Applied Human Factors and Ergonomics (AHFE2025), Vol. 199, 2025, 661–670
https://doi.org/10.54941/ahfe1006878

Evaluating Interface Layout, Button Area, and Quantity on Screen Reader Navigation for Visually Impaired Mobile Users

Hsiang-Ping Wu[1], Chih-Fu Wu[2], Yung-Hsiang Tu[2], and Cheung-Choi Ching[1]

[1]Department of Product Design, Ming Chuan University, Taoyuan City, Taiwan
[2]Department of Industrial Design, Tatung University, Taipei, Taiwan

ABSTRACT

With the widespread adoption of smartphones, visually impaired individuals increasingly rely on built-in screen reader functionalities for daily learning and activities. However, many current mobile interfaces lack inclusive design considerations, particularly in interface layouts and button configurations, leading to decreased operational efficiency and higher error rates. Although prior studies have examined the effects of interface layout, simplification, button area, shape, and quantity on user interaction, most have focused on individual factors. Comprehensive analyses of how these design elements interact are limited. This study collaborated with a Taiwanese school for the visually impaired, recruiting 30 students to participate in an experiment evaluating the combined effects of interface layout (grid vs. list), button area (fixed vs. equally divided), and button quantity (4, 6, 8) on task performance and user preference. Participants completed tasks using 12 different interface configurations, and their performance was assessed based on task completion time, error rate, and subjective preference. Statistical analysis using repeated measures ANOVA revealed that under the four-button condition, equally-divided button areas led to better performance ($M = 40.2$ s, $SD = 4.2$) compared to fixed button areas ($M = 51.5$ s, $SD = 5.7$), $F(1, 29) = 8.74$, $p = .006$. The Grid layout produced fewer errors than the List layout (10 vs. 25). Under the six-button condition, fixed button areas outperformed equally-divided ones, with mean times of 42.6 s ($SD = 3.6$) vs. 51.7 s ($SD = 3.9$), $F(1, 29) = 14.38$, $p = .001$; here, the List layout showed fewer errors compared to Grid (22 vs. 33). In the eight-button condition, though differences were not statistically significant, low-vision participants preferred the List layout (5 out of 7), while blind participants favored the Grid layout (6 out of 7). These findings offer practical guidance for designing accessible mobile interfaces and support the standardization of assistive technology products.

Keywords: Visual impairment, Screen reader, Mobile interface design, Inclusive design, Interface layout (grid vs. list), Button area (fixed vs. equally divided), Button quantity, Human-computer interaction (HCI), Assistive technology

INTRODUCTION

With the widespread adoption of smartphones, visually impaired users have become increasingly dependent on built-in screen readers for daily learning and activities. However, many mobile interfaces still lack inclusive design considerations, leading to navigation challenges, cognitive overload, and inconsistent interaction patterns—particularly when users rely on screen readers that may fail to announce controls or present information in illogical sequences (Hamideh et al., 2024; Grussenmeyer & Folmer, 2017; Khan & Khusro, 2019). True inclusive design should not place the burden of adaptation on visually impaired users but instead focus on eliminating barriers in interface interaction (Brunk & Ireton, 2022). Therefore, this study seeks to advance accessible design by empirically investigating key factors influencing mobile interface usability for screen reader users.

Various interface design elements - including layouts, simplification, button quantity, area, and shape - may influence user interaction efficiency to some degree. In menu layout design, The List and Grid interfaces are two common layout paradigms in menu design. Kammerer et al. (2010) suggested that the vertical sequential arrangement of the List Interface appears to facilitate top-to-bottom browsing patterns, while the Grid Interface's multi- row/column structure might enable more balanced navigating and selection. Scott et al. (2025) further noted that although both layouts show no significant difference in actual task completion time, Grid Interface enhances users' subjective perception of efficiency.

Existing research has primarily examined sighted users, with relatively few studies comparing interface layouts for visually impaired individuals. Some evidence from horizontal interfaces (Kamel et al., 2013; Ohene- Djan et al., 2018) indicates that a 3×3 Grid Interface could help visually impaired users develop spatial cognition, particularly for complex navigation tasks. However, in vertical mobile interfaces, researchers like Priowibowo et al. (2020) and Madrigal-Cadavid et al. (2020) have tended to favor List Interface approaches in their design modifications. Nevertheless, further investigation is needed to compare the effects of list versus grid layouts in vertically oriented mobile interfaces on the task efficiency of users with visual impairments.

