Challenges and Opportunities for Accessible Seoul Metropolitan Buses: An Interview Study of People with Visual Impairments

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ABSTRACT
Nowadays, a number of people with visual impairments (PVI) access public buses in the Seoul metropolitan area. Existing studies reported the challenges PVI faced when they use buses in multiple cities. Nevertheless, little is known about the accessibility issues of Seoul metropolitan buses (SMB). To reduce the gap, we conducted semi-structured interviews with nine PVI to investigate the challenges and opportunities for accessible SMB. We discovered ten challenges PVI faced when they use SMB. Based on the identified challenges, we propose three opportunities for improving accessibility of the SMB system.

Author Keywords
Visual Impairments; Accessibility; Public Transportation; Seoul Metropolitan; Interview Study

CCS Concepts
•**Human-centered computing** → **Empirical studies in accessibility;**

INTRODUCTION
According to the Statistics Korea, 41,900 people with visual impairments (PVI) live in the Seoul metropolitan area as of April 2018 [13]. The Seoul metropolitan government offers facilities that enable citizens to use public buses. As of 2019, it is reported that 6,244 bus stops, 6,990 public buses, and 387 bus routes are available in the Seoul metropolitan area [16, 9, 10]. In addition, the Seoul metropolitan government provides a well-developed payment service that is widely accepted on public transport and allows citizens to transfer other buses for free within a certain amount of time. In particular, central bus-only lanes installed in the upper-middle lane help public buses avoid traffic congestion (see Figure 1).

AsianCHI '20, April 25, 2020, Honolulu, HI, USA

DOI: https://doi.org/10.1145/3391203.3391209

Figure 1. The bus stops are in the middle of the central bus-only road, such as an island. People have to cross a crosswalk to get to the street.

Previous studies show that PVI living in urban areas have difficulties in a variety of situations, such as identifying bus numbers and routes [18, 4, 8], getting on and off a bus [17], exploring or moving unfamiliar bus routes [7], moving inside the bus [1], and using inconvenient Braille-marked exit buttons [14], when they use buses. In addition, when PVI receive directions through apps, they find it difficult to perform various tasks, such as understanding complex syntax heard in the app [2, 5], identifying and using an elevator [11], and hearing voices due to the noise around crowd [2]. Prior studies proposed a variety of smartphone apps that might help PVI when they get on the buses. For instance, the apps provided PVI with voice notifications as information about scheduled time of bus arrival [3, 19, 20], the bus routes [3], and notifies them when they are near the bus stop [19, 20]. Although the needs of PVI for other cities have been identified and smartphone apps have been developed to address such needs, little is still known about the accessibility issues of public buses in the metropolitan where card-based payment service and bus stops in the central bus-only lanes are provided to PVI.

To reduce such gap, we aim to answer the following research question: what are the challenges PVI face when using public buses in the Seoul metropolitan area? To our knowledge, this is the first interview study to identify the challenges PVI faced when using Seoul metropolitan buses (SMB). We explore concerns of PVI taking public buses in the Seoul metropolitan area. Based on the identified challenges, we propose three opportunities for accessible SMB.

Participants	Gender	Age	Period of Disability	Frequency of using SMB
P1	F	31	18	Once in two or three months
P2	F	27	27	Three times a week
P3	M	49	30	Twice or Three times a months
P4	M	27	5	Twice a week
P5	M	33	29	Once a month
P6	M	46	7	Once or Twice a month
P7	F	31	31	Once a week
P8	M	52	5	Almost every day
P9	F	44	44	Almost every day

Table 1. Participants demographics. Period of disability is unit of years.

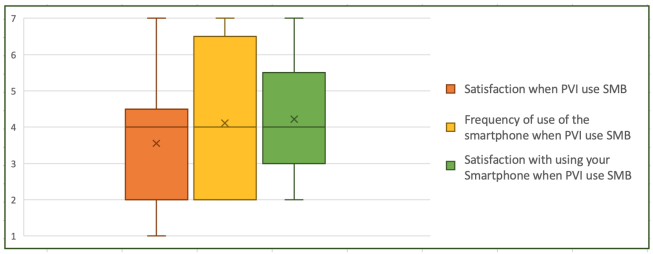

Figure 2. Participants awarded ratings out of 7 point on the y-axis if they strongly agreed with the statements regarding their behaviors when using SMB. X marks on the box-plots indicates the average value of responses from participants.

