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DEVELOPING INTELLIGENT KIOSK FUNCTIONS THAT PROVIDE APPROPRIATE VOLUME

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Abstract. *Kiosks are used in various fields, including information provision and goods/service transactions. Although the auditory feedback function is installed to effectively deliver information on the touch screen, the feedback effect is not high owing to the background noise of the place where the kiosk is installed. In this study, a function that involves providing an appropriate volume according to the size of background noise was developed, and a study was conducted to verify the effect of auditory feedback. Experiments were conducted on 20 users; accordingly, cognitive load, simplicity, and voice information satisfaction items were measured. As the results, the auditory feedback of appropriate speech size exhibited advantages in simplicity and voice information satisfaction. Furthermore, we also verified that the developed function was effective in transmitting auditory information. The results of this study are expected to be applied to kiosks in the noise environment, which can help improve accessibility and usability.*
Keywords: Kiosk, Background noise, Self-service terminal, Kiosk usability, Kiosk accessibility

1. **Introduction.** Kiosks are devices that use touch screens to provide information or facilitate the trade of goods/services [1-4], and are employed in various industries [5,6] and retailing joints [7,8]. Kiosks are widely used for non-face-to-face consumption owing to COVID-19 [9], high availability, fast service, and low latency [10,11]. They convey information visually and adopt visual and auditory feedback to ensure that the user's input is correct [12]. Generally, auditory feedback is an alternative to the delivery of information to users with visual difficulties [13,14], and auditory feedback is more important for kiosks to communicate most of the information visually. In their study [13], they analyzed challenges encountered by visually impaired people when they use a Self-Service Terminal (SST), and emphasized the importance of providing clear and accurate audio guidance and feedback. In [15], authors developed an intelligent user interface for accessible SSTs whose interface height and text size change depending on the user's physical characteristics. As future work, they emphasized the need for audio support to help users with visual impairment or blindness [15]. In accessibility guidelines and laws, the provision of the same level of auditory information as visual [16-19], and the provision of auditory feedback when controlled, were emphasized [16,17]. As such, auditory feedback is an essential function for kiosk accessibility, but the location of the kiosk sometimes prevents information delivery. In an environment in which kiosks are installed in public places and

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are usually exposed to noise in all directions [20], background noise needs to be considered for effective transmission of auditory information. Background noise reduces the stimulation quality of auditory information, making it difficult to recognize [21,22]. A common adjustment to make to ensure audibility in human communication is to raise the voice in response to background noise [21]. In accessibility guidelines and laws, the importance of guaranteeing sound quality [16] and volume control [16-19,23] for recognizing auditory information is also emphasized. In [20], a noise reduction algorithm was developed such that a kiosk could recognize the user's voice clearly, even in a noisy environment based on microphone arrays and spectral subtraction. Several related studies have been conducted, and although they mention auditory feedback as an essential function of the kiosk, developing and verifying the function of the kiosk for delivering auditory information to the user at an appropriate volume is still insufficient. When the Signal-to-Noise Ratio (SNR) decreases due to background noise, the cognitive load increases for voice identification [32], and voice recognition becomes difficult [33]. SNR above a certain level is required for clear speech transmission [33].

This study attempts to verify whether auditory feedback is useful for universal users. The function that intelligently provides an appropriate volume of speech according to background noise was developed and verified, and we expect this function could be extended to improve kiosk accessibility. For this purpose, we established the following two hypotheses.

H1. High background noise increases the cognitive load and decreases simplicity and voice information satisfaction.

H2. Auditory feedback of appropriate volumes decreases the cognitive load and increases simplicity and voice information satisfaction.

In this study, four prototypes with two conditions, background noise (low/high) and auditory feedback (O/X), were developed. All prototypes included the appropriate speech level function proposed in this study. Participants use these prototypes, and then they conducted quantitative surveys and interviews on cognitive load, simplicity, voice information satisfaction. In Section 2, the participants, prototype, and process are elaborated, and Section 3 presents the results obtained from validating the hypothesis. Section 4 discusses the study's limitations and future research directions. Finally, Section 5 concludes the entire study.

2. Method.

2.1. **Participants.** The experiment was conducted with 20 university students (six females) living in Korea (23.15 years old, SD = 2.52). The participants were recruited from the university community and were provided with an entry fee of approximately $8 USD.

2.2. **Experimental environment and apparatus.** The experiments were conducted in a quiet laboratory environment. Speakers (BZ-SL7) that played background noise were arranged side by side such that the distance from both ears of the participants was the same, and a touch screen (Samsung Flip2.0, LH55WMR) was arranged in the middle of the two speakers [24]. Noise was measured using a sound level meter (WS1361C) placed behind the participants' backs. The background noise was output from the speaker, and the kiosk voice and interface were projected from the touch screen.

