# A Method for Expressing Intention for Suppressing Careless Responses in Participatory Sensing*

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**Abstract.** In recent years, with the spread of mobile devices, "participatory sensing," in which users are asked to contribute information, such as their surrounding environment, via their smartphones, has attracted increasing attention. However, in active participatory sensing, which asks users to input text or upload photos, respondents often try to complete the request quickly and effortlessly, and consequently, not always accurately. In this study, we propose a method of *expressing intention to contribute* (*EIC*) for suppressing careless responses in participatory sensing tasks. We implemented a prototype system that requests two types of EIC method (tap the button, shake the phone), and conducted the experiment over two weeks with 20 participants. Through the statistical tests, we found that proposed EIC methods significantly suppressed the number of careless responses compared with the normal situation.

**Keywords:** participatory sensing · mobile sensing · response reliability · satisficing · answering behavior

## 1 Introduction

In recent years, with the increasingly widespread use of smartphones, participatory sensing [3] has been attracting attention as a means of collecting data regarding surrounding environments by requesting contributions from device users. Participatory sensing offers several advantages, such as enabling the acquisition

* This study was supported in part by JST PRESTO under Grant No. JPMJPR2039.
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of data from a wide area and not requiring the installation of sensors. In particular, active participatory sensing, in which a mobile device user consciously provides information, makes it possible to acquire data based on human perceptions of environmental aspects such as congestion, noise, and scenery, which are difficult to calculate from values obtained from physical sensors [9].

A well-known issue with participatory sensing is that when asked to contribute to sensing tasks (e.g., uploading photos, inputting subjective feedback), respondents try to complete requests quickly and easily, often at the expense of accuracy. An approach that detects and excludes careless responses from collected response data is effective when there is a large amount of data, such as in crowdsourcing-type surveys. However, in participatory sensing, this approach might result in a lack of data. Some research has been conducted on paper-based and online questionnaires in an effort to suppress careless responses by asking users to express their intention to provide careful answers. These previous studies have been based on human psychological characteristics, such as once we make a decision or take a certain position, we tend to stick to that decision or position [11]. To the best of our knowledge, the effectiveness of methods for expressing an intention to help suppress careless responses has not yet been tested in the field of participatory sensing.

In this paper, we introduce a method for *expressing the intention of contributions* (*EIC*) to improve reliability in participatory sensing. In the prototype system, we implemented two types of simple motions for the EIC method: a tap screen and a gesture action. A tap screen involves pressing a button on a dialog with a finger, and a gesture action involves holding the smartphone and shaking it up and down. Using these motions in an experiment conducted under laboratory conditions over 2 weeks with 20 participants, we investigated whether our EIC method could significantly suppress careless responses. In addition, we analyzed the number of responses and response times, as well as the results of a post-survey, to assess the effects and challenges of the EIC method.

The structure of this paper is as follows. In Section 2, we describe related research and clarify the position of this study. In Section 3, we describe our proposed method and participatory sensing system. In Section 4, we describe the setup of an evaluation experiment using our system, and in Section 5, we present the experimental results and a related discussion. Finally, in Section 6, we conclude and discuss future prospects.

## 2 Related Work

Studies on questionnaire surveys have pointed out that the attitude of respondents who try to complete a task effortlessly and quickly, called *satisficing*, leads to a decrease in the reliability of the results. Miura *et al.* [10] reported that 51.2% and 83.8% of the responses to an online questionnaire survey conducted on 1,800 people by two different research companies were inappropriate. Careless responses caused by satisficing are undesirable as they make the survey results difficult to interpret.

### 2.1 Careless Response Detection

To address this problem, Maniaci *et al.* [6] devised the Attentive Responding Scale (ARS) and the Directed Question Scale (DQS) to detect satisficing. The ARS can be divided into two types: inconsistency and infrequency. Inconsistency focuses on differences between responses to questions with the same content but slightly different wording, while infrequency focuses on differences between expected and actual choices for a question with a choice expected to be chosen by everyone. For both scales, the higher the total difference score, the more likely it is to be satisficing. For the DQS, participants are instructed to choose a specific answer in a sentence, and if they do not follow the instruction, they are judged to be satisficing.

