Research on Wearable Shopping Aid Device for Visually Impaired People

Yu-Hsiu Hung[1], Chia-Hui Feng[1,2(✉)], Chia-Tzu Lin[2], and Chung-Jen Chen[3]

[1] Department of Industrial Design, National Cheng Kung University, No. 1, University Road, Tainan, Taiwan R.O.C.
p38041075@ncku.edu.tw

[2] Department of Creative Product Design, Southern Taiwan University of Science and Technology, No. 1, Nan-Tai Street, Yongkang District, Tainan, Taiwan R.O.C.

[3] Department of Visual Communication Design, Southern Taiwan University of Science and Technology, No. 1, Nan-Tai Street, Yongkang District, Tainan, Taiwan R.O.C.

Abstract. This study explored the effect of three different shopping modes, namely shopping alone, shopping with a companion, and shopping using a shopping aid device, on the efficiency of in-store shopping and compared the behavioral difference between these three shopping modes using in-depth interviews with visually impaired people, their companions, and sales agents. The goal is to understand the current condition of shopping of visually impaired people and their related needs. Lastly, the researchers of this study designed and developed the prototype of a smart shopping aid wearable device for product recognition for visually impaired people. The study participants were six students, four males and two females, from Huei-Ming School and Home for Blind Children. For all participants, their task performance accuracy rate and task performance time were recorded and then analyzed by one-way repeated measure ANOVA to determine if shopping time was affected by the mode of shopping. System Usability Scale (SUS) was applied to determine the usability score of the wearable device of this study. The study results are as follows: (1) When comparing the average number of correct task performance between the three modes, the difference was statistically significant. From the post-hoc comparison, the correct rate of using a wearable device for shopping (95%) was significantly higher than of shopping alone (75%) and shopping with a companion (75%). Moreover, there was no difference between shopping alone and shopping with a companion. (2) For the task performance time, no significant difference was found between the variables. (3) The average SUS score was 74.2 (grade C) and the percentile rank was 71. This finding indicates that the wearable device developed in this study is easy to understand and easy to use. The participants showed a short learning curve and a high use intention.

Keywords: Assistive technology · Visually impaired people · Product recognition · Smart wearable device

M. Antona and C. Stephanidis (Eds.): HCII 2019, LNCS 11572, pp. 244–257, 2019.
https://doi.org/10.1007/978-3-030-23560-4_18

1 Introduction

According to the World Health Organization (WHO), by 2018 worldwide there are about 253 million people with visual impairment, and among them, 3.6 million people suffer from complete blindness; 217 million, medium or serious visual impairment [1]. According to studies based on the 2017 Global Vision Database, the age of populations with complete blindness, medium visual impairment, and severe visual impairment has gone down. In other words, visual impairment is more and more common among young people now [2].

People with visual impairment often need to rely on either their experiences or their family and friends for coping with various dangers and inconveniences in their daily lives. There are welfare organizations providing visually impaired people with vocational training, orientation training, and self-help skill training. Nonetheless, there are still numerous everyday tasks challenging people with visual impairment but no solutions available. Take shopping as an example, some shop owners refuse to have guide dogs enter their stores, making shopping difficult for visually impaired people [3].

Psychologically, studies have shown that because there are many daily matters, such as exploring a foreign environment, that visually impaired people cannot handle independently, and moreover, neither stable nor comprehensive aids are available for visually impaired people in the physical environment, visually impaired people need to look for help. However, seeking help often make visually impaired people anxious because of social and family relationship concerns, time pressure, etc. [4].

Physiologically, studies have shown that the major differences between people with congenital visual impairment and people with acquired visual impairment are the challenges they face and the use of their perception. Congenital visual impairment refers to impairment that happens before the age of five, and people with congenital visual impairment have usually lost their visual memory. In contrast, acquired visual impairment normally happens after the age of five, and people suffering from acquired visual impairment usually have their visual memory partially kept [5]. Visual impairment affects people both mentally and behaviorally depending on how much life experience they have accumulated. The more visual life experience a visually impaired person has accumulated, the more mental characteristics of non-visually impaired people this visually impaired person possesses [6], and the longer time it takes for this visually impaired person to learn to use his/her acute sense of touch and of hearing instead of the vision.