In addition to menu layout, the division of interface areas— the number of buttons—also plays a critical role in user performance. Paap et al. (1986) found that optimizing the number of options per level, particularly maintaining it between four and eight, can significantly enhance search time and efficiency. Similarly, Khan et al. (2019) demonstrated that users with visual impairments benefited from simplified interfaces featuring 4, 6, or 8 grid divisions, along with adaptive interaction modes. For instance, in a web browsing task, the simplified interface reduced task time from 45.00 to 34.25 minutes. In an email task, it achieved 92% accuracy and reduced errors by 87.7%. Drawing on these findings, this study adopts three button quantity levels—4, 6, and 8—in each interface configuration to examine their effects on task performance and user preferences.

Moreover, the division of interface areas inherently affects button area. Previous studies by Chang et al. (2008), Romero et al. (2011), and Chiti et al. (2012) explored how the number and size of segmented buttons on smart device interfaces impact the performance of users with visual impairments. Their findings suggested that buttons should be positioned near the edges of the screen and designed as large as possible, with size determined by maximizing the use of available screen space.

Regarding the minimum touch target size, Duff et al. (2010) and Chen et al. (2013) recommended that button dimensions should be no smaller than 20 millimeters, as smaller targets can significantly reduce operational performance. However, considering the limited screen space on mobile devices, current accessibility design guidelines for Android and iOS platforms (Developer et al., 2022) suggest a minimum tappable area of 44 × 44 pt, which corresponds to approximately 16 millimeters. Accordingly, this study adopts two button area conditions: one based on equally dividing the available interface space, and another using a fixed minimum height of at least 44 pt, aligned with current mobile accessibility guidelines.

Regarding button shape, Tao et al. (2018) found no significant difference in task accuracy among square, vertical rectangle, and horizontal rectangle buttons. While earlier studies tended to use square buttons primarily, rectangle shapes proved helpful in reducing the overall footprint of on-screen keyboards—making them especially appropriate for space- constrained touchscreen environments like those in our study. These previous investigations into interface design elements—interface layout, button area, and quantity—provided a guiding foundation for us to develop and refine the evaluation metrics and experimental configurations used in this research.

METHODS

This study employed a within-subjects repeated-measures experimental design to evaluate how interface layout (grid vs. list), button area (fixed vs. equally divided), and button quantity (4, 6, 8) affect task performance. Each participant completed tasks across 12 interface conditions, with task completion time serving as the primary outcome measure. In addition to time, error rate and subjective preference were collected as supplementary data to present a comprehensive view of each interface combination's performance. Ethical approval was granted by the Institutional Review Board of the National Taiwan University on May 27, 2024. Prior to participation, informed consent was obtained from all adult participants and from the parents or guardians of minor participants.

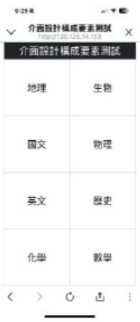
Participants

This study was conducted in collaboration with a school for visually impaired students in Taiwan. We invited all students to participate, a total of 30 volunteers (16 males and 14 females) joined the experiment. The participants' ages ranged from 12 to 20 years (mean = 16 years). Among them, 19 students had low vision (visual acuity ≤ 0.3) and 11 were completely blind. To ensure fairness and baseline competence, all participants—regardless of previous screen reader familiarity—completed two operation practice sessions before the main experiment to confirm they could perform the required tasks.

Materials

The experiment took place in a classroom equipped with a long table and two chairs. Two GoPro cameras, each capturing different angles, were set up on the table. The experimental interfaces were implemented on an iPhone (6.3-inch screen) running iOS with the built-in VoiceOver screen reader. The device displayed twelve menu screens, encompassing all combinations of two interface layouts, two button-area configurations, and three button quantities (see Table 1). Each screen featured a fixed title at the top, with buttons labeled using different learning subject names arranged below. As users swiped into each segment, VoiceOver spoke the corresponding subject name to guide navigation.

Table 1: Experimental interface configurations.

