Understanding the Experiences During Meals of People With Visual Impairments: A Qualitative Study

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A number of studies have been conducted to improve the accessibility issues that people with visual impairments face for various tasks such as navigation and object recognition. However, little has studied what challenges they face while having meals and how these problems can be resolved. To understand the kinds of assistance and information that can be provided during meals for people with visual impairments, we first conducted an online survey with 91 participants with visual impairments as a preliminary study. Then we conducted an in-depth interview study with eight participants with visual impairments and two social workers. Our findings show that people with visual impairments face various difficulties at mealtimes and receive help from other people, but most feel uncomfortable when receiving assistance. Based on the results, we suggest implications for designing an assistive meal support system for people with visual impairments.

Additional Key Words and Phrases: Meal assistance, visual impairments, online survey, interview

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1 INTRODUCTION

According to WHO's 2019 statistics [42], at least 2.2 billion people have visual impairment or blindness worldwide, who experience difficulties with various meal-related problems[5]. To be specific, people with visual impairments (PVI) tend to have unbalanced nutrition due to their limited food choices or restrictions in accessing to the nutrition information [5, 20, 40]. For instance, PVI have difficulties acquiring nutrition facts since most of the information is in magazines or newspapers which are not accessible to them [5]. It is also challenging for PVI to purchase ingredients that are in good condition, and prepare meals safely without getting hurt [5, 19–21, 25, 40]. According to the findings from the survey by Jones *et al.* [21], PVI face difficulties when the information of a food product, such as expiration date, is written in very small words. Detecting uncooked meat and spoiled food, cooking hot meals, and reading the oven's display are also found to be problematic for PVI when preparing meals.

To better understand meal-related challenges that PVI face, Kostyra *et al.* [25] focused on identifying environmental factors that need to be considered when purchasing food ingredients, preparing meals, and eating out. Similarly, other researchers [5, 41] studied barriers that PVI encounter in a restaurant. Based on the semi-structured interview, Bilyk *et al.* discovered that the format of a menu, attitude of the server, and the distance and the familiarity of the route to a restaurant are factors that PVI consider when they plan to eat out [5]. Also, Wan *et al.* [41] concluded that the server's attitude, facilities of the restaurant, and aids of navigating to or inside a restaurant

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need to be improved for the PVI, through the in-depth interview. While these are inspiring, most have focused on investigating the inconveniences experienced rather than suggesting solutions to this problem to improve the meal-related experience of PVI. In addition, while eating with others consists of great social implications, little research has been conducted to relieve issues that PVI face when eating with other people.

In this study, we not only investigate difficulties that PVI face related to meals but also propose implications for relieving the issues focusing on the experiences of eating out. The research questions that we hope to be answered by this experiment are listed below.

- RQ1. What challenges do PVI face during meals, if any? How do they cope with these issues?
- RQ2. What kinds of assistance do PVI receive from others during meals, and how do these differ from what they hope to get?
- RQ3. How can an assistive technology be designed to provide the information of the dishes and help PVI locate food?

When PVI eat out, they experience a variety of difficulties and therefore receive various help from others. In particular, there were a number of difficulties in determining the location of the food, and there is a certain type of help PVI receive to solve such problems. However, it has been found that PVI feel uncomfortable asking for help and have a desire to have a meal independently. Furthermore, the information PVI need differ when distinguishing the overall dishes, when starting a meal, and when looking for a specific food during a meal.

The contributions of this research are as follows: (i) the identifications of challenges that PVI face before and during meals, (ii) design implications for assisting PVI with independent meal experience of them.

2 RELATED WORK

This work builds upon prior studies to identify food-related challenges that PVI experience and provide information about the surroundings to PVI.

2.1 Food-related Challenges

A number of studies have been conducted to understand food-related barriers that PVI experience (see [20] for a review). It can be divided into two main categories: nutrition balance and eating out. As for the balanced nutrition, Vagi *et al.* [40] investigated the factors that affect the nutritional status of PVI. The authors confirmed that it influences one's behaviors in grocery shopping, meal preparations, and food intake. For instance, PVI purchase food without knowing that there are healthier choices, or that do not require cooking (*e.g.*, cutting, boiling), as found in [5, 25]. In addition, Bilyk *et al.* [5] also stated that PVI have difficulties in accessing the nutritional information since most information is provided through visual sources. As a result, nutritional problems have occurred, such as abnormal body mass index (BMI) with a high proportion of obesity and malnutrition.

