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The way children look at the upright photograph of a male dentist's face —Analysis using non-contact type of eye movement measuring apparatus FreeView®—

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Abstract We investigated how child patients take in information from a dentist's face and whether there is any age difference in the way of scanning the face. For this purpose, we used a non-contact type of eye movement measuring apparatus tradenamed FreeView® and an upright photograph of a male dentist's face as the test image. The subjects consisted of a total of 90 children between the ages of 2 years 11 months and 12 years 11 months. The subjects were divided into three age groups-group A (below 7 years), group B (7–9 years) and group C (10 years or above), and their eye movements were measured and analyzed. Our findings are as follows.

1. The saccadic movements to the background of the photo and the fixation points in the background decreased most in group C, followed by group B and group A, in that order.
2. The overlapping of saccadic movements to the features of the face (the eyes, nose and mouth) was remarkably in all age groups. However, the subjects did not scan the whole of the appearance of the face (the hair, forehead, cheeks, ears and chin).
3. The fixation points on the appearance of the face were unevenly distributed. Many fixation points were found close to the features of the face. This peculiarity was common to all the groups.
4. The fixation points on the features of the face increased most in group C, followed by group B and group A, in that order.

Key words
Eye movement,
FreeView,
Upright photograph of a face

Introduction

In everyday life, we receive lots of perceptual information from other people's face regarding their identity, their feeling, their characters, their health conditions and so on, to say nothing of their ethnicity, gender and age[1]. In interpersonal communication, you may infer from the facial expression of your partner what he or she has in mind right now and what he or she is wanting, and adjust yourself to the situation. In other words, one's face plays an important role in interpersonal communication.

In the practice of pediatric dentistry, what is important is to establish a trusting relationship between the dentist, child patients and their mothers in the sociocultural context. Therefore, it is essential for the dentist to set the time and place to communicate with the patient enough to deepen mutual understanding. Regarding this, there are many published studies[2–6]. Some researchers delved into how a human perceives another human's face[7,8],

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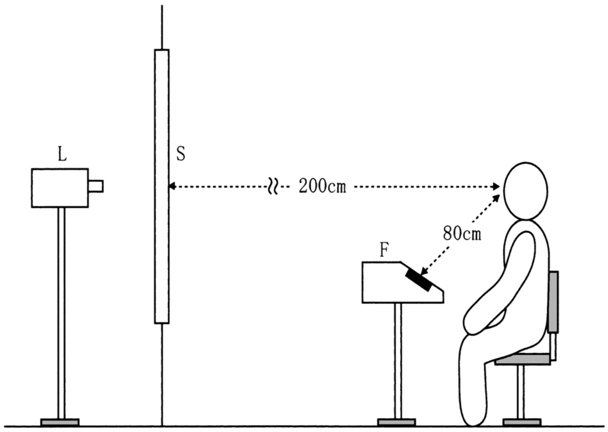


Fig. 1 Arrangement of experimental devices
L: Liquid-crystal projector, S: Screen, F: FreeView

Fig. 2 Experimental scene

while other researchers looked into the emotions expressed on the face[9–11]. In the domain of dentistry, however, not a single ecological study has been done on how dentists and child patients take in perceptual information from one another's face when they meet.

In order to gain insight into how child patients look at the other people's face, it would be best that we could measure the eye movements of them in an actual clinical setting and examine their characteristics closely. However, at this point in time, further improvements are yet to be made to eye movement measuring apparatus so that it is impossible to measure eye movements three dimensionally. Dent[12] reported that child patients could recognize a person much more accurately when that person's photograph was shown than when they saw the very person in a lineup.

In our latest experiment, we presented a upright photograph of a male dentist's face to child patients to find out where they fixed their eyes for taking in information, and examined whether there was any difference between the different age groups in their way of scanning the face. To measure the child patients' eye movement, an apparatus of a non-contact type (FreeView, Takei Kiki Kogyo Co., Japan) was used.

Subjects and methods

1. Subjects

The subjects enrolled for this study totaled 90 child patients who were receiving treatment at Pediatric Dentistry, Nippon Dental University Hospital at Niigata. They were between the ages of 2 years 11 months and 12 years 11 months. As there was nothing wrong with their visual acuity, we judged them fit for the experiment. The subjects and their guardians were told all about this study and its purpose, and all gave their informed consent.