No.1 Grid–Eq–4	No.2 Grid–Eq–6	No.3 Grid–Eq–8	No.4 Grid–Fix–4	No.5 Grid–Fix–6	No.6 Grid–Fix–8
					
No.7 List–Eq–4	**No.8 List–Eq–6**	**No.9 List–Eq–8**	**No.10 List–Fix–4**	**No.11 List–Fix–6**	**No.12 List–Fix–8**
					

*No.12 spans onto the next page

Note: Grid = grid layout; List = list layout; Eq = equally divided button area; Fix = fixed button area

Procedure

Stage 1 – Practice

Participants began with two practice sessions—first with four labeled buttons, then with eight—each with randomized button order. In each session, Voice Over read the fixed title aloud, followed by the researcher announcing a target subject name. Participants tapped the matching button, heard an "item selected" confirmation with audio feedback, then returned via the back arrow. After selecting all targets in each session, they proceeded to the next. Upon completing both sessions, they advanced to the main experiment (Stage 2).

Stage2 – Main Experiment

Participants were required to complete tasks on 12 menu screens, each with 4, 6, or 8 buttons labeled with subject names. Regardless of the interface, participants were required to select four subjects, and the selection order was randomized to ensure objectivity. Upon tapping a subject button, they heard an "item selected" audio confirmation, then used the back arrow to return and select the next button. Once all four were selected, they proceeded to the next interface.

The entire session was video-recorded to capture participants' actions, task duration, and responses. Participants were not time-constrained while using the screen reader and could ask questions at any time. After completing all tasks, we asked them which interface they liked best and why.

RESULTS AND DISCUSSION

A repeated-measures ANOVA examined the effects of interface layout, button area, and button quantity on task completion time. No significant main effects were found for layout or area. However, button quantity exerted a strong influence: the 8-button configuration ($M = 61.6$ s, $SD = 5.3$) took significantly longer than the 6-button ($M = 47.1$ s, $SD = 3.6$) and 4-button ($M = 45.9$ s, $SD = 4.6$) configurations, $F(2, 58) = 19.26$, $p < .0001$. This was largely due to the increased auditory scanning required—especially in the List–Fix–8 layout, which necessitated paging. Additionally, a significant three-way interaction among interface layout, button area, and button quantity was found, $F(1.6, 46.4) = 4.03$, $p = .033$. To further explore this interaction, we conducted follow-up analyses for each button quantity separately.

Performance Under the Four-Button Condition

A repeated-measures ANOVA revealed a significant effect of button area on task completion time. The equally-divided button configuration ($M = 40.2$ s, $SD = 4.2$) led to significantly faster performance than the fixed-area configuration ($M = 51.5$ s, $SD = 5.7$), $F(1, 29) = 8.74$, $p = .006$. This is likely due to the larger touch targets afforded by the equally- divided layout—a finding consistent with previous research by Chang et al. (2008), Romero et al. (2011), and Chiti et al. (2012), which also support the use of larger button areas for improved usability.In addition, a significant interaction was observed between interface layout and button area, $F(1, 29) = 11.7$, $p = .002$. Within the grid layout, the equally- divided configuration resulted in a mean completion time of 36.1 seconds ($SD = 4.0$), significantly shorter than the fixed-area configuration at 58.5 seconds ($SD = 7.0$), $F(1, 29) = 28.4$, $p < .0001$. This difference likely stems from the fact that the Grid–Fix–4 buttons were confined to the upper half of the screen, occupying only about half of the display area and forcing users to spend additional time locating and confirming target positions. By contrast, in the list layout, no significant difference was found between equally-divided and fixed-area configurations. The linear scanning nature of the list layout appears to mitigate the impact of button area on user performance.

Performance Under the Six-Button Condition

A repeated-measures ANOVA revealed that button area significantly affected task completion time. Specifically, the fixed button configuration (M = 42.6 s, SD = 3.6) resulted in faster performance than the equally- divided configuration (M = 51.7 s, SD = 3.9), $F(1, 29) = 14.38$, $p = .001$— an effect opposite to that observed under the four-button condition. This suggests that with six buttons, the performance difference between equally- divided and fixed layouts diminishes and may impact efficiency.

Performance Under the Eight-Button Condition

A repeated-measures ANOVA indicated no significant effects of interface layout or button area on task completion time, even when the List–Fix–8 configuration required paging.

In addition to recording task completion times, this study also monitored and documented participant errors during the tasks. Analyzing these error patterns helps identify usability challenges not reflected in quantitative performance metrics, offering a deeper understanding of potential issues in real-world interface use. Table 2 below details the types and frequencies of errors made by participants under each interface condition.

Table 2: Participant errors under different interface configurations.