Meanwhile, the difficulties of visiting restaurants for PVI were also studied [10, 25, 41]. For instance, Chung and Lue [41] conducted an interview study with 10 participants with visual impairments and identified a number of issues; the unfriendly attitude of restaurant servers, inaccessibly designed facilities which make it hard or unsafe for PVI to navigate to or inside a restaurant. Moreover, identifying the location of the dishes and utensils on a dining table was found to be difficult. Similarly, Kostyra *et al.* [25] conducted an interview and a survey with PVI (8 and 250, respectively). They also discovered that the restaurant servers' unfriendly attitude, inconsistent menu layouts, restrictions for visiting a restaurant with a guide dog as well as discomfort of asking others for help were common problems. Dias de Faria *et al.* [10], on the other hand, conducted a focus group study and a survey with 203 PVI to determine the attributes of an ideal restaurant that

PVI consider to be important and the results are as follows, from the most to the least important attributes: easy access to a server (*e.g.*, a button bell to call a server), low-intensity lights and sounds, round tables, a menu read from the server, and a customer service.

Despite the large number of studies on food-related accessibility problems for PVI, there have been few studies on how PVI access dish-related information on a table with or without the assistance of others and how their meal experience can be improved. In this study, we focused on providing useful information to PVI while they are having meals so that they can enjoy their meals independently without asking for others' assistance.

2.2 Existing Technologies for Improving Meal Experiences of PVI

Although not particularly designed for improving dining experiences, various technologies have been proposed for PVI, which can be used or extended for the very purpose—from leaving one's house to visit a restaurant, walking inside a restaurant, ordering and identifying food. As for visiting a restaurant, outdoor navigation systems for PVI can be used to assist PVI with the trip [2, 12, 15, 33, 38]. Moreover, for fixed spatial information such as a floor plan, accessible maps [11, 17, 46] and navigation systems for indoors [18, 34, 37, 45] can help PVI to navigate inside a restaurant. Meanwhile, computer-vision based object recognition techniques [8, 13, 14] can also be used to detect and inform objects located inside a restaurant such as obstacles on the way, an empty seat and signs (*e.g., exit, restrooms*). Once seated, optical character recognition techniques [3, 30] can be used to read out the menu items. Existing food recognition system, which was designed to support food tracking for anyone who wished to have healthy diet, [28, 29] can assist PVI to identify different food on a table once served. For instance, Ming *et al.* implemented a smartphone application called DietLens, which identifies food photos and tracks users' dietary habits using deep-based recognizer. Also, it links users, doctors, and social media, through which users can get real-time feedback such as medical information related to food nutrition.

Inspired by these promising studies and technologies, our ultimate goal is to provide a holistic meal experience. As a first step, we conducted a study to identify current accessibility issues that PVI face focusing on dining out experience with others, and how a future system can be built to provide the right information at the right time.

Despite various studies, few studies have been conducted on dynamic interaction and guidance toward specific objects. Moreover, research in the special context of the meal situation has not been conducted although knowing the location of certain food on a table during meals is considered important [41]. We study how a meal assistance can be supported with spatial information about the surrounding environment and directional guidance towards a specific food.

3 PRELIMINARY STUDY: ONLINE SURVEY

To have a deeper understanding of the barriers PVI face when having a meal at a restaurant with or without others, we conducted an online survey with 91 participants with visual impairments. The survey lasted for 7 days starting from May 1st, 2020.

3.1 Participants

We recruited participants aged from 18 to 65 and who have visual impairments through local organizations and by word-of-mouth. A total of 91 PVI participated in our survey where 52 of them were male (N = 57.1%) and 39 of them were female (42.9%). Most of them were in their 20's and 30's; 2.2% were in their 10's, 31.9% were in their 20's, 26.4% were in their 30's, 30.8% were in their 40's, 6.6% were in their 50's, and 2.2% were above 60's. In terms of their vision, 63 participants reported themselves as totally blind, whereas 28 reported that they have low vision.

3.2 Procedure

The survey was conducted using Google Forms, which was designed to take approximately 15 minutes consisted of 20 questions. The questions covered various topics including their frequency of dining out, difficulties in identifying dishes, and types of assistance they get from others during mealtimes. All participants had a chance to opt for a draw for a Starbucks gift card at the end of the survey.

3.3 Findings

3.3.1 Frequency of Dining Out. When asked how often they eat out alone, the majority of the participants (61.5%) answered that they hardly do so. The most common reason was *'difficulties getting help from others'* (47.3%). Other reasons include *'self-conscious about others'* (36.3%), *'Others (e.g., difficulty using kiosks, unable to get information about the restaurant)'* (17.6%), *'There is no menu I wish to eat'* (11.0%), and *'No time to eat'* (9.9%). On the other hand, when asked how often participants eat out with other people, almost half of the participants responded to *'at least once a week'*, which is similar to the frequency of United States citizens dining out per week [9]; *'once every two to three days'* and *'once a week'* had the highest number of responses (23.1% each). When asked about their reasons for dining out with other people, the top response was *'an appointment with others'* (81.3%), followed by *'desire to eat a specific menu'* (39.6%),*'a special day'* (23.1%), and *'uncomfortable eating alone'* (14.3%).