2. Time and place

The experiment was carried out in a shield room built within our research laboratory from 9 a.m. and to 6 p.m. on the day when each child patient visited our hospital. The shield room was 315 cm wide, 380 cm deep and 265 cm high. It was equally partitioned off into two parts—one allocated for experimentation and the other being the centralized monitoring and data recording room.

3. Experimental equipment and recording devices

For measuring eye movements, FreeView was used. First, weaknear-infrared rays were applied to the eyes of the subjects. Then, the photographs of the Purkinje-Sanson images and the position of the reflection of the cornea were taken by the camera attached to the detector of FreeView. Eye movements were measured by processing the images on the computer (LPC-CE53SE®, Logitec Co., Japan). FreeView was set up 80 cm downward in front of the median point between the eyes of each subject.

To present a test image, a screen 106 by 141 cm was set up. The test images was projected on this screen from behind with a liquid-crystal projector (XVH-1®, Sharp Co., Japan). The distance between the screen and the subject was 200 cm, the position

Fig. 3 Test image

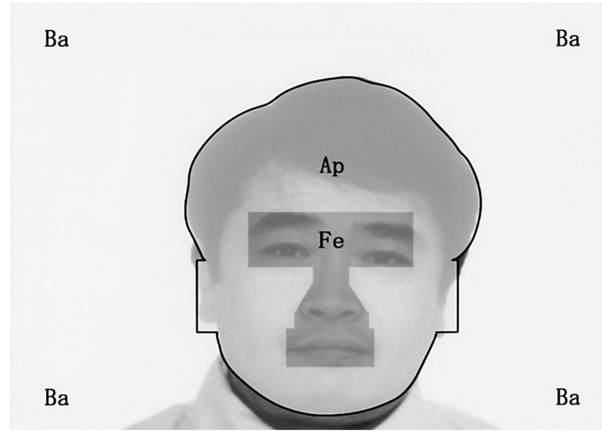


Fig. 4 Division of test image at analysis
Fe: Features of the face, Ap: Appearance of the face, Ba: Background

where the size of the screen agreed with the effective picture angle (±20 degrees) of FreeView (Fig. 1).

For recording eye movements, the above-mentioned computer was used. The data of eye movements were inputted at every 33.0 ms in accordance with the method employed in a series of studies we had conducted using a contact-type apparatus tradenamed Visicon Eye Camera[13–17].

To analyze eye movements, the statistics program for eye movements (Takei Kiki Kogyo Co., Japan) was used together with the computer and display (LCM-17FS2®, Logitec Co., Japan).

4. Experimental protocol

The subjects were seated in the chair so accommodated that their Frankfort horizontal plane became just level with the center of the screen. Their head was placed at the jaw rest (Takei Kiki Kogyo Co., Japan) (Fig. 2). Then, a calibration picture was shown on the screen and corrected with the computer by automatically turning on the light spots in the middle, upper, left, lower and right parts of the screen one by one in that order. Each of the subjects was made to follow the lights with the eyes. When the calibration was done, the test image was shown for 5 seconds and the eye movements were measured and recorded.

The test image used was a upright photograph of a male dentist's face (Fig. 3). This was on the assumption of the scene in which the child patients were confronting at the dentist in the clinic. However, the subjects had not been told anything at all about the test image.

Analytical methods

For the sake of analysis, the subjects were divided into three age groups, each being composed of 30. Group A consisted of children under 7 years of age; group B, between the ages of 7 and 9; and group C, between 10 and 12. Analyses were made of the eye movements which appeared for 3 seconds from the first appearance of the subjects' eyes on the test image[16,17]. More specifically, the fixation points with less than 5 degrees in terms of angular speed per second and the saccadic movements with 5 degrees[18] or more were examined as regards the following items in each group.

