Beauty in Motion: Insights from Digital Human Simulations of Real Human Facial Movements

Megumi Nagashima[1]*, Shuntaro Okazaki[1], Nozomi Takuwa[1], Haruna Yamanami[1], Seiko Matsumoto[1], Keith Kawabata Duncan[1]

[1] MIRAI Technology Institute, Shiseido Co., Ltd., Yokohama, Japan

1. Introduction

To create a world where more people recognize their own beauty and cultivate self-esteem, we are expanding the concept of beauty. As one of our approaches, we are focusing on facial movements. Facial movements can express individuality, convey impressions and emotions, and offer a different standard of beauty compared to static impressions.

Traditionally, discussions about facial beauty have primarily focused on static features, such as facial structure. Numerous studies in cognitive psychology and information science have identified the morphological elements that contribute to perceptions of attractiveness in static faces [1-5]. However, it is essential to recognize that the face also communicates dynamic information that reveals insights beyond static features [6]: There is beauty in movement that is independent of morphology.

While some research has explored the beauty of facial movements, it has often been limited to smiles and positive emotions [7,8] or relied on video of actual people's facial expressions [9]. These approaches have not fully investigated how various facial movements, including those unrelated to positive emotions, affect impressions. Moreover, using real facial movements complicates the ability to remove the influence of facial morphology from the assessment of movements, making it challenging to analyze how facial movements impact impressions. Consequently, many questions remain regarding which specific elements of movement influence perceptions of beauty and attractiveness causing consumers to miss out on optimized cosmetic solutions that enhance their natural beauty through facial movements, potentially limiting their ability to achieve desired aesthetic outcomes.

To overcome these challenges, this study took a novel approach and implemented an impression survey using a single digital human model which simulated various facial movements. Recent advancements in gaming engines and facial motion capture technology enable the creation of photorealistic digital avatars that accurately reproduce human facial movements. This technology allows the reproduction of diverse facial movements from different individuals on the same digital human model, enabling us to identify which elements of facial movements most significantly influence the perception of beauty and attractiveness, independent of morphological factors.

We collaborated with makeup artists to develop and test makeup that highlights facial movements identified as significantly impacting attractiveness. Next, we applied these makeup techniques to digital humans and created videos that emphasized facial movements. Using these videos, we conducted impression surveys to verify the potential of makeup to enhance the beauty of facial expressions.

Recognizing the importance of self-esteem in the perception of beauty, we further hypothesized that self-esteem is strongly related to facial movements and analyzed this relationship. Specifically, we investigated how different levels of self-esteem affect facial movements and examined ways to utilize these movements based on the results. This approach aimed to clarify how facial movements themselves contribute to the perception of beauty and attractiveness, not just through makeup, and to propose more comprehensive beauty solutions.

In summary, this study aims to expand the concept of beauty by incorporating the dynamic beauty of facial movements alongside traditional static morphological features. By utilizing digital human models, we have demonstrated that facial movements play a crucial role in shaping perceptions of beauty and attractiveness. Additionally, we explored the potential of makeup to enhance the impressions of facial movements and proposed techniques that emphasize these movements. Furthermore, our investigation into the relationship between self-esteem and facial movements provides valuable insights into how these movements can be utilized to promote beauty. Through this research, we aim to broaden the ways beauty is expressed, thereby increasing opportunities for more people to appreciate their own beauty.

2. Materials and Methods

This study consisted of three surveys: a preliminary survey to collect facial movement data, a second survey to investigate the relationship between facial movements and impressions using digital human animations, and a third survey to confirm whether makeup highlighting positive facial movements improves impressions.

2.1 Survey 1: Collection of face movement data

2.1.1. Participants

Seventy Japanese females aged between 20 and 59 were recruited, with each age group and self-esteem level (low, middle, high) roughly equal. Self-esteem was measured using the Japanese version [10] of the Rosenberg Self-Esteem Scale [11] during the screening process to ensure balanced groups. This approach was taken to consider the possibility of a link between self-esteem and facial movements. All participants provided informed consent, and the study was approved by the company's ethics committee (C10483).