In recent years, shopping for visually impaired people has received great attention. Visually impaired people need to shop for fresh produce and daily necessities, and according to the physical store shopping methods of visually impaired people provided by the American Foundation for the Blind (AFB), common difficulties encountered during shopping by people with visual impairment include navigating among the aisles or reading the price tags or labels to find out the name, production date, list of ingredients, or nutritional facts of grocery products. Depending on their personal backgrounds, for example, people with severe visual impairment often find shopping difficult and are anxious about how to find out the content of products. Currently, people with mild visual impairment can use a shopping cart scanning device or a magnifier to read such information or to ask a shopping assistant to read the information for them. In research, studies have explored problems experienced by visually impaired people when shopping in physical stores and the corresponding solutions, but all these studies are centered on the use of scanning devices to assist visually impaired people in shopping [7–11].

Because of poor eyesight, the most frequently encountered obstacles by visually impaired people in shopping are associated with seeking and reading information. These obstacles include personal obstacles, interpersonal information obstacles, information and media access obstacles, and physical environment obstacles. For personal obstacles, information acquisition is affected primarily by the level of visual impairment and the age, and psychologically and cognitively, some visually impaired people may lack confidence, independence, a sense of security, and motivation for information acquisition [12, 13]. For interpersonal information obstacles, they are mainly caused by the gap between the assistance provided by non-visually impaired people and the actually needs requested by visually impaired people. Moreover, the assistance provided by non-visually impaired people is often affected by the amount of time available and their willingness [14]. In the physical environment, visually impaired people may encounter information obstacles, traffic flow obstacles, fine movement obstacles, and distance obstacles, and the last obstacle is the most problem one [15]. All these obstacles prevent visually impaired people from completing their shopping independently.

According to the above, visually impaired people when exploring new things may encounter physical difficulties, including locating product shelves or reading product labels, and psychological burdens, including social and family relationship concerns and other mental issues, and these issues make people with visual impairment worry about shopping in physical stores. To solve these problems, this study explored the use of a smart wearable device to assist visually impaired people in shopping. More specifically, the objective of this study is to use technology to help visually impaired people to locate product shelves and acquire product information so they can shop independently. Aside from providing useful information for promoting shopping environments and services accessible to visually impaired people, this study also presents insights to researchers investigating the shopping behavior of distinctive user groups.

2 Method

2.1 Subjects

The study participants were six junior high school students, four boys and two girls, aged between 12 and 15 from Huei-Ming School and Home for Blind Children. See Fig. 1. The participating students had to be capable of communicating and expressing their ideas and walking independently. Students with multiple disabilities were excluded from this study. For students participating in this study, the researchers of this study first explained the objectives of this study and the experiment procedure to the school, their parents and themselves and requested them to sign the informed consent for participants in order to protect the rights of these students.

Fig. 1. Interviewing visually impaired students

2.2 Subjects Experimental Design

To compare between the current shopping modes and the shopping mode of using a wearable device of visually impaired people, this study selected 24 products that were available on the market and divided them into four groups: cookies and crackers, beverages, household items, and snack foods. The participating students were asked to perform experimental tasks in three shopping models, and to eliminate the effect of learning, the sequence of the tasks and the location of the products were different between the students. In the following paper, the task of shopping alone is referred to as Task A, the task of shopping with a companion is referred to as Task B, and the task of using the wearable device is referred to as Task C. The sequence of these tasks of the first participating student was A first, B second, and C third (ABC), the sequence of the tasks of the second participating students was B first, C second, and A third (BCA), the sequence of the tasks of the third participating students was C first, A second, and B third (CAB), and the sequence of the rest of the students was arranged in the same fashion. For each task, the participating students had to find four designated products in a simulated shop, and after completing the experimental tasks, the task performance accuracy rate, the task performance time, and data collected from the system usability scale (SUS) regarding the wearable device were analyzed.

2.3 RFID Product Tags

The 24 selected products were divided into four groups, and most of these products were boxed or canned items. A passive RFID tag was attached to the inside of these boxes and cans. Information carried by the tags included the content of the product, the ingredients, the production date, the expiration date, and the price.