1. Overlapping of saccadic movements

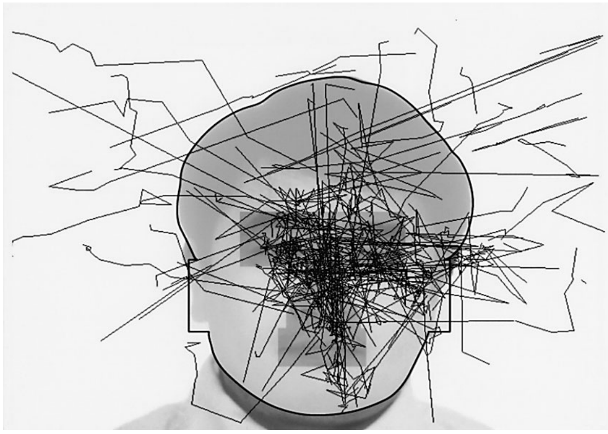
In the beginning, the test image was divided into three areas as shown in Fig. 4—the features of the face such as the eyes, nose and mouth[19], the appearance of the face containing the hair, forehead, cheeks, ears and chin[19], and the background. Next, all the saccadic movements were overlapped upon the test image (Fig. 4) and then the tracks of the eye movements were examined.

2. Distribution of fixation points

The distribution of fixation points was examined by plotting all the fixation points on the test image (Fig. 4).

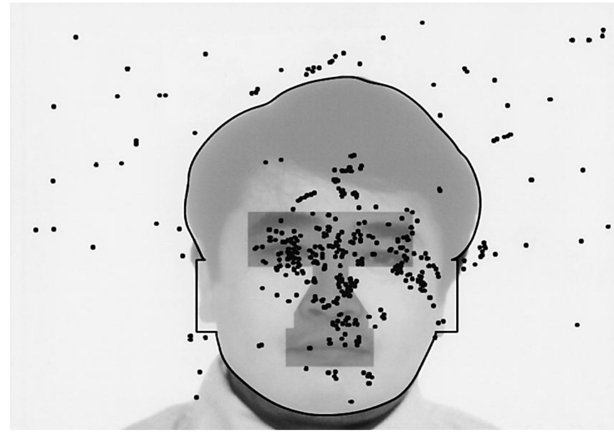
3. Frequency of fixation

The number of times the subjects' eyes were fixed was investigated for each area of the test image.



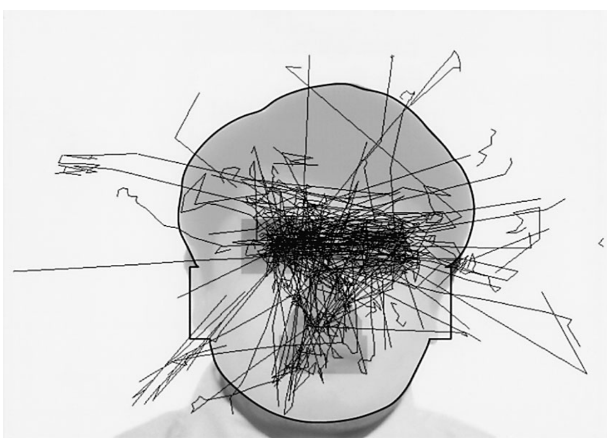
n = 30

Fig. 5 Overlapping of saccadic movements (Group A: Below 7 years)
——: Saccadic movements



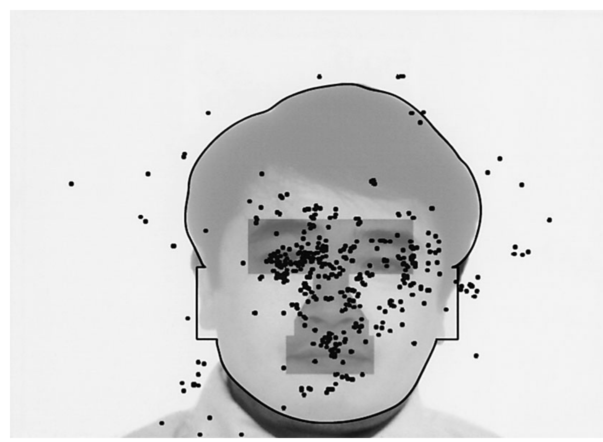
n = 30

Fig. 8 Distribution of fixation points (Group A: Below 7 years)
•: Fixation points (396 times)