2.1.2. Procedure

Survey 1 was a central location test (CLT). To collect a diverse range of facial movements, two methods were used to ask participants to express their emotions, and their facial movements were measured. The first method involved engaging participants in conversation with the experimenter. To elicit a wide variety of facial expressions, we prompted them to discuss topics such as their favorite things, personal interests, recent frustrating incidents, cherished memories, and their saddest moments. The second method required participants to imitate facial expressions from videos depicting the six basic emotions [12].

2.1.3. Data collection

The camera (MNXH3J/A, Apple) was positioned approximately 30 cm in front of the participants to capture their entire face. For data acquisition, we utilized the LiveLinkFace app (Epic Games, Version 1.3.2) integrated with Unreal Engine (Epic Games, Version 5.4.2). This setup employed advanced facial recognition technology to recreate realistic digital human movements within the game engine. During this process, we collected data on time information, the positions of facial landmarks, and the movements and deformations of various facial regions at a frame rate of 59.90 FPS. The facial movements captured included 61 types of actions, such as "left eye blink" and "left cheek squint." This detailed data allowed us to analyze and replicate subtle facial expressions accurately.

2.2. Survey 2: Study of Movements that Affect Impressions

2.2.1. Participants

Two thousand Japanese females aged between 20 and 59 were recruited, evenly divided across age groups. All participants provided informed consent, and the study was approved by the company's ethics committee (C10551).

2.2.2. Stimulus

Based on the data collected in Survey 1, we selected 80 facial expressions that could be classified as single movements, considering the balance of facial expression types, self-esteem scores, and ages. Utilising the information on facial part movements and deformations obtained from the LiveLinkFace app (Epic Games, Version 1.3.2), we reproduced these movements in photorealistic digital humans using Unreal Engine (Epic Games, Version 5.4.2). Each movement was captured in a video lasting approximately 10 seconds. To maintain consistency, the same digital human was used in all 80 videos, with the camera position and environment fixed to ensure that the only variable was the facial movement. The digital human used in this study was a woman of East Asian descent (Figure 1(a)), reflecting the demographic of the Japanese women who participated in the study.

2.2.3. Procedure

Survey 2 was conducted online. Participants were divided into four groups, with each group assigned 20 of the 80 videos. They viewed each video in full-screen mode on their web browser. After watching each video, participants responded to 13 impression-related questions, including a dummy question, on a 7-point scale. Responses were only allowed after the video had been fully viewed. The questions included: ‘attractive’, ‘reveal one’s true character’, ‘confident’, ‘vibrant’, ‘youthful’, ‘expressive’, ‘not influenced by others’ opinion’, ‘honest’, ‘have consistent appearance and personality’, ‘true to self’, ‘high self-esteem’, and ‘free-spirited’. The order of the videos and questions was randomized.