3.3.2 Information Needs Regarding Dishes. We also asked participants about the types of information they would like to know before and during a meal, and the responses are presented in Table 1. When dishes are served on a table, participants wished to have the following information about each dish such as name, location, price, served amount, ingredients and temperature as well as the total number of dishes. Similarly, participants wished to be informed with the following during a meal: left amount, ingredients, temperature, and calories. However, while participants wished to know the overall location of dishes at the beginning of a meal, they care about a specific *'direction'*(76.9%) and *'distance'*(31.9%) towards a particular dish during a meal.

3.3.3 Difficulties in Identifying Dishes. We further asked participants in which situations identifying the location of dishes become more difficult at the beginning of a meal. Most of the participants (82.4%) responded to *'when there are too many dishes'*. Also, one-third of participants (33.0%) responded to *'when dishes have similar-looking'* (33.0%), followed by *'when not having anyone to explain the overall locations of the served dishes'* (30.8%).

Identifying the location of a dish is still a great challenge during a meal. For instance, almost half of the respondents (49.5%) replied that they struggle when the dish they thought they found

Table 1. Types of information participants wish to know about served dishes before and during a meal.

Before a meal	Responses (%)	During a meal	Responses (%)
Names	80.2%	Direction	76.9%
Location	76.9%	Amount (left)	41.8%
Prices	48.4%	Distance	31.9%
Total number of dishes	33.0%	Ingredients	30.8%
Amount (served)	29.7%	Temperature	19.8%
Ingredients	23.1%	Calories	4.4%
Temperature	13.2%		
Calories	6.6%		

was different from what they actually got. Moreover, 34.1% of the participants reported that they had trouble remembering the location of certain dishes during the meal. Having to keep asking for help was the next frequent response (33.0%).

3.3.4 Types of Mealtime Assistance. When asked for the types of help participants receive during meals, more than three-quarters of the participants (78.0%) answered that they received help in getting a small portion of a dish to their plate. Furthermore, they received help from others to know the location of the dishes; 72.5% of the participants said they get help in knowing the location of the overall dishes before they start eating, and 34.1% get help in knowing the location of a specific dish they wish to eat during a meal. Apart from that, 20.9% get help in knowing the correct way of eating a particular dish.

Although PVI get various types of help, most of the respondents (79.1%) felt uncomfortable when asking for help from others. In addition, one-third of the respondents (29.7%) felt that asking for help is cumbersome, and 23.1% experienced discomfort when the conversation does not go smoothly with someone who is helping them.

3.3.5 Ways PVI Use to Locate Dishes. We asked how participants locate dishes during a meal. About half of the participants reported that they memorize the dish locations (47.3%), or have someone else bring a specific dish they like closer to them (45.1%). Other responses included listening to another person's explanation about the location (37.4%) and someone else leading their hand towards the dish they wish (33.0%). Finally, there were respondents who did not care to look for certain dish (*e.g.*, eating whatever comes in hand) (19.8%), and few wished to first visually grasp the kinds of dishes served on a table before they start eating (17.6%).

3.3.6 Other Concerns While Dining Out. When asked about the concerns participants have while eating out with or without others, the most frequent two responses were *'reading menus'* and *'making mistakes'* (*e.g.*, spilling food or bothering others). Interestingly, we discovered that the tendency of the responses was different depending on whether they are eating with others or not. When eating alone, two-third of the responses was *'reading menus'* (70.3%), followed by *'making mistakes'* (40.7%). However, the order was reversed when eating with others; 47.3% for *'making mistakes'* and 42.9% for *'reading a menu'*. Other responses were not having anyone to inform the locations of dishes when eating alone (37.4%), discomfort of asking for help when eating with others (31.9%), and difficulty of keeping pace with others while eating with others (22.0%).

We also asked about the types of food PVI find uncomfortable to eat when dining out. Remarkably, the most dominant response was the type of food that requires diners to cook, such as Korean barbeque or hotpot (81.3%). Also, they felt uncomfortable when they had to share dishes with others, for example, sharing several dishes with others (*e.g.*, Chinese restaurants) or sharing one particular type of dish (*e.g.*, fried chicken).

4 MAIN STUDY: A IN-DEPTH INTERVIEW

4.1 Participants

To recruit the interview participants with visual impairments, we asked the survey participants to leave their phone numbers at the end of the survey if they were interested in participating in a follow-up phone interview. In total, we recruited eight participants with visual impairments for the interview. In order to more objectively investigate the various eating experiences of PVI, we recruited two social workers who eat with PVI almost every day from the social welfare center for PVI. One social worker (S1) was male in his 40s working as a living rehabilitation teacher for PVI, and the other social worker (S2) was female in her 30s working for publishing braille.