Gogami *et al.* [5] developed a satisficing detection system that records time-series data such as the amount of screen scrolling, response time per question, and changes in options when answering online surveys using a smartphone.

However, these methods are difficult to use in participatory sensing where a small number of questions is generally given and short response times can be assumed. Even if good and careless responses could be discriminated, excluding careless responses would result in a problematic lack of data.

### 2.2 Improving Motivation with Monetary/Non-Monetary Incentives

To improve the quality of responses, methods for improving user motivation with monetary or non-monetary incentives have been proposed in the domains of crowdsourcing and participatory sensing.

Monetary incentives provide rewards (e.g., redeemable points) directly to responders. General crowdsourcing services such as Amazon Mechanical Turk[5] employ this scheme to motivate people to contribute to microtasks. However, several studies on crowdsourcing [12, 7, 2] have reported that monetary incentives do not improve the quality of responses.

Non-monetary incentives provide a type of experience (e.g., fun, fulfilling a desire) as a reward. In conventional participatory sensing, Arakawa *et al.* [1, 14] attempted to increase the motivation of users to contribute by using gamification mechanisms. Gamification motivates users by adding gaming elements into sensing systems and tasks. However, many studies using gamification have reported that although it can increase the amount of data, cases in which it can even improve the quality of data are limited.

### 2.3 Careless Response Suppression

Ward *et al.* [15] examined the effects of the method which gives instructions and virtual presence when the quality of responses was low, for suppressing careless responses. Their results revealed a significant interaction effects between

[5] `https://www.mturk.com/`

instructions and a virtual presence, although a virtual presence alone had no effect. However, it has also been pointed out that this method is not suitable for small screens such as smartphones.

Masuda *et al.* [8] introduced an opening pledge (a question that asks whether the respondent pledges to respond to an item seriously before answering) to prevent satisficing in PC-based online surveys. An opening pledge aims to take advantage of the fact that once a person declares a certain position, they feel natural psychological pressure to behave in a way consistent with that commitment [13]. Compared with the control group, the group that answered "I will answer seriously" to this question showed higher values in several indices of the quality of their answers. This finding suggested that such approaches can be useful for improving response behavior in participatory sensing. Hereinafter, we define these approaches as the *EIC* mechanism.

### 2.4 Study Position

Existing approaches for detecting careless responses are not suitable for participatory sensing, and methods for motivating respondents with monetary and non-monetary incentives have not been able to improve the quality of responses. In the present study, we aimed to establish a method for suppressing careless responses in participatory sensing by employing the EIC mechanism. In the following sections, we propose and verify the effectiveness of a new participatory sensing system utilizing the EIC mechanism.

## 3 Proposed Method

### 3.1 Expressing the Intention of Contributions (EIC) Method

In this section, we propose a new participatory sensing system utilizing an *EIC* mechanism to suppress careless responses.

As mentioned above, Masuda *et al.* [8] succeeded in placing psychological pressure on respondents to "answer seriously" by asking them to click a checkbox next to the sentence "I will answer seriously" before responding to an online questionnaire. To generate psychological pressure, the following two conditions must be satisfied:

1. The respondents read a statement saying, "I will respond seriously."
2. The respondents express their agreement with the statement.

To satisfy the above conditions in the participatory sensing system, the EIC method consists of the following two steps: (1) making the user read the sentence of agreement, and (2) eliciting the user to express their contribution intention.

*Step (1) making the user read the sentence of agreement:* In the study by Masuda *et al.* [8], agreement sentences and checkboxes were placed at the end of the questionnaire instructions. However, unlike web-based questionnaires, the tasks assumed in participatory sensing require only a short amount of time to answer each question (i.e., a question-and-answer format), so displaying a large amount of information on a single screen is considered a cause of skipping. In addition, since expressing consent generates psychological pressure, whether to read the consent statement is thought to be affected by the preceding action. Therefore, we propose a mechanism that makes it easier for the user to read the consent statement by changing the timing of the statement from "before reading the question" to "the moment the user taps the response field to respond to the question."