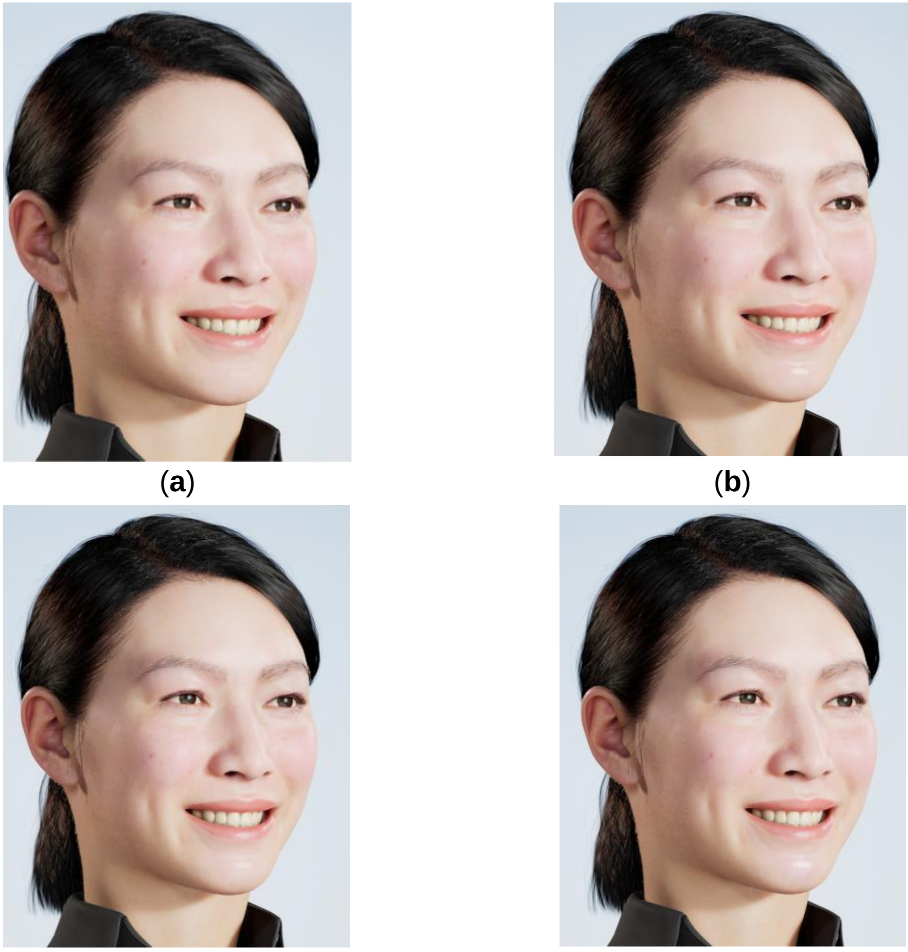
2.3. Survey 3: Examination of Makeup-Induced Changes in Movement Impressions

2.3.1. Participants

Two thousand four hundred participants aged between 20 and 59 were recruited, evenly divided across age groups. All participants provided informed consent, and the study was approved by the company's ethics committee (C10601).

2.3.2. Stimulus

We used videos of the digital human with several different types of makeup for the survey. The digital human was the same as that used in Survey 2. In Survey 2, we found that jaw movement size and sudden changes influenced impressions of vibrancy and self-assurance. Therefore, we collaborated with a makeup artist to create makeup with a glossy finish for the chin to make the jaw appear more dynamic. We prepared three types of gloss: water-like gloss, blurred, pearly gloss, and metallic gloss. Digital humans were created with each type of makeup applied (Figure 1).



(**a**) (**b**) (**c**) (**d**)

Figure 1. Images of virtual humans from the videos in Surveys 2 and 3. The images are angled to highlight texture differences, but in the survey videos, they were displayed from the front. (a) bare face, (b) watery gloss on the chin, (c) blurred pearly gloss on the chin, (d) metallic gloss on the chin.

We selected eight types of movement from Survey 1, focusing on jaw movements, movements of the corners of the mouth, and movements of the lower lip, which significantly impacted impressions of vibrancy and self-assurance. These movements were reproduced on four digital humans: three with different types of makeup and one without makeup. A total of 32 videos were created for the survey. To ensure comparison of each texture alone, the digital humans, movements, video length, and background were kept consistent across videos, with the only variable being the makeup.

2.3.3. Procedure

The test was conducted online in the same way as Survey 2. The participants were divided into eight groups, and each group was assigned one of the eight types of movements. In other words, the participants viewed videos of the same movement but with four different makeup textures. As in Survey 2, the participants viewed the assigned videos one by one in full-screen mode on their web browsers, and then answered questions about their impressions of the person in the video on a seven-point scale. The questions and dummy questions were the same as in Survey 2.

3. Results

3.1. Survey 1 Study of Movements that Affect Impressions

We analyzed the relationship between participants' self-esteem and facial movements. The analysis revealed correlations with nose-sneering (left side: $r = 0.31$, $p < .01$; right side: $r = 0.32$, $p < .01$), but no correlation with smiling movements (left corner of the mouth: $r = -0.06$, p = .64; right corner of the mouth: $r = -0.05$, $p = .69$). Scatter plots are shown in Figure 2.

