journal of prosthodontic research xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Journal of Prosthodontic Research

journal homepage: www.elsevier.com/locate/jpor

Original article

Relationship between preference and gaze in modified food using eye tracker

Yuka Yasui*, Junko Tanaka, Masaki Kakudo, Masahiro Tanaka

Department of Fixed Prosthodontics and Occlusion, Osaka Dental University, Osaka, Japan

ARTICLE INFO

Article history:
Received 11 July 2018
Received in revised form 31 October 2018
Accepted 28 November 2018
Available online xxx

Keywords:
Eye tracking
Gaze point
Modified food
Preference

ABSTRACT

Purpose: The relation between preference and the gaze for the test foods under unconsciousness using the eye-tracking system was investigated.
Methods: Participants consisted of 37 healthy volunteers. Test foods were steamed rice 150 g, grilled salmon approximately 45 g and slice cooked squash 60 g, all of which were served on a tray. Foods forms were regular food, chopped food, and blended food. After attached to the eye tracker, participants watched the each dish arranged in front of them freely for 10 s. And they ate test foods freely within 10 min. The gazing point was measured for 10 s from the time when the food was ordered and just before the eating. Preference levels were interviewed. The number of gaze point fixations and the total gaze point fixation time of the viewpoint during 10 s just before eating were analyzed. The analysis items were (1) the total number of gaze point fixations (2) the total gaze point fixation time (3) the amount of food intake and (4) the preference level details.
Results: For foods with higher preference levels, the number of gaze point fixations increased significantly and the total gaze point fixation time significantly increased. In both groups, maximum food intake was observed for food forms with a high preference level. Most of the participants' selected regular foods as their most preferred food form among the food forms.
Conclusions: The results suggested that subjects gazed at regular food which had high preference level.

1. Introduction

The mean life expectancy in Japan has increased in a relatively short period owing to higher economic, health, and medical standards. Furthermore, in 2007, the country became a super-aged society [1]. Going forward, the elderly population is expected to increase with increased aging. Therefore, supporting the health of elderly individuals is becoming an important issue [1].

Eating is essential for an individual's daily lifestyle and is a joy in life [2]. Health awareness surveys among elderly individuals reveal that the elderly dedicate their greatest effort in ingesting a balanced diet to support their health. It has been reported that 80% of elderly individuals take particular care of their diets to maintain their health [3]. Continued intake of unsatisfying food worsens mental, physical, and social quality of life (QOL) while harmfully affecting life purpose [4]. Food occupies an extremely important place in daily life and may greatly contribute to improving QOL. A diet aimed at maintaining a healthy long life in elderly individuals required maintaining food intake targets and satisfactory of taste [5]. An offering food that delighted the tastes of elderly individuals significantly affected satisfaction [5]. A previous study demonstrated that food is a means to ingest nutrients important for health, and that food preferences are very important [5,6]. In Japan, modified foods offered to facility residents during their stay is often determined, based on the evaluation of residents' ingestion and deglutition disorders and during meetings among medical staff. Of note, this indicates that it is difficult to take the preferences of a patient into consideration.

Numerous fields use gaze analysis using the eye-tracking technique [7–12]. Eye tracking facilitates the measurement of unconscious movements in gaze and provides objective data that cannot be obtained via interviews [13]. We believe that this technology could be utilized to identify an individual's unconscious food preferences. Yamamoto et al. reported that individuals focused their gaze on sites that strongly interested them [14]. We previously investigated whether individuals unconsciously fixed their gaze on foods that they liked. Individuals were randomly shown different foods on the left side and right side of a photographs. Each photograph contained two pictures of food (one food on the left and one food on the right) in the following combinations: (1) bread and sandwiches, (2) an omelet and boiled egg, (3) rice balls and rice, (4)

* Corresponding author at: Department of Fixed Prosthodontics and Occlusion, Osaka Dental University, 5-17, Otemae 1-chome, Chuo-ku, Osaka, 540-0008, Japan.
E-mail address: yasui-y@cc.osaka-dent.ac.jp (Y. Yasui).

https://doi.org/10.1016/j.jpor.2018.11.011

potato chips and French fries, and (5) an apple and grated apple. Our purpose was to investigate the extent to which individuals concentrated their gaze on foods for which they had a strong preference. Our findings demonstrated that among all foods shown to the individuals enrolled in the study, their gaze stopped more frequently and for a longer time on foods for which they had a strong preference. Based on these results, we reported a correlation between food preferences and gaze stopping [15].

