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TACTILE EMOTIONAL FACTORS FOR IN-VEHICLE SURFACE MATERIALS

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Abstract. *Automobile drivers and passengers feel tactile emotions from surface texture of in-vehicle materials, and it affects satisfaction of automobile users. Prior studies have examined a variety of emotional dimensions, including 'rough-smooth', 'hard-soft', 'sticky-slippery' and 'warm-cold', from various kinds of surface materials, but there were few studies that considered the characteristics of surface texture and its usage context. This study focused on investigating tactile emotional factors of in-vehicle surface textures. The experiments were conducted with 17 participants and 10 types of acrylonitrile butadiene styrene (ABS) resin-based material samples. Each of participants was asked to respond to the agreeability of 16 emotional expressions after feeling each of material samples. From the factor analysis, three tactile emotional factors, such as factor 1 (smooth/slippery/cold), factor 2 (soft/warm/sticky) and factor 3 (hard), were derived and validated by showing good internal consistency. It is concluded that automobile users mainly feel three kinds of emotions from surface textures of ABS resin-based in-vehicle materials.*

Keywords: Emotional dimensions, In-vehicle surface textures, Emotional design, Sense of touch

1. **Introduction.** Automobile manufacturers want drivers and passengers to feel the in-vehicle materials comfortable and to have good sense of touch in their cars to increase customers' satisfaction. Since good sense of touch comes from processing of information about surface materials, tactile surface texture perception plays an important role in feeling in-vehicle materials. Researchers in the area of psychophysics involved in studying the tactile surface texture perception, and tried to extract emotional factors from textural information that could be obtained through touch. Hollins et al. [1] examined the subjective dimensionality of tactile surface texture perception by using seventeen tactile stimuli, such as wood, sandpaper and velvet, and concluded that 'rough-smooth' and 'hard-soft' were found to be robust and orthogonal dimensions. Hollins et al. [2] also investigated the subjective dissimilarity between the members of all possible pairs of seventeen tactile surfaces, such as corduroy, sandpaper and synthetic fur, and suggested 'sticky-slippery' as the third dimension of perceived surface texture in addition to 'rough-smooth' and 'hard-soft' dimensions. Chen et al. [3] examined tactile perceptions of 37 surface textures related to food packaging. They used emotional dimensions, including 'warm-cold', 'rough-smooth', 'hard-soft' and 'sticky-slippery' to assess responses of the textures, and their results implied that emotional assessment of surface textures should be designed according to the characteristics of surface textures and their usage contexts. In sum, there were many

studies that used emotional dimensions, such as 'warm-cold', 'rough-smooth', 'hard-soft' and 'sticky-slippery', to assess tactile perceptions of various surface textures [1-13], including wood, sandpaper, velvet, corduroy, synthetic fur and food packaging materials. However, despite the fact that tactile emotional dimensions depend on the characteristics of surface textures and their usage contexts, there were few studies that were conducted to find tactile emotional dimensions or factors according to the characteristics of surface textures and their usage contexts.

This study sought to examine tactile emotional factors of in-vehicle surface textures and focus on the automobile interior as the usage context of surface textures. Although 'warm-cold', 'rough-smooth', 'hard-soft' and 'sticky-slippery' have been used as the common emotional dimensions of tactile perceptions for various surface textures, there is not enough empirical evidence of emotional factors that automobile users perceive when they run their fingers across a surface texture of in-vehicle materials. In this study, we focused on acrylonitrile butadiene styrene (ABS) resin-based materials that are commonly used for automobile interior. Based on the experimental results of this study, it is expected that the derived tactile emotional factors can be utilized to control automobile user's perceptions on the surface texture of in-vehicle materials. This paper is organized as follows. Section 2 describes research methods, including preparation of material samples, participants and experimental procedures. Sections 3 and 4 provide the results of the experiments and discussion on the results with conclusions, respectively.

2. **Methods.** In order to find the tactile emotional factors for acrylonitrile butadiene styrene (ABS) resin-based materials, the experiment was conducted with 17 participants, who were asked to respond to the questionnaire after freely touching the surfaces of 10 ABS resin-based material samples each.