*Step (2) eliciting the user to express their contribution intention:* The study by Masuda *et al.* [8] have adopted a method involving having the user click a checkbox next to the agreement sentence. In the present study, we adopted a button-tapping method similar to the conventional method. We also propose a new method of expressing consent using gesture recognition based on the accelerometers in smartphones. This study adopts the gesture of "shaking the smartphone," which requires sufficiently large movements and is easy to imagine, since it is used by many standard smartphone applications.

The following section describes how to apply the express intention function in a participatory sensing application.

### 3.2 Implementation

To collect response data using the proposed method, we designed and implemented a smartphone application for participatory sensing, which we named *OathSurvey*. The system flow is shown in Fig. 1.

The respondent installs OathSurvey (hereafter "app") on their smartphone in advance. When the respondent receives a response request notification from the app and opens it, a question and text form for response input are displayed. Then, the respondent taps on the text form, which causes a dialog box asking the respondent to express their intention to appear on the screen. This dialog shows the agreement statement and the action to take in expressing one' s intention when agreeing. By performing this action, the user is able to enter the answer input form. In this application, the user is presented with either "tap the button," which is the same as the conventional method, or "shake the smartphone," which is a newly proposed method in this paper. The screens displayed in each method are shown in Fig. 2 (a) and (b), respectively.

Moreover, to analyze the response behavior in this experiment, we implemented a function to record the timing of the following screen operation events: "notification published," "notification tapped," "text form tapped," "express intention dialog displayed," "express intention completed," "response data sent," "application goes to foreground," and "application goes to background." The response data are also stored in the database.

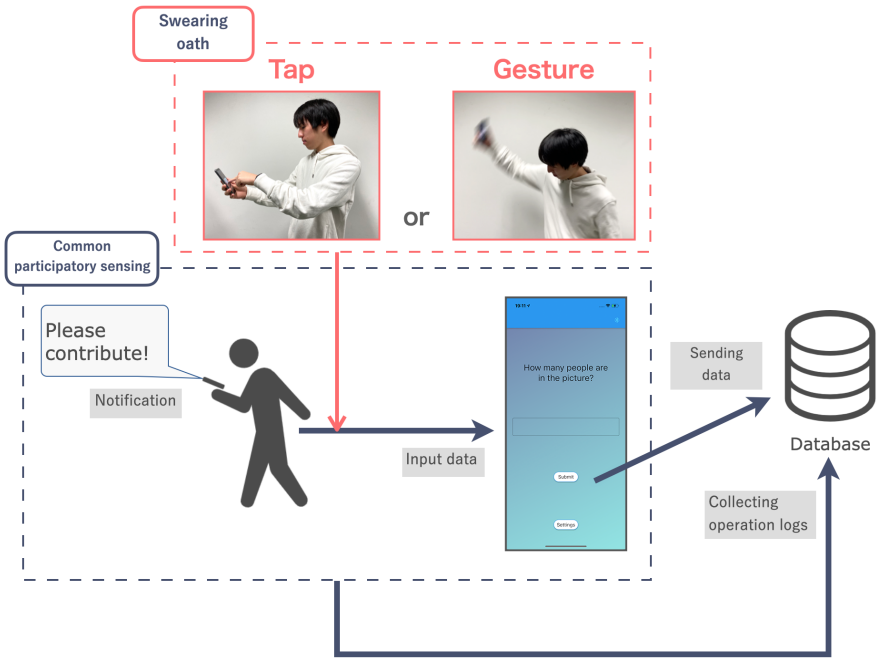



Fig. 1: System overview of "OathSurvey"