In elderly people, there is concern that decrease in the amount of food intake may occur due to deterioration of the visual form of food form, which may lead to decreased appetite [16]. In Japan, modified foods offered to residents at nursing home for the elderly during their stay is often determined, based on the evaluation of residents' ingestion and deglutition disorders and during meetings among medical staff. Of note, this indicates that it is difficult to take the preferences of a patient into consideration. At nursing home for the elderly, the decided meals are served every day. Especially, those who are difficult to communicate cannot understand even if they explain that a nutritionally balanced meals is important. They do not eat disgusting foods. Therefore, they tend to be malnourished. It is necessary to consider not only preference but also the food form. It appears that the evaluation of individuals' preferences and food form must be considered to improve dietary QOL.

It has been studied the correlation between food preferences and gaze stopping. However, it remains unclear whether the same correlation exists between food preferences and gaze associated with actual foods offered as modified foods.

In this study, it is assumed that the same result as the previous research can be obtained. The introduction of an eye tracking system (eye tracker) for evaluating selection under unconsciousness can be expected to improve nutrition intake for people with difficult communication. As a result, we think it will be a great help to clear the important issues of Japan "maintaining the health of the elderly".

The present study aimed to investigate the relationship between an individual's unconscious food preferences and gaze for actual foods offered as various modified foods while they used an eye tracker.

2. Materials and methods

2.1. Study participants

The study protocol was approved by the Medical Ethics Committee. Participant recruitment advertisements were posted within the University and the University Hospital. Fifteen individuals were recruited for the young healthy adult group (21–32 years old) and 22 individuals were recruited for the middle-aged to elderly group (51–86 years old). The sample size was calculated by conducting a pilot study using Cohen's index as a determinant with a prior analysis. The level of significance was set at 0.05% and statistical power at 0.8. The necessary sample size of the total number of participants (n = 37) was included. Individuals were given verbal guidelines ahead of commencing the experiment using an explanation sheet. Written consent was then obtained, after confirming that the participants sufficiently understood the content of the study. The data obtained were thereafter processed and stored in an unlinkable anonymized form beginning with the first data collection. When presenting the results at academic societies and so forth, the authors explained that sufficient consideration was provided to make it impossible to identify the participants.

2.2. Eye-tracking system

An eye tracker device (Tobii pro/glasses 2; Tobii Technology Japan, Ltd., Tokyo, Japan) was used for eye tracking (Fig. 1). With this system, four cameras fitted to the head apply infrared rays to the eyeball to sense light and dark areas in the pupils. Images reflected in the cornea were obtained via a video camera to create reflection points (i.e., the Purkinje effect) on the cornea. The pupil points and reflection points were subsequently detected in real-time. Gaze points were measured using the corneal reflex method, which detects eyeball movement based on the positional relationship between the central point of the pupil and the Purkinje effect [13,17]. The corneal reflex method facilitates the measurement of gaze while placing minimal burden on an individual and causing no health damage. The gaze point shifts rapidly due to saccadic movements [18–20]. Therefore, it is difficult to quantify gaze points. Martinez-Conde et al. reported that the gaze point stops when the angular velocity of eyeball movement decreased to $\leq$100°/s [13]. Therefore, they defined a gaze point as motionless when its sampling rate was 50 Hz and the angular velocity of eyeball movement was decreased to $\leq$100°/s [13]. Measured gaze points were recorded using the recording unit. The unit consists of a small computer controlling the head unit (i.e., eye-tracking glasses). Data were recorded in the removable secure digital memory card of the recording unit. The removable secure digital memory cards record and store the eye-tracking data. The memory cards can also be used to store gaze data and sound and moving images. Gaze data stored in the recording unit were analyzed using analytical software (Tobii Studio, version 4.2; Tobii Technology Japan, Ltd.).

Fig. 1. Measuring equipment. Tobii pro/glasses 2 (Tobii Technology Japan, Ltd., Tokyo, Japan) was used.

2.3. Gaze measurement methods

The measurements were obtained from the participant while in a silent private room. The test foods were 150 g of boiled rice, approximately 45 g of baked salmon, and 60 g of sliced cooked squash, all of which were laid out on a tray. The food forms were regular food, chopped food, and blended food (Fig. 2). The participants fitted the eye tracker (Fig. 3). The trays were then randomly placed in front of them. They were asked to freely view the foods for 10 s while standing up. They were given free for up to maximum of 10 min to move places and eat foods. Gaze point measurements lasted 10 s from the time at which the food was presented until just before the food was eaten (Fig. 4). Analysis software was used to analyze the gaze points. We measured the number of gaze point fixations and gaze point fixation time recorded at the analysis sites.

2.4. Interviews on preference levels

After eye tracking was completed, the participants were then presented with photographs of trays containing the same food forms and asked to rank their preference for each food forms and were asked to rank their preference for each food form (i.e., regular food, chopped food, and blended food) to determine their preference levels. Preference levels were ranked as follows: "high" for the food form that they liked the most, "moderate" for the food

Please cite this article in press as: Y. Yasui, et al., Relationship between preference and gaze in modified food using eye tracker, J Prosthodont Res (2018), https://doi.org/10.1016/j.jpor.2018.11.011

Fig. 2. Test food forms. (A) Regular food, (B) chopped food and (C) blended food.

