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Evaluation of the impression imparted on others by a smile that shows the teeth, using the Semantic Differential Method

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We attempted to clarify how the impressions imparted on observers are affected by smiles with exposed teeth. Sixty young adults participated in the study, 23 men and 37 women, who had a mean age of 23±2 years. Impressions of composite (average) male and female faces were rated to eliminate individual bias. Ten facial photos were processed for each of 10 adult males with a mean age of 25±2 years and 10 adult females with a mean age of 26±1 years. Three stimulus images were used for each gender : a neutral face (teeth hidden), a smiling face (teeth hidden), and a grinning face (teeth exposed). The average male faces were rated by 30 subjects and the average female faces by the other 30. The semantic differential method was used to rate the impressions. Group ratings were then subjected to factor analysis. The two common factors having the greatest explanatory power were : "Sociable" and "Active" for the male stimulus images and "Friendly" and "Elegant" for the females. Significant differences between stimuli were observed for scores on both the first and second factors. In all cases, the grin was rated highest, followed by the smile and neutral face. We found that when smiling with the teeth exposed, male faces give a strong impression of sociability and activity, while females give a strong impression of friendliness and elegance. (J Osaka Dent Univ 2019 ; 53 : 179-186)

Key words : Average Faces ; SD Method ; Facial impression

INTRODUCTION

Dentistry has diversified in response to changes in social environment, especially in terms of aesthetic requirements.[1] These demands have prompted the development of new aesthetic materials and dental treatments, which have begun to see wider application in clinical settings.[2] However, no research has attempted to evaluate dental aesthetics in an objective manner. Although at least one study has examined the concept using an attitude survey, it was questionnaire-based.[3] Previously, our team compared how different groups focus their attention on pictures of the human mouth using an eye-tracking system. We found that both dental patients and non-dental patients (lay persons) fixate their gazes on non-esthetic restorations for a longer time than do dentists.[4] However, our investigations did not extend to determining the specific impressions formed in the viewer's mind during communication of 'beautiful' versus 'ugly' teeth.

Psychological research has looked at how changes in a person's facial expressions can modify a viewer's impressions of them using the Semantic Differential Method (SD).[5, 6] In this technique, the connotative structure of an object of interest is explored by measuring people's attitudes towards that object in terms of a series of opposite adjective pairs. Facial expressions are an important means of interpersonal communication,[7] with smiling in particular helping facilitate smooth interactions.[8] Smiling people engender more positive impressions in others than unsmiling people.[9, 10] Observer preferences for smiles are reportedly governed by stabil-

ity in the face's vertical axis, primarily in the area between the eyes and the mouth. Notably, mouth shape is an important morphological feature that influences a smile's perceived vitality.[5] We hypothesized that smiles convey the most positive impression if the teeth are exposed ; if so, aesthetic dental work can no doubt help to optimize images. This study's objective was to utilize the SD method to empirically determine how observers' impressions of smiles are influenced by visible teeth.

MATERIALS AND METHODS

Subjects

Sixty students at Osaka Dental University took part in this study, 23 men and 37 women who had a mean age of 23 ± 2 years. Subjects were divided into two groups of 30 each, which were respectively presented with male or female facial images. Male stimulus images were shown to 10 men and 20 women who had a mean age of 22 ± 2 years. Female stimulus images were shown to 13 men and 17 women who had a mean age of 24 ± 3 years. The researchers fully explained the purpose of the study and obtained consent from each subject before proceeding.

Methods

The subjects were seated facing a computer display at a viewing distance of approximately 60 cm on which the image stimuli were presented. During measurements, the subjects were equipped with noise-canceling headphones to aid their concentration for the ratings (Fig. 1). The presentation stimuli consisted of composite (average) male or female faces, for three different facial expressions : Neutral (expressionless, teeth unexposed), Smile (smiling without teeth exposed), and Grin (smiling with teeth exposed). First, several facial photos were taken of 10 men with a mean age of 25 ± 2 years, and 10 women with a mean age of 26 ± 1 years), who were different from the experimental subjects. For a given model, researchers chose the three photos they thought were most natural. The 10 selected photos for the corresponding conditions and gender were merged with specialized software to create the average faces using Facetool, a data-processing software for the PC (Information-technology Promotion Agency, Tokyo, Japan), and Heikin, a Facetool extension for creating average faces from this data (Harashima & Naemura Laboratory at the University of Tokyo, Tokyo, Japan) (Fig. 2). For each model, several facial photos were taken, and the expression the researchers felt was most natural was selected for processing.