METHODS

A total of 9 participants were recruited to participate in our study: 4 females and 5 males aged 18−65 (M = 37.78, SD = 9.89) (see Table 1). The inclusion criteria were individuals who: 1) are over 18 and under 65 years, 2) are legally blind, 3) who have no additional disabilities other than visual impairments, and 4) used their smartphones at least once over the past three months. However, we excluded any participants who had any other disabilities except for visual impairments. Survey and interviews took place in the Siloam Visually Handicapped Welfare Center located in the city of Seoul in July 2019.

Data Collection

Prior to conducting each interview, we asked participants to fill out a survey form to identify the level of satisfaction of PVI when they use SMB in their daily lives. During the survey, we used seven-point Likert scale. and asked participants the questions regarding the following topics: participants' ratings of the satisfaction with using the SMB, the frequency of use of the smartphone when they use SMB and the satisfaction with using your smartphone when using the SMB. After participants filled out the survey form, we conducted semi-structured interviews with the participants. We devised a semi-structured interview template based on the following topics about concerns of study participants when they take SMB: participant demographics (e.g., what is your age and gender?), and experiences taking SMB (e.g., how often do you take a bus? what is your main difficulty taking the bus?) Each participant was asked to understand and sign a consent form. For those who were not able to see, consent forms and survey questions were read by the interviewer. Each interview lasted 20 to 30 minutes. After the interviews, we collected a set of interview voice recordings and transcribed the recordings into text.

Data Analysis

To analyze the responses from surveys, we conducted descriptive statistics to obtain the average and standard deviations of responses. For the analysis of the transcribed text, we used qualitative analysis steps guided by grounded theory [15]. We then identified themes by conducting systematic examination including highlighting the importance of the specific findings for all the transcriptions.

RESULTS

After analyzing the interview responses, we identified ten challenges PVI faced when they use SMB (see Table 2). We found ten challenges of PVI for taking SMB and three opportunities for making SMB accessible.

Survey Results

The scores reported by participants were satisfaction with using the SMB, M= 3.56 and SD= 1.88; frequency of use of the smartphone when they use SMB, M= 4.11 and SD= 2.09; satisfaction with using your smartphone when using the SMB, M= 4.22 and SD= 1.56, out of 7 points (see Figure 2). As shown in Figure 2, the result about satisfaction using SMB showed the mean result ('x' signs) were measured worse then the median (black lines) and this confirmed that PVI were not satisfied using SMB. Also, the other results showed the mean results were measured better then the median. And this confirmed that PVI use smartphone sometimes and they more or less agree about satisfaction using their smartphone when they use SMB.

Interview Results

We identified ten challenges PVI faced when accessing SMB in multiple situations (e.g., while PVI wait for a bus, during getting on the bus and until leaving the bus).

Challenges during waiting for a bus

We found 2 challenges PVI faced waiting for a bus (Stage 1). Two participants are hard to obtain necessary information for a taking bus (C1) and difficult to estimate arrival time of the bus they aimed to take.

> *"My bus is already going when I check the expected arrival time of the bus, but I don't know."* (P3)

Also, two PVI had hard time when they listen to the announcement from speakers deployed at each bus stop (C2).

Stages	Index	Challenges	Opportunities
Stage 1	C1	Hard to obtain necessary information	Use simple buttons
	C2	Inaccurate provided information	& functions in a user interface
Stage 2	C3	Hard to climb the stairs of the bus	
	C4	Difficulty of getting additional information to get on the bus	Distinguish a bus
	C5	Difficult to find bus fare payment device	among multiple buses
	C6	Hard to identify the bus number and routes	using app
	C7	Inaccurate stop position of bus arrive to station	
Stage 3	C8	Hard to moving inside the bus	Announce PVI
	C9	Expressing to the bus driver when to get off	where to get off
	C10	Hard to get additional information to get off the bus	the bus

Table 2. Ten challenges PVI faced when using SMB are classified into three stages. Stage 1 represents the event of waiting for a bus. Stage 2 demonstrates the event from moments PVI get on the bus to the bus departs. Stage 3 shows the event from the bus departs to PVI get off the bus.

Challenges during getting on the bus and until leaving the bus
We found 5 challenges PVI faced from getting on the bus and until leaving the bus (Stage 2). Seven participants mentioned that it was hard to PVI for getting on the bus physically (C3).