2.3. **Prototype.** The prototype was developed using C# winform [25] and by referring to the interface of L Company, a representative Korean fast-food restaurant (Figure 1). To order a hamburger set, the prototype displays a screen before ordering (1-A), a screen presenting the main menu (1-B), a screen for selecting a set and individual items (1-C), a screen for selecting a side menu and drinks (1-D), a screen for confirming order details (1-E), and a screen displaying the order number (1-F).

FIGURE 1. Prototype interface

In the Korean interface, the task description voice (black letters) comprised not more than seven words, while the auditory feedback (blue letters) comprised no more than five words (Figure 2). The task flow of the prototype is illustrated in Figure 2.

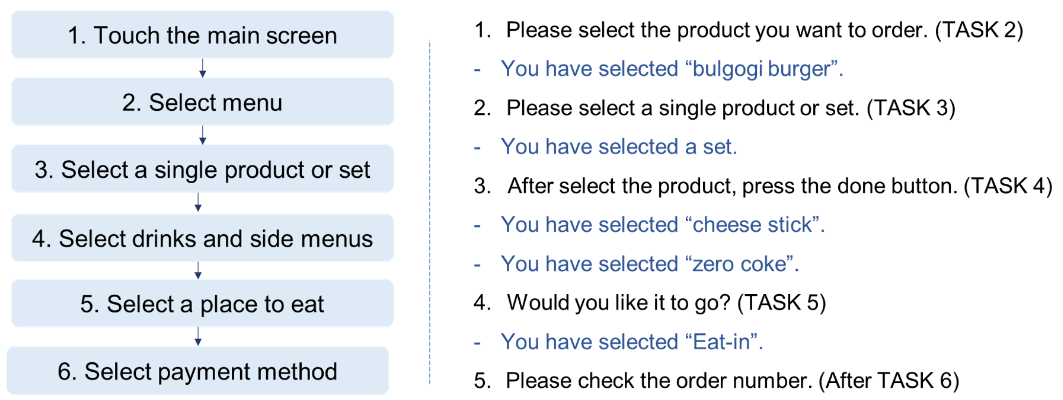
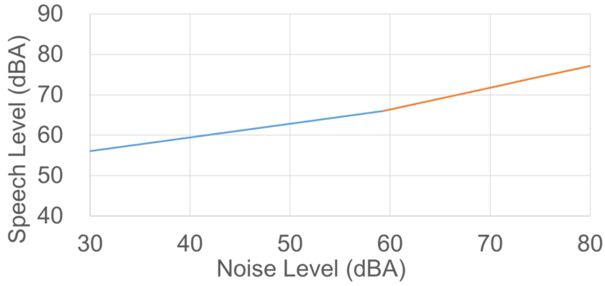


FIGURE 2. (color online) Prototype task-flow and auditory feedback

2.4. **Development of a function to provide auditory feedback according to the background noise level.** To determine the level of auditory feedback according to background noise, we referred to a previous study [26]. Because kiosks perform guidance with human voices, we selected similar listening situations. We selected a study of people with hearing difficulties for various user groups. The level of background noise was determined as low (50 dBA) and high (62 dBA), according to the general prototype listening situation in a previous study [26]. The level of the final auditory feedback was determined using the speech-level calculation formula according to the noise level in [26], and the calculation formula is presented in Figure 3. If the noise is 59.30 dBA or less, the speech level is calculated with $y = 0.34x + 45.838$, and if it is more than that, $y = 0.54x + 33.978$ suffices. The levels of background noise and auditory feedback are denoted by x and y, respectively. Because the sound is not output in a constant decibel, the background noise was measured for 0.1 s on an A-weighted decibel scale [27], measured for 15 s, and then the average decibel was calculated. Subsequently, the volume of the auditory feedback was calculated using the calculation formula (Figure 3). For a more accurate measurement of decibels, four researchers, comprising two men and two women, set and marked an easy-to-manipulate position and fixed the position of the sound level meter to measure noise directly behind the participants. To reduce the difference between the output decibels and the decibels actually heard by the user, the system volume was adjusted after the kiosk voice and background noise were measured with a sound level meter at



(Less than 59.3 dBA (blue): $y = 0.34x + 45.838$, more than 59.3 dBA (orange): $y = 0.54x + 33.978$)

Figure 3. (color online) Auditory feedback calculation according to background noise

the described location. A recording of a specific cafe uploaded to YouTube [28] was used to set up the background noise like that of an actual kiosk usage environment, and this noise included people talking and background music from the cafe.