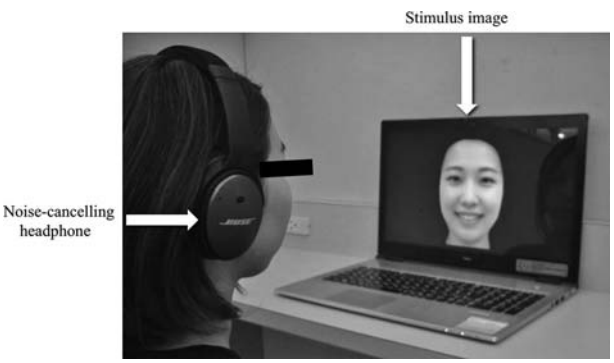

Fig. 1 Experimental set-up.

The subjects' impressions of each facial image were measured using the SD method. Table 1 lists the 20 adjective pairs used in the experiment. Subjects rated their impressions of stimuli using seven-level scales, each anchored by a different adjective pair, following a procedure similar to that used by Sugahara *et al*.[5] Experiments consisted of 60 trials, 20 each for each type of image, presented in random order. For a given trial, the subject was presented with an image on the computer display of a seven-level scale (Fig. 3), with each adjective in a pair on either end, to be used for rating the stimulus. They were instructed to press a key on the keyboard to show the next image once they understood the prompt. A stimulus (average face) image was then displayed for five seconds. Finally, the display automatically switched back to the image of the same adjective pair, and the subject verbally rated their impression on the seven-level scale shown and the reported value was recorded by a researcher.

Subjects' ratings were compiled in a dataset and subjected to common factor analysis using the maximum likelihood method (promax rotation) to identify the two latent factors associated with the

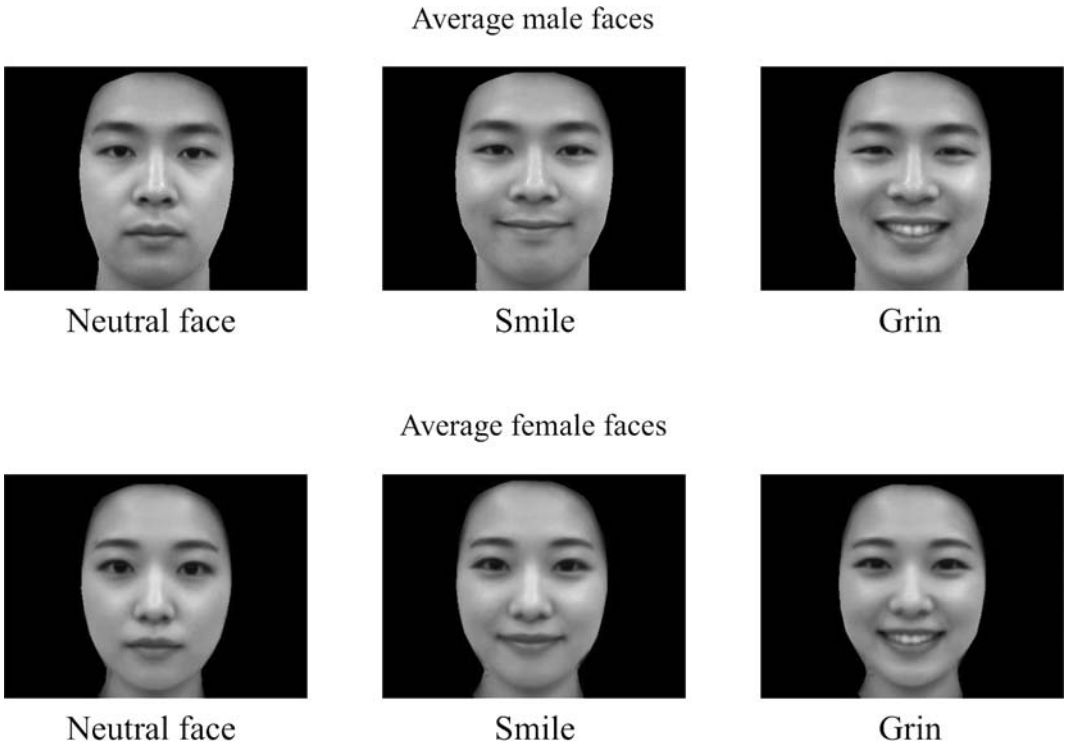

Fig. 2 Stimulus images.