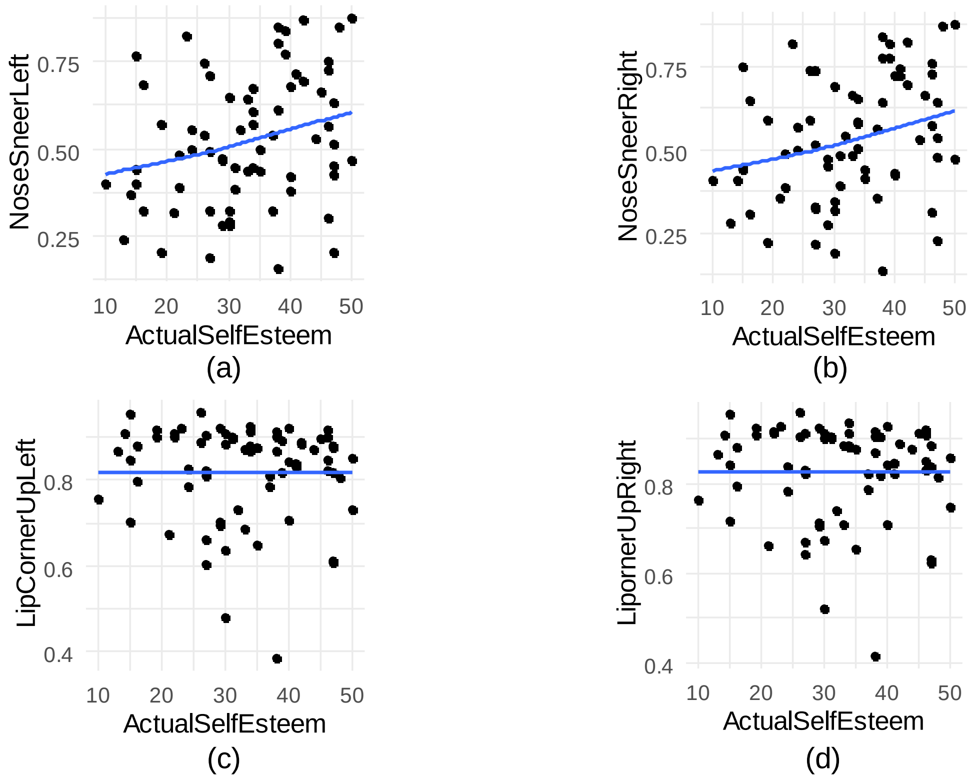


Figure 2. Scatter plots show Survey 1 participants' self-esteem scores and facial movement changes, with blue lines representing smoothed spline curves. (a) Self-esteem and left nose sneering, (b) self-esteem and right nose sneering, (c) self-esteem and left mouth corner lifting, (d) self-esteem and right mouth corner lifting.

