Glasses Encourage Your Choices: A System that Supports Indecisive Choosers by Eye-tracking

Tatsuya Komatsubara[1] and Satoshi Nakamura[1]

[1] Meiji University, Japan
cs222019@meiji.ac.jp

Abstract. There is the problem of worrying when making a choice. To solve this problem, we propose a system that recommends products like a clerk in a store when in need. In this study, we focus on the fact that people tend to gaze at what they are interested in. Our system observes eye movement during selection and encourages selection by suggesting to a person who is having difficulty choosing that they select the product they have been looking at most. We developed a prototype system that implements the proposed method using a wearable eye-tracking system. We conducted two selection experiments, a selection from a menu (number of options: N=20) and a selection from a catalog (N=116), to test the system's usefulness. As a result, the selection from a menu reduced the time required for selection and resulted in high selector satisfaction. There was no such tendency in the case of selection from a catalog. Gaze movements during selection were more complex than in the selection from a menu, suggesting that the timing of recommendation may be necessary.

Keywords: Gesture and Eye-gaze Based Interaction, Selection Support

1 Introduction

People make choices in various situations in their daily lives, such as choosing food, scheduling their day, purchasing products, choosing a route, and so on. In such situations where we have to choose, we sometimes fall into a state of indecision where we cannot easily decide. One of the causes of this is the anxiety caused by imagining regrets after making a choice [1].

Although thinking is essential in choice-making behavior, indecision and pondering may cause the chooser to feel fatigued and less satisfied with the choice [2]. Therefore, for the chooser to make a comfortable choice, it is necessary to overcome the state of indecision during the selection process in some way.

Even if they are indecisive, people may be able to make a choice if prompted by a friend or an expert, such as a salesclerk, during the selection progress. In other words, prompting by others may help the person overcome the problem of choice. Shimojo et al. [3] showed that when people perform selection behavior based on multiple stimuli, they spend more time gazing at the stimulus they finally select than at other stimuli, which the researchers call the cascade effect of gaze. Furthermore, Patalano et al. [4] compared indecisive and decisive participants in a decision-making information retrieval task. They found that indecisive participants paid more attention to the final choice content before choosing it. From these studies, analyzing the eye movements of people making choices is an effective way to read their preferences.

In this study, we propose a system that assesses the user's state of indecision and the options in which the user is interested using a spectacle-type eye-detection device worn by the user and recommends it for the user in the form of advice. It determines whether the user is in a state of indecision based on the thinking time. If so, it encourages the user to choose by recommending the object that the user has been gazing at for the longest time. In addition, we will conduct an experiment in which the user makes a choice and we will verify whether the proposed system can improve the user's level of satisfaction with the choice by encouraging the user to make a choice.

2 Related work

Yamamoto et al. [5] propose an IoT (Internet of Things) awareness system to respond to the various needs of users in online shopping. In particular, by analyzing the user's line of sight, the system can identify what the user is interested in and is not interested in. Then it can introduce products that match the user's interests and set up sales to promote user awareness. By doing this automatically, it can improve online shopping efficiency without requiring shopkeepers to have IT knowledge. Similar to Yamamoto’s research, our study aims to assess users' interests automatically and provide insight into their choices. We are considering using this system for offline shopping by using an eye-tracking device.

Jaiswal et al. [6] proposed a recommendation system that incorporates users' emotions and interests. They focused on the fact that the system can function without requiring a massive amount of data, as with conventional methods, using a webcam to capture the user's gaze and facial expressions as data.

Bee et al. [7] developed a system that acquires the eye movements of users answering two-choice questions about products appears on a screen and used the data to assess the visual preferences of the users in the choice selection. They tested the system for assessing visual preferences, and the accuracy was 81%, which is a high result. However, the system was valid only in a limited number of choice situations since these studies were conducted in situations where only two choices were available. In this study, we investigate a design that has many choices simultaneously to develop a system suitable for daily life.

