. Friend. "The Permeability Barrier in Mammalian Epidermis", *Journal of Cell Biology*, 65 (1), pp. 180-191, 1975.

[10] D.T. Downing, A.M. Stranieri, J.S. Strauss. "The Effect of Accumulated Lipids on Measurements of Sebum Secretion in Human Skin", *Journal of Investigative Dermatology*, 79 (4), pp. 226-228, 1982.

[11] H.-M. Sheu, S.-C. Chao, T.-W. Wong, J.Y.-Y. Lee, J.-C. Tsai. "Human Skin Surface Lipid Film: an Ultrastructural Study and Interaction with Corneocytes and Intercellular Lipid Lamellae of the Stratum Corneum", *British Journal of Dermatology*, 140 (3), pp. 385-391, 1999.

[12] K.B. Korb, A.E. Nicholson. *Bayesian Artificial Intelligence*, Chapman & Hall/CRC, London, 2004.

[13] A. Abrishamian, T. Saito, J. Wakatsuki, M. Sakamoto, K. Fukuta, T. Uozumi. "Bayesian Network for Classification the Skin Factors of Facial Pack Application". In *Proceedings of the International Conference on Humanized Systems (ICHS2010)*, pp. 124-125, 2010.

Author Biographies

Junichiro Wakatsuki graduated in earth and planetary science in 2001 and received his ScD degree in information and media science in 2007 from Kobe University. Now he serves as a postdoctoral research fellow in Satellite Venture Business Laboratory at Muroran Institute of Technology. His main research interests are in graphical modeling of biological and psychological information.

Takaaki Saito received his master's degree in computer sciences and system engineering from Muroran Institute of Technology in 2007. Now he is a doctoral student of the Division of Production and Information Systems Engineering at Muroran Institute of Technology. His main research interests are in image processing and modeling of Kansei information.

Ali Abrishamian graduated in electrical engineering from Amirkabir University of Technology, Tehran, Iran, in 2006. He completed his master in computer science and system engineering from Muroran Institute of Technology, Japan, in 2009. He is pursuing PhD degree in computer science from Muroran Institute of Technology since 2009. His research activities are in the areas of Bayesian network and ontology for Kansei engineering.

Makiba Sakamoto completed a course of study in the Department of Industrial Design at Akita Municipal Junior College of Arts and Crafts in 2006. After she served as a teaching assistant in the same department at the same college, now she is a doctoral student of the Division of Production and Information Systems Engineering at Muroran Institute of Technology. She produces works of visual arts, mainly paintings. Utilizing her experiences of production, she studies relation between the impressions of coloration of user interfaces and user's operation. She held an exhibition of her works titled "MONSTERS" at Coco Laboratory, an exhibition hall in Akita City, Japan, in October 2008. She is a student member of Human Interface Society, Japan Society of Kansei Engineering, and the Color Science Association of Japan.

Takashi Uozumi graduated from the Department of Electronic Engineering, Muroran Institute of Technology, in 1973. He received his PhD degree in engineering from Hokkaido University in 1980. After he served at University of Saskatchewan as a postdoctoral research fellow in Canada and at National Institute of Special Needs Education in Japan, now he is an associate professor in College of Design and Manufacturing Technology at Muroran Institute of Technology. His main research interests are in time series analysis of biological signals, image processing, and application of machine learning to medical welfare engineering. He is an author of books about regulation of heart and blood vessel, and kansei and information. He is a member of Japan Society of Kansei Engineering, the Society of Instrument and Control Engineers, the Japan Society for Artificial Intelligence, and IEEE.