2.4 Product Shelves

Product shelves were set up in a simulated shop for displaying the products. These product shelves were arranged based on findings from retail product display studies. The products were arranged on shelves about 60 cm to 150 cm high from the floor for the best visual effect and an easy access [16, 17]. See Fig. 2. Each product shelf was equipped with an active RFID tag, and the sensing range was set to be within one meter for positioning the visually impaired participants and informing them which product shelf it is. Each product shelf displayed three products.

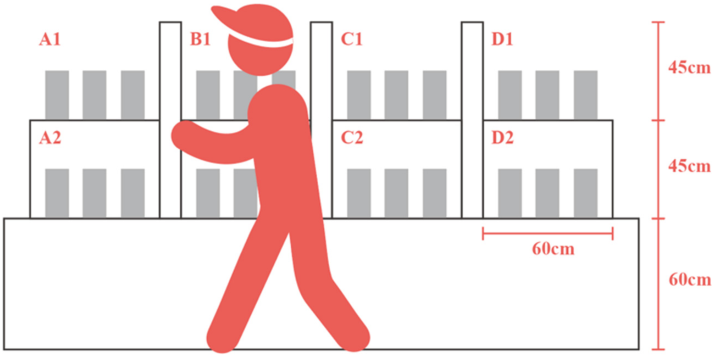

Fig. 2. Product shelf position and recommended optimal access range

2.5 The Wearable RFID Reader Device

This wearable RFID reader was to be worn on the wrist. See Fig. 3. This device was paired with an anti-metal interference high-frequency RFID tag, a Mp3Player module with a memory card, an 5DBI antenna, a RFID read write device, an Arduino RUNO microcontroller board, a read write device, and a speaker.

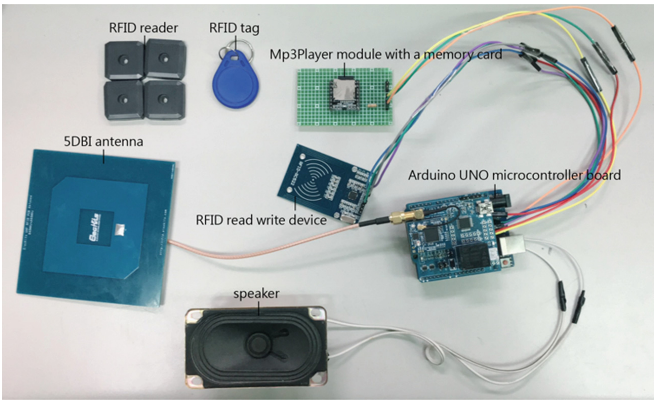

Fig. 3. Wearable device functional components

2.6 IoT Database

This study set up a simulated shop, product shelves, and a product information database. When participants put on the wearable device, information can be transmitted through the cloud network.

2.7 Programming Tools

An Arduino UNO board and Arduino IDE were used for software development and programming. The wearable device used in the experiment here was equipped with a RFID read writ module. On the product shelf, an active RFID tag was installed for transmitting information of the type of the product shelf. A passive RFID tag was attached to each product displayed on the package. A simulated shop information cloud was established to link all equipment used in the experiment to receive information from them.

2.8 System Usability Scale (SUS)

Developed by John Brooker in 1986, the system usability scale (SUS) has been extensively used for a quick test of products, systems, and websites. A major advantage of this scale is that it can be accurately and rapidly implemented for usability evaluation, even if the sample size is small [18]. In 2008, Bangor conducted a study using a large sample and found the reliability of SUS of 0.91. The scores of the scale can be divided into six levels, and each level is paired with a text description [19]. See Fig. 4.

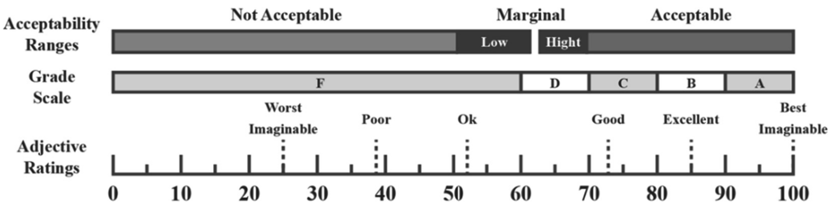

Fig. 4. SUS score cross reference chart

3 Results

This study used IBM SPSS Statistics Version 25 for the quantitative analysis of the acquired data in terms of the task performance time, the task performance accuracy rate, and the SUS score for the wearable device. The objective here is to present the experiment results comprehensively from various aspects.