3 Proposed system

3.1 Method

In this research, we aim to overcome the situation in which users need help to make a choice in several daily situations. To overcome this indecision, we propose a method in which a device worn by the user assesses what is bothering the user and provides support to help the user solve the problem. In order to support the user's decision, it is necessary to assess the number of choices the user is undecided about. We focus on the user's eye movement during the selection process since when there are multiple choices, the user may move his/her gaze to various choices. By assessing in real time what the user is looking at during the selection process and by giving option recommendations, it helps user make decisions. For the method we propose, assessing what the user is looking at is necessary. Therefore, we use a spectacle-type eye-tracking device which is worn by the user to capture information on what the user is looking at in real time. Based on the results of this, we assess what the user is having trouble choosing about and which possibilities the user is interested in, and we make a recommendation to the user, like "If you are having trouble, why don't you choose this one?" Furthermore, it encourages the user's selection behavior (Fig. 1.).

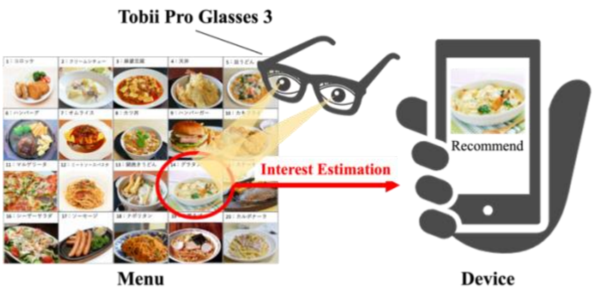

Fig. 1. Image of the proposed system

3.2 Implementation

Since the proposed method aims at a real-time recommendation, it is necessary to recognize what the user is looking at in real-time and assess the recommendation target. For this purpose, we use Tobii Pro Glasses 3 [8]. This device can capture images of the environment in front of the user through a scene camera attached to it. The eye camera and LEDs can also measure the wearer's eye movement. Assessment process of the proposed method from images of the viewing environment captured by the scene camera. The scene camera captures images of the user's viewing environment with a resolution of 1920px in height and 1080px in width. The eye camera and LEDs measure the user's gaze, and only the part of the image that the user gazes at gets cropped. A machine learning system analyzes the cropped images from the video. It assesses the options that lie beyond the point of gaze.

In this system, Teachable Machine [9] is used to identify the options captured by the camera of the eye-tracking device. The system calculates the degree of agreement regarding the video image obtained in real time and assesses what the selector is currently looking at. Due to the system's processing speed, this image recognition process occurs four times per second.

The system uses the object the user looked at most frequently during the selection as the option used to recommend. Therefore, based on the recognition results, the system calculates the total gaze dwell time for each selected object and recommends the one with the longest dwell time as the recommended item. To draw the user's attention to the recommended possibilities, we use voice to guide the user's gaze to the screen and then present the possible choices.

The system execution screen is shown in Fig. 2. Before starting the experiment, the experiment participants enter their names in the text box in the center of the screen, and clicking the “start” button begins the measurement of eye movement information. Participants select the number corresponding to the option from the pull-down list in the lower-left corner of the screen and press the button labeled "Decide!" next to it to submit their option, and the measurement finishes. At the end of the measurement, a CSV-formatted file containing the participant's name, gaze data, the recognition result of the object analyzed by the Teachable Machine, the confidence level of the result (0~1), the measurement time, the object finally selected, and the recommended object is output. After a certain amount of time has elapsed since selection had started, the system assesss the object that the user gazed at the longest based on the analysis results. The system sounds alert and presents a text on the screen recommending that object, as shown in Fig. 3.

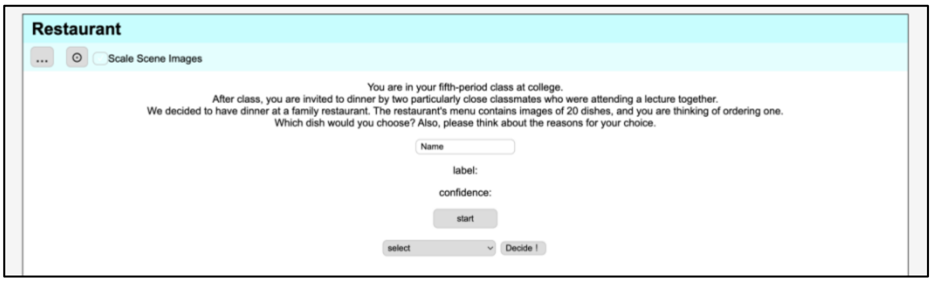

Fig. 2. An example of the screen of the system.