Table 2. Participants' demographics including age, gender, visual acuity as well as their frequency of dining out alone and with others

PID	Age	Gender	Visual Impairment (best eye)	Dining Out Alone	Dining Out with Others
1	40s	Male	Totally blind	Hardly ever	Hardly ever
2	20s	Male	Totally blind	Once in two weeks	Once every 2-3 days
3	50s	Male	Totally blind	Once in two weeks	Once a week
4	40s	Female	Totally blind	Hardly ever	Hardly ever
5	30s	Female	Totally blind	Hardly ever	Once a week
6	30s	Male	Low vision	Once a week	Once every 2-3 days
7	30s	Male	Totally blind	Once every 2-3 days	Once every 2-3 days
8	20s	Female	Totally blind	Hardly ever	Once a week

4.2 Procedure

We conducted in-depth mobile phone interviews with eight participants with visual impairments. In the interview, we asked follow-up questions based on the participants' responses from our survey as a semi-structured interview. Moreover, two social workers participated in our mobile phone interviews. The duration of the interviews ranged from 20 to 40 minutes, and each participant was given a Starbucks gift card.

4.3 Data and Analysis

All interview responses were audio-recorded and transcribed. Next, we conducted open coding [32] where two researchers developed initial codebooks, and two researchers independently coded 10% of the randomly chosen responses iteratively. To evaluate the inter-rater reliability of two independent coders, we computed Cohen's kappa, which was found to be 0.94 for the final iteration. Affinity diagramming [16] was conducted to find common themes across the codes.

4.4 Findings

We found that PVI wish to know diverse food-related information and mostly faced difficulties in identifying the location of dish. Moreover, there were other challenges when eating out, including problematic situations caused by eating with other people. Finally, we found out PVI's discomfort in getting help from sighted people.

4.4.1 Frequency of Dining Out. As shown in Table 2, in terms of frequency of dining out alone, half of the interview participants (P1, P4-5, P8) hardly ever dine out alone, two participants (P2-3) eat out alone once in two weeks, P6 in once a week, and P7 eat out alone once every two or three days. As for dining out with others, three participants (P2, P6-7) eat out with others once every two or three days, the other three participants (P3, P5, P8) in once a week, and two participants (P1, P4) hardly ever dine out with others. We noticed that interview participants do not eat out alone often and more often eat out with others.

4.4.2 Food-Related Information Needs. We identified various food-related information that PVI prefer to know: names, dish price, dish temperature, ingredients, the total number of dishes, ways of eating, amount of dish, and preferred dish layout. As in the survey, participants wished to know the overall names of dishes, location, price, and the total number of dishes at the beginning of the meal, and it was important to know the amount leftover during the meal. However, we found that temperature was of high importance during their meals, unlike the results of the survey.

Furthermore, the way of eating and the preferred dish layout was not mentioned in the survey, but it was mentioned as the information that participants wished.

Dish names. When asked if there are any information participants wish to get concerning dishes other than location, all participants answered the overall names of the dishes before starting a meal, mentioning that they usually have the names of the dishes provided along with the dishes' location description. Two social workers also mentioned that when giving the overall dish information, they would provide names of the dishes along with its location.

Dish price. In addition, for the reason of wishing to know the overall dishes' prices before starting a meal as mentioned in the survey, five participants (P1-3, P5, P8) answered that it would be more effective to receive information about the prices when getting an explanation about the menu.

Amount of food. The amount of food left was mentioned often as an information PVI would like to check while eating. Five participants (P1, P3, P5-7) wished to know the amount of food left on the dishes during their meals. P3 explained that it is necessary to know the amount of food left, which enables the participant to decide how much more to eat. In addition, P1 and P3 mentioned that they prefer the description of the amount of food left to be described as one mouthful or one serving, rather than "a lot, little." Besides, two participants (P1, P7) said they wish to know the total amount of food when the meal is first served. P1 said that if a description of the amount of food is provided, it will help to control the amount of food being consumed beforehand. According to S1, assistance is necessary for PVI because they sometimes hover around empty spots when they do not know the amount left during their meals.

Dish temperature. Unlike the survey results, which showed that the dish temperature is not an important factor, half of the interviewees (P3-5, P7) wished to know the information. Especially in the case of temperature, we identified that participants simply wish to know whether the food is hot rather than it's accurate temperature. Relatively, all four participants wished to be warned about hot foods during a meal, and in the case of P7, the participant wished to be informed whether there are any dangerous foods when the meal is first served. P5 mentioned it would be nice if someone warned the participant to be careful because she might burn herself when there is hot food. Both social workers said they had explained the temperature of the food before and would only warn the PVI about hot foods rather than detailed information about the foods' temperature. For example, S1 noted that,

> *"Instead, I inform them only the hot ones. Something like this looks hot, be careful. I don't tell them about the temperature in every detail, but I do tell them that it's hot if they could get hurt or needs extra caution."* (S1)

Ingredients. Two participants (P1, P7) wished to know the ingredients used in dishes when the meal is served and even during a meal. P7 noted that while some dishes' names contain the ingredients used, if not, it may be difficult to decide whether to eat it or not if the ingredients used are unknown. On the other hand, two participants (P2, P6) said they do not have to know the dish ingredients. P6 explained that he is not a picky eater and considers the dishes' ingredients relatively less important than its name or location. Regarding the ingredients of the dishes, social worker S2 would explain the ingredients only for dishes that are new.