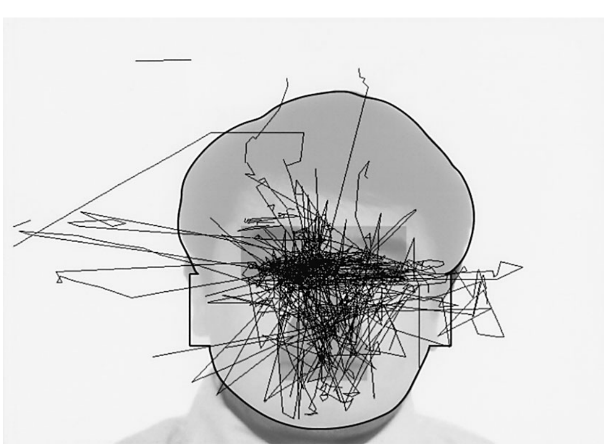
n = 30

Fig. 6 Overlapping of saccadic movements (Group B: 7–9 years)
——: Saccadic movements



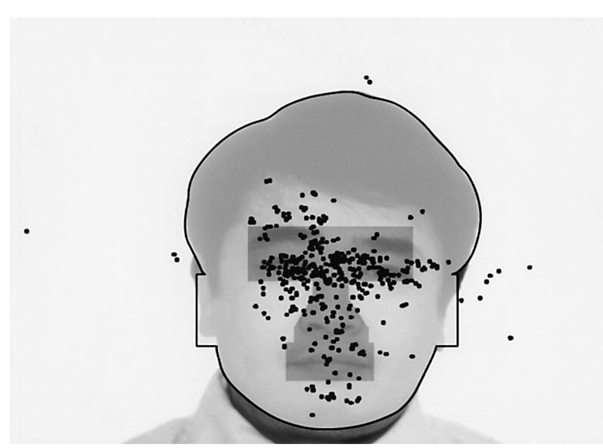
n = 30

Fig. 9 Distribution of fixation points (Group B: 7–9 years)
•: Fixation points (412 times)



n = 30

Fig. 7 Overlapping of saccadic movements (Group C: 10 years or above)
——: Saccadic movements



n = 30

Fig. 10 Distribution of fixation points (Group C: 10 years or above)
•: Fixation points (439 times)

Table 1 Frequency of fixation

Area	Group A (n = 30)	Group B (n = 30)	Group C (n = 30)
Fe	189 (47.7)	221 (53.6)	299 (68.0)
Ap	132 (33.3)	148 (36.0)	127 (29.0)
Ba	75 (19.0)	43 (10.4)	13 (3.0)
Total	396 (100.0)	412 (100.0)	439 (100.0)

times (%)

Group A: Below 7 years, Group B: 7–9 years, Group C: 10 years of above
Fe: Features of the face, Ap: Appearance of the face, Ba: Background

Table 2 Duration of fixation

Area	Group A (n = 30)	Group B (n = 30)	Group C (n = 30)
Fe	10,659 (46.9)	12,111 (57.1)	16,434 (68.8)
Ap	8,217 (36.2)	7,458 (35.1)	6,831 (28.6)
Ba	3,828 (16.9)	1,650 (7.8)	627 (2.6)
Total	22,704 (100.0)	21,219 (100.0)	23,892 (100.0)

ms (%)

Group A: Below 7 years, Group B: 7–9 years, Group C: 10 years of above
Fe: Features of the face, Ap: Appearance of the face, Ba: Background

4. Duration of fixation

The length of time the subjects' eyes were fixed was investigated for each area of the test image.

5. Patterns of fixation

The patterns of fixational eye movements were investigated and the number of subjects was counted according to the type of pattern for each group.

Results

1. Overlapping of saccadic movements

All the saccadic movements shown by 30 subjects in each group within the space of 3 seconds were presented in Figs. 5, 6 and 7.

2. Distribution of fixation points

The distribution of all the fixation points shown by 30 subjects in each group within the space of 3 seconds were presented in Figs. 8, 9 and 10.