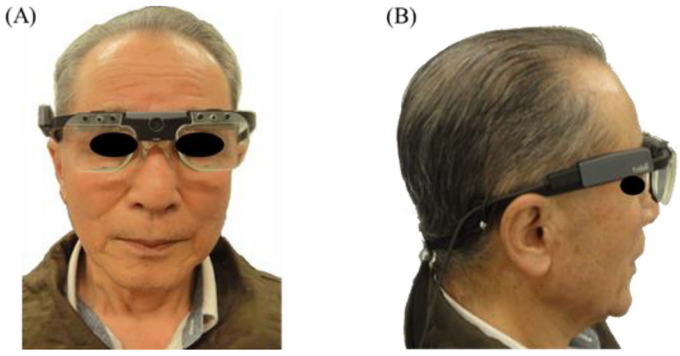

Fig. 3. Attachment of the eye tracker. (A) Front view, (B) side view.

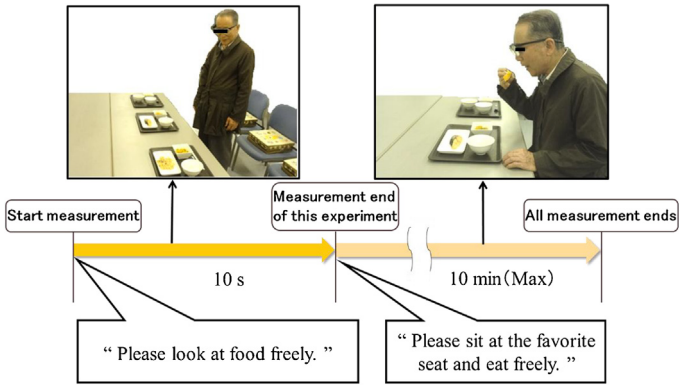

Fig. 4. An example of measurement scenery. After attached to the eye tracker, participant watched the each dish arranged in front of them freely for 10 s. And they ate test foods freely within 10 min. The gazing point was measured for 10 s from the time when the food was ordered and just before the eating.

form that they liked less, and "low" for the food form that they did not like. After the interview on preference levels, the number of participants was tabulated, based on their preference for each of the three food forms.

2.5. Analysis sites and items

The analysis sites were set on the general form of the tray. The analysis items for each food form were (1) the total number of gaze point fixations, based on the individuals' preference level; (2) the total gaze point fixation time, based on the preference level; (3) the amount of food intake; and (4) the preference level details. Gaze points focusing on chopsticks and sites other than the dishes were excluded for analysis items 1 and 2. The same dishes were used for each test food. To investigate the amount of food intake, each test food was weighed with an electronic scale (Cooking Scale Digital KD-162, Tanita Japan, Ltd., Tokyo, Japan.) before the experiment. After completing all measurements, each test food was weighed again.

2.6. Analysis methods

For analysis items 1–3, statistical analysis was performed using the Friedman test. If a significant difference was observed, the Wilcoxon signed-rank test was conducted. Then Bonferroni correction was conducted. The effective dose "*r*" was also calculated so as to be determined using Cohen's index. The level of significance was set at 5%. Statistical analyses software (IBM SPSS Statistics ver.19; Japan IBM, Co, Ltd., Tokyo, Japan.) was used for statistical analysis. The food intake volume was calculated as the intake volume/overall weight of the test food $\times 100$ (%). Based on the results of the preference level interviews, a possible correlation between the number of gaze point fixations and the total gaze point fixation time as well as food forms with moderate and low preference levels was comparatively investigated.

3. Results

3.1. Total number of gaze point fixations, based on the preference level for each food form

The median total number of gaze point fixations, based on the preference level for each food form in the young adult group was 1.0 time for food forms with a low preference level, 3.0 times for food forms with a moderate preference level, and 9.0 times for food forms with a high preference level. The finding indicates a significant increase as the preference level increased (Fig. 5). The effective dose *r* was 0.86 between food forms with low and moderate preference levels, 0.88 between food forms with moderate and high preference levels, and 0.88 between food forms with low and high preference levels.

The median total number of gaze point fixations, based on the preference level for each food form in the middle-aged to elderly group was 2.0 times for food forms with a low preference level, 3.0 times for food forms with a moderate preference level, and 8.0 times for food forms with a high preference level. These findings also showed a significant increase as the preference level increased (Fig. 5). The effective dose *r* was 0.56 between food forms with low and moderate preference levels, 0.88 between food forms with moderate and high preference levels, and 0.87 between food forms with low and high preference levels.