Total number of dishes. Three participants (P1-3) said that being acknowledged about the total number of dishes served on the table before eating would be useful. P1 noted that knowing the total number of dishes allows himself to determine the location of the dish. For instance, P1 mentioned that,

> *"Uh... if I know the total number of dishes, I think I can guess the location to some extent. I can judge the location of dishes in my own way. And now, when there are many kinds of dishes, I think I can choose what to eat often, what I don't eat often."* (P1)

Ways of eating. Ways of eating was mainly about how to eat unfamiliar dishes. P7 talked about the challenging experience which took a considerable time due to not knowing how to eat when eating at a new restaurant or encountering a new dish. In response to this difficulty, two participants (P1, P7) said that it was nice when someone told them how to eat such dishes. In this situation, both of the participants wished to know how to eat certain dishes when served, for example, when the dish they encountered was new. P7 shared the experience that it was nice when someone explained the specific types of tablewares that should be used for certain types of dishes.
Preferred dish layout. Additionally, when asked about preferred dish layouts when having a meal, five participants (P1-2, P6-8) mentioned that they do have a preferred dish layout. They mainly preferred the dish to be arranged one by one as a checkerboard or in squares. Both social workers said that they have certain ways of dish arrangements for PVI. S1 arranged the dishes in a semi-circular form to make it easier for the PVI to eat, and S2 usually placed the dish in a tray form.

4.4.3 Difficulties in Getting Information About the 'Location' of Food. In this section, we deal specifically with the difficulties PVI face in identifying the location of a dish. As in the survey, we recognized that they had experienced difficulty locating the dishes, especially when there were too many dishes.

Too many dishes. In particular, all the participants mentioned that it was difficult to grasp the overall locations of the dishes if there are too many dishes (*e.g.,* more than 5 dishes). Seven participants, except P2, experienced difficulties in identifying the location of the dish in certain restaurants such as buffets where there is an excessive number of dishes.
Two social workers also mentioned that it is difficult to help the PVI if there are too many numbers of dishes, and is especially difficult to assist them when eating out in buffets. According to S1 and S2, many PVI deter going to buffets by themselves, and even social workers experience difficulties giving assistance when visiting a buffet with multiple PVI.
Plates that are indistinguishable or in close proximity. Five participants (P1-2, P6-8) said that they had difficulty locating the dish due to similar-looking food or plates. For example, P2 and P6 explained that it is difficult to distinguish each food because of its similar color, and P8 because of the identical size or shape of the plates. Furthermore, there were a total of four participants (P1, P3, P5, P7) who found it difficult to determine the overall location of the dishes due to close distances between each dish.
Changes in the location of the dish. While it was not mentioned in the online survey, three participants (P1, P7-8) reported that they experienced difficulty in locating the dishes when its location changed from before. P1 mentioned that despite having listened to the explanation of the dishes' location before starting a meal, it was difficult to locate the dish when someone changed the location of the dishes and did not notify which made it impossible for the participant to find the dish they wished. Similar to P1, a total of four participants (P1-3, P7) had faced similar difficulties such as the dish they finally found was different from what they wished.

4.4.4 Types of solutions PVI adopt to locate food: with assistance. All participants responded that if there was someone nearby to help, they generally received four types of assistance from sighted people. In addition, social workers suggested that they provide all four types of assistance to PVI depending on the situation, for instance, what PVI prefer or the duration of their visual impairments.

Explanation of the location through words. When receiving explanation of the location of each dish from someone, participants mainly got help on the directions of the dishes. All participants mentioned that they received a description of the dishes' overall direction when the food was first-served, and the participants other than P2 said that they sometimes even got an explanation

about a specific food when they wished to know its direction during a meal. When listening to the description of the position in words, all participants except P3 said that they listened to the explanation in relation to the clock, and exceptionally, P3 preferred sequential description from the left or the right without analogy to the clock.

Furthermore, six participants (P1, P3, P5-8) said that when they listen to descriptions of the dishes' locations in words, they sometimes receive the explanation based on a certain factor. For example, three participants (P5-6, P8) got a description of the plates' locations based on specific tableware (food), and the other three participants (P1, P3, P7) received an explanation based on where they sat.

Small portion of food to plates. While it was not indicated in the survey, all participants had received help in transferring a small portion of a dish to their plate, and some of the participants stated specific situations regarding this. For example, P2 and P7 asked the other person to have some moved to their plate when a large amount of food had been served. P7 noted that if there are many side dishes, instead of asking for directions or locations of each food, the participants' companion would bring small amounts of what the participant wishes to eat. P3, P5, and P8 said that they use personal dishes depending on the food, such as when eating soup or foods that are too hot. P6 said that when several people are sharing the same table, someone brings a small amount of food from a dish that is far away from the participant.