2.1. **Preparation of material samples.** Before conducting the experiment, ten types of in-vehicle material samples were prepared. They were manufactured by giving additional processes on the ABS resin as a base material that was used for various parts of interior in automobiles, including instrument panels, steering wheels, and door trims. By experts of in-vehicle material design, those ten types of in-vehicle material were selected as samples that showed typical characteristics of the ABS resin-based materials in the automobile interior. As shown in Table 1 and Figure 1, each of samples has the same base material of the ABS resin, but is characterized in terms of color, coating paint, glossiness, embossing type (i.e., shape, grain size and shape of groove edges) and pattern. Specifically, sample 1 is a fine and clear grain-patterned ABS resin with black and matte coating, and sample 2 is a big and dull grain-patterned ABS resin with black and soft coating. Sample 3 is the ABS resin that is coated with black and rubbery paint to make it have elastic texture. It is also embossed with medium-sized grain. Sample 4 is the ABS resin that is coated with black leather-like paint. It has also fine and clear pattern of grain. Sample 5 is the ABS resin that is coated with clear paint to make it shiny. Sample 6 is the ABS resin that is coated with semi-gloss chrome to make it look like real metal. Sample 7 is the ABS resin that is coated with silver color paint. It looks like a metal but it has its paint texture. Sample 8 is the ABS resin that carbon pattern is printed on. Sample 9 is the ABS resin that is coated with black matte paint. Sample 10 is the ABS resin that is coated with black leather-like paint.

2.2. **Participants.** Seventeen participants, who were 3 businessmen, 11 graduate students and 3 undergraduate students, took part in the experiment. They were 9 males and 8 females, and were 26.2 years old on average, with a standard deviation of 4.43 years. Participants did not have any problem to feel the surfaces of materials with their fingers.

Table 1. Characteristics of material samples

No.	Base material	Color	Paint	Glossiness	Embossing			Pattern
					Shape	Grain size	Shape of groove edges	
1	ABS resin	Black	Matte	N/A	Grain	Very coarse	Sharp	N/A
2	ABS resin	Black	Soft	N/A	Grain	Fine	Dull	N/A
3	ABS resin	Black	Elastic	N/A	Grain	Medium coarse	Medium sharp	N/A
4	ABS resin	Black	Leather -like	N/A	Grain	coarse	Very sharp	N/A
5	ABS resin	Black	N/A	High	N/A			N/A
6	ABS resin	Silver	N/A	Semi	N/A			N/A
7	ABS resin	Silver	N/A	High	N/A			N/A
8	ABS resin	Silver	N/A	N/A	N/A			Carbon
9	ABS resin	Black	Matte	N/A	N/A			N/A
10	ABS resin	Black	Leather -like	N/A	N/A			N/A

Notes. ABS: acrylonitrile-butadiene-styrene, N/A: not available.