Interfac e No.	Errors	Misunders-tandings	Hesitations	Incomplete Tasks	Questions Asked	Syste m	Trial Error	Total
1	6	0	3	0	0	0	1	10
2	15	0	12	0	1	0	1	29
3	21	1	16	0	3	0	3	**44**
4	17	2	17	0	3	0	1	**40**
5	16	0	12	0	4	0	1	33
6	16	0	8	0	5	0	3	32
7	15	0	8	0	0	0	2	25
8	16	0	2	0	2	0	1	21
9	20	0	8	0	1	0	2	31
10	9	0	8	0	0	0	2	19
11	10	1	8	0	2	0	1	22
12	14	4	16	0	3	0	2	**40**
*Total	175	8	118	0	24	0	20	346

Based on the error statistics across interface conditions, **errors** and **hesitations** were the most common issues and appeared in almost all variants, especially in Interfaces 3, 4, and 12. This suggests that these configurations may confuse users or disrupt the flow. **Misunderstandings** of task instructions occurred only in a few interfaces (e.g., 3, 4, and 12), indicating generally clear instructions but potential comprehension issues in complex layouts. Participants asked slightly more questions in Interfaces 5 and 6, suggesting a minor increase in uncertainty or lack of clarity. Notably, Interface 1 had the fewest total errors but still exhibited hesitations and trial-and-error behaviors, indicating room for improved intuitiveness. Overall, Interfaces 3 and 4 had the highest error counts and should be prioritized for redesign.

Finally, to understand participants' subjective impressions of the different learning interface designs, we conducted brief interviews after the tasks. Table 3 presents a summary of their preferences. Because we later found differences between low-vision and blind participants, preferences are annotated according to participant type.

Table 3: Subjective interface preferences among low-vision and blind participants.

Interface No.	Low-Vision (n = 19)	Blind (n = 11)
No.1 Grid–Eq–4	0	0
No.2 Grid–Eq–6	3	0
No.3 Grid–Eq–8	1	4
No.4 Grid–Fix–4	1	1
No.5 Grid–Fix–6	0	1
No.6 Grid–Fix–8	1	2
No.7 List–Eq–4	4	1
No.8 List–Eq–6	0	0
No.9 List–Eq–8	5	1
No.10 List–Fix–4	1	0
No.11 List–Fix–6	3	1
No.12 List–Fix–8	0	0

Interface Layout Preferences

Fourteen participants preferred the grid layout—six low-vision and eight blind. They commented that the two-row, four-button grid offers optimal spacing and pacing for VoiceOver, resembles a keyboard structure that aids positional memory, and prevents difficulties from buttons being too large. Fourteen participants preferred the grid layout—six low-vision and eight blind. They commented that the two-row, four-button grid offers optimal spacing and pacing for VoiceOver, resembles a keyboard structure that aids positional memory, and prevents difficulties from buttons being too large.

Button Area Preferences

Nineteen participants favored the equally divided button area—13 low-vision and six blind. They noted that fixed-area layouts left large unused parts of the screen and required extra navigation time.

Button Quantity Preferences

Most participants found eight-button configurations challenging in terms of memory and operation, particularly less experienced users. They reported that when buttons were tightly spaced and VoiceOver read too quickly, it was easy to miss targets. Nevertheless, 14 participants still chose the eight- button layout, suggesting that its higher information density and potential efficiency appealed to some users.

CONCLUSION

Based on performance times, error counts, and user preferences, we compiled a set of recommended "best-performing" interface combinations of layout, button area, and button quantity (see Table 4). In the four-button condition, equally-divided layouts outperformed fixed-area ones, and the Grid–Eq–4 configuration yielded fewer errors than List–Eq–4 (10 vs. 25), making Grid + Equally-Divided the preferred choice. In the six-button condition, fixed-area layouts performed better, and List–Fix–6 had fewer errors than Grid–Fix–6 (22 vs. 33), leading to List + Fixed-Area as the recommendation. For the eight-button condition, no statistically significant differences emerged, but preferences varied by vision status: low-vision users favored the List layout (5 out of 7), and List + Equally-Divided produced fewer errors than List + Fixed-Area (31 vs. 40); blind users preferred the Grid layout (6 out of 7), and Grid + Fixed-Area had fewer errors than Grid + Equally-Divided (32 vs. 44). We hope these recommended configurations contribute to an inclusive mobile interface design framework for screen reader users with visual impairment.

Table 4: Best-Performing Interface Combinations for Different Button Quantities.