Having the dishes brought nearby. Seven participants (P1-3, P5-8) also commented on how other people bring food near their plate. For example, they requested to have all the food or dishes they especially prefer before starting a meal or sometimes requested a specific dish to be brought near them during a meal.

Hands being lead to identify the location. Half of the participants (P1, P3, P5, P8) received help by someone leading their hand to identify the overall location of the food. In this situation, all four participants emphasized that leading their hand to locate the food helps to measure the "distance between food." So, except two participants (P4, P7), others preferred the way of their hand being lead to the dishes by someone. In particular, P1 mentioned that their hand being lead is more helpful than simply listening to a description when trying to acknowledge the overall accurate location of the dishes. P1 suggested that,

> *'Um... I think locating the dishes is more accurate than when locating with voice, but I usually eat side dishes with a chopstick, so I lift the chopstick and let someone hold my wrist or the back of my hand to lead me to the where the food is. I think this way is a little better than being assisted only by words."* (P1)

Assistance provided by social workers. Both social workers also indicated that they provide assistance with the overall food location before starting a meal. In the case of S1, usually, he would place the foods close to PVI to make it convenient for them to eat (method 3), however depending on the PVI's tendency or the duration of their visual impairments, the preferred assistance differed. Depending on whether PVI desire explanation of the location by words, their hand being lead to identify the location, and transferring a small amount of food to their plate, the type of assistance could vary. Indeed, S1 mentioned that,

> *"That could vary a lot, too. Now if the PVI has had visual impairment for a long time or if I know the person very well, um, then only explaining the location by words can be enough for them. Or for those who recently became visually impaired or lack of spatial perception ability, I would just take their hands and if this is not even possible, I would bring a bit of the food to their personal plate. I adjust the method based on the people."* (S1)

Both social workers said that if the food's location is explained vocally, mainly the direction is explained and the location of the food compared with the clockwise direction. Also, in the case of

S1, when explaining the location of the dishes, instead of explaining the distance vocally, S1 led the PVI' hands to feel the distance just as PVI participants mentioned earlier. Furthermore, both social workers said that when PVI ask for help in determining the location of food while eating, the social workers would help them notice the location of one specific food. In the case of S1, when PVI asks for help in locating a particular food during a meal, they would usually adopt the method of taking and leading hands of PVI to resolve the problem quickly.

4.4.5 Types of solutions PVI adopt to locate dish: without assistance. Additionally, participants listed three ways to locate dish when no assistance was available or did not wish to receive assistance.

Memorizing all the locations when first informed. In terms of locating the dishes without any assistance, five participants (P1-3, P5, P7) said that after listening to the whole description of the overall dishes' location, they would memorize it all and identify the location of a specific dish. P1 added that it is not difficult to memorize it unless there are more than 10 dishes, or the location has changed.

Trying all the dishes one by one. Four participants (P2-3, P5, P7) said that if they couldn't get help from sighted people to figure out the location of all the food, they would have to try each one of them to determine the location. For example, P5 noted that,

> *"If it's a restaurant I have once been to, then the clerk knows that I'm blind so if I ask them to explain it for me then they would but it's available only when they are free. If they are busy then this is impossible. Yeah, so in this situation, there's nothing else I can to then finding out the location of the food by trying all of them one by one."* (P5)

Eating food that comes first in hand. Four participants (P2-P3, P6, P8) talked about the case of not caring to look for food. P2 mentioned that when he feels sorry to ask sighted people a favor, he would have a meal without looking for a specific food, while P8 said that she would not try to locate a specific food since there are times when it could be annoying for others and is a bit of a hassle to ask for a favor.

4.4.6 Difficulties caused by eating with other people. We also examined the difficulties PVI experience in cleanliness, pace of eating, self-consciousness, and identifying the amount of food caused by eating with others.

Eating neatly. Similar to the result of survey, four participants (P1-3, P7) had difficulty with cleanliness when dining with others. P3 cited concerns about picking up food when sharing multiple dishes, and P1, P2, and P7 made a mess when moving small portions of food moved to their plates. Indeed, P3 said that,

> *"When there are a lot of dishes, even if someone next to me tells me where the dishes are, since I can't see them, I can't grab it correctly. When I'm eating with chopsticks, I can't seem to pick it up correctly and keep dropping it, which is really frustrating. I would feel uncomfortable eating with other people because I keep spilling and dropping food. So yeah, it's really uncomfortable."*(P3)

Both social workers also mentioned that PVI frequently drop food on their clothes or on tables, making a mess.

Eating pace. As shown in the survey, four participants (P2, P5, P7-8) found it difficult to keep up with the pace when dining with others. P8 noted having a stomachache due to eating hurriedly as a result of not knowing how fast other people were eating. On the other hand, P7 shared the experience of eating too fast while other people had not even started their meal yet.