Table 1 Twenty pairs of adjectives

① Western－Eastern	⑪ Unfriendly－Friendly
② Static－Dynamic	⑫ Dark－Bright
③ Unnatural－Natural	⑬ Unrefined－Refined
④ Masculine－Feminine	⑭ Dull－Sharp
⑤ Childish－Adult	⑮ Unimpressive－Impressive
⑥ Sick－Healthy	⑯ Negative－Positive
⑦ Rural－Urbane	⑰ Sordid－Fresh
⑧ Cold－Warm	⑱ Not Attractive－Attractive
⑨ Fragile－Strong	⑲ Unpolished－Elegant
⑩ General－Individual	⑳ Dislike－Like

greatest explanatory power in the model. Factor scores were then calculated and plotted, for each subject, in several plots to compare rating tendencies across stimulus images. Repeated measures one-way ANOVA was performed to compare mean factor scores across stimulus images ($\alpha = .05$). If statistically significant, Tukey's post-hoc test for multiple comparisons was used to check for score differences between each of the stimulus pairs ($\alpha = .05$). SPSS Statistics ver.19 analyses software (Japan IBM, Tokyo, Japan) was used for statistical analysis.

Fig. 3 Example of an SD scale questionnaire.

RESULTS

Factor analysis for average male faces

Factor analysis for average male faces yielded four factors with an eigenvalue greater than 1 (Table 2). Only Factors 1 and 2 were named to focus the analysis on latent variables with good explanatory power. Factor 1 had the greatest explanatory power, and was named "Sociable", based on the connotations of the associated adjective pairs, including Elegant－Unpolished, Positive－Negative, Attractive－Not Attractive, Refined－Unrefined, and Friendly－Unfriendly. Factor 2 was labeled "Active", based on the four associated pairs including Impressive－Unimpressive and Childish－Adult. The factor scores of each subject who rated the male faces ($n = 30$) were individually plotted, separately

Table 2 Factor loadings for the average male facial images

Pairs of adjectives	Factor			
	1	2	3	4
Elegant－Unpolished	.782	.271	−.162	.167
Positive－Negative	.634	.163	−.072	.218
Attractive－Not Attractive	.620	.347	.093	.239
Refined－Unrefined	.615	−.297	.245	.043
Friendly－Unfriendly	.600	−.051	.218	−.326
Warm－Cold	.573	.180	.124	−.170
Bright－Dark	.562	.205	.128	−.159
Feminine－Masculine	.451	−.178	.046	−.177
Natural－Unnatural	.393	−.071	−.096	.128
Healthy－Sick	.377	.205	.346	.087
Dynamic－Static	.118	.670	−.204	−.235
Impressive－Unimpressive	.018	.637	.115	.148
Individual－General	−.099	.576	.140	.215
Childish－Adult	−.206	.466	.219	−.427
Like－Dislike	−.107	.179	1.036	.129
Fresh－Sordid	.350	−.090	.373	−.201
Strong－Fragile	.199	.220	−.095	.605
Urbane－Rural	.352	−.351	.123	.527
Sharp－Dull	−.284	.199	.198	.439
Eastern－Western	−.084	−.101	.051	.123

Maximum likelihood method, Promax rotation

for the Neutral, Smile, and Grin facial stimuli (Fig. 4). Factor 1 (Sociable) is plotted on the horizontal axis, and Factor 2 (Active) on the vertical axis. The neutral male face was associated with negative factor scores in both sociability and activity for nearly all subjects. The impressions grew more positive in both dimensions for the smiling face, and even better for the grinning face.

The grinning face was perceived as the most sociable and the most active, followed by, in descending order, the smiling face and the neutral face. Figure 5 compares the mean factor scores for each stimulus. The mean Sociability scores (Neutral : −1.07, Smile : 0.45, Grin : 0.74) were found to be significantly different by repeated-measures one-way ANOVA ($p<0.05$). Subsequent multiple comparisons testing revealed that significantly greater sociability was perceived for the Smile and Grin than for the Neutral facial images ($p<0.05$), and for