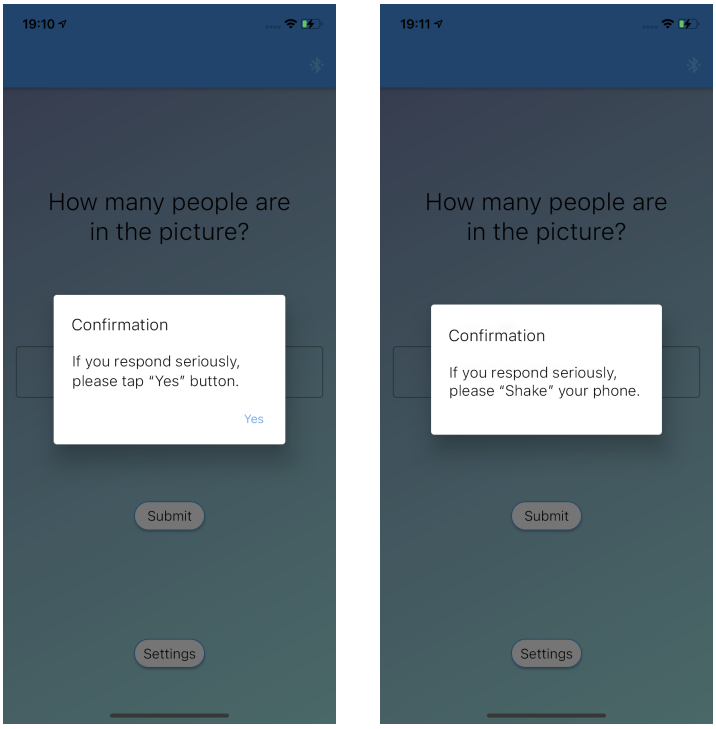
## 4 Evaluation Experiment

In this section, we describe an evaluation experiment to verify the effectiveness of the proposed method. This study was approved by the Nara Institute of Science and Technology Ethical Review Committee for Research Involving Human Subjects (Approval No.: 2020-I-16).

### 4.1 Experimental Settings

The purpose of the evaluation experiment was to clarify the effects of the EIC method on the suppression of careless responses in participatory sensing. For this purpose, to check whether the presence or absence of an EIC or differences in the EIC method affected the quality of responses (correct response rate) and response behavior (response time), we asked the participants in the experiment to use the application implemented in Section 3.2.

The participants in the experiment were 20 graduate students in their 20s who belonged to our laboratory. The experimental period was 2 weeks, from April 13 to 27, 2021. The participants were briefed in advance and completed a consent form before participating in the experiment. In the preliminary explanation, we explained only that this was a survey on participatory sensing




(a) Tap (b) Gesture

Fig. 2: Screen examples requesting "EIC" (it is translated to English)

and did not explain careless response behavior because doing so in a survey on careless response behavior would affect the responses. After the experiment was finished, we explained that the experiment was about careless response behavior and confirmed the participants' consent to participate.

Before participating in the experiment, the participants installed the app on their Android or iOS device. The app requests the sensing tasks described in the next section. For each request, one of the following methods was selected and presented to the experiment participants: "no EIC (nothing)," "tap the button (tap)," and "shake the smartphone (gesture)." The participants followed the instructions for the presented EIC method and input their responses. The participants could also ignore the request.

### 4.2 Sensing Task Setting

The flow of the sensing task is shown in Fig. 3. The app scans an iBeacon signal placed in the hallway near the elevators and then sends a notification requesting the participants to perform the sensing task when they enter. After receiving the