Button Quantity	Recommended Interface No.	Notes
4	No.1 Grid–Eq–4 	Equally-divided layout outperformed fixed; Grid–Eq–4 had fewer errors than List–Eq–4 (10 vs. 25)
6	No.11 List–Fix–6 	Fixed-area layout performed better; List–Fix–6 had fewer errors than Grid–Fix–6 (22 vs. 33)

Continued

Table 4: Continued

Button Quantity	**Recommended Interface No.**	**Notes**
8 (Low-Vision)	No.9 List–Eq–8 	low-vision users preferred list; List–Eq–8 had fewer errors (31 vs. 40)
8 (Blind)	No.6 Grid–Fix–8 	Blind users preferred grid; Grid–Fix–8 had fewer errors (32 vs. 44)

ACKNOWLEDGMENT

The authors gratefully acknowledge funding support from the National Science and Technology Council (grant number NSTC 113-2410-H-130- 011-MY2).

REFERENCES

Brunk, A., & Ireton, D. (2022). Failures in library website accessibility: A problem of accountability. Human Factors in Accessibility and Assistive Technology, 37, 78.

Chang, G., Tan, C., Li, G., & Zhu, C. (2008, December). Developing mobile applications on the Android platform. In Workshop of Mobile Multmedia Processing (pp.264–286). Springer, Berlin, Heidelberg.

Chen, K. B., Savage, A. B., Chourasia, A. O., Wiegmann, D. A., & Sesto, M. E. (2013). Touch screen performance by individuals with and without motor control disabilities. Applied ergonomics, 44(2), 297–302.

Chiti, S., & Leporini, B. (2012, July). Accessibility of android-based mobile devices: a prototype to investigate interaction with blind users. In International Conference on Computers for Handicapped Persons (pp. 607–614). Springer, Berlin, Heidelberg.

Developer. (2022). Human Interface Guidelines Retrieved November 14, 2022, from https://developer.apple.com/design/.

Duff, S. N., Irwin, C. B., Skye, J. L., Sesto, M. E., & Wiegmann, D. A. (2010, September). The effect of disability and approach on touch screen performance during a number entry task. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (Vol. 54, No. 6, pp. 566–570). Sage CA: Los Angeles, CA: SAGE Publications.

Grussenmeyer, W., & Folmer, E. (2017). Accessible touchscreen technology for people with visual impairments: a survey. ACM Transactions on Accessible Computing (TACCESS), 9(2), 1–31.

Hamideh Kerdar, S., Bächler, L., & Kirchhoff, B. M. (2024). The accessibility of digital technologies for people with visual impairment and blindness: a scoping review. Discover Computing, 27(1), 24.

Kamel, H. M., & Erhan, H. I. (2013). WebSight: the use of the grid-based interface to convey layout of web-pages in a non-visual environment. In Universal Access in Human-Computer Interaction. User and Context Diversity: 7th International Conference, UAHCI 2013, Held as Part of HCI International 2013, Las Vegas, NV, USA, July 21–26, 2013, Proceedings, Part II 7 (pp. 674–683). Springer Berlin Heidelberg.

Khan, A., & Khusro, S. (2019). Blind-friendly user interfaces–a pilot study on improving the accessibility of touchscreen interfaces. Multimedia Tools and Applications, 78, 17495–17519.

Madrigal-Cadavid, J., Amariles, P., Pino-Marín, D., Granados, J., & Giraldo, N. (2020). Design and development of a mobile app of drug information for people with visual impairment. Research in Social and Administrative Pharmacy, 16(1), 62–67.

Ohene-Djan, J. F., & Fernando, S. A. (2018). Screen navigation system for visually impaired people. Journal of Enabling Technologies, 12(3), 114–128.

Paap, K. R., & Roske-Hofstrand, R. J. (1986). The optimal number of menu options per panel. Human Factors, 28(4), 377–385.

Priowibowo, B., Effendy, V., & Junaedi, D. (2020, April). Designing user interface using user-centered design method on reproductive health learning for visual impairment teenagers. In IOP Conference Series: Materials Science and Engineering (Vol. 830, No. 2, p. 022092). IOP Publishing.

Romero, M., Frey, B., Southern, C., & Abowd, G. D. (2011, August). BrailleTouch: designing a mobile eyes-free soft keyboard. In Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services (pp. 707–709).

Tao, D., Yuan, J., Liu, S., & Qu, X. (2018). Effects of button design characteristics on performance and perceptions of touchscreen use. International Journal of Industrial Ergonomics, 64, 59–68.