3.2. Total gaze point fixation time, based on the preference level for each food form

The median total gaze point fixation time, based on the preference level for each food form in the young adult group was 0.2 s for food forms with a low preference level, 1.3 s for food forms with a moderate preference level, and 2.2 s for food forms with a high preference level, which indicated a significant prolongation of

Please cite this article in press as: Y. Yasui, et al., Relationship between preference and gaze in modified food using eye tracker, J Prosthodont Res (2018), https://doi.org/10.1016/j.jpor.2018.11.011

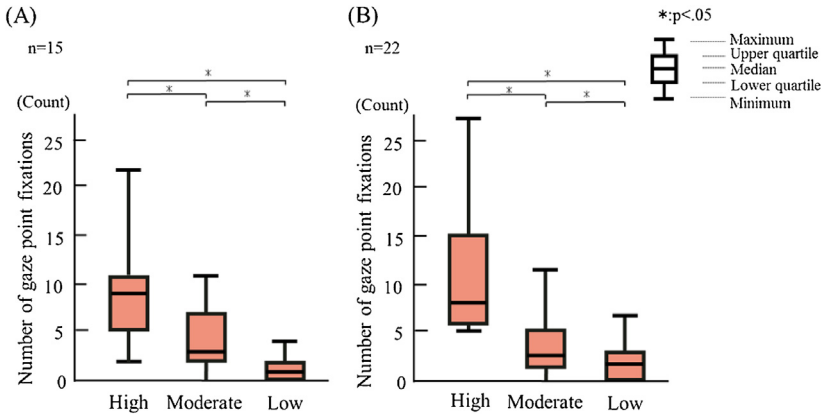

Fig. 5. Total number of gaze point fixations, based on the preference level for each food form. (A) Young adult group and (B) middle-aged to elderly group. Its vertical axis is for number of gaze point fixations and the horizontal for the preference. Number of gaze point fixations significantly increased.

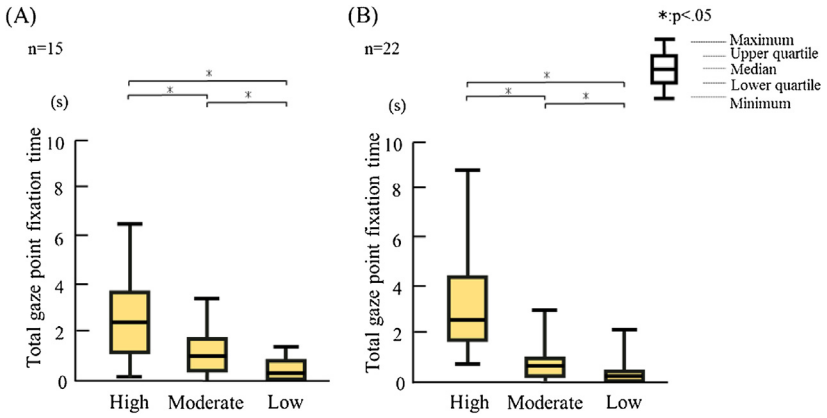

Fig. 6. Total gaze point fixation time, based on the preference level for each food form. (A) Young adult group and (B) middle-aged to elderly group. Its vertical axis is for total gaze point fixation time and the horizontal for the preference. Total gaze point fixation time significantly increased.

the gaze point fixation time as the preference level increased (Fig. 6). The effective dose *r* was 0.85 between food forms with low and moderate preference levels, 0.88 between food forms with moderate and high preference levels, and 0.88 between food forms with low and high preference levels.

Moreover, the median total gaze point fixation time, based on the preference level for each food form, in the middle-aged to elderly group was 0.2 s for food forms with a low preference level, 0.8 s for food forms with a moderate preference level, and 2.5 s for food forms with a high preference level. These findings also indicated a significant prolongation of the gaze point fixation time as the preference level increased (Fig. 6). The effective dose *r* was 0.67 between food forms with low and moderate preference levels, 0.88 between food forms with moderate and high preference levels, and 0.88 between food forms with low and high preference levels.

3.3. Food intake volume

Fig. 7 presents the food intake volume. In both groups, participants had the maximum food intake for food forms with a high preference level, and minimal food intake for food forms with a moderate or low preference level.

3.4. Preference levels

Fig. 8 presents the breakdown of preference levels. In the young adult group, a high preference level was expressed by 14 participants for regular food, 1 participant for chopped food, and 0 participants for blended food. A moderate preference level was expressed by one participant for regular food, 14 participants for chopped food, and 0 participants for blended food. A low preference level was expressed by 0 participants for regular food, 0 participants for chopped food, and 15 participants for blended food. Thus, all participants in the young adult group selected regular food as their most preferred food form among the three food forms.