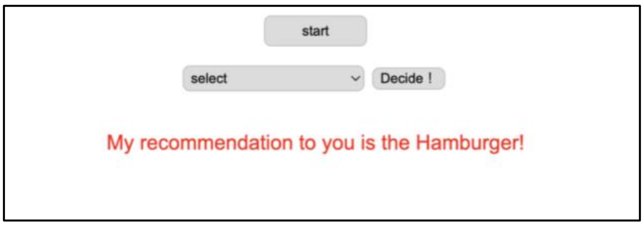

Fig. 3. An example of a recommendation message appears in the system.

4 Experiment 1

We hypothesize that the proposed system will help the user to make a decision, shorten the time required to make a decision, and increase satisfaction with the decision. To test this hypothesis, we conducted an experiment in which users made choices while using the system.

4.1 Experimental Design

The purpose of this study is to eliminate indecision and to verify the usefulness of the system. As an experimental environment, it is necessary to reproduce an actual situation in which people are prone to indecision. Therefore, we prepared the background of three choice categories (tourist attractions, food, and New Year's greeting card templates) to be realistic and not complicated, as shown in Table 1. In each category, we prepared 20 choices. Here, we made sure that the range of choices was wide enough to avoid instantaneous selection based on the bias of individual interests. The 20 choices were arranged in tiles of four squares (vertical) and five squares (horizontal), as shown in Fig. 4, and printed.

Based on prior experiments, the system made recommendations one and three minutes after the user began viewing the menu. The timing of the decision was not specified. The decision may have taken place before the first recommendation was displayed. These were assumed to be no recommendation trials. Since this targeted indecisive individuals, we classified those results as not indecisive.

The experiment conducted in this study began with the participant wearing Tobii Pro Glasses 3 (Fig. 5). We first explained that participants were in each of the specified conditions described in Table 1. Next, they browsed the printed menus for each selected category while using the system described in section 4.4, selecting from a list of 20 possible selections. We also gave them a questionnaire about their choices after each trial.

Fig. 4. Fictitious restaurant menu used in experiment.

Table 1. Selection categories and conditions for selection

Categories	Conditions
Sight-seeing area	An American of the same generation and gender whom you met on a social networking service is planning to travel to Japan alone after Covid-19 is over. He (she) has never visited Japan yet and is worried that there are too many places he (she) would like to visit. He (she) has given you 20 suggestions of places he (she) would like to visit, and you have asked him (her) to recommend the best of these. Which one would you recommend? Also, please think about the reasons for your recommendation.
Restaurant	You are in your fifth-period class at college. After class, you were invited to dinner by two particularly close classmates who were attending a lecture together. We decided to have dinner at a family restaurant. The restaurant's menu contains images of 20 dishes, and you are thinking of ordering one. Which dish would you choose? Also, please think about the reasons for your choice.
New Year's Card Design	On New Year's Day, you received a New Year's greeting card from a friend from junior high school. It has been several years since you received a New Year's card from this friend, and the New Year's card contains updates on what has been happening over the past few years. You are thinking of sending a New Year's greeting card in reply. However, you didn't have any New Year's cards at home, so you went to buy some commercially available ones and found 20 different types of New Year's cards on sale. Which design of the New year's greeting card would you choose? Also, please think about the reasons why.

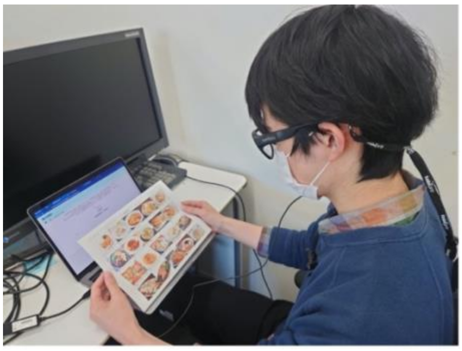

Fig. 5. An image of participant taking part in the experiment 1.

4.2 Results

Twelve university students participated in the experiment. They were asked to make selections concerning tourist attractions, food, and New Year's greeting card templates, yielding a total of 36 trials of data.

Table 2 shows the number of selections made before or after each category recommendation. Table 3 shows the cases in which the system-recommended object matched the one selected by the chooser for the 21 trials decided after the system recommendation took place.