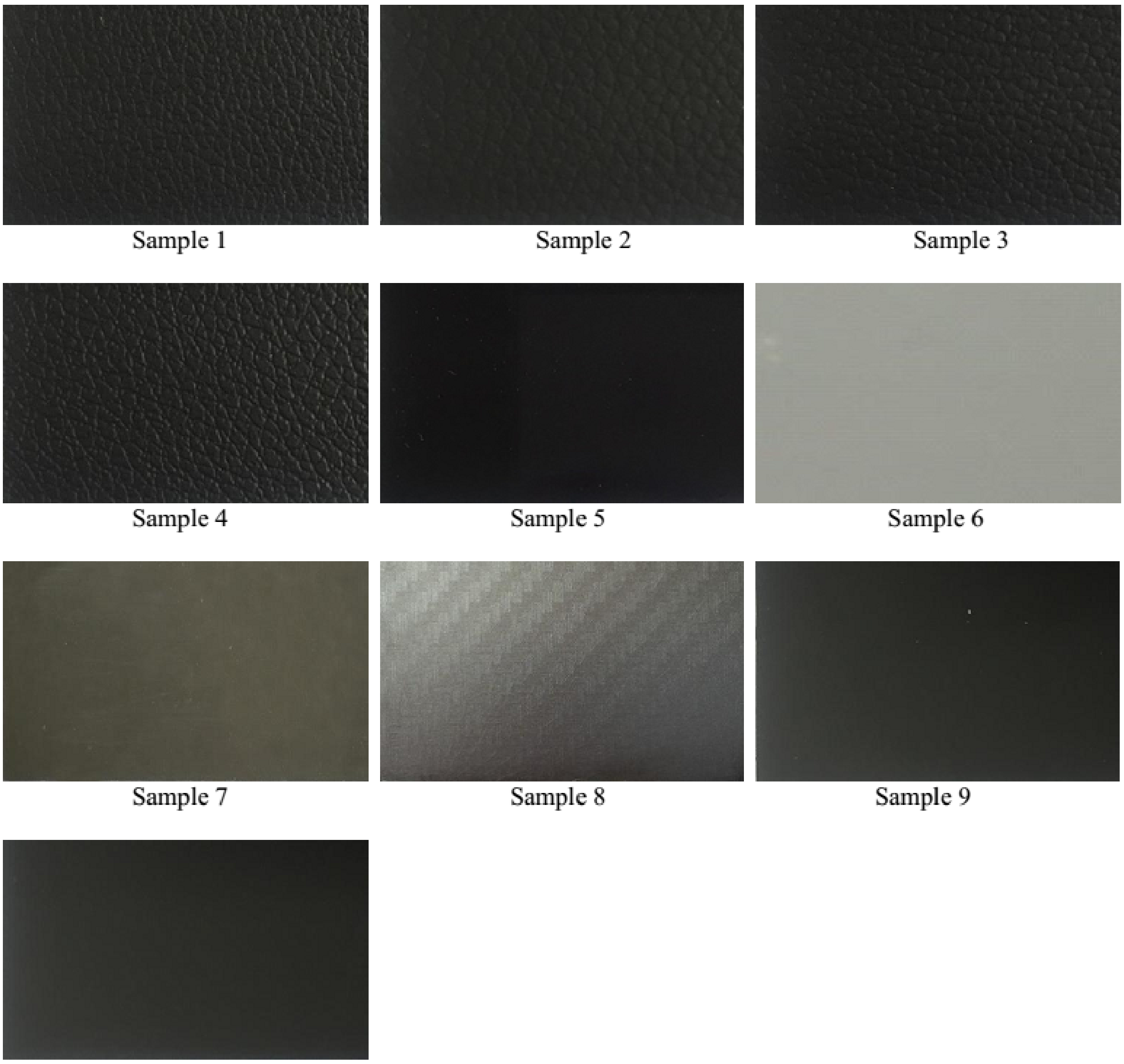

Figure 1. Pictures of material samples

Table 2. Factor loadings for three emotional factors

Emotional expressions	Factor 1	Factor 2	Factor 3	Communality estimates
Sleek	**.831**	.324	−.095	0.804
Smooth	**.816**	.334	−.230	0.831
Slippery	**.812**	.279	−.234	0.792
Oily	**.796**	.326	−.156	0.763
Bumpy	**−.607**	−.288	.412	0.621
Rough	**−.521**	−.357	.310	0.495
Cold	**.681**	−.051	.413	0.637
Cool	**.662**	−.076	.368	0.579
Soft	−.405	**.698**	−.007	0.652
Tender	−.366	**.692**	−.075	0.618
Warm	−.401	**.636**	.296	0.653
Mild	−.413	**.600**	.257	0.597
Slushy	−.001	**.635**	.508	0.662
Sticky	.094	**.593**	.452	0.564
Firm	.468	−.310	**.639**	0.724
Hard	.563	−.310	**.569**	0.736
Variance explained by each factor	5.365	3.297	2.066	10.728

Notes. Factor loadings in bold type were considered to be significant.

2.3. **Procedure of experiment.** By the within-subject experimental design, each of 17 participants was asked to answer the questionnaire after feeling the surface of each of 10 material samples in random order. The questionnaire includes 16 emotional expressions (see the first column of Table 2), which were used to measure the agreeability of emotions invoked by material surfaces in many previous studies [3-13]. The agreeability of 16 emotional expressions was measured in a 5-point scale (1: undecided, 2: slightly agree, 3: moderately agree, 4: mostly agree, 5: strongly agree). Every participant was allowed enough time to feel the surfaces of material samples with his/her fingers and answer the questionnaire.

3. **Results.** Factor analysis was utilized to derive tactile emotional factors from 16 emotional expressions, and the tactile emotional factors were validated by checking their internal consistency in terms of Cronbach's alpha coefficient.

3.1. **Tactile emotional factors.** Factor analysis using a principal component method with varimax rotation was conducted to find tactile emotional factors for the in-vehicle material. As shown in Table 2, three emotional factors were derived and named by 'factor 1', 'factor 2' and 'factor 3'. These three factors explain 67.1% of the total sample variance, which means that three factors are enough, with parsimony, to represent 16 tactile emotional expressions in the experiments. Factor 1 represents smooth-, slippery- and cold-related emotional expressions, which include sleek, smooth, slippery, oily, bumpy, rough, cold and cool. Factor 2 represents soft-, warm- and sticky-related emotional expressions, which include soft, tender, warm, mild, slushy and sticky. Factor 3 represents hard-related emotional expressions, which include firm and hard.

3.2. **Internal consistency of each factor.** Internal consistency was investigated to validate the reliability of three factors as tactile emotional factors for the in-vehicle material. Cronbach's alpha coefficient is well known as an indicator of internal consistency, which indicates how consistent multiple items (or variables) are internal when they measure the

Table 3. Cronbach's alpha coefficient of each factor

Factors	Emotional expressions	Cronbach's alpha coefficients
1	Sleek Smooth Slippery Oily Bumpy Rough Cold Cool	0.902
2	Soft Tender Warm Mild Slushy Sticky	0.824
3	Firm Hard	0.845

same construct [14]. As a commonly accepted rule of thumb, if Cronbach's alpha coefficient is more than 0.7, the internal consistency is acceptable, and also if Cronbach's alpha coefficient is more than 0.8 and 0.9, the internal consistency is good and excellent, respectively. Table 3 summarizes Cronbach's alpha coefficient values of each factor. Emotional expressions that belong to factor 1 show 0.902 as the value of Cronbach's alpha coefficient, which indicates 'excellent' internal consistency. Emotional expressions, which belong to factor 2 and factor 3, show 0.824 and 0.845 as the values of Cronbach's alpha coefficient, respectively, which indicates 'good' internal consistency. In sum, it was validated that three tactile emotional factors could be reliably measured by the emotional expressions in Table 3.