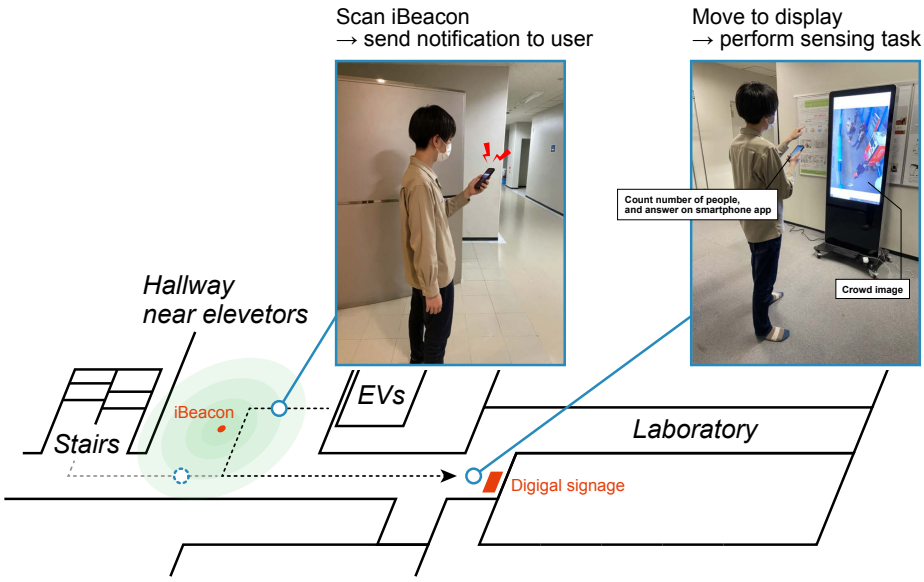



Fig. 3: Answer flow

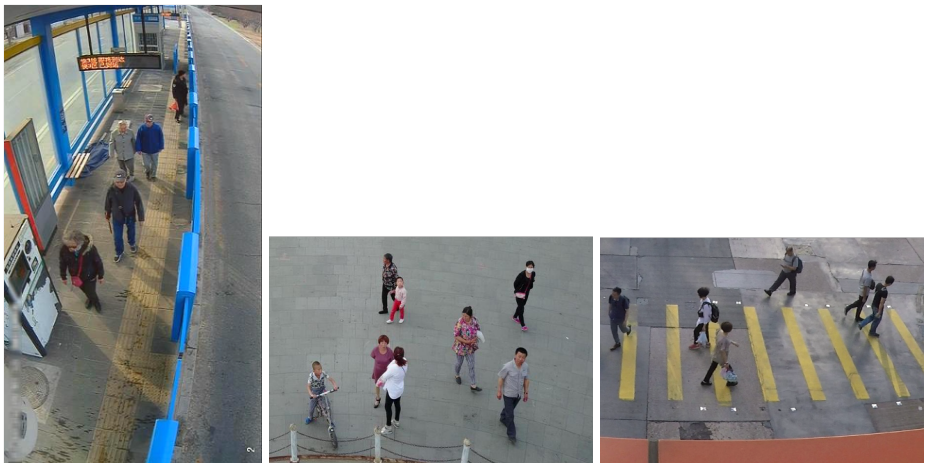
notification, the participant moves toward the digital signage near the entrance of the laboratory, which displays the sensing target, and completes the requested task.

The sensing task is "counting the number of people in the crowd image," and the answer can be sent through the app. This task imitates a participatory sensing task that collects the level of congestion in the city (e.g., sightseeing attractions, bus stops, restaurants). This task is suitable for analyzing the quality of the response data because the correct answer value is uniquely determined. For the crowd images, we used the Beijing-BRT-dataset [4], the VisDrone2019-SOT dataset [17], and the CityStreet dataset [16]. An example of an image is shown in Fig. 4. The crowd image is updated at 0:00 (midnight) and 12:00 (noon) every day, and participants can answer up to twice a day.

### 4.3 Evaluation Method

To quantitatively clarify the effects of EIC on the quality of responses and response behavior in participatory sensing, we compared the correct response rate and response time for each EIC method. The correct response rate was calculated from the total numbers of responses and careless responses for each EIC method. The response time was collected separately as the EIC and response input times, and the sum of these is the total response time.

To confirm the impact of the EIC on the psychology of the respondents, a subjective evaluation was conducted by use of a post-survey. The following ques-



Beijing-BRT-dataset[4] VisDrone2019-SOT[17] CityStreet[16]

Fig. 4: Examples of crowd images used in this study

Table 1: Experimental results (summary of response data)

| EIC method | All responses | Careless responses | Correct response rate [%] | EIC time[s] | Response time[s] | Total response time[s] | Dropout rate [%] |
|---|---|---|---|---|---|---|---|
| Nothing | 99 | 7 | 92.9 | - | 8.6 | 8.1 | 7.5 |
| Tap | 113 | 3 | 97.3 | 1.2 | 9.1 | 10.3 | 14.4 |
| Gesture | 90 | 3 | 96.7 | 2.2 | 9.3 | 11.5 | 17.3 |

tions were asked using a four-point Likert scale: Q1) Did you find it troublesome to declare your position by tapping?; Q2) Did you find it troublesome to declare your position by gesturing?; Q3) Did you think that the number of responses decreased because you were asked to declare your position?; and Q4) Did the declaration of your position make you feel that you should answer seriously? Additionally, to obtain feedback about the EIC method, we asked the participants to provide free-text comments (Q5: What did you think about being asked to state your position when answering?) and suggestions regarding the OathSurvey application (Q6: Do you have any suggestions for improving the OathSurvey application?).