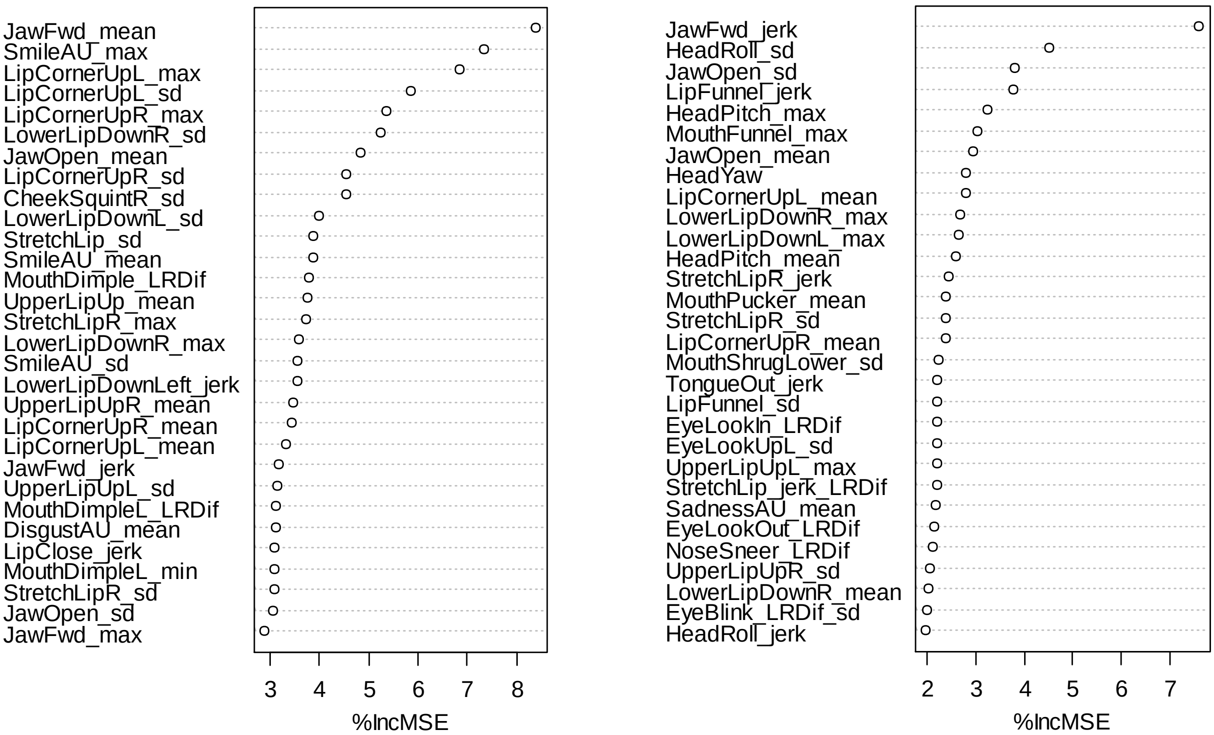
3.2. Survey 2: Study of Movements that Affect Impressions

Before examining the relationship between movement and impression, we confirmed the suitability of the 12 impression questions for factor analysis using the KMO measure, which had a value of 0.95. We then performed factor analysis to group the data into latent factors. Following MAP criteria, we identified two factors, used the maximum likelihood method, and performed factor analysis with Oblimin rotation. We removed items with high independence and those that compromised structural simplicity. As a result, two factors, 'vibrant' and 'self-assured,' were extracted (Table 1).

Next, we examined which movements contributed most to each impression factor. We used the factor scores of the two impression factors for each video as the objective variables. The explanatory variables included the maximum, minimum, average, and standard deviation of the amount of movement and distortion of each facial feature within each video, the degree of movement within the video, and the magnitude of temporal or spatial differences between the left and right sides of each feature. Given the limited amount of data, we adopted random forest analysis, which is suitable for small datasets.

Table 1. Results of factor analysis of impression questions in Survey 2

Impressions	Factor 1 Vibrant	Factor 2 Self-assured	Communality	Uniqueness
Vibrant	0.884	0.034	0.823	0.177
Expressive	0.881	-0.061	0.708	0.292
Attractive	0.809	0.040	0.700	0.300
Youthful	0.781	0.042	0.656	0.344
Not influenced	-0.056	0.903	0.751	0.259
True to self	-0.091	0.823	0.587	0.412
Self-esteem	0.290	0.633	0.730	0.270
Confident	0.328	0.691	0.761	0.239



(a) Vibrant factor (b) Self-assured factor

Figure 3. List of factors contributing to each impression. %IncMSE shows the influence of each variable on model accuracy, with higher values indicating greater influence. AU stands for Action Unit in FACS [12]. (a) movements contributing to vibrancy, (b) movements contributing to self-assurance.