In the middle-aged to elderly group, a high preference level was expressed by 22 participants for regular food, 0 participants for chopped food, and 0 participants for blended food. A moderate preference level was expressed by 0 participants for regular food, 22 participants for chopped food, and 0 participants for blended food. A low preference level was expressed by 0 participants for regular food, 0 participants for chopped food, and 22 participants for blended food. Thus, all participants in the middle-aged to elderly group also selected regular food as their most preferred food form among the three food forms.

3.5. Number of remaining teeth and dentures

In the young adult group, 15 participants had ≥20 teeth (Fig. 9). With regard to dentures, participant used both upper and lower dentures, no participant used either upper or lower dentures, and 15 participants used no dentures.

In the middle-aged to elderly group, nine participants had ≥20 teeth, nine participants had 10–19 teeth, and 4 participants had ≤9

Please cite this article in press as: Y. Yasui, et al., Relationship between preference and gaze in modified food using eye tracker, J Prosthodont Res (2018), https://doi.org/10.1016/j.jpor.2018.11.011

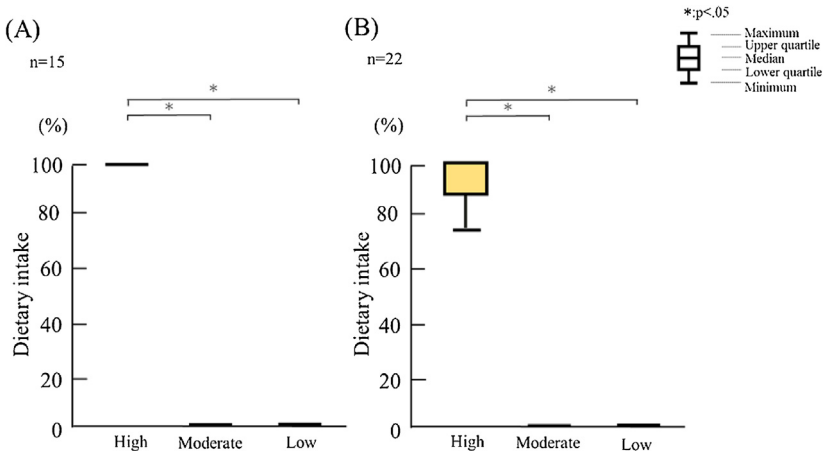

Fig. 7. Food intake volume. (A) Young adult group and (B) middle-aged to elderly group. Its vertical axis is for dietary intake and the horizontal for the preference. Most subjects ingested foods with a high preference level.

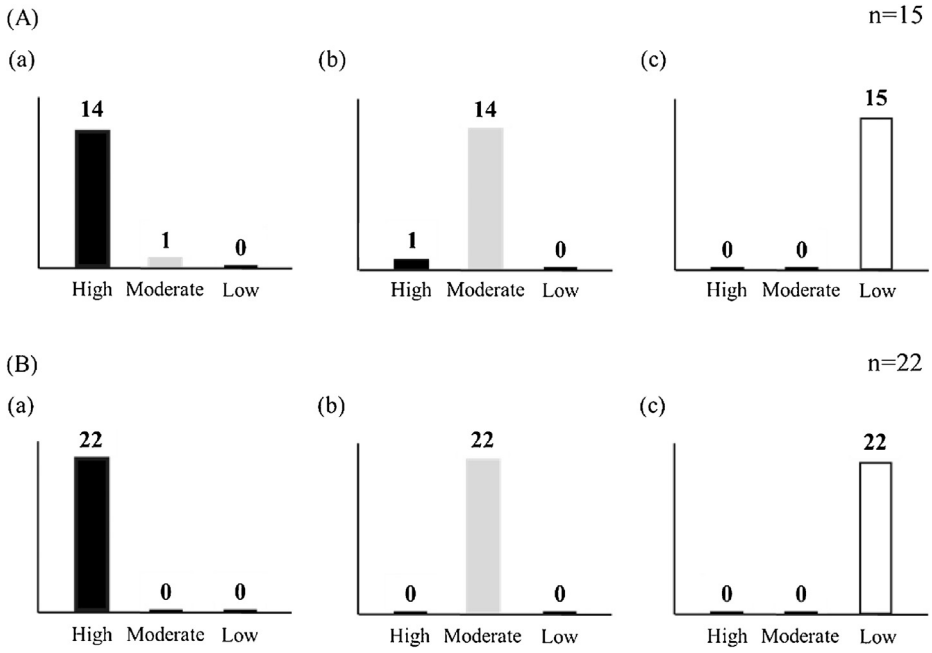

Fig. 8. Presents the breakdown of preference levels. (A) Young adult group and (B) middle-aged to elderly group. (a) Regular food, (b) chopped food and (c) blended food. Its vertical axis is for the number of people and the horizontal for the preference. As a food with a high preference level, most subjects chose the regular food.