## 5 Experimental Results

### 5.1 Quantitative Results

The results of the quantitative evaluation experiment are shown in Table 1. The quality of the responses and the differences in response behavior are described separately.

*Analysis of Response Quality:* As shown in Table 1, no significant difference was seen in the total number of responses for each EIC. The total number of responses for each EIC was 99, 113, and 90, with only 7, 3, and 3 incorrect responses, respectively. We assume that this was due to the fact that the participants in the experiment were students who belonged to the same laboratory as the authors.

The correct response rate when the EIC was not requested was lower than that when the EIC was requested. The results of a residual analysis of the cross-tabulation table showed that the adjusted standardized residual (one-sided P-value) for no EIC was significant at the 5% level, confirming that the actual frequency of careless responses was significantly larger than the expected frequency. This result indicates that the EIC had a positive impact on the awareness of the respondents.

In this experiment, we did not find any difference between the two types of EIC (button tap and gesture). This point needs to be clarified through future experiments with more participants.

*Analysis of Response Behavior:* As shown in Table 1, the total response time from the EIC to the completion of answer input increased by 1.2 s and 2.2 s with the addition of button tapping and smartphone shaking, respectively. However, even when only the response input actions were compared, the total response time increased by 0.5–0.7 s in the case of the EIC. We believe that this was due to the fact that the awareness of the respondents was affected by the EIC, and that they sought to complete the task more carefully than usual.

*Analysis of the Dropout Rate:* From the response data, we calculated the attrition rate (the percentage of respondents who stopped answering in the middle of the survey). Table 1 shows the average withdrawal rate for each statement method during the entire experiment. From the results, we could confirm that the withdrawal rate increased when an EIC was required. This may have been because requiring an expression of intention was stressful for the participants.

*Analysis of Time-Series Changes:* Daily trends in the number of careless responses during the experiment are shown in Fig. 5. From this graph, it could be confirmed that the defective responses were biased toward the latter half of the experiment. The reason for this reduction in the effect of suppressing careless responses may be that the respondents became accustomed to the response behavior or bored or stressed by the frequent EIC requests.

### 5.2 Subjective Evaluation

The results of the subjective evaluation through the post-survey are shown in Table 2.

The results show that the majority of the participants answered that they did not consider tapping the button to be troublesome at all, but they did find

[6] This score was calculated with Very much = 3, A little = 2, and Not much = 1, Not at all = 0.

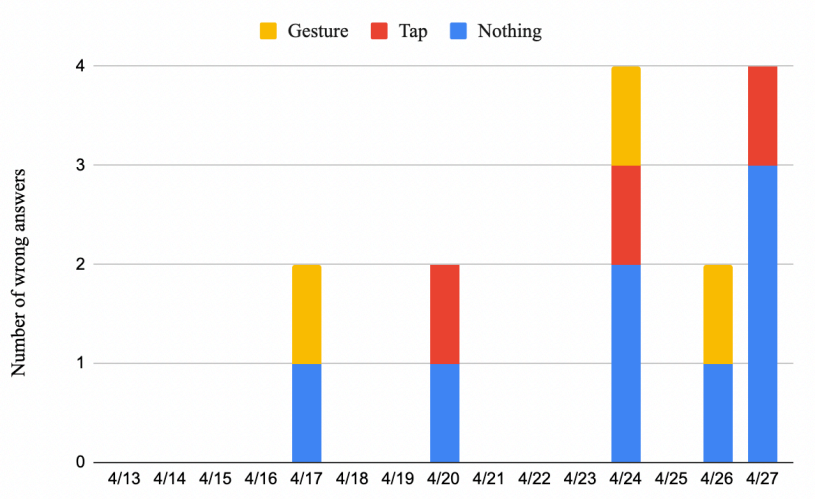



Fig. 5: Number of careless responses by day

shaking the phone to be troublesome to some extent. We believe that this was partly due to the fact that the intensity required for shaking the phone was too high, as mentioned in the comments from the respondents shown below.