For the 'Vibrant' factor, 500 decision trees tested 150 variables at each branch. The mean squared error was 0.0941, explaining 58.54% of the variance. The movement variables with high contribution were identified by calculating the percentage increase in mean squared errors (%IncMSE) (Figure 3(a)). The analysis showed that, besides smiling-related facial movements, jaw movement forward and lower lip movement were significant contributors. Additionally, Nose Sneering, which correlated with self-esteem in Survey 1, had a correlation coefficient of 0.48 ($r < 0.01$, $p < .01$) with the Vibrant factor.

For the 'Self-assured' factor, under the same conditions, the mean squared error was 0.0789, explaining 20.87% of the variance. Despite the model's low explanatory power, %IncMSE were calculated. Figure 3(b) lists the movements with the largest contributions. The analysis revealed that the intensity of movements, such as jerking the jaw forward and tilting the face upward, affected this impression.

3.3. Survey 3: Examination of Makeup-Induced Changes in Movement Impressions

In Survey 3, we used the same impression items as in Survey 2. However, unlike Survey 2, participants evaluated videos with identical facial movements but different makeup textures. This change in procedure could affect the evaluation structure. Therefore, we conducted a factor analysis of the impression items again before analyzing how makeup texture influences movement impressions.

The KMO value of 0.96 confirmed the data's suitability for factor analysis. According to MAP criteria, we identified two factors. Using maximum likelihood estimation, we removed highly independent questions to maintain structural simplicity and performed factor analysis with Oblimine rotation. The results are shown in Table 2. Like Survey 2, two factors, ‘vibrant’ and ‘self-assured,’ were extracted, but the impressions ‘confident’ and ‘self-esteem’ were removed from the ‘self-assured’ factor.

Table 2. Results of factor analysis of impression questions in Survey 2

Impressions	Factor 1 Vibrant	Factor 2 Self-assured	Communality	Uniqueness
Expressive	0.875	-0.064	0.694	0.306
Vibrant	0.826	0.063	0.757	0.243
Attractive	0.817	0.022	0.692	0.308
Youthful	0.802	0.000	0.643	0.357
Not influenced	-0.013	0.910	0.812	0.188
True to self	0.032	0.775	0.635	0.365

To examine differences in the impact of makeup textures on impressions, we conducted a three-factor mixed analysis of variance. The analysis included eight levels of facial movement type as the between-subjects factor, and two levels of impression factor and four levels of makeup texture factor as the within-subjects factors.

The results revealed significant main effects for facial movement type ($F(7,2392) = 18.7635$, $p < .01$) and makeup texture ($F(3,7176) = 4.7998$, $p < .01$). Additionally, significant interaction effects were found between facial movement type and impression factor ($F(7,2392) = 79.6730$, $p < .001$), and between impression factor and makeup texture factor ($F(3,7176) = 3.8654$, $p < .01$). Further analysis of simple main effects indicated that makeup texture factors significantly influenced the Vibrant factor ($F(3,7176) = 5.6351$, $p < .01$) and the Self-assured factor ($F(3,7176) = 3.8612$, $p < .01$).

Using Shaffer's Modified Sequentially Rejective Bonferroni Procedure, multiple comparisons were conducted between levels of the makeup texture factor for each impression factor. For the Vibrant factor, significant differences were found between metallic gloss and watery gloss ($t(2392) = 3.7394$, adjusted $p < 0.001$), metallic gloss and bare face ($t(2392) = 3.3559$, adjusted $p < .01$), and metallic gloss and pearly gloss ($t(2392) = 3.7394$, adjusted $p = 0.0214$). For the Self-assured factor, significant differences were observed between pearly gloss and watery gloss ($t(2392) = 2.7055$, adjusted $p = .0412$) and pearly gloss and bare face ($t(2392) = 2.6800$, adjusted $p = .0412$). Figure 4 shows the average factor scores for each makeup texture by impression factor.

Figure 4. Average scores for impression factors by makeup texture. Differences in movement have been integrated. Error bars represent standard errors. * indicates $p < .05$, and ** indicates $p < .01$.