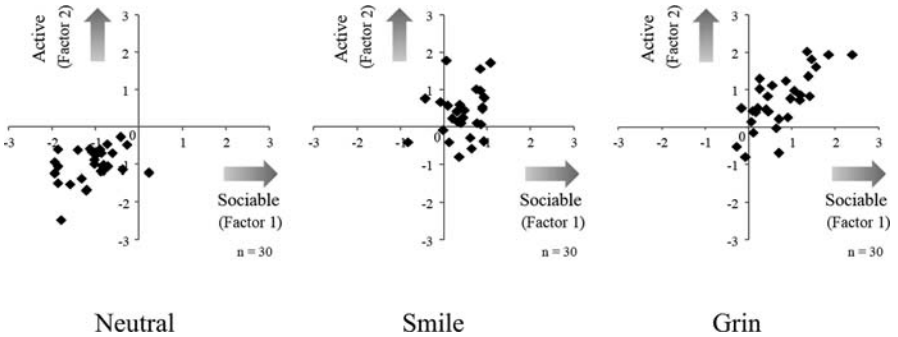

Fig. 4 Factor score distribution for the average male facial images.

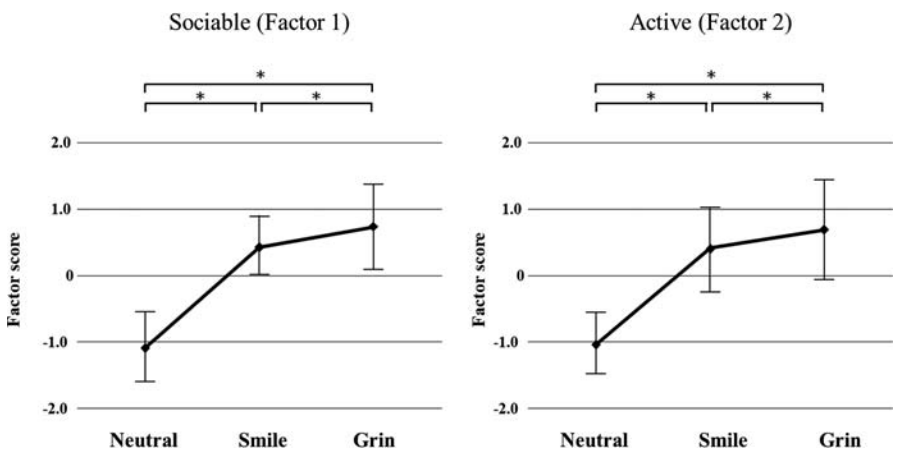

Fig. 5 Comparison of factor scores for the three average male facial images (n＝30, *$p<0.05$, ◆ Mean±SD).

the Grin than the Smile stimuli ($p<0.05$). Thus, for males, grinning faces appear to give the most sociable impressions to observers, followed by smiling and neutral faces. The mean activity scores (Neutral : −1.01, Smile : 0.39, Grin : 0.70) were also found to be statistically different by repeated-measures one-way ANOVA ($p<0.05$). Subsequent multiple comparisons testing revealed that significantly greater activity was perceived for Smile and Grin than for Neutral facial images ($p<0.05$), and for the Grin than the Smile stimuli ($p<0.05$). Thus, for males, grinning faces appear to give the most active impressions to observers, followed by smiling and neutral faces.

Table 3 Factor loadings for the average female facial images

Pairs of adjectives	Factor			
	1	2	3	4
Like－Dislike	.865	−.192	.023	.276
Friendly－Unfriendly	.816	.104	.028	−.085
Attractive－Not Attractive	.704	.277	−.046	−.021
Refined－Unrefined	.683	.052	−.029	.116
Healthy－Sick	.647	.113	.194	.005
Bright－Dark	.637	.340	−.031	−.073
Feminine－Masculine	.627	−.178	.367	−.191
Warm－Cold	.584	.422	−.130	.037
Positive－Negative	.530	.085	.027	.105
Natural－Unnatural	.406	−.067	−.179	−.161
Elegant－Unpolished	.053	.775	.158	.014
Dynamic－Static	−.088	.773	.089	−.001
Strong－Fragile	−.008	.587	.116	.032
Fresh－Sordid	.104	.472	.013	.010
Childish－Adult	.200	.373	−.220	−.103
Impressive－Unimpressive	.200	−.056	.724	−.143
Urbane－Rural	−.127	.194	.497	.014
Individual－General	−.002	.019	.487	.334
Sharp－Dull	−.098	.062	.190	.669
Eastern－Western	−.269	.098	.296	−.453