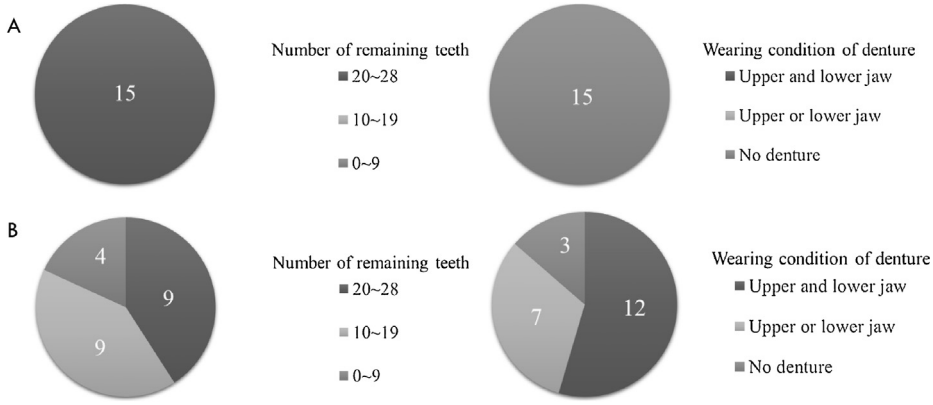

Fig. 9. Number of remaining teeth and dentures. (A) Young adult group and (B) middle-aged to elderly group. Left figure is a pie chart showing the number of people by number of remaining teeth. Right figure is a pie chart showing the number of people by wearing condition of denture.

Please cite this article in press as: Y. Yasui, et al., Relationship between preference and gaze in modified food using eye tracker, J Prosthodont Res (2018), https://doi.org/10.1016/j.jpor.2018.11.011

teeth. With regard to dentures, 12 participants used both upper and lower dentures, seven participants used upper or lower dentures, and three participants used no dentures.

4. Discussion

4.1. Participant selection

Various studies have conducted experimental research on eyeball movement in healthy and in vision impaired individuals. In general, eyeball movement involves repeated gaze movement and fixation. Decreased speed of eyeball movement may be occur in daily life and in healthy individuals as a result of presbyopia or similar eye problem. It has been reported that there is no difference in the fixation time [21]. With aging, cognitive and awareness functions decline. We are considering using the eye tracking method presented in this study for middle-aged to elderly individuals. To this end, we divided participants into a young healthy adult group and middle-aged to elderly group to determine whether results would vary.

4.2. Eye-tracking recording

Tabletop eye trackers and glasses-type eye trackers exist. A previous study using a tabletop eye tracker device (Tobii X2–30; Tobii Technology Japan, Ltd.) limited the measurement range to the size of the monitor screen, which was a very narrow range [15]. It also facilitated the recording of only two-dimensional data. Therefore, in the present study, we used a glasses-type eye tracker, which offers a wide measurement range, obtains three-dimensional data, and can record in a setting that more closely resembles how foods are consumed in daily life.

4.3. Eating utensils/plates

The test foods were commercially available foods familiar to Japanese people. It has been reported that if the dishes used during measurement are the same but the logo or illustration. Differs, the gaze moves toward the altered logo or illustration rather than the experimental item [22]. To prevent the participants' gaze from moving toward something other than the food, only plain plates were used in the present study. We eliminated color factors by making all of the plates white. In addition, we used brown trays to facilitate the contrast against the white plates.

4.4. Preference levels

The preference level was how much each participant expressed liking a food. Preference is the stimulation of the subjective evaluation of the participants received from the sensory organ of the individual. It also refers to various responses caused by the reaction of the nervous system to a higher order cognitive processing (e.g., subjective evaluation) [23]. Most studies investigating the relationship between food image, based on visual sensation and preferences, have used subjective evaluations such as surveys [24–26]. However, when an eye tracker was used and participants were asked to select whether they liked or disliked items presented in two-dimensional images, their gaze stopped predominantly on the food items that they liked more. For example, previous studies have shown that before actually selecting a food image, a person's gaze tends to incline toward the food image that the person will choose [27].

4.5. Total number of gaze point fixations and gaze point fixation time

The preferential looking method involves the phenomenon of an individual's unconscious comparisons and selections while looking for a longer time at the item that they prefer [23]. We previously conducted a study to investigate unconscious preferences, based on eyeball movement. Different foods on the left and right sides of a photograph were randomly displayed. Our purpose was to investigate the extent to which participants focused their gaze on foods with a high preference level. Our results showed a correlation between the displayed food preference and gaze point fixation [15].

In the present study, we also predicted an increased number of fixations and a longer fixation time for foods with a high preference level would occur. Previous reports indicate that people tend to gaze at their preferred food form, based on memory [27]. The results of the present study supported this finding: the number of fixations increased and the fixation time was prolonged for foods with a higher preference level.