3.1 Participants' Profile

As shown in Table 1, this study had six participants, and they were all junior high school students from Huei-Ming School and Home for Blind Children. There were four male students (66.7% of the study sample) and two female students (33.3% of the study sample).

Table 1. Descriptive statistics of participants' gender

Item	Sample size	Percentage (%)
Male	4	66.7
Female	2	33.3
Total	6	100

As shown in Table 2, all six participants (100% of the study sample) had retail shopping experience, and no participants (0% of the study sample) had no retail shopping experience.

Table 2. Descriptive statistics of participants' shopping experience

Item	Sample size	Percentage (%)
With retail shopping experience	6	100
Without retail shopping experience	0	0
Total	6	100

3.2 Task Performance Time Analysis Result

As shown in Table 3, in Task A shopping alone where participants were asked to go to the simulated shop alone to find the designated products, the participants in average spent 134.66 s for performing the task. In Task B shopping with a companion, participants went to the simulated shop with a companion and ask the companion for product information. For this task, the participants in average spent 166.50 s for performing the task. In Task C shopping using the wearable device, the participants went to the simulated shop wearing the wearable device, and in average, they spent 190.16 s performing the task.

Table 3. Task performance time analysis

Mode	Item	Mean	SD	Number
A	Time spent when shopping alone	134.66	39.05	6
B	Time spent when shopping with a companion	166.50	75.04	6
C	Time spent when shopping wearing a wearable device	190.16	66.00	6

As shown in Table 4, both the general assumption of variance analysis and the assumption of sphericity were met by the repeated measure ANOVA. Mauchly's W was 0.482, which when used for calculating the chi-square distribution gave a value of 2.922 ($p = 0.232 > 0.05$, nss).

Table 4. Mauchly's Sphericity test: task performance time analysis

Within subjects effect	Mauchly's W	Approx. chi-square	df	Sig.	Epsilon(b)		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Factor	.482	2.922	2	.232	.659	.801	.500

Table 5 shows that the assumption of sphericity was satisfied, and therefore, the data can be the sphericity assumed rows. It was found from between-group effect test that the sum of squares (SS) of the effect of the independent variable was 9307.444, the mean square was 4653.722, the F value was 3.133 ($p = 0.088$, nss). This finding suggests a lack of significant difference between the three shopping modes in the amount of time spent for completing the tasks.

Table 5. Testing the within-subject effect of task performance time

Source		Type III sum of squares	df	Mean square	F	Sig.
Factor	Sphericity assumed	9307.444	2	4653.722	3.133	.088
	Greenhouse-Geisser	9307.444	1.317	7066.088	3.133	.119
	Huynh-Feldt	9307.444	1.603	5806.596	3.133	.105
	Lower-bound	9307.444	1.000	9307.444	3.133	.137
Error (factor)	Sphericity assumed	14852.566	10	1484.256		
	Greenhouse-Geisser	14852.566	6.586	2255.172		
	Huynh-Feldt	14852.566	8.015	1853.200		
	Lower-bound	14852.566	5.000	2907.511		

Table 6 shows the within-subject test result and it was affected by repeated measures. For the between-subject effect, the repeated measured ANOVA revealed a sum of squares (SS) between-subject of 42717.111, a degree of freedom of 5, and a mean square of 8543.422. Because the between-subject effect was statistically significant ($p < .001$), the amount of time required for completing the tasks varied among the participants.

Table 6. Testing the within-subject effect of task performance time

Source	Type III sum of squares	df	Mean square	F	Sig.
Intercept	482816.889	1	482816.889	56.513	.001
Error	42717.111	5	8543.422		

See Table 7. The dependent sample sphericity test result indicated that the assumption of sphericity was not violated. Mauchly's W was 0.482 ($\chi^2 = 2.922$, p = 0.232), and therefore no correction was required. The difference between the means of the three tasks was not statistically significant, and for the between-group effect, F (2,10) = 3.133 (P = 0.088 > 0.05), it can be found that the amount of time required for participants to complete the tasks in the three modes (shopping alone, shopping with a companion, and shopping using a wearable device) was not much different. Because the between-group difference for the task performance time was not statistically significant, a post-hoc comparison was not required.