The interaction among facial movement type, participant-level factors, and impression factors was not significant ($F(12,7176) = 1.5360$, $p = .55$). However, we checked if changes in makeup texture also affected impressions in videos with minimal movement. Results showed a simple interaction between impression factors and makeup texture ($F(3,897) = 3.2327$, $p = .02$), but no main effect of makeup texture across impression factors ($F(3,897) = 0.1888$, $p = .90$; $F(3,897) = 2.4077$, $p = .07$). Therefore, makeup texture did not change impressions in videos with minimal movement.

4. Discussion

The primary aim of this study was to propose a new concept of beauty from the perspective of facial movements, rather than the traditional static aspects of facial morphology, thereby embracing the diversity and uniqueness of individual expressions. To achieve this, we examined elements that contribute to beauty and positive impressions in movements. By controlling morphology by using digital humans, we measured impressions caused by differences in movements and extracted facial movements that contributed to positive impressions. We aimed to investigate whether emphasizing these extracted movements through makeup could enhance the overall impression.

We found that a vibrant impression is significantly influenced not only by well-known movements related to smiling but also by movements like pushing the jaw forward and lowering the lower lip. Additionally, we found that for the self-assured factor, movements such as raising the face and the jerk when pushing the jaw forward were influential. These findings indicate that both vibrant and self-assured impressions are strongly related to the movement of pushing the jaw forward.

A large jaw is known to give a masculine and dominant impression [5] and to enhance perceived reliability [4], while an angled jaw is considered attractive [3].The movement of pushing the jaw forward may make the jaw appear larger or more angled, which could have influenced the attractive impressions included in our vibrancy factor. Regarding the movement of the lower lip, it is known that the muscle strength around the mouth declines with age [13], and movements around the mouth are associated with youthfulness, which may influence the vibrant impression.

We also examined whether makeup could enhance or alter the impression of the jaw and lower lip movements. As we were unsure of what makeup might alter the impressions, we used watery gloss, blurred pearl-like gloss, and metallic gloss. Unfortunately, we did not find makeup textures that improved impressions compared to the bare face. However, it was shown that metallic gloss on the chin lowered the evaluation for a vibrant impression, and pearly gloss on the chin lowered the evaluation for a self-assured impression. These findings suggest that inappropriate makeup can reduce the impression of movements, indicating the need to consider makeup from the perspective of movements. Moreover, although we could not find textures which enhanced the impressions, the fact that a change due to makeup was observed leaves open the possibility that other, untested makeup may enhance the impressions.

An alternative explanation for the changes in impressions is that they are merely due to the static gloss effect rather than dynamic impressions. While we do not deny the influence of static gloss appearance, the results from stimuli with less movement showed no differences in impressions due to makeup textures, suggesting that the changes in gloss accompanying facial movements significantly influenced impressions.

We also looked at the characteristics of facial movements in people with high and low self-esteem. People with high self-esteem had more nose sneering (which expresses disgust [12]) compared to those with low self-esteem. High self-esteem individuals also smiled to a similar degree to those with low self-esteem. Taken together, this may indicate that people with low self-esteem are more conscious of how they may be perceived by others and consequently may suppress facial movements that might be perceived negatively to portray themselves in a more positive light. As a beauty company, we can convey the message that there is no need to suppress any facial expressions: It is okay to show your true feelings.

Our findings underscore the transformative potential of embracing dynamic facial movements in the realm of beauty. By shifting the focus from static features to the fluidity of expressions, we pave the way for more inclusive and personalized cosmetic solutions. This approach does more than simply enhance the beauty of movement or make people appear more self-confident; it celebrates the unique beauty inherent in each person's natural movements. As we continue to explore and innovate in this field, we envision a future where cosmetics empower individuals to express their true selves confidently and authentically. The journey towards this future is rooted in science, and through our research, we demonstrate that the future of beauty is not just about appearance but about embracing the dynamic essence of human expression.