4.6. Food intake volume

In subjective evaluations, it has been reported that regular food is preferred over blended food [27]. In the present study, regular food was the food form eaten more frequently by participants in their daily life. Furthermore, the participants visually selected the food form for 10 s before they ate the food. We observed that participants only sampled a very small amount of foods with low and moderate preference levels in the 10 min during which they ate the food. They appeared to eat only this small amount owing to the poor texture.

4.7. Effective dose and statistical power

It has been indicated that for statistical power, in addition to determining the p value, the effective dose should also be calculated [28–31]. The effective dose is the size of the actual difference when making comparisons [28–31]. We also calculated each effect size. Cohen's index was used to determine whether the effect size was large (0.5), moderate (0.3), or small (0.1) [28]. The effective dose r between the groups for the total number of gaze point fixations and total gaze point fixation time, based on the preference level, was at least 0.5, which indicated validity.

4.8. Issues for future investigation

We were able to use an eye-tracking system to measure gaze and objectively evaluate an individual's preference for food forms. For this research to proceed further, the following issues need to be investigated.

We will individually investigate participants requiring gaze analysis and evaluation items. Gaze analysis depends on higher order brain functions (e.g., attention, memory, thinking, and decision-making) [32]. Therefore, potential future participants of preference evaluation using an eye tracker should be individuals with mild to moderate dementia because communication is more difficult for these individuals. It could also be used for individuals with intractable neurological diseases (i.e., amyotrophic lateral sclerosis, multiple system atrophy, and muscular dystrophy). We plan to consider the application of this method in these patient groups. In terms of evaluation items, patients with mild dementia might exhibit attention disturbance symptoms [33,34]; therefore, it may be appropriate to evaluate gaze fixation frequency in these individuals. Individuals with intractable neurological diseases have normal higher order function. Therefore, the number of gaze point fixations and gaze point fixation time could be assessed in these individuals.

In the present study, we were unable to unify the number of remaining teeth and dentures. The question of whether the number of remaining teeth and their wear have a role in preference selection needs to be investigated.

Please cite this article in press as: Y. Yasui, et al., Relationship between preference and gaze in modified food using eye tracker, J Prosthodont Res (2018), https://doi.org/10.1016/j.jpor.2018.11.011

5. Conclusion

The young adult group and middle-aged to elderly group participants unconsciously exhibited different gaze point fixation frequencies and time, depending on food form differences. We observed increased fixation frequency and fixation time for food forms with a higher preference level. Thus, participants' gazes stopped on food forms for which they had higher preferences. Therefore, food forms with higher preferences tend to be easily gazed at. This finding demonstrated that they were unconsciously selecting their preferences. The present study indicated a correlation between food form preference and gaze fixation by using eye tracker.