2.5. **Procedure.** All participants were informed of the purpose of the experiment and were guided through kiosk operation and experimental procedures. The participants performed all four prototypes (Table 1), and after each prototype was performed, a survey and interview were conducted. We employed a balanced Latin square design to avoid predictions and learning effects. The experimental scenarios comprised Scenario 1 (Type 1, Type 2) and Scenario 2 (Type 3, Type 4), and the same scenario between the types was adopted to check the effect of auditory feedback (Table 2). The NASA-TLX [29] was employed to measure cognitive load. Based on the objective of this study, the voice information satisfaction [30] and simplicity [31] items were selected. The questionnaire comprised 13 questions, and a 7-point Likert scale was used. The experiment time was approximately 1 h, and the participants could rest or stop when they wanted.

Table 1. Type of prototypes

		Auditory feedback	
		Feedback X	Feedback O
Background noise	Noise low	Type 1	Type 2
	Noise high	Type 3	Type 4

Table 2. Example of an experimental scenario

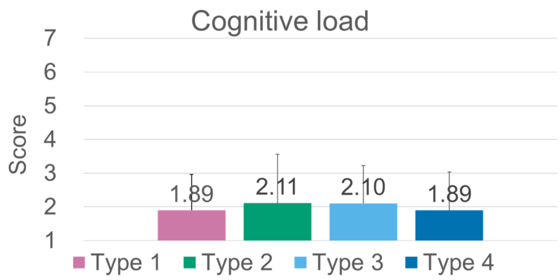
	Experimental scenarios
Scenario 1	Buy a bulgogi burger set (side: cheeses-stick; drink: zero coke; eat in)
Scenario 2	Buy french fries and strawberry shakes (take out)

3. **Results.** The results were analyzed with ANalysis Of VAriance (ANOVA). There were two independent variables, background noise and auditory feedback, and three dependent variables, cognitive load, voice information satisfaction, and simplicity. The analysis was performed using the R software [32], and the obtained results are presented in Table 3.

3.1. **Cognitive load.** In cognitive load, Types 1, 2, 3, and 4 scored 1.89 (SD = 1.07), 2.11 (SD = 1.45), 2.10 (SD = 1.12), and 1.89 (SD = 1.14), respectively (Figure 4). There was no significant difference between background noise ($p = 0.982$, $\alpha = 0.05$) and auditory feedback ($p = 0.982$, $\alpha = 0.05$).

TABLE 3. Analysis results

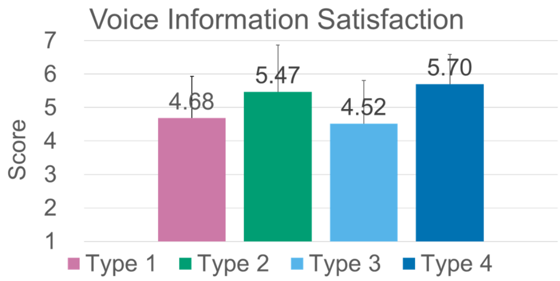
	Cognitive load		Voice information satisfaction		Simplicity	
	F	p	F	p	F	p
Background noise	0.000	0.982	0.029	0.865	0.027	0.871
Auditory feedback	0.000	0.982	25.273	0.000	34.180	0.000



1 (Noise Low, Feedback X), 2 (Noise Low, Feedback O)
3 (Noise High, Feedback X), 4 (Noise High, Feedback O)

FIGURE 4. Cognitive load due to background noise and auditory feedback

3.2. **Voice information satisfaction.** In voice information satisfaction, Types 1, 2, 3, and 4 scored 4.68 (SD = 1.24), 5.47 (SD = 1.40), 4.52 (SD = 1.30), and 5.70 (SD = 0.90), respectively (Figure 5). There was no significant difference between their background noise ($p = 0.865$, $\alpha = 0.05$). However, there was a significant difference between their auditory feedback ($p = 0.000$, $\alpha = 0.05$).

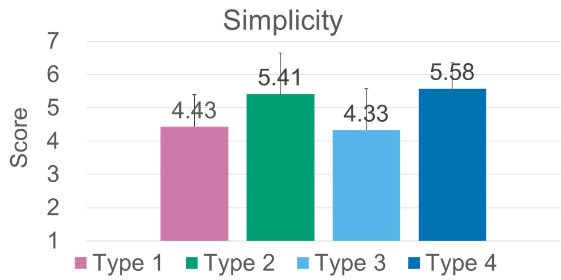


1 (Noise Low, Feedback X), 2 (Noise Low, Feedback O)
3 (Noise High, Feedback X), 4 (Noise High, Feedback O)

FIGURE 5. Voice information satisfaction due to background noise and auditory feedback

3.3. **Simplicity.** In simplicity, Types 1, 2, 3, and 4 scored 4.43 (SD = 0.96), 5.41 (SD = 1.23), 4.33 (SD = 1.25), and 5.58 (SD = 0.77), respectively (Figure 6). Although there was no significant difference between their background noise ($p = 0.871$, $\alpha = 0.05$), there was a significant difference between their auditory feedback ($p = 0.000$, $\alpha = 0.05$).