Table 7. ANOVA test result for task performance time of different shopping modes

Source	Between-group variation	df	Mean square	F	Sig.
Between groups	9307.444	2	4653.722	3.133***	0.088
Within group (error)					
Between subjects	42717.111	5	8543.422		
Residuals	14852.566	10	1485.256		
Total	66877.121	17			

3.3 Analysis of Task Performance Accuracy Rate

As shown in Table 8, participants in Task A shopping alone were asked to go to the simulated shop alone to find the designated products, and their average number of correct task performance was 75.00, with a standard deviation of 15.81. For Task B where participants went to the simulated shop with a companion and needed to ask the companion for product information, the participants' average number of correct task performance was 75.00, with a standard deviation of 15.81. For Task C where participants wore the wearable device to the simulated shop, the average number of correct task performance was 95.83, with a standard deviation of 10.20.

Table 8. Analysis of task accuracy rate

Mode	Item	Mean	Std. deviation	N
A	Shopping alone	75.00	15.81	6
B	Shopping with a companion	75.00	15.81	6
C	Shopping using the wearable device	95.83	10.20	6

As shown in Table 9, both the general assumption of variance analysis and the assumption of sphericity were met by the repeated measure ANOVA. Mauchly's W was 0.476, which when used for calculating the chi-square distribution gave a value of 2.966 (p = 0.227 > 0.05, nss).

Table 9. Mauchly's test of Sphericity for task performance accuracy rate

Within subjects effect	Mauchly's W	Approx. chi-square	df	Sig.	Epsilon[(b)]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Factor	.476	2.966	2	.227	.656	.797	.500

Table 10 shows that the assumption of sphericity was met, and therefore, the data can be the sphericity assumed rows. From testing the between-group effect, it was found that the sum of squares (SS) of the effect of the independent variable was 1736.111, the mean square was 868.056, and the F value was 5.435 ($p = 0.025$, reaching the statistically significance ($p < 0.05$). This finding suggests that in different shopping modes, participants' task performance accuracy rate was significantly different, and therefore, a post-hoc comparison was required.

Table 10. Test of the within-subject effect for the task performance accuracy rate

Source		Type III sum of squares	df	Lower-bound	F	Sig.
Factor	Sphericity assumed	1736.111	2	868.056	5.435	.025
	Greenhouse–Geisser	1736.111	1.313	1322.595	5.435	.049
	Huynh–Feldt	1736.111	1.593	1089.468	5.435	.037
	Lower-bound	1736.111	1.000	1736.111	5.435	.067
Error (factor)	Sphericity assumed	1597.222	10	159.722		
	Greenhouse–Geisser	1597.222	6.563	243.357		
	Huynh–Feldt	1597.222	7.968	200.462		
	Lower-bound	1597.222	5.000	319.444		

See Table 11. According to the test result of the between-subject effect, repeated measures had an effect. For the between-subject effect, the repeated measured ANOVA revealed a sum of squares between-subject of 1423.611, a degree of freedom of 5, $p < .001$, and a mean square of 284.722.

Table 11. Test of the between-subject effect for the task performance accuracy rate

Source	Type III sum of squares	df	Mean square	F	Sig.
Intercept	120868.056	1	120868.056	424.512	.0001
Error	1423.611	5	284.722		

See Table 12. According to the mean difference and the significance from the Bonferroni post-hoc test, the average task performance accuracy rate of shopping using the wearable device was significantly higher than that of shopping with a companion or of shopping alone. As for shopping with a companion and shopping alone, no significant difference was found between their average task performance accuracy rates.

Table 12. Post-hoc comparison of the task performance accuracy rate between different shopping modes

(I) factor	(J) factor	Mean difference (I-J)	Std. error	Sig.(b)	95% confidence interval for difference(b)	
					Lower bound	upper bound
A	B	.000	9.129	1.000	−23.466	23.466
	C	−20.833*	4.167	.004	−31.544	−10.123
B	A	.000	9.129	1.000	−23.466	23.466
	C	−20.833*	7.683	.042	−40.583	−1.084
C	A	20.833*	4.167	.004	10.123	31.544
	B	20.833*	7.683	.042	1.084	40.583

Note: A for shopping alone, B for shopping with a companion, and C for shopping using the wearable device