4. **Conclusions and Discussion.** Based on the experimental data, we derived three tactile emotional factors, such as factor 1 (smooth/slippery/cold), factor 2 (soft/warm/sticky) and factor 3 (hard), for surface textures of ABS resin-based in-vehicle materials, and validated these three factors by showing good or excellent internal consistency. It is concluded from the experimental results that emotions of 'smooth', 'slippery' and 'cold' are closely related with each other when automobile users feel tactile emotions from in-vehicle surface textures. Likewise, in-vehicle tactile emotions of 'soft', 'warm' and 'sticky' are closely related with each other, but the tactile emotion of 'hard' is different from the others in in-vehicle surface textures. Thus, these results imply that automobile users mainly feel these three kinds of emotions from surface textures of ABS resin-based in-vehicle materials, and it is important for in-vehicle material design to control these three emotional factors. For further study, we need to study various in-vehicle surface materials other than ABS resin-based materials (e.g., natural leather) for more comprehensive conclusions to in-vehicle material design. We also need to study about how to control these tactile emotional factors by changing physical properties of surface textures.

REFERENCES

[1] M. Hollins, R. Faldowski, S. Rao and F. Young, Perceptual dimensions of tactile surface texture: A multidimensional-scaling analysis, *Perception & Psychophysics*, vol.54, pp.697-705, 1993.

[2] M. Hollins, S. J. Bensmaia, K. Karlof and F. Young, Individual differences in perceptual space for tactile textures: Evidence from multidimensional scaling, *Perception & Psychophysics*, vol.62, pp.1534-1544, 2000.

[3] X. Chen, F. Shao, C. Barnes, T. Childs and B. Henson, Exploring relationships between touch perception and surface physical properties, *International Journal of Design*, vol.3, no.2, pp.67-76, 2009.
[4] S. Guest, A. Mehrabyan, G. Essick, N. Phillips, A. Hopkinson and F. McGlone, Physics and tactile perception of fluid-covered surfaces, *Journal of Texture Studies*, vol.43, pp.77-93, 2012.
[5] N. Kawasegi, M. Fujii, T. Shimizu, N. Sekiguchi, J. Sumioka and Y. Doi, Physical properties and tactile sensory perception of microtextured molded plastics, *Precision Engineering*, vol.38, pp.292-299, 2014.
[6] N. Kawasegi, M. Fujii, T. Shimizu, N. Sekiguchi, J. Sumioka and Y. Doi, Evaluation of the human tactile sense to microtexturing on plastic molding surfaces, *Precision Engineering*, vol.37, pp.433-442, 2013.
[7] K. Choi and C. Jun, A systematic approach to the Kansei factor of tactile sense regarding the surface roughness, *Applied Ergonomics*, vol.38, pp.53-63, 2007.
[8] W. M. B. Tiest and A. M. L. Kappers, Analysis of haptic perception of materials by multidimensional scaling and physical measurements of roughness and compressibility, *Acta Psychologica*, vol.121, pp.1-20, 2006.
[9] M. Karlsson and A. V. Velasco, Designing for the tactile sense: Investigating the relation between surface properties, perceptions and preferences, *CoDesign: International Journal of CoCreation in Design and the Arts*, vol.3, no.1, pp.123-133, 2007.
[10] S. W. Bahn, C. Lee, J. H. Lee and M. H. Yun, Development of luxuriousness models for automobile crash pad based on subjective and objective material characteristics, *Journal of the Ergonomics Society of Korea*, vol.25, no.2, pp.187-195, 2006.
[11] H. W. Jung and K. Nah, A study on the meaning of sensibility and vocabulary system for sensibility evaluation, *Journal of the Ergonomics Society of Korea*, vol.26, no.3, pp.17-25, 2007.
[12] S.-C. Kim, K.-U. Kyung, J.-H. Sohn and D.-S. Kwon, An evaluation of human sensibility on perceived texture for real haptic representation, *Journal of KISS: Software and Applications*, vol.34, no.10, pp.900-909, 2007.
[13] Y. I. Choi, S. Lee, H. W. Song, I. M. Choi and Y. K. Park, The development of tactile-emotion scale and emotion rating of temperature, pin and frequency, *Proc. of 2012 Spring Conference on KSPE (Korean Society of Precision Engineering)*, pp.881-882, 2012.
[14] C. Duncan, *Basic Statistics for Social Research*, Routledge, 1997.