3.4. **Interview results.** When providing voice feedback, they answered that it was helpful to provide auditory feedback, except for a small number of participants. The reason for this perspective was expressed in their own words: "it was good to check the selected menu and know the price information", "I was able to relieve anxiety and be certain because there was feedback on the options I chose", "It helped when I chose the wrong one",



1 (Noise Low, Feedback X), 2 (Noise Low, Feedback O)
3 (Noise High, Feedback X), 4 (Noise High, Feedback O)

FIGURE 6. Simplicity due to background noise and auditory feedback

"It sounded rather quiet when I provided auditory feedback", and "I felt the kiosk working". Participants who answered that it was not helpful said, "I could do well without it" and "I think it was inappropriate in a situation where I had to order quickly because the utterance was too long". There were opinions such as in response to whether the kiosk's voice was heard well in a noise environment, all subjects answered that they heard it well, and the reasons for thinking so were also expressed in their own words: "Sounds sufficient in case of a noisy environment", "The pronunciation of auditory information was good, the speed was appropriate", and "Good with simple sentences". Others said, "Auditory feedback was good, but it was burdensome to tell the amount", "I hope the kiosk provides me with the total amount", "I do not know if it will help the disabled, but it will help the elderly", "Speed of voice was stuffy", and "The level of the first kiosk voice felt loud".

4. **Discussion.** There were no significant differences in the simplicity, cognitive load, and voice information satisfaction of the auditory feedback relative to the level of background noise. Therefore, in an environment in which the proposed function was applied, Hypothesis 1 was rejected. It is difficult to recognize voice information in a noisy environment by covering voice information compared to a quiet environment [21]; however, there is no significant difference relative to the background noise because the function of providing an appropriate size of speech was successfully considered in this study. Users responded that the kiosk voice was heard well even in environments with high background noise, and the user preference differed in terms of voice speed and sentence length; however, the kiosk volume provided in this study was sufficient to recognize information.

When providing auditory feedback with an appropriate volume of speech, there was no advantage in cognitive load compared to when auditory feedback was not provided. However, there are advantages to providing auditory feedback in terms of speech information satisfaction and simplicity. This result partially supports Hypothesis 2. Cognitive load was not reduced via the provision of feedback probably because the kiosk-use task did not generate a high cognitive load or because auditory feedback did not help reduce the cognitive load. User experiences, such as voice information satisfaction and simplicity, improved when auditory feedback was provided, as confirmed in user interviews. From the interviews, it was verified that when providing auditory feedback, it was possible to audibly check whether the input was made as intended by the user and visual information once more, and that auditory feedback was provided to reduce background noise. Accordingly, even in a universal user group, there is an opinion that it is effective when using auditory feedback and that the voice level is high for users without hearing loss; however, it was verified via experiments that it is not difficult for users to recognize the kiosk voice.

5. **Conclusions.** A kiosk is a device that provides various services using a touchscreen. As information is delivered in a visual form, the provision of auditory information is

sometimes ignored, and the delivery of auditory information is crucial in improving the usability and accessibility of the kiosk. Because kiosks are primarily installed in environments with background noise, a kiosk design that considers background noise is required to effectively transmit auditory information. Few studies have developed kiosk functions and conducted user experiments according to background noise without requiring additional headsets. Accordingly, this study developed a function for developing a noise environment similar to the actual kiosk-use environment and measuring the background noise to output an appropriate volume. We verified the importance of auditory feedback by developing auditory guidance and feedback scenarios for fast-food restaurants. In this study, four prototypes were developed according to the background noise level and presence or absence of voice feedback; in addition, experiments were conducted with 20 participants. There was no significant difference in user experience in terms of background noise when applying the developed function, and there were advantages in voice information satisfaction and simplicity when auditory feedback was adopted. The function developed in this study worked successfully in that there was no difficulty in recognizing the kiosk voice regardless of background noise, and it was also effective in terms of usability when providing auditory feedback. In this study, the function of providing an appropriate volume according to background noise was developed, and the effect of auditory feedback was confirmed; however, there are several limitations. First, it was conducted as an initial accessibility study and comprised a small number of participants without physical aging. To compensate for this, it is necessary to determine whether it is suitable for various age groups and users with physical aging and disabilities. Second, because limited experiments have been conducted in only two levels of background noise environments, there is a limitation that investigations are required under conditions where there is no background noise, or the background noise is higher. In future studies, background noise conditions can be included, and various groups of participants can be recruited to further verify and improve the sound volume-providing function developed in this study. The results of this study can be applied to kiosks and voice information devices in environments with background noise, to improve user experience.

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