As shown in Table 13 that the assumption of sphericity was not violated according to the test result. Mauchly's W was 0.476 (χ^2 = 2.966, p = 0.227), and therefore no correction was required. The mean difference of the three tasks reached statistical significance, and the between-group effect was significant (F (2,10) = 5.435, P = 0.025 < 0.05). In other words, the participants' task performance accuracy rate was significantly different between the three shopping modes (i.e., shopping alone, shopping with a companion, and shopping using a wearable device). It was found from the post-hoc comparison that the average number of correct task performance of Task C (using the wearable device) was 3.38, significantly higher than 3.0 of Task B (shopping with a companion) or 3.0 of Task A (shopping alone). Moreover, the task performance accuracy rate of Task A and Task B did not differ significantly.

Table 13. Analysis of variance of the task performance accuracy rate of different shopping

Source of variation	SS	df	MS	F	Sig.	Post-hoc comparison
Between groups	1736.111	2	868.056	5.435***	0.025	C > B = A
Within group (error)						
Between subjects	1423.611	5	284.722			
Residuals	1597.222	10	159.722			
Total	4756.944	17				

3.4 SUS Result for the Wearable Device

As shown in Table 14, the SUS score of the wearable device of this study was 74.2 of grade C, and because this score exceeded the average SUS score of 68.5, this wearable device passed the usability evaluation test. As for the easy-to-learn score of the device, the device tested in this study was easy to learn and to use. The short learning curve of the participants means that they could easily understand how to use the device, and because the device was easy to use, the participants showed a good use intention and considered that the functions of the device met their daily needs.

Table 14. SUS result of the smart wearable device

No.	1	2	3	4	5	6
Score	82.5	75	77.5	30	87.5	92.5
Rating	B	C	C	F	B	A
Mean	74.2					

According to Fig. 5 of SUS, the wearable device had a grade of C and a score of 74.2 (between 70 and 80). This finding suggests that the participants considered that the device has a good usability, a good acceptability, and no operating problem.

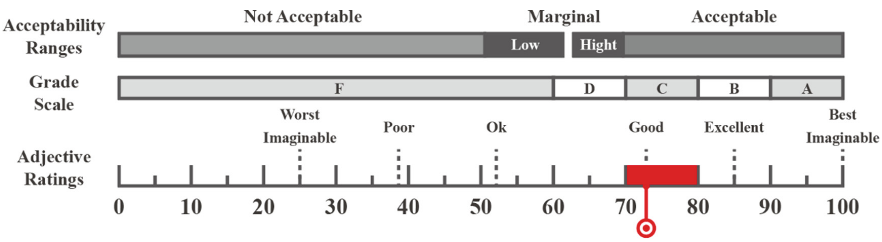

Fig. 5. SUS score cross resulted chart

4 Discussion and Conclusion

According to the participant task performance accuracy rate, task performance time, and the SUS result, the shopping mode of using the wearable device and the functions of the wearable device were accepted by the six participants and received positive feedback from these participants. In other words, this wearable device can meet the daily needs of the participants currently. This study considered that there is still a lot of room for the development of shopping aid devices for visually impaired people. The shopping aid device developed in this study has three major contributions; one is that this shopping aid device can meet visually impaired people's expectation for shopping independently. Another is that this shopping aid device enables visually impaired people to acquire information easily. The other contribution is that this shopping aid device can eliminate the social and family relationship concerns and mental stress experienced by visually impaired people when looking for a companion for shopping.

It can be found from the task performance time analysis that there was no significant difference between the three shopping modes. The reason for spending more time when shopping using the wearable device than the other two shopping modes is that the participants in the experiment had to first touch the products before listening to the information of the products and judging which one is the designated one. The task performance time was increased because the participants might listen to the information more than once.

For shopping with a companion, the amount of time spent performing the task was affected by how extrovert the participants were; those who were more willing to ask for information voluntarily spent relatively more time performing the task than those who were reluctant to ask questions. For shopping alone, the amount of time spent performing the task was affected by participants' subjective product perception; they would touch the products, feel the weight, or smell the products to help identify them. For unfamiliar products, they had to guess and to intuitively and subjectively make decision. In this case, though less time was spent, the error rate was high.