References

[1] Ministry of Health Japan, Labor and Welfare. Health Japan 21 (general). Chapter 1. Japan's health level. 2013 http://www1.mhlw.go.jp/topics/kenko21_11/s0.html. [Accessed 23 June 2017].
[2] Ministry of Agriculture. Present situation of Japanese dietary life and promotion of food education. 2018 http://www.maff.go.jp/j/syokuiku/attach/pdf/index-13.pdf. [Accessed 10 September 2018].
[3] Ministry of Agriculture. Awareness survey report on food education. 2017 http://www.maff.go.jp/j/syokuiku/ishiki/attach/pdf/H29PDF-20.pdf. [Accessed 10 September 2018].
[4] Milte CM, Thorpe MG, Crawford D, Ball K, McNaughton SA. Associations of diet quality with health-related quality of life in older Australian men and women. Exp Gerontol 2015;64:8–16.
[5] Ministry of Health Japan, Labor and Welfare. Report of the study group on the way of "healthy diet" that supports Japanese longevity. 2014 https://www.mhlw.go.jp/file/05-Shingikai-10901000-Kenkoukyoku-Soumuka/0000070498.pdf. [Accessed 10 September 2018].
[6] Chang NY, Kimura Y, Ishimoto Y, Wada T, Fukutomi E, Chen WL, et al. Relationship between oral dysfunction, physical disability, and depressive mood in the community-dwelling elderly in Japan. J Am Geriatr Soc 2016;64:1734–5.
[7] Argyle M. Bodily communication. 2nd ed. London: Methuen; 1988.
[8] Martinez-Conde S, Macknik SL, Hubel DH. The role of fixation eye movements in visual perception. Nat Rev Neurosci 2004;5:229–40.
[9] Martin-Gonzalez A, Kotliar K, Rios-Martinez J, Lanzl I, Navab N. Mediated-reality magnification for macular degeneration rehabilitation. J Mod Opt 2014;61:1400–8.
[10] Aspinall PA, Borooah S, Al Alouch C, Roe J, Laude A, Gupta R, et al. Gaze and pupil changes during navigation in age-related macular degeneration. Br J Ophthalmol 2014;98:1393–7.
[11] Wiener S, Ito K. Do syllable-specific tonal probabilities guide lexical access? Evidence from Mandarin, Shanghai and Cantonese speakers. Lang Cogn Neurosci 2015;30:1048–60.
[12] Arunachalam S. A new experimental paradigm to study children's processing of their parent's unscripted language input. J Mem Lang 2016;88:104–16.
[13] Tobii Technology. Accuracy and precision test method for remote eye trackers. Stockholm, Sweden: Tobii Technology; 2011. p. 5–25.
[14] Yamamoto M, Torii K, Sato M, Tanaka J, Tanaka M. Analysis of gaze points for mouth images using an eye tracking system. J Prosthodont Res 2017;61:379–86.
[15] Yasui Y, Matsuo S, Kakudo M, Tanaka J, Tanaka M. Association between food preferences and gaze in healthy young adults using eye tracker. Jpn J Dysphagia Rehab 2017;21:11–9.
[16] Ministry of Health Japan, Labor and Welfare. Current situation of elderly with dementia. 2017 http://www.mhlw.go.jp/houdou_kouhou/kaiken_shiryou/2013/dl/130607-01.pdf. [Accessed 23 June 2017].
[17] Ebisawa Y, Fukumoto K. Head-free, remote eye-gaze detection system based on pupil-corneal reflection method with easy calibration using two stereo-calibrated video cameras. IEEE Trans Biomed Eng 2013;60:2952–60.
[18] Findlay JM. Global visual processing for saccadic eye movements. Vision Res 1982;22:1033–45.
[19] Lee C, Rohrer WH, Sparks DL. Population cording of saccadic eye movements by neurons in the superior colliculus. Nature 1988;332:357–60.
[20] Hafed ZM, Clark JJ. Microsaccades as an overt measure of convert attention shifts. Vis Res 2002;42:2533–45.
[21] Peltsch A, Hemraj A, Garcia A, Munoz DP. Age-related trends in saccade characteristics among the elderly. Neurobiol Aging 2011;32:669–79.
[22] Varela P, Antúnez L, Silva Cadena R, Giménez A, Ares G. Attentional capture and importance of package attributes for consumers' perceived similarities and differences among products: a case study with breakfast cereal packages. Food Res Int 2014;64:701–10.
[23] Shimojo S, Simion C, Shimojo E, Scheier C. Gaze bias both reflects and influences preference. Nat Neurosci 2003;6:1317–22.
[24] Geiselman PJ, Anderson AM, Dowdy ML, West DB, Redmann SM, Smith SR. Reliability and validity of a macronutrient self-selection paradigm and a food preference questionnaire. Physiol Behav 1998;63:919–28.
[25] Fildes A, Van Jaarsveld CH, Llewellyn CH, Fisher A, Cooke L, Wardle J. Nature and nurture in children's food preferences. Am J Clin Nutr 2014;99:911–7.
[26] Leenaars CH, Zant JC, Aussems A, Faatz V, Snackers D, Kalsbeek A. The leeds food preference questionnaire after mild sleep restriction — a small feasibility study. Physiol Behav 2016;154:28–33.
[27] Tanaka M, Honma T, Inoue H, Niiyama Y, Takahashi T, Kumagai M, et al. ERP measurement with bottle pictures for objective evaluation of food appearance. IEEJ Trans Electron Inf Syst 2011;131:1271–2.
[28] Cohen J. A power primer. Psychol Bull 1992;112:155–9.
[29] Olejnik S, Algina J. Measures of effect size for comparative studies: applications, interpretations, and limitations. Contemp Educ Psychol 2000;25:241–86.
[30] Field A, Hole G. How to design and report experiments. London: Sage Publications; 2002 p. 152.
[31] Grissom RJ, Kim JJ. Effect sizes for research: a broad practical approach. Mahwah, NJ, USA: Lawrence Erlbaum Associates; 2005. p. 1–22.
[32] Barton JJ. Disorder of higher visual function. Curr Opin Neurol 2011;24:1–5.
[33] Koedam EL, Lauffer V, van der Vlies AE, van der Flier WM, Scheltens P, Pijnenburg YA. Early-versus late-onset Alzheimer's disease: more than age alone. J Alzheimers Dis 2010;19:1401–8.
[34] Makino T, Umegaki H, Suzuki Y, Yanagawa M, Nonogaki Z, Nakashima H, et al. Relationship between small cerebral white matter lesions and cognitive function in patients with Alzheimer's disease and amnestic mild cognitive impairment. Geriatr Gerontol Int 2014;14:819–26.

Please cite this article in press as: Y. Yasui, et al., Relationship between preference and gaze in modified food using eye tracker, J Prosthodont Res (2018), https://doi.org/10.1016/j.jpor.2018.11.011