5. Conclusion

This study highlights the significant role of facial movements in the perception of beauty and attractiveness. By utilizing advanced digital human models, the study investigates how various facial movements influence perceptions of beauty and attractiveness, independent of traditional morphological factors. The findings reveal that movements such as jaw and lower lip actions significantly contribute to positive impressions, like vibrancy and self-assurance. Additionally, the research explores the potential of makeup to enhance these movements, highlighting the impact of specific makeup textures on impressions. The study also examines the relationship between self-esteem and facial movements, indicating that individuals with low self-esteem may suppress expressions that could be perceived negatively, despite these movements potentially conveying positive impressions. This research highlights the need for a broader understanding of beauty that embraces individual expressions and suggests future directions for makeup that encourages natural facial movements, ultimately fostering greater self-esteem and appreciation of personal beauty.

6. References

[1] Langlois, J. H., & Roggman, L. A. (1990). Attractive Faces Are Only Average. *Psychological Science*, 1(2), 115-121. https://doi.org/10.1111/j.1467-9280.1990.tb00079.x

[2] Todorov, A. (2017). *Face value: The irresistible influence of first impressions*. Princeton University Press.

[3] Todorov, A., Baron, S. G., & Oosterhof, N. N. (2008). Evaluating face trustworthiness: A model based approach. *Social Cognitive and Affective Neuroscience*, 3(2), 119–127. https://doi.org/10.1093/scan/nsn009

[4] Valenzano, D. R., Mennucci, A., Tartarelli, G., & Cellerino, A. (2006). Shape analysis of female facial attractiveness. *Vision Research*, 46(8–9), 1282–1291. https://doi.org/10.1016/j.visres.2005.10.024

[5] Wolffhechel K, Fagertun J, Jacobsen UP, Majewski W, Hemmingsen AS, Larsen CL, et al. (2014). Interpretation of Appearance: The Effect of Facial Features on First Impressions and Personality. *PLoS ONE* 9(9): e107721. https://doi.org/10.1371/journal.pone.0107721

[6] Dobs, K., Bülthoff, I., & Schultz, J. (2018). Use and usefulness of dynamic face stimuli for face perception studies—A review of behavioral findings and methodology. *Frontiers in Psychology*, 9, Article 1355. https://doi.org/10.3389/fpsyg.2018.01355

[7] Yamaguchi, M., Ikeda, K., Kawasaki, Y., Sugimori, E. (2025). Role of Dynamic Facial Expressions in Judgement of Attractiveness: AI and Human Analysis. *American Journal of Applied Psychology*, 14(1), 1-13. https://doi.org/10.11648/j.ajap.20251401.11

[8] Takano, R., Yamanami, H., Machida, A., & Takata, S. (2013). Relationships between Facial Impressions of Appearance and Actual Facial Movements of Cheek and Mouth Areas during Dynamic Smile. *Transactions of Japan Society of Kansei Engineering*, 12(2), 319-326. https://doi.org/10.5057/jjske.12.319

[9] Garrido, M. V., Lopes, D., Prada, M., & et al. (2017). The many faces of a face: Comparing stills and videos of facial expressions in eight dimensions (SAVE database). *Behavior Research Methods*, 49(4), 1343–1360. https://doi.org/10.3758/s13428-016-0790-5

[10] Yamamoto, M., Matsui, Y., & Yamanari, Y. (1982). The structure of various aspects of perceived self. *Educational Psychology Research*, 30(1), 64-68. https://doi.org/10.5926/jjep1953.30.1_64

[11] Rosenberg, M. (1965). *Society and the adolescent self-image*. Princeton: Princeton University Press.

[12] Ekman, P., & Friesen, W. V. (1978). *Facial Action Coding System: A Technique for the Measurement of Facial Movement*. Consulting Psychologists Press.

[13] Minakuchi, S., Tsuga, K., Ikebe, K., Ueda, T., Tamura, F., Nagao, K., Furuya, J., Matsuo, K., Yamamoto, K., Kanazawa, M., Watanabe, Y., Hirano, H., Kikutani, T., & Sakurai, K. (2018). Oral hypofunction in the older population: Position paper of the Japanese Society of Gerodontology in 2016. *Gerodontology*, 35(4), 317–324. https://doi.org/10.1111/ger.12347