3. Frequency of fixation

In group A, subjects fixed their eyes 189 times (47.7%) on the features of the face, 132 times (33.3%) on the appearance of the face and 75 times (19.0%) on the background. Likewise, the fixation frequencies for group B were 221 times (53.6%), 148 times (36.0%) and 43 times (10.4%), and those for group C were 229 times (68.0%), 127 times (29.0%) and 13 times (3.0%) (Table 1).

4. Duration of fixation

Subjects in group A gazed on the features of the face for 10,659 ms (46.9%), on the appearance of the face for 8,217 ms (36.2%) and on the background for 3,828 ms (16.9%). Likewise, the fixation time scores for group B came to 12,111 ms (57.1%), 7,458 ms (35.1%) and 1,650 ms (7.8%), and those for group C came to 16,434 ms (68.8%), 6,831 ms (28.6%) and 627 ms (2.6%) (Table 2).

5. Patterns of fixation

Five types of fixation pattern were recognized in group A, four types in group B and three types in group C. Broken down by type, one person (3.3%) in group A, two persons (6.7%) in group B and six persons (20.0%) in group C focused their eyes only on the features of the face. The features and appearance of the face were shown by nine persons (30.0%) in group A, 14 persons (46.6%) in group

Table 3 Patterns of fixation

Pattern	Group A	Group B	Group C
Fe	1 (3.3)	2 (6.7)	6 (20.0)
Fe • Ap	9 (30.0)	14 (46.6)	17 (56.7)
Fe • Ap • Ba	15 (50.0)	12 (40.0)	7 (23.3)
Ap • Ba	4 (13.4)	2 (6.7)	0 (0.0)
Ba	1 (3.3)	0 (0.0)	0 (0.0)
Total	30 (100.0)	30 (100.0)	30 (100.0)

person (%)

Group A: Below 7 years, Group B: 7–9 years, Group C: 10 years of above
Fe: Features of the face, Ap: Appearance of the face, Ba: Background

B and 17 persons (56.7%) in group C. Likewise, the features and appearance of the face plus the background was accounted for by 15 persons (50.0%) in group A, 12 persons (40.0%) in group B and seven persons (23.3%) in group C; the appearance of the face plus the background by four persons (13.4%) in group A and two persons (6.7%) in group B and none in group C; and only the background by one person (3.3%) in group A and none in groups B and C (Table 3).

Discussion

1. FreeView

FreeView is a new type of eye movement measuring apparatus. With the eye movement detector installed at the front of the apparatus, it is capable of determining the position of fixation points of the eyes and the traces of eye movement on the screen. The subjects do not need to put on this apparatus.

The principle of detection is something like this: Faint near-infrared rays are applied to the eyes, and by the corneal reflex method, Purkinje-Sanson images and the position of the pupillary reflex are photographed with the camera attached to the detector. Moreover, this measuring apparatus is an extremely time-saving device because fine adjustment, calibration, measurement and all can be done in a minute. This has made it possible to greatly lessen the burden of child subjects, thus paving the way for the participation of very young children in this kind of experiment without much difficulty.

2. Eye movement

When the full-face of a male dentist's face was shown to subjects, they moved their eyes in various ways. In our experiment, the subjects had not been told that the photo of a male dentist's face would be presented as a test image. Therefore, it was only natural that the subjects actively exploring the given environment had shown diverse eye movements. Differences in eye movement were so diverse from one individual to another that in the previous studies, we had not been able to clarify specific age differences in eye movement among subjects, although this had been one of the primary objectives of our studies. In the latest experiment, the subjects between the ages of 2 years 11 months and 12 years 11 months were divided into three groups — group A consisting of infants, group B of lower-grade elementary schoolchildren and group C of students in the upper grades according to the classification used in the previous study[16].

When one person is looking at another person's face, that person is doing nothing but looking at another person's facial expression[20]. To put it differently, that person is not looking at "mono" such as the eyes, the nose and the mouth but "koto" such as changes in expression. Nonetheless, in our experiment, we used a test image in which a person's expression stayed unchanged. In such circumstances, it is necessary to take in a form of an object as such and to deal with the test image as a snapshot of a human face. In our latest experiment, we regarded the face as gestalts and divided the photo into the features of the face, the appearance of the face, and the background — the area outside the head — for the sake of analysis.