> *"You have to go down the road, get on the bus, and go up the bus stairs. It's dangerous and sensitive."* (P7)

Next, we also identified getting additional information to get on the bus is not easy to two participants (C4). When they asked questions, the passengers and drivers were so fierce that they said it was difficult to continue the conversation until they got the information they wanted. Four participants even felt difficult to find bus fare payment device (C5). Furthermore, seven participants had hard time to finding the bus to take, when several buses arrived (C6). They almost waste their time to identify the bus number and routes.

> *"There are several buses coming at once. Then I don't know which one."* (P6)

Three participants state getting on the bus is difficult because of inaccurate stop position of bus arrive to station (C7).

Challenges during leaving the bus and before getting off
We identified three challenges PVI faced from leaving the bus and before getting off (Stage 3). Six participants reference that the bus driver's driving is violent and there is a high risk of falling down when they moving inside the bus (C8).

> *"Yes, I'm little scared. The bus was shaking so much that I was afraid of getting hurt."* (P1)

Therefore, expressing what to get off the bus driver is difficult for two participants (C9). Six participants argued they are suffering from getting additional information to get off the bus. They were not hear the internal notification that the bus had arrived at the station (C10).

> *"The announcement isn't accurate. Sometimes it skips..."* (P6)

Challenges compared to other studies
It is common for PVI in Tehran [18], Ireland [4], Santa Barbara [8] and Seoul to obtain information about bus (e.g., routes, departing and arriving time). In addition, in Ireland [4], it is hard to get enough information to get off the bus inside the bus like in Seoul. Unlike previous studies, challenges we found were that PVI had a hard time paying bus fares when they boarded the bus and that they had a hard time expressing their intentions to bus drivers that they will get off.

Opportunities for Accessible Seoul Metropolitan Buses
We propose three design opportunities leveraging a smartphone as a means for improving accessibility of SMB (see Table 2). We focus on how to leverage a smartphone because the number of smartphone users with visual impairments has increased as follows: 7.6 percent (2011), 38.8 percent (2014), 55.9 percent (2017) over the past few years [12].

First, in order to overcome the challenges PVI faced during the event of waiting for a bus, we suggest a talkback feature by pressing any part of the screen and has the least amount of information on one screen. For example, the app has up to 4 buttons on one screen. PVI touch a portion of the smartphone screen that is not turned on, then receives information about the button in the upper left by voice. They can swipe right to the screen to check the information of other buttons, receive information about the next button by voice and quickly tap twice to select it.

Second, to address the challenges that might occur while a bus is arriving, we suggest that we develop a smartphone app that distinguishes a bus among multiple buses arriving at the bus stop, simultaneously. For instance, a barcode/QR code attached to each bus could be used to recognize a bus. Research on availability of barcode/QR code for PVI has already been conducted and the app has been announced [6]. If a QR code that is attached to outside of bus is recognized as a Smartphone that is owned by PVI, it will print bus number through Smartphone speakers through voice. Similarly, the bus fare could be automatically paid by scanning a QR code attache to the interior of a bus.

Last, to address the challenges while finding bus stops to get off, our suggestion is to add to the smartphone app a function to tell PVI where to get off the PVI. If a bus is nearby the station, the app may tell PVI with voice or vibration through the smartphone that he/she has to get off. PVI enters the bus number and destination voice into the app before boarding the bus, and automatically compares the PVI position and bus location to find the bus they are riding. PVI receives voice

communication about the station's location two stops before the arrival station.

CONCLUSION

The goal of this research was to identify the difficulties experienced by PVI using public SMB. The primary contribution of this study is that it presents challenges faced by PVI and opportunities for accessible SMB. We conducted semi-structured interviews with PVI by asking them questions about the difficulties of using SMB. The identified difficulties include issues during the event of paying a bus fare, determining a bus to take, and interacting with existing smartphone apps designed for using public buses. Also, we propose three opportunities for creating technologies to make SMB accessible: simple buttons in a user interface, distinguishing a bus, informing PVI where to get off the bus.

However, the sample size might not be enough to generalize the findings of this study. They might not represent the opinions of all the PVI in the Seoul metropolitan area, though they could be applied to investigate the challenges people with disabilities face in other Metropolitan cities, such as Shanghai and Tokyo. Future work still remains to create technologies to address the identified challenges for accessible SMB and evaluate the effectiveness of the technologies through a long-term period deployment study. Opportunities proposed in this study can be applied to establishing existing systems (e.g., card-based payment service and bus stops in the central bus-only lanes) to support PVI in the metropolitan.

ACKNOWLEDGMENTS

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. 2020R1G1A1009133).

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