Through the free-text comments on the EIC method (Q5), we gained several valuable insights. A summary of these comments is shown below.

- Positive comments
  - I am no longer inclined to respond in a random manner.
  - I think it was good to have the expressing intention because it made us aware that we should not answer carelessly.
- Negative comments
  - I thought it would be quite stressful to have to state a position several times before answering.
  - I had an uncomfortable feeling of not being trusted.
- Other comments
  - I didn't think much of it (I was trying to answer seriously from the beginning).
  - I didn't think anything of it.

The positive comments suggest that the EIC method exerted a certain effect in participatory sensing. The negative comments refer to the stress of repeatedly stating one's position. This point may be due to the negative effects of the characteristic of participatory sensing, in which a large task is divided into smaller tasks and solved by many people, as well as the psychological pressure exerted by such stance statements. To solve this problem, it will be necessary to

Table 2: Post-survey questions and results of subjective evaluations

| Question No. | Sentence |
|---|---|
| Q1 | Did you feel it is troublesome? (Tap) |
| Q2 | Did you feel it is troublesome? (Gesture) |
| Q3 | Do you feel your answering frequency has decreased? |
| Q4 | Did you feel the need to answer seriously? |
| Q5 | What did you think about being asked to state your position when answering? (Free-text comments) |
| Q6 | Do you have any suggestions for improving the OathSurvey application? (Free-text comments) |

| Question No. | Number of answers | | | | Average score[6] |
|---|---|---|---|---|---|
| | Very much | A little | Not much | Not at all | |
| Q1 | 1 (5.0%) | 2 (10.0%) | 6 (30.0%) | 11 (55.0%) | 0.65 |
| Q2 | 5 (25.0%) | 9 (45.0%) | 3 (15.0%) | 3 (15.0%) | 1.80 |
| Q3 | 0 (0.0%) | 0 (0.0%) | 12 (60.0%) | 8 (40.0%) | 0.60 |
| Q4 | 7 (35.0%) | 11 (55.0%) | 2 (10.0%) | 0 (0.0%) | 2.25 |

investigate how long the effect lasts after declaring a position and to introduce a mechanism that does not require the declaration of a position every time.

Another possible solution is to estimate the number of people who need to express their intention (e.g., those who have answered inappropriately in the past) and to encourage them to express their intention at an appropriate time.

We also asked for suggestions to improve the OathSurvey application (Q6). A summary of these comments is shown below.

- I had to shake it very hard to get it to work.
- I felt that if I waved my phone in the street, I would worry about what the people around me were thinking.
- The text asking me to express my intention should be in red to convey a sense of urgency.
- I felt that more variety was needed for expressing my intention.

### 5.3 Limitations

This study had several limitations. As mentioned in Section 5.1, the overall quality of the data collected in this experiment was high. In this experiment, the respondents were students in the same laboratory, so they may have taken the task more seriously than normal respondents. In the future, it will be necessary to

conduct experiments on people with a larger variety of attributes, as in ordinary participatory sensing.

In addition, the effect of suppressing careless responses progressively decreased in the latter half of the experiment. This may have been due to the fact that the respondents became bored, stressed, or accustomed to the high frequency of EIC every time they tried to answer. In the future, it will be necessary to develop a new way for requesting EIC that does not make the respondents feel bored or stressed, or allow them to become accustomed to it.

## 6 Conclusion and Future Prospects

In this paper, we have proposed a new participatory sensing system utilizing an EIC mechanism to suppress careless responses. At present, two types of EIC methods–button tap and gesture–have been implemented, and these can be applied regardless of the task content in participatory sensing. In the evaluation experiment, we investigated the effects of EIC on the quality of the response data and the response behavior. In the future, we plan to conduct a survey under conditions similar to those of actual participatory sensing to explore more effective methods of stating a position.

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