

Muscle Activity Patterns and Geometrical Features in Attractive Facial Expressions

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Abstract—The purpose of this study is to clarify the factors of the attractive smile by measuring geometrical features of face and facial muscle activities. In the geometrical features of smile, we found that the aspect ratio of the rectangle composed by straight line that connected the corner of eyes and straight line that connected the corners of the mouth gave an approximate value of the golden proportion (1.618). Then the facial muscle activities that caused a change on skin surface were measured by surface electromyography and the physiological mechanism of the smile was examined. It became clear that the muscle activities of the risorius and depressor labii inferioris had a significant effect on the formation of the smiling faces.

1. INTRODUCTION

The good face represented by a smile is the symbol of happiness. It fascinates us, and comforts our heart. For example the face of Mona Lisa with a smile and children's one are regarded as the good face. But we feel like that the number of people with the good face

recently have decreased in Japan. Modern society has lost an environment with the smile and humor; the people who are absorbed in the mobile phone fill the town to overflowing. Human communication abilities seem to decline though telecommunication equipments are in wide use. The depression and withdrawal are on the increase because of the lack of communication and the truancy of schoolchildren becomes a social problem. We think that a blockade of mind has relations with the control of expressions closely. The face is generally said as the window of mind. We would like to take a close-up of the face that tends to be cloudy in this study.

Over the past few decades, a considerable number of studies have been conducted on the face in the psychology, the psychophysiology and the physiognomy [1]. The good face has a wide diversity of interpretation because it is the theme of *kansei* field. The recognition of the good face cannot be shared, because it is vague and it has not been analyzed sufficiently. Therefore we examined the recognition of the good face in this study, and clarified the factor that the good face fascinated people. As a result we found that geometrical beauty was shown in the fascinating smile.

2. IMPRESSION EVALUATION OF EXPRESSIONS

It is generally said that the good face is a smile. The impression evaluation about the expressions was done to confirm it with facial photographs.

The task for making of 11 emotional expressions (No.1 lack of expression, No.2 surprise, No.3 attractive expression that subject regard, No.4 expression of seeing attractive expression photograph, No.5 expression of staring the opposite sex with a smile, No.6 expression of staring the same sex with a smile, No.7 surprise, No.8 fear, No.9 hatred, No.10 anger, No.11 forced smile, No.12 sorrow) was given to two university students aged 21 and 23; photographs of their expressions were taken. The photographs of the good face were clarified by the principal component analysis. They were arranged in the two-dimensional display that the horizontal axis showed attractiveness and the vertical axis showed a dynamic feeling (Fig.1). Furthermore a facial part of the good face that watched with interest was investigated by the questionnaire. We asked 50 responders to answer the most attractive part of face that was divided into 12 regions when the good face was chosen (Fig.2).

It was found from the result that the good face was a natural smile which had attractive factors in eyes and a mouth. This result is in accord with reports that show

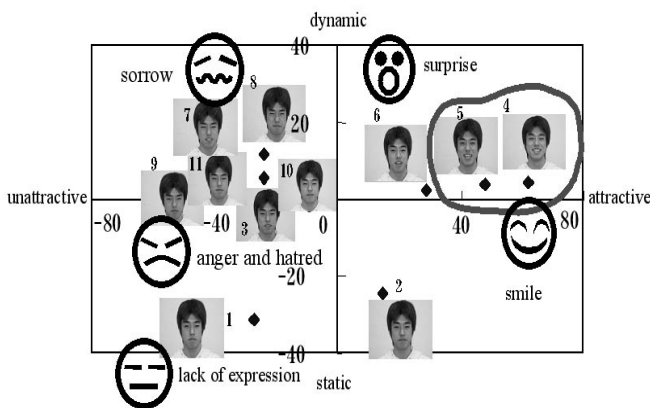
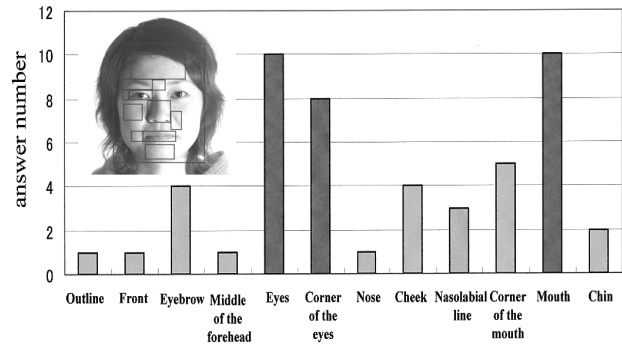


Fig.1 Impression evaluation of expressions. This is a result of the analysis of the expression in the man subject. The horizontal axis shows the level of the charm, and the vertical shows the level of activity.