Although we examined the range, distance and direction of the saccadic movements as we had done in the previous studies[17], we could not find typical differences between groups A, B and C. This was because the results of analysis were all expressed in numerical values and statistically significant differences were not found. To overcome this problem, we attempted to make analyses visually by overlapping all the saccadic movements shown in a fraction of 3 seconds by every one of the 30 subjects in each group. As a result, it was found that the tracks of the saccadic movements toward the background decreased most in group C, followed by group B and group A, in that order. This was substantiated by the fact that the frequency and duration of fixation on the background and the number of subjects whose eyes were fixed on the background decreased more in group B than in group A and more in group C than in group B. In light of Gibson's theory[21], it could be inferred that the background had become an invariant for our elderly children because as the age group became older from group A to group B, further from group B to group C, they empirically took it for granted that the background exists even if they did not look at it.

Yarbus[22] reported that the tracks of saccadic movements reminded him of a human face in an eye movement study in which he showed the subjects a photograph of a human face. If the tracks of saccadic movements were to appear a human face, the tracks had to be found densely in the areas where the eyes, the nose and the mouth are located and also had to be found along the contour of the face. However, our experiment showed that overlapped traces of eye movements concentrated densely on the features of the face in every age group but that either the subjects in group A, B or C did not scan the whole appearance of the face. Therefore, the traces of eye movements did not resemble the shape of a human face at all. We inferred from this that the subjects did not scan the face all over but focused on certain specific area of the face.

Yarbus[22] also reported that his subjects quite frequently focused on the eyes and the mouth of the person in the photograph. In an experiment to find out which part of the face infants look at most frequently, Maurer *et al.*[23] presented a human face to an infant and found that the subject focused on the eyes for longer than any other parts of the face. Thanks to these and other researchers' efforts, it has now become a well-known fact that there is a part children are most likely to look at when shown a picture of a human face. Nonetheless, it is still open to discussion as to whether there is any difference in eye fixation between children of different ages when they are scanning a human face. In our experiment, we found from the frequency and duration of fixation that the fixation points concentrated on the features of the face in every age group. This finding suggested that the features of the face must have been useful for the subjects to gather information. Furthermore, we visually examined the distribution of all the fixation points recorded while 30 subjects in each group were scanning the test image for 3 seconds each. The results indicated that subjects in group C fixed at the eyes the most frequently, followed by subjects in group B and subjects in group A, in that order. This suggested that there was an age difference in the way of scanning the features of the face.

It is not that our subjects looked only at the features of the face. They also looked at the appearance of the face. Specifically, there were 28 subjects in group A and the same number of subjects in group B who showed the their eye fixation area included the appearance of the face. In group C, there were 24 such subjects. The fixation points in the appearance of the face were distributed unevenly and were mostly found close to the features of the face. This fact suggested that most of the subjects did not survey the whole appearance of the face. In other words, the appearance of the face was thought to be present beyond all doubt to the subjects without seeing it and invariant. Consequently, it could be inferred, fixation points were concentrated in the features of the face. Furthermore, it could be interpreted that the cluster of fixation points close to the features of the face must have occurred prior to turning the subjects' eyes to the features of the face. Polanyi[19] stated that a meaning of the features of the face is perceived within the appearance of the face by attending from the former (1st proximal term) to the latter (2nd distal term) in an act of tacit knowing. After all, the features of the face cannot be explained without borrowing the meaning of the appearance of the face. However, we have become aware that the subjects did not recognize the features and appearance of the face as logically as the adults do.