The questionnaire responses (Q1-1~3) are shown in Fig. 6, Fig. 7, and Fig. 8, respectively. The results show that, except for the trials in which the decision was made before the recommendation, many respondents were interested in the recommended object for Q1-1, and many felt that the timing of the recommendation was late. No trials were rated low in terms of satisfaction with the selection itself.

Table 2. The number of trials determined before the recommendation of each condition and the number of trials determined after the recommendation.

	Before recommendation	After recommendation
Sight-seeing area	6	6
Restaurant	4	8
New Year's card design	5	7
Total	15	21

Table 3. Number of recommended and selected options that match and that didn't match.

	Number of trials
Match	6
Mismatch	15

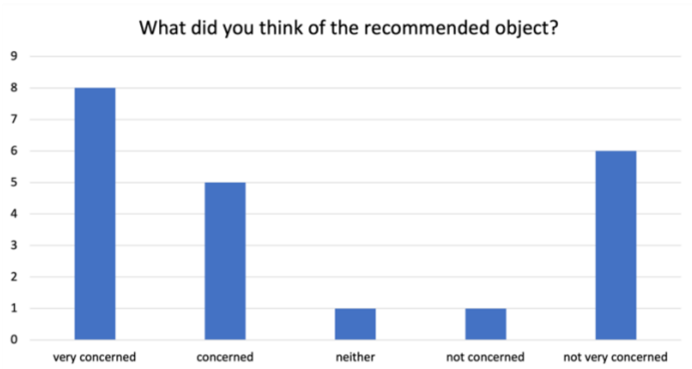

Fig. 6. The result of Q1-1: What did you think of the recommended option?

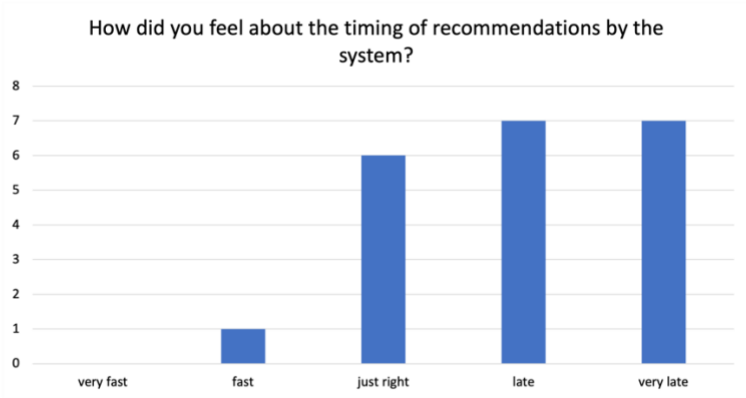

Fig. 7. The result of Q1-2: How did you feel about the timing of recommendations by the system?

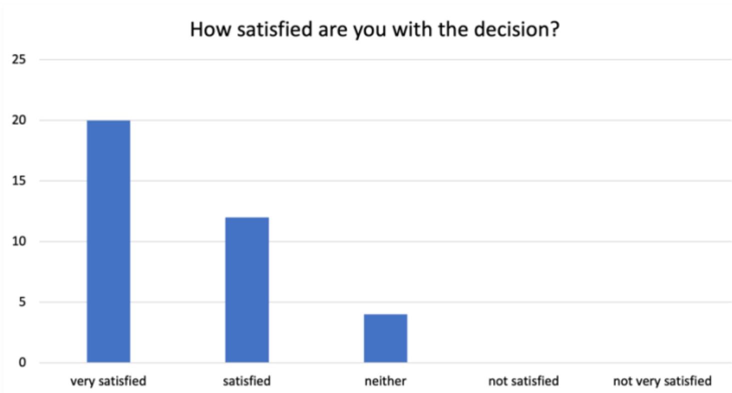

Fig. 8. The result of Q1-3: How satisfied are you with the decision?

4.3 Discussion

As shown in Table 3, for six out of 21 trials, the same selection as that recommended by the system was chosen. In the results of the questionnaire, the following responses were given: "I was thinking that number 10 was a good choice, and it was suggested and I was encouraged to choose it," and "Next year's zodiac sign is the tiger, so I thought that anything with a tiger design printed on it would be fine, and waited for the system to recommend it." These results suggest that our system can encourage product selection. We checked 15 cases of mismatch trials, and we found that in eight out of 15 trials, the system failed to recognize the option which the selector was paying attention to.