Attractive parts in the face

Fig.2 Part of face that paid attention to judgment of attractive expression. The answer was requested referring to the photograph of face divided in figure.

the importance of eyes and mouths in the smile cognition [2][3]. The expression of surprise got the impression that it was attractive next to the smile. Unexpectedly the lack of expression was judged to be a face of as unattractive as the anger and hatred expression that showed negative emotions.

In this chapter, we assume that the good face is a smile that changing eyes and a mouth cause. Then it is necessary to analyze the mechanism and the shape of the smile so as to design the good face more attractively. In Chapter 3, we clarify an internal mechanism of the smile for the purpose of designing the good face by facial exercise. In Chapter 4, we search the geometrical information of smile for the factor of the charm in the recognition of the smile.

3. INVESTIGATION FOR MECHANISM OF SMILE AND GRIN

We seems that other expressions are lively because the smile is attractive. The question now arises: How are eyes and a mouth transformed, and does a smile become attractive as a result? Strictly speaking the smiling face is divided into the smile that covers teeth and the grin that is a toothy smile. The formation of these expressions consists of various muscle activities such as orbicularis oculi, zygomaticus major, risorius (Fig.3). But the muscle activity patterns of smile and

grin are not clear; the detailed mechanism in the good face are unknown. We carried out an experiment to reveal the muscle activities that produce smile and grin, which we analyzed the good face from an electrophysiological point of view.

We have to keep the smile and grin on fixed posture of face to know a mechanism of the good face. The muscle activities of zygomaticus major that the control of voluntary contraction is easy were adjusted to 25%, 50%, 75%, 100% of maximum voluntary contraction (MVC) by the visual biofeedback of electromyogram (EMG) [4], and we made it possible that expressions of 4 strength level were formed in each of smile and grin. The muscle activity patterns of 8 expressions were measured in 4 subjects.

The muscle activities of zygomaticus major,

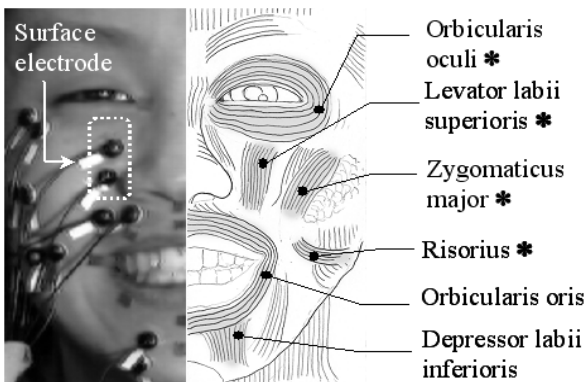


Fig.3 Facial muscles targeted for measurement. The leading part in smile is zygomaticus major. The muscles attached the asterisk are considered that they form the smile and grin.

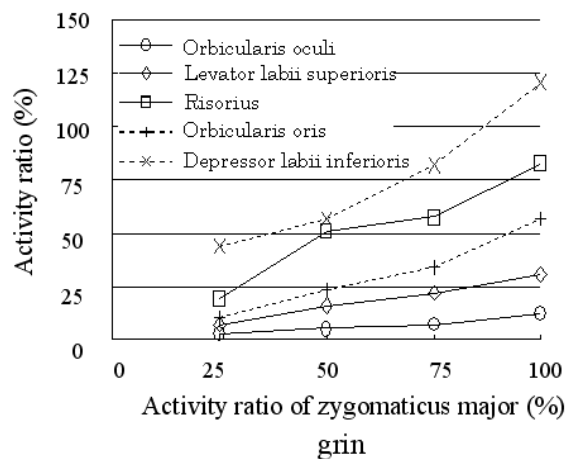
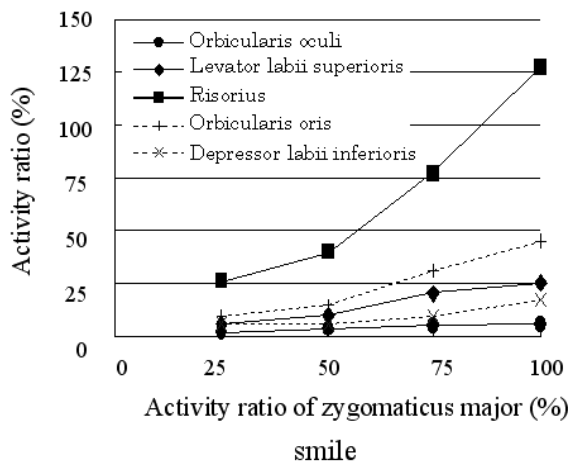