Self-consciousness. Three participants (P2, P7-8) noted that they are uncomfortable with getting other people's attention and feel self-conscious, which were not mentioned in the survey. P7

preferred to eat in a secluded room rather than in an open hall due to feeling self-conscious and being pressured when making mistakes such as spilling food. P2 and P8 said they were uncomfortable with the gazes they received when they asked fellow diners to help them get food to their plates or to find a specific dish. For instance, P2 mentioned,

> *"You can't even do this? I've heard a lot of things like that. I've often heard people say, like why do you keep asking me to do it for you? You can do it by yourself."* (P2)

Identifying the amount of food. Three participants (P1, P3, P7) said they feel uncomfortable when they eat with others because they do not know how much food is left, which was an additional difficulty that was not shown in the survey. In situations where people share food with others, P7 mentioned the problematic experience of not knowing the amount of food served, and P3 talked about the difficult experience of not being able to determine the amount of food being transferred to one's plate.

4.4.7 Inconvenience of getting help. While we identified possible assistance PVI received, most of them felt uncomfortable when getting help from other people.

Hesistant to ask for help repeatedly. All participants, except P4, felt sorry and were reluctant to continuously ask for help when they needed help. P2 and P8 said they feel sorry to keep asking for help during a meal because they might distract the other people from eating properly. P2 mentioned that although asking for directions regularly happens daily, it might not be common for others. In particular, three participants (P1, P3, P8) felt sorry for asking about the menu when they were presented with too many menu options.

Mixed attitudes towards assistance. Four participants (P1, P3, P5, P7) said they sometimes do not wish any help. P7 noted that he would receive help if someone offered to but would not ask first, while the other three participants said even though they do not wish to get help, but there are times when they have no choice but to ask for help. P5 explained that requesting help is inevitable when taking a portion of food or requires additional cooking; however, tries best not to ask for help. For instance, P5 said,

> *"First of all, I do what I can do. For example, I can cut the pork cutlet or mix the rice myself. I don't need any help with that. Besides that, I inevitably get help from sighted people when bringing dish to my plates or doing additional cooking during the meal."* (P5)

Moreover, S1 tried not to help PVI as much as possible so that they could do it by themselves. S2 took a neutral stance on assisting PVI and was concerned about the reduced meal time due to assistance and the desire to help PVI.

Inconvenience to ask for help when eating with unfamiliar people. Half of the participants said they had no difficulty eating with their acquaintances, but they felt uncomfortable eating with those they were not close to. P3 noted that when dining with close people, they provide proper consideration and assistance, while when eating with those who are unfamiliar, it is uncomfortable to receive assistance. Moreover, P2 mentioned that it is difficult to ask people encountering for the first time to serve dish to their plates if there are many types of dishes on the table.

Excessive care from others. On the contrary, three participants (P3, P5, P8) expressed discomfort in getting excessive care. P3 also talked about uncomfortable experiences due to extreme care regarding the sauce. The participant requested for only one type of sauce, but the other person was too considerate and would bring another, which made P3 quite uncomfortable. P8 expressed that it was a burden when the other person kept spoon-feeding and asking questions, although the participant had only asked for the dish's location and whether the location had changed. Similarly, P5 said it was uncomfortable when the other person held and led one's hand to the dish, even though words were enough to fully inform him.

Inaccurate communication. As in the survey, two participants (P3, P5) experienced inconvenience due to poor communication when receiving help. P3 had experienced poor communication while adding the sauce. The participant explained that it was difficult because of the difference in the amount and type of sauce the other person added when providing help.

5 DISCUSSION

5.1 Social Eating: Tendency of Desiring for Independent Eating

Findings from our survey and the interview confirmed that the PVI also prefer eating out with others and the frequency of eating out is not quite different from sighted people [5]. Unlike eating alone, however, when eating with someone, they were self-conscious of others. For instance, they were concerned about making mistakes, such as messing up the surroundings, eating all the food left due to not knowing the amount left, failure to keeping up the eating pace with others, and bothering other people's mealtime by asking for help repeatedly. Indeed, social workers had difficulty with the balance between helping the PVI and their mealtime.

On the other hand, when asking for help, PVI felt high pressure when the others were excessively considerate, especially when PVI lacked intimacy with the other person. For instance, PVI received undesired help in some situation because of inaccurate communication with others who are not familiar.

Conflicting PVI's tendency not to receive assistance if possible during mealtimes, however, getting help is inevitable sometimes (*e.g.,* when a dish is served that needs additional cooking). Thus, a system that can help PVI have a meal independently without disturbing others will not only satisfy the needs of PVI, but it would also be able to eliminate the discomfort that others, including social workers, might experience.

5.2 Consideration on When to Provide Which Information at Mealtimes

Our findings reveal that the information PVI wish to know differed when starting a meal and during a meal. Therefore, when designing the system, we recommend providing an overall description of the number of dishes and the names and location of the dishes right after the meal is served. Particularly during a meal, providing information about a specific dish including the location, amount left, ingredients, and the temperature is recommended. Through PVI who claim that there is a risk of getting injured from hot food, we recognize the need to prioritize safety-related information particularly during the meal.