It can be found from the task performance accuracy rate that participants when using the wearable device can identify three to four products correctly. Though this mode was more time consuming than the other two modes, the accuracy rate was better than the other two because the information the participants listened to can help them identify the correct products. For shopping with a companion, some participants felt uncomfortable to be accompanied, and their understanding of the products was dependent upon their willingness to ask questions. As for shopping alone, participants' subjective viewpoints and their familiarity with the products affected their accuracy rate.

This study made the following contributions: (1) This study developed a shopping aid wearable device for visually impaired people and improved the use artificial intelligence for product recognition. The information is useful for product developers interested in developing products meeting the needs of visually impaired people and possessing a good usability and an easy-to-learn feature. (2) This behavioral study investigating the physical retail shopping experience of people with visual impairment offers the pros and cons of shopping alone, shopping with a companion, and shopping using a wearable device. (3) This study found from the experiment that product packages containing metal lead can interfere with the sensitivity of product sensing of the device; (4) The length of time of product voice information should not be too long or visually impaired users may lose their patience and concentration.

References

1. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. Accessed 31 Dec 2018
2. Bourne, R.R., Flaxman, S.R., Braithwaite, T., Cicinelli, M.V., Das, A., Jonas, J.B., et al.: Magnitude: temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. Lancet Glob. Health **5**(9), e888–e897 (2017)
3. Lai, S.L.: The current status and future outlook of adaptive devices for the visually impaired in Taiwan. Spec. Educ. **99**, 31–36 (2006)
4. Wang, Y.Y.: The role of 'personal assistance': the case of visual assistant service. NTU Soc. Work Rev. **12**, 89–138 (2005)
5. Moore, J.E., Graves, W.H., Patterson, J.B.: Foundation of Rehabilitation Counseling with Persons Who Are Blind or Visually Impaired. AFB Press, New York (1997)
6. Sato, T.: Psychology and Education for Children with Visual Impairment. Wu-Nan Book Inc., Taipei (1983)
7. Gharpure, C.P., Kulyukin, V.A.: Robot-assisted shopping for the blind: issues in spatial cognition and product selection. Intell. Serv. Robot. **1**(3), 237–251 (2008)
8. Nicholson, J., Kulyukin, V., Coster, D.: ShopTalk: independent blind shopping through verbal route directions and barcode scans. Open Rehab. J. **9**(2), 11–23 (2009)
9. Kulyukin, V., Kutiyanawala, A.: Accessible shopping systems for blind and visually impaired individuals: design requirements and the state of the art. Open Rehab. J. **2**, 158–168 (2010)
10. Lanigan, P.E., Paulos, A.M., Williams, A.W., Rossi, D., Narasimhan, P.: Trinetra: assistive technologies for grocery shopping for the blind. In: Proceedings of the 10th IEEE International Symposium on Wearable Computers, pp. 147–148 (2007)
11. Yang, C.Y.: Assisting the visually impaired to identity objects using smart phone. Master's thesis (2012). https://hdl.handle.net/11296/8994ev
12. Graeme, D., Christine, C., Sue, P.: The role of the WHO ICF as a framework to interpret barriers and to inclusion. Br. J. Vis. Impair. **25**(1), 32–50 (2007)
13. Saumure, K., Given, L.M.: Digitally enhanced? An examination of the information behaviors of visually impaired post-secondary students. Can. J. Inf. Libr. Sci. **28**(2), 25–42 (2004)
14. Elaine, G.: The benefits of and barriers to computer use for individuals who are visually impaired. J. Vis. Impair. Blind. **97**(9), 536–550 (2003)
15. Gold, D., Simson, H.: Identifying the needs of people in Canada who are blind or visually impaired: preliminary results of a nation-wide study. Int. Congr. Ser. **1282**, 139–142 (2005)
16. Lin, C.H., Huang, Y.C.: Business Strategies for Successful Shopping Center Management. Tiaohe Culture Co., Ltd., Taiwan (1999)
17. Hsieh, C.H.: Retail Store Planning and Management, Highlights. Wu-Nan Book Inc., Taipei (2009)
18. Brooke, J.: SUS: a retrospective. J. Usabil. Stud. **8**(2), 29–40 (2013)
19. Bangor, A., Kortum, P.T., Miller, J.T.: Determining what individual SUS scores mean: adding an adjective rating scale. J. Usabil. Stud. **4**(3), 114–123 (2009)