Fig.4 Muscle activity patterns of smile and grin. The horizontal axis shows %MVC of zygomaticus major, and the vertical shows %MVC of the other facial muscles.

orbicularis oculi, levator labii superioris, orbicularis oris, depressor labii inferioris in right side of the face were recorded by EMG. These are the muscles that relate to changing eyes and mouth that are the charm factors clarified by the questionnaire. EMG recordings were bipolar from pairs of 3.5 mm Ag/Ag-Cl surface electrodes with inter-electrode distance of 10 mm. Derived signals were amplified 2000 times, and sampled at a rate of 2300 Hz with an A/D converter. Recorded EMG signals were integrated and their value was showed continuously on the CRT display. The subject watched the CRT while they adjusted their facial muscle contraction.

As for the formation of smile, risorius was active remarkably in proportion to the activity of zygomaticus major. The muscle activity of risorius in the smile exceeded the activity in MVC by 26 %. The formation of grin was clarified that the activities of risorius and depressor labii inferioris influenced it greatly (Fig.4). The muscle activity of depressor labii inferioris in the grin exceeded the activity in MVC by 23 %.

These results indicate that grin exercises more complex than smile by using facial muscles of lower part to form the triangle of mouth. The feature of the muscle activity in grin is similar to the laugh [5]. We recognized an important role of depressor labii inferioris that had not receive much attention for the face of grin. The activity of the orbicularis oculi

which had been expected was small with regard to the smile and grin. However, their expressions showed the narrow optic fissure. This was presumed that the dermal compression caused by the bulge of cheek changed eyes. In this chapter, we understood the physiological mechanism of smiles and obtained the clue to design the good face by facial muscle exercise.

4. GEOMETORICAL FEATURES THAT APPEARS IN THE GOOD FACE

We clarified the feature of some kinds of smiles but this was an attempt to search for a physiological feature of the smile. The factor of beauty to which the smile attracts people is not referred. When we pay attention to not the shape of eyes and mouth but the change in a relative position, the figure that specially appears with a smile is discovered. The figure is a rectangle imagined that eyes and mouth are the upper and lower vicinity. In the formation of the smile, eyes narrow and the upper lip is changed horizontally by the lift of the angle of mouth. The rectangle that consists of eyes and a mouth is acknowledged as fascinating information with a smile. Then, we measured the aspect ratio of this expression rectangle, and investigated the difference by the

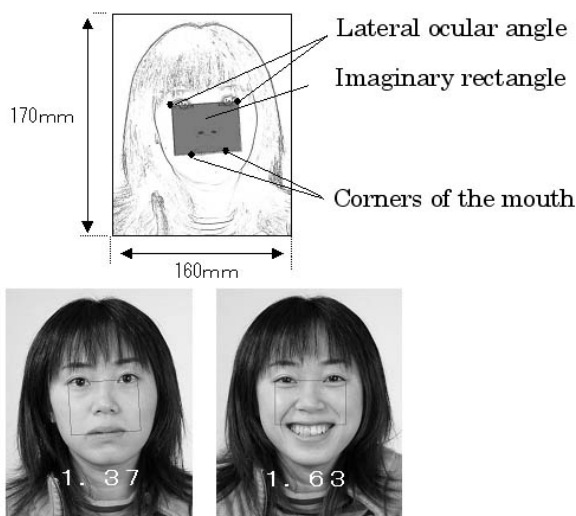


Fig.5 Comparison of expression rectangles of the lack of expression and the smile. The numerical value in this figure shows the calculation result of the expression rectangular aspect ratio of subject CY.