Next, we classified participants into three groups: participants who chose the recommended item (successful group), participants who did not choose the recommended item (unsuccessful group), and participants whom the system failed to recognize their interest (error group). Table 4 shows the average of selection time which was over one minute and the satisfaction level in Q1-3, in each participant group. This table shows that the average selection time of the successful group was eight seconds earlier than the average of the unsuccessful group, and the unsuccessful group took longer than the overall average. The satisfaction level of the successful group was the highest. This result indicates that suitable recommendations can increase satisfaction for the selectors.

The question "Do you consider yourself indecisive?" asked after the experiment concluded did not correlate with the level of satisfaction. This result means that it seems that even choosers who have trouble making a decision in everyday life could decide the case of the choices used in this experiment. To solve this problem, we should redesign the experiment test for selection.

Table 4. Average selection time and satisfaction in experiment 1.

	Number of cases	Selection time	Satisfaction
Participants chose a recommended item	6	71.50	4.67
Participants did not choose a recommended item	7	79.25	3.88
The system failed to recognize participants' interest	8	73.57	4.14

5 Experiment 2

5.1 Experimental Design

Since the menu used for the selection in the previous experiments were created by us, we were concerned that it might give a slightly different impression from the actual selection situation to the participants. In addition, the evaluation method was based on whether the system's recommendations matched the user's interests, so we could not discuss the effect of the system's recommendation compared to the condition without such recommendation.

In this experiment, we investigate the influence of system support during the selection process by conducting an inter-experiment comparison with and without the support of our system described above. We also investigate the system's usefulness in a situation closer to a realistic environment by having the participants choose a gift from a catalog including over 100 options (Fig 9).

To minimize the effect of wearing an eye-tracking device, we asked all participants to wear Tobii Pro Glasses 3 even in conditions where our system was not used. None of the participants were instructed that there was going to be a recommendation but were only reminded to look at the PC screen when the system alerted them for the recommendation. Our system recommended an option 90 seconds after participants had viewed the catalog's last page.

Fig. 9. An image of participant taking part in the experiment 2.

5.2 Results

The number of experiment participants was 29, including undergraduate and graduate students. We except four cases because they have fails. Then, we obtained 14 cases "using our system" and 11 cases "not using our system."

In this experiment, none of the "with our system" trials resulted in the selection of the recommended option.

Fig. 10 shows the results of Q2-1, "How helpful was the recommendation in making your choice?" This result shows that while half the participants answered that the recommendation was helpful, others half answered that it was not helpful. Table 5 shows the selection time and satisfaction. The result indicated that respondents did not seem to be encouraged by the recommendations in this experiment.

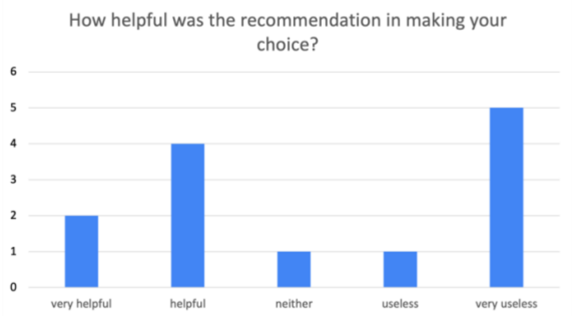

Fig. 10. The result of Q2-1: How helpful was the recommendation in making your choice?

Table 5. Average selection time and satisfaction in the second experiment

	Number of cases	Selection time	Satisfaction
Using our system	14	882.28	4.43
Not using our system	11	814.40	4.36

5.3 Discussion

These results indicate that the system did not work effectively in this experiment. The first issue was that the timing of the recommendation was not good. Fig. 11 shows the browsing behavior of a participant. The horizontal axis represents the elapsed time, and the vertical axis represents the page they viewed in the catalog. The red line indicates the page number of the recommended option, the green line indicates the page number of the option decided by the participant, and the black line indicates the timing of the recommendation. This figure indicates that the chooser's intended browsing behavior was interrupted by the recommendation and that the recommendation failed to serve as an encouragement. However, some participants responded in the questionnaire that the recommendation had caused them to think again.