Maximum likelihood method, Promax rotation

Factor analysis for the average female faces

Factor analysis for the average female faces yielded four factors with an eigenvalue greater than 1 (Table 3). Only Factors 1 and 2 were named to focus the analysis on latent variables with good explanatory power. Factor 1 had the highest explanatory power, and was named “Friendly” based on the connotations of the adjective pairs associated with it, including Like－Dislike, Friendly－Unfriendly, Attractive－Not Attractive, and Bright－Dark. Factor 2 was labeled “Elegant” based on the associated pairs, including Elegant－Unpolished, and Strong－Fragile. The factor scores of the subjects who rated the female faces (n＝30) were then individually plotted, separately for the Neutral, Smile, and Grin facial stimuli (Fig. 6). Factor 1 (Friendly) is plotted on the horizontal axis and Factor 2 (Elegant) on the vertical. The neutral female face was associated with negative factor scores in both Friendliness and Elegance for nearly all subjects. The impressions grew more positive in both dimensions for the smiling face, and even better for the grinning face. The grinning face was perceived as the friendliest and most elegant, followed by, in descending order, the smiling and the neutral faces.

Figure 7 compares the mean factor scores for each stimulus. Mean Friendliness scores (Neutral :

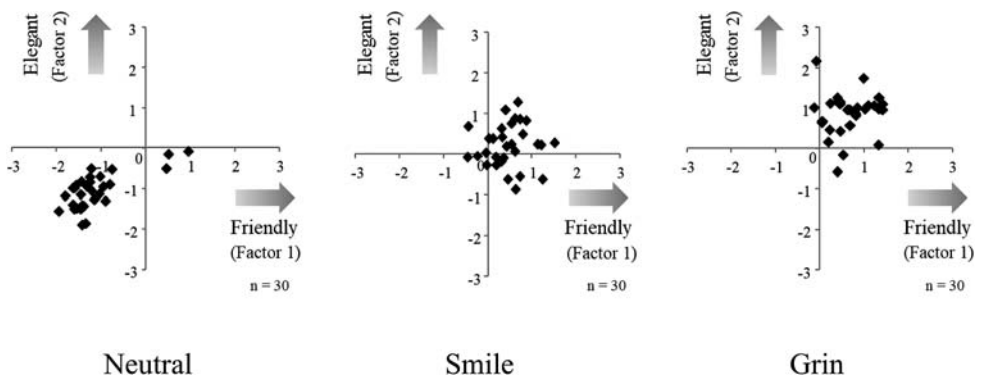

Fig. 6 Factor score distribution for the average female facial images.

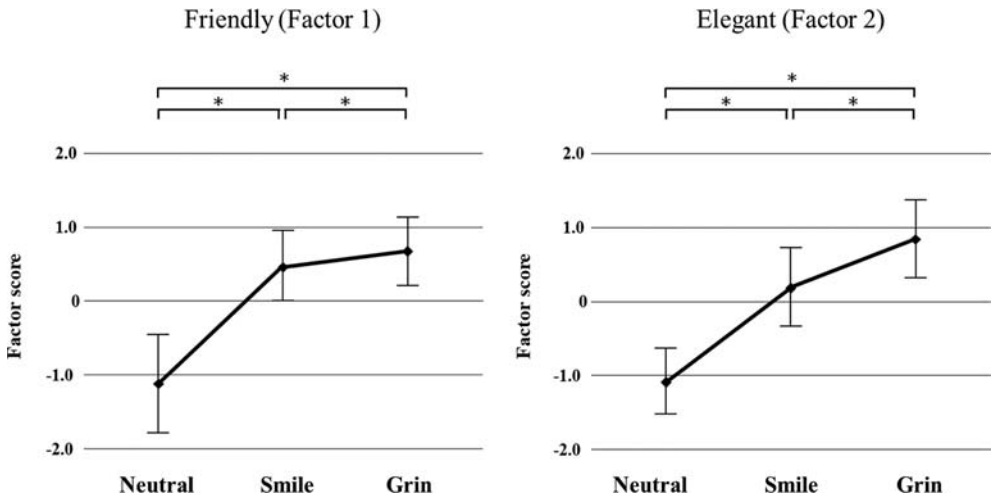

Fig. 7 Comparison of factor scores for the three average female facial images (n＝30, *$p<0.05$, ◆ Mean±SD).