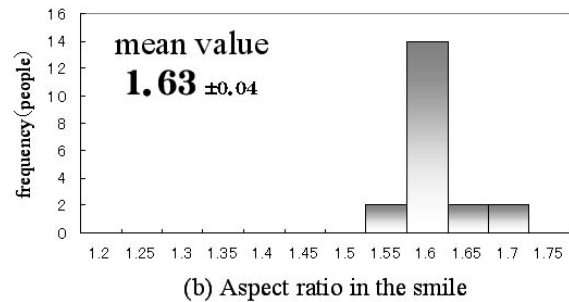
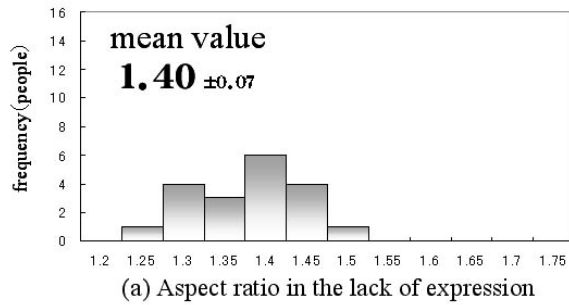


Fig.6 Histogram that shows frequency of aspect ratio of the lack of expression and the smile.

individual (Fig.5).

The photographs of smiles and expressionless faces with 20 adult men and women were taken during the communication between the photographer and the subject. Several photographs of smiles were taken in 3 minutes. The photographer chose the photograph that the impression of the smile was the strongest as an experiment sample. The rectangular aspect ratio of the smile was calculated; an interesting finding was obtained consequently. The mean value of a rectangular aspect ratio that appeared with a smile was 1.63, which was an approximate value of the golden ratio (1.618). In addition, this ratio became clear that the individual variation was small (Fig.6). We deduce from the result that smiling will form the golden rectangle called a symbol of beauty [6]. On the other hand, the mean value of the aspect ratio in the lack of expression was 1.40, which was an approximate value of the silver ratio (1.41).

In addition, we performed the comparative experiment with respect to the rectangular aspect ratio of the attractive smile and the unattractive smile. At the beginning, 5 photographs of faces with smile were taken with the shout of "Smile" in 20 volunteers. The

subjects confirmed five photographs were able to be recognized the smile. They chose what liked most and the hated one from their smile photographs. Those two were assumed to be the best smile and the worst smile and the aspect ratio was calculated. We showed the mean value of the aspect ratio of the lack of expression, the best smile and the worst smile in Fig.7.

The mean value of the best smile was 1.60, which was an approximate value of the golden ratio. The mean value of the worst smile was 1.56 and it was different from the golden ratio. The mean value of the aspect ratio in the lack of expression was 1.40; the value similar to the previous result was obtained.

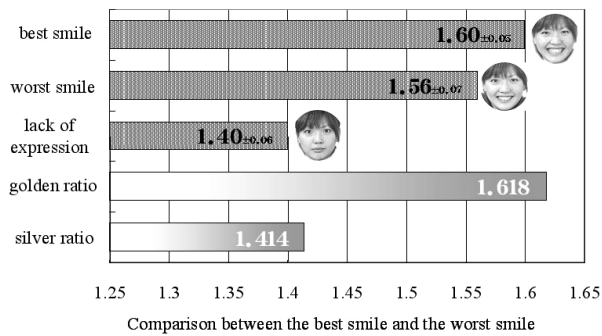


Fig.7 Bar graph shows the aspect ratio of the best smile, the worst smile, the lack of expression and the golden ratio, the silver ratio.

5. DISCUSSION

Euclid defined the golden rectangle but the golden ratio exists in the nature essentially. The human being has used the golden ratio that was the harmony of nature for the construction, the size of article and the art since old times. The reason why the golden ratio fascinates the people is not understood. Therefore it is very interesting that these results showed that the golden rectangle appeared in the best smile. The golden ratio might be related to the judgment of the good face because the worst smile in some smiles was considered as the unattractive face. Moreover, the lack of expression had the silver ratio in the rectangle on the face. The silver ratio is the beautiful proportion next to the golden ratio. Though the lack of expression was assumed to be the one of unattractive in the impression

evaluation, it seems to have the stable geometrical feature.

The smile is wide from the attractive to the ugly because it is a combination of two or more muscle activities; it is generally recognized that a big smile is attractive. The golden ratio appeared with a big smile that lifted up the angle of mouth in this study. As for the face, it consists of various parts and a lot of the volume of information exists. It is quite likely that the facial information is reduced to the geometric figure that has the golden ratio and recognized with a smile. It will be necessary to clarify the recognition mechanism of the golden rectangle that appears with a smile in the future.

6. CONCLUSIONS

The golden proportion found in the face had been reported about features. However, the result of this research shows that every person can form the attractive smile and the gold beauty be acquired without depending on features. If the movement of risorius that forms smile and the movement of depressor labii inferioris that forms grin are trained, it will become easy to design the good face.

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