The second issue was that the criterion of recommending the most viewed object was not good for selecting an option in the catalog. In response to the question in the questionnaire about what they thought about the recommended products, some participants answered that they ignored them. This may have been due to the eye-catching pictures and words on the catalogs, which influenced the viewing time of each option. Therefore, we believe that adding a time series component to the interest assessment will allow us to focus more on the selector's interest than on the appearance factor and to achieve an assessment of interest with less inconvenience. We plan to improve this point in future studies.

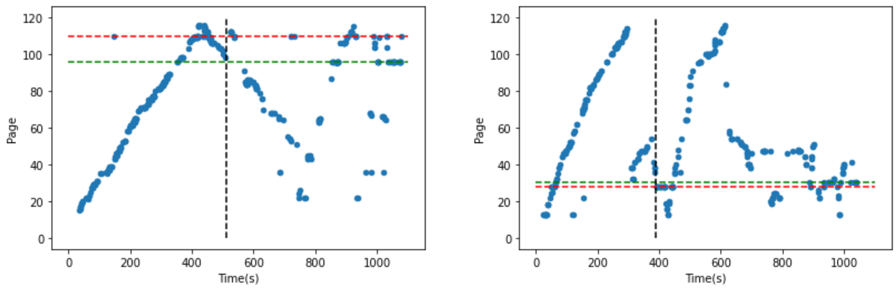

Fig. 11. Selective action logs for the group with our system.

6 Conclusion

In this study, we developed a system in which an eyeglass-type device assesses the selector's interest by using eye-tracking and recommends to the selector to eliminate indecision during the selection process. Then, we conducted two experiment tests. The results of experiment 1 suggested that a recommendation during the selection process positively affects the indecisive chooser. However, the results of experiment 2 revealed many concerns that need to be addressed in order to implement the system in a practical way. Selection is affected by various factors, such as the importance of choice and the number of options, and people's selection behavior changes depending on these. Therefore, the proposed system needs to be implemented taking account of this.

In the future, we intend to improve the system to encourage the user to choose more effectively. Specifically, we will add the function that enables users to ask our system to recommend an option if they have difficulty in choosing. It is also possible to improve the accuracy of interest assessment at the end of the process, which is considered particularly important, by considering time series in the interest evaluation at the time of the recommendation. We also plan to redesign the experiment to ensure that this system will be used in daily choices.

Acknowledgement

This work was partly supported by JSPS KAKENHI Grant Number JP22K12135.

References

1. David E. Bell, (1982) Regret in Decision Making under Uncertainty. Operations Research 30(5):961-981..
2. Rassin, E. and Muris, P.. Indecisiveness and the interpretation of ambiguous situations. Personality and Individual Differences, 2005, vol. 39, no. 7, pp. 1285-1291.
3. Shimojo, S., Simion, C., Shimojo, E. and Scheier, C.. Gaze bias both reflects and influences preference. Nature Neuroscience 6, 2013, pp. 1317-1322.
4. Patalano, A. L., Juhasz, B. J. and Dicke, J.. The relationship between indecisiveness and eye movement patterns in a decision making informational search task. Journal of Behavioral decision making, 2009, vol. 23, no. 4, pp.353-368.
5. Yamamoto, Y., Kawabe, T., Tsuruta, S., Damiani, E., Yoshitaka, A., Mizuno, Y. and Knauf, R.. IoT-aware online shopping system enhanced with gaze analysis. 2016 World Automation Congress (WAC), 2016, Rio Grande, PR, USA, 2016, pp. 1-6.
6. Jaiswal, S., Virmani, S., Sethi, V. et al. An intelligent recommendation system using gaze and emotion detection. Multimed Tools Appl 78, 14231–14250 (2019).
7. Bee, N., Prendinger, H., Andre, E. and Ishizuka, M.. Automatic preference detection by analyzing the gaze ‘Cascade Effect’. COGAIN 2006: Gazing into the Future. 2006.
8. Tobii Pro Glasses 3, https://www.tobii.com/products/eye-trackers/wearables/tobii-pro-glasses-3, last accessed 2023/02/09.
9. Teachable Machine, https://teachablemachine.withgoogle.com/, last accessed 2023/02/09.