To implement such a system, a deep learning model trained with an excessive amount of food data can be used to identify different dishes [22, 23, 39]. Through this, information about the total number of dishes, types of food, and its' location will be recognized and delivered. We also suggest using voice user interface with speech as the main input modality to receive information about a specific dish as found to be effective for PVI [4, 6, 36]. In addition, one can consider applying mobile infrared sensor [24, 44] to inform users with temperature of the food especially during a meal.

5.3 Ways of Locating Dishes

Through surveys and interviews, we investigated that the majority of PVI face challenges locating dish when there were too many dishes and PVI have different preferred ways of locating dishes. Listening to the location of dish primarily for its' direction, dishes being brought near them by someone, having a small portion of the food being transferred to their plates, and checking the location with their hand lead by someone were the usual help the PVI received. Among these, the assistant of moving the dishes or transferring a small portion of food will be possible through the feeding assistant robot [7, 31, 43]. However, it will be a huge burden to move this robot to dining

places that change every time, rather than when dining at a fixed place. Therefore, we propose a method as below, in which PVI only need a mobile phone to locate dish without the help of others.

5.3.1 Listening to explanation about the location. First is the method of assisting in distinguishing the overall location of the dishes when it is served. In order to identify the location of the objects in space, we use a smartphone that has a depth camera-equipped and perform 3D object detection [1, 26] to check the positions of the dish in 3-dimensional space. When the dishes' location is identified, we provide information in the most preferred way by the PVI, which is providing the dishes' directions in relation to the clock vocally. Also, if the PVI wishes to know the location of a particular dish during a meal, we use speech as the input modality and provide dishes' direction through vocal assistance.

5.3.2 Leading the hands towards the dishes. Instead of directing the PVI hand to locate the dishes, we can enable them to figure out the accurate dishes' location without any help from others by having themselves touch the dishes. At this point, incorporating augmented reality technology, virtual objects are displayed on each dish that is detected. Also, by performing real-time hand tracking [27, 47], hand can also be detected in 3D space. With interactions between virtual objects of hands and dishes, the overall location of the dishes can be distinguished. If the PVI wish to approach a specific dish during a meal, we can provide audio and haptic feedback based on the spatial distance between the hand and the dishes so that the user can do way-finding and guide the hand to the location of the specific dish [35]. With the method presented above, PVI can locate dishes without any help from others and satisfy their desire for independent eating, and we look forward to eliminating the trouble of PVI having to try all the dishes when the help from others are unavailable.

5.4 Limitation and Future Work

While we present a qualitative study of PVI eating out experiences, our study has several limitations that need to be addressed. First, the restaurants' environments and dietary culture may vary depending on different cultures. However, we conducted surveys and interviews only with those who have grown up in South Korea, failing to reflect the variety of dining experiences people from different cultures may have. Second, we mainly focused on the challenges PVI experienced during a meal and did not consider other factors that can affect their dining habits, including going to the restaurant, restaurant's indoor environment, and selecting the menu and order. In particular, the survey results showed that PVI significantly experienced difficulties in reading the menu when eating out. Although it has been dealt with in several previous studies, we have not addressed the ultimate solution to this. Third, as for social workers who can provide more objective indicators, the sample size was insufficient. Furthermore, we were not able to broaden our investigation with close acquaintances of PVI.

For future work, we plan to reflect data from different countries with various dining cultures and address other dining experiences mentioned above to solve the problems faced by PVI. Moreover, we will conduct a study with ordinary acquaintances of PVI.

As mentioned before, there have been many studies in the past, such as navigation and object identification to help PVI's dietary life. Still, it was difficult to find a case that actually solved such problems and helped PVI in real life. In the future, we look forward to seeing a single system that combines technologies that are currently divided, and hope that there will be an application that is easy to use with smartphones.

6 CONCLUSION

To understand the dining experiences of PVI, we conducted an online survey with 91 participants who have visual impairments and phone interviews with eight PVI and two social workers. Through the survey and interview, we found that the majority of PVI experience difficulties identifying dishes' locations in several situations (*e.g.*, overly number of dishes, similar-looking dishes, or changes in the location of food). Most of PVI ask for help to their surrounding people before and during the meal to cope with these issues. The most general types of assistance include explaining location through words, transferring food to their plates, having the dishes brought nearby their plates, and their hands being led to dishes. However, the assistance could cause inconvenience to PVI due to the anxiety of the possibility of bothering others, complex thoughts on the assistance, and excessive care. PVI also wished to acquire the various information of dishes in proper time, and the desired information was different between at the start of the meal (*e.g.,* the total number of dishes, overall names, and location) and during the meal (*e.g.,* location, temperature, and amount of food left). Based on the findings, we offered design recommendations that could help PVI have a meal independently. We plan to complete the development of the meal assistance application to see our design guidelines' potential and test the user experience directly. We hope our ideas will help researchers in the field to enhance the eating experiences of PVI.

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