−1.13, Smile : 0.47, Grin : 0.67) were found to be significantly different by repeated-measures one-way ANOVA ($p<0.05$). Subsequent multiple comparisons testing revealed significantly greater friendliness was perceived for Smile and Grin than for Neutral ($p<0.05$), and for Grin than for Smile ($p<0.05$). Thus, for females, grinning faces appear to give the friendliest impressions to observers, followed by smiling and neutral faces. The mean elegance scores (Neutral : −1.07, Smile : 0.21, Grin : 0.86) were also found to be statistically different by repeated-measures one-way ANOVA ($p<0.05$). Subsequent multiple comparisons testing revealed that significantly greater elegance was perceived for Smile and Grin than for Neutral ($p<0.05$), and for Grin than for Smile ($p<0.05$). Thus, for females, grinning faces give the most elegant impression to observers, followed by smiling and neutral faces.

DISCUSSION

Osgood *et al*. originally designed the semantic differential method as a psychosocial measurement tool for quantifying the conceptual meanings of words, as well as mental images of people and governments.[11] Since then, the method has been utilized in a variety of non-linguistic research, such as in psychology and sensory analysis, as a way to empirically and quantitatively identify the underlying structure of concepts using language-based scales. Modern applications are wide-ranging, and include construction planning,[12] product development,[13] and questionnaire research.[14] Experimental subjects are asked to rate an object of interest along a number of scales, each anchored by a pair of opposite adjectives. Typically, each scale is bipolar and consists of five or seven levels, commonly known as a Likert scale. Corresponding numerical ratings are quantified as scores, and the entire dataset is subjected to factor analysis to uncover the latent dimensions of the evaluation.

Factor analysis is a type of multivariate analysis procedure for reducing a high number of variables to a smaller number of latent, common variables ; when successful, these extracted 'factors' can well explain the original data. In this work, subjects rated their impressions of composite, "average" faces, which had been processed to neutralize features unique to single faces and photos, leaving only common traits.[15] Average faces are a visualization of an archetypal face within a given population, making them a useful tool for studying faces. Our decision to use 10 facial photos for each composite image was based on previous work by Nishitani *et al*., showing that using more than 10 does not produce substantial differences in recall, specificity, or attractiveness ratings.[16]

Neutral vs. smiling/grinning faces

Characteristic physical changes occur in the face when someone smiles : the corners of the mouth rise, the cheeks bulge outward, and the eyelids change shape. The extent of these changes, along with movement patterns, affect an observer's impression of that smile.[17] Faces exhibiting positive and negative affectations tend to produce congruent impressions in the mind of an observer.[18] Smiling is undoubtedly a biological signal－a display of inner happiness－but it is also universally understood as a gesture of sociability and intimacy.[19] These notions agree with our findings of higher scores on major factors for smiling and grinning faces than for neutral faces, regardless of gender. Moreover, the highest common factors－ sociability followed by activity for men, and friendliness followed by elegance for women－were invariably positive, eliciting strong positive impressions.

Smiling vs. grinning faces

Our findings of enhanced positive impressions of smiling faces corroborate those of Sugahara *et al*., on whose work our own was modeled.[5] However, our study did not compare smiles with teeth exposed versus unexposed at a constant smile intensity. Attractiveness ratings can be constrained when a smile is too intense (e.g. broad or exaggerated), while the exposure of rows of teeth can alter observers' feelings as well.[20] Since the stimulus faces were prepared without specifying the intensity of the smiles, our findings do not necessarily mean that teeth exposure led viewers to perceive the faces as more attractive. However, scores for the two highest common factors were significantly higher for the grinning than the smiling faces, for stimuli of both genders. Since teeth exposure was the primary difference between our Smile and Grin stimuli, it can be assumed that visible teeth are involved in the formation of positive impressions.

Average male vs. female faces

Previous studies have noted gender differences in how attractiveness ratings are influenced by smiling. The effects of smiling are more pronounced in women than men. Rating gaps between smiling and neutral faces are greater for female than for male stimuli.[21] Moreover, smiling improves observer perceptions of a woman's femininity, whereas behavior reduces a man's perceived masculinity.[22] Elegance was associated with the greatest difference in factor score between the Smile and Grin stimuli across all factors and genders. It seems logical that this score was particularly enhanced, because unlike the other factors, elegance is an archetypically feminine trait. Our work revealed that average photos of men smiling with teeth exposed convey impressions of sociability and activeness, while comparable photos of women give impressions of friendliness and elegance. Future studies are planned to assess how people's impressions are affected by non-aesthetic dental restorations and discolored teeth.

This study was conducted with the approval of the Ethics Committee of Osaka Dental University (Approval no.110986). The authors declare no conflict of interests.

This study was presented at the 563 th meeting of the Osaka Odontological Society, June 8, 2019, in Hirakata, Japan.

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