References

1) Inui, T.: Perception and Motor Control (Cognitive Psychology 1). University of Tokyo Press, Tokyo, 1995, pp. 143–167. (In Japanese)
2) Ireland, R.L. and Nebr, L.: Introducing dentistry to the child. *JADA* **30**: 280–286, 1943.
3) Jenks, L.: How the dentist's behavior can influence

the child's behavior. *J Dent Child* **31**: 358–366, 1964.
4) Wright, G.Z., Alpern, G.D. and Leake, J.L.: The modifiability of maternal anxiety as it relates to children's cooperative dental behavior. *J Dent Child* **40**: 265–271, 1943.
5) Wright, G.Z. and Lenchner, V.: Behavior Management in Dentistry for Children. W.B. Saunders Co., Philadelphia, 1975, pp. 215–216.
6) Walker, V.J., Voineskos, G. and Dunleavy, D.L.: The effects of psychiatric nurses ceasing to wear uniforms. *Brit J Psychiat* **118**: 581–582, 1971.
7) Bruce, V. and Young, A.W.: Understanding face recognition. *Brit J Psychology* **77**: 305–327, 1986.
8) Ellis, H.D.: Processes underlying face recognition. *In:* The Neuropsychology of Face Perception and Facial Expression. (Bruyer, R. ed.) Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1986, pp. 1–27.
9) Smith, E.E. and Nielsen, G.D.: Representation and retrieval processes in short-term memory: Recognition and recall of faces. *J of Experimental Psycology* **85**: 397–405, 1970.
10) Homa, D., Haver, B. and Schwartz, T.: Perceptibility of schematic face stimuli: Evidence for a perceptual Gestalt. *Memory and Cognition* **4**: 176–185, 1976.
11) Sergent, J.: An investigation into component and configural processes underlying face recognition. *Brit J Psychology* **75**: 221–242, 1984.
12) Dent, H.R.: Stress as a factor influencing person recognition in identity parades. *Bulletin of the British Psychological Society* **30**: 339–340, 1977.
13) Shimooka, S., Seki, N., Takahashi, M., Kobayashi, S., Tsuda, T. and Oka, M.: Cognition for visual perception of operator to the presence of a parent beside the dental chair—The study of relationship between maternal anxious expression and child's behaviors—. *Shigaku* **74**: 58–72, 1986. (In Japanese with English abstract)
14) Seki, N., Shimooka, S., Takahashi, M., Umetsu, H., Chieda, K. and Ashikaga, M.: Cognition for visual perception of operator to the presence of a parent beside the dental chair—The study of relationship between maternal eyes and child's behaviors—. *Shigaku* **74**: 73–87, 1986. (In Japanese with English abstract)
15) Ashikaga, M., Seki, N., Takagi, M. and Shimooka, S.: Cognition for visual perception of a student apprentice of dental hygiene to the presence of a parent beside the dental chair for dental treatment. *Jpn J Ped Dent* **27**: 377–394, 1989. (In Japanese with English abstract)
16) Tomii, E. and Shimooka, S.: Analysis of child patients' visual perception of the dentist's face, using photographs, upright and inverted. *Jpn J Ped Dent* **29**: 396–419, 1991. (In Japanese with English abstract)
17) Kobayashi, M., Suzuki, H. and Shimooka, S.: Analysis of child patients' visual perception of the dentist's face photograph—Analysis of development of eye movement and psychological, circumstantial factors—(Report 1). *Jpn J Ped Dent* **32**: 1081–1091, 1994. (In Japanese with English abstract)
18) Yamada, M. and Fukuda, T.: Definition of gazing point for picture analysis and its applications. *The Transactions of the Institute of Electronics and Communication Engineers of Japan* **9**: 1335–1342, 1986. (In Japanese)
19) Polanyi, M.: The Tacit Dimension. Peter Smith Pub. Inc., Gloucester, 1983, pp. 15–53.
20) Miyako, H.: Psychosomatic Dentistry. Ishiyaku Publishers Inc., Tokyo, 2003, pp. 21–48. (In Japanese)
21) Gibson, J.J.: The Ecological Approach to Visual Perception. (Kozaki, T., Kozaki, A., Tsuji, K. and Murase, A. translated) SAIENSU-SHA Co., Ltd., Tokyo, 1998, pp. 137–157. (In Japanese)
22) Yarbus, A.L.: Eye Movements and Vision. Plenum Press, New York, 1967, pp. 171–211.
23) Maurer, D. and Salapatek, P.: Developmental changes in the scanning of faces by young infants. *Child Dev* **47**: 523–527, 1976.