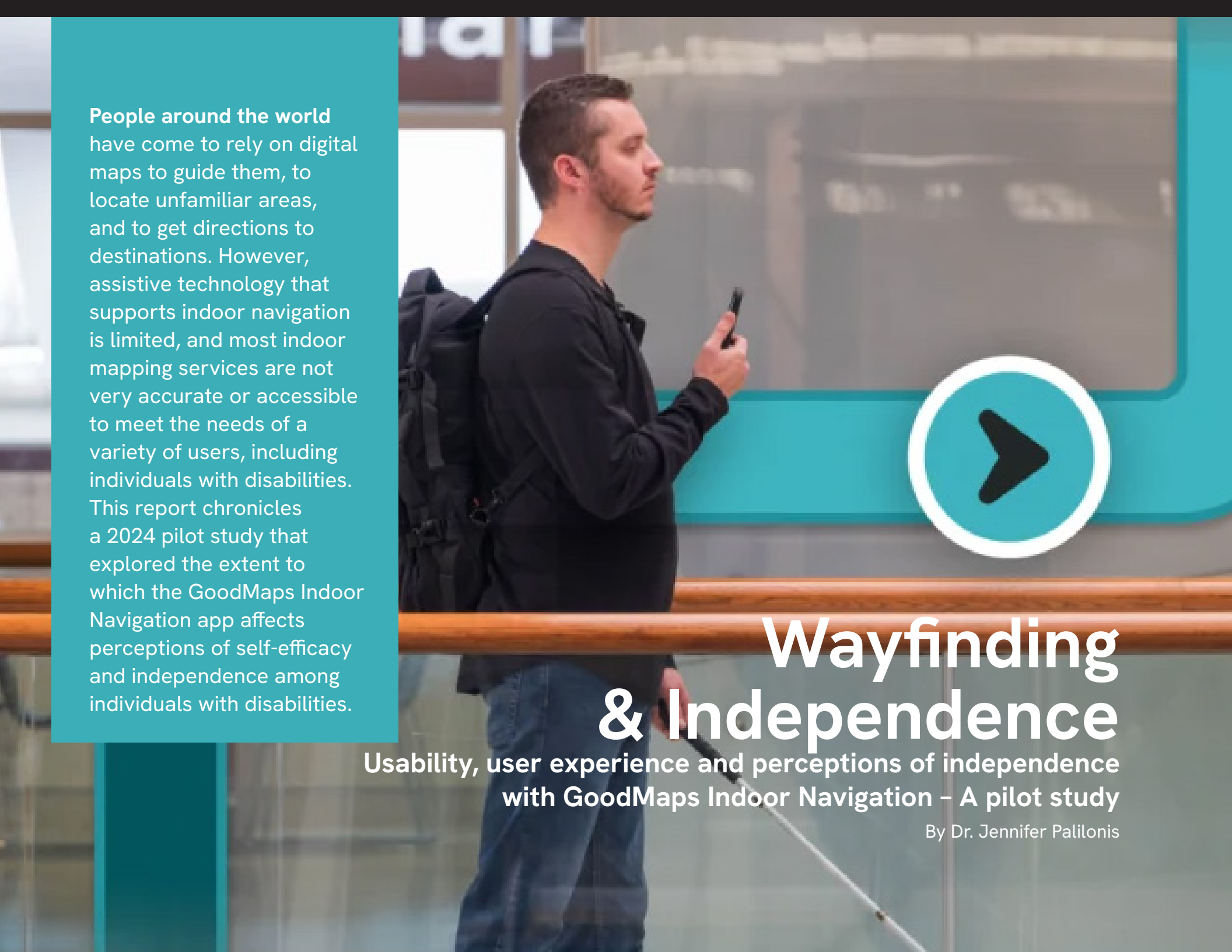


People around the world have come to rely on digital maps to guide them, to locate unfamiliar areas, and to get directions to destinations. However, assistive technology that supports indoor navigation is limited, and most indoor mapping services are not very accurate or accessible to meet the needs of a variety of users, including individuals with disabilities. This report chronicles a 2024 pilot study that explored the extent to which the GoodMaps Indoor Navigation app affects perceptions of self-efficacy and independence among individuals with disabilities.

Wayfinding & Independence

Usability, user experience and perceptions of independence with GoodMaps Indoor Navigation – A pilot study

By Dr. Jennifer Palilonis

People with disabilities must enjoy self-advocacy and self-determination. This means they must have the opportunity to live as self-sufficiently as possible. This can prove challenging, however, for individuals with visual impairments, hearing impairments, neurodiversity, and who use wheelchairs or other mobility aids. Independent travel can be difficult at best, and impossible at worst, for individuals who need navigation assistance in complex, unfamiliar places, healthcare facilities, transit stations, airports, and workplaces. Enter GoodMaps.

Founded by American Printing House (APH) in 2019, GoodMaps is an indoor mapping and navigation company. Using GoodMaps' fully inclusive technology, a blind or visually impaired student can find their classroom; a wheelchair user can be guided along an accessible route; or someone who is neurodiverse can navigate to an airport terminal with less anxiety about traveling. In Summer 2024, researchers conducted a pilot study that explored the extent to which indoor navigation support improves perceptions of independence among individuals with disabilities. This study was funded by the Gregory S. Fehribach Center at Eskenazi Health in Indianapolis.

Research Questions

RQ1: To what extent does GoodMaps Indoor Navigation improve users' perceptions of independence in the workplace?

RQ2: What are the primary pain points for new users of the GoodMaps Indoor Navigation app?

GoodMaps is designed to offer the confidence and convenience of autonomous wayfinding for all users, regardless of vision, hearing, or physical ability.

Background

Independent living is the right of all people – regardless of age or ability – to live, work, and navigate within mainstream communities and to have the same rights as anyone to accessible housing, transportation, education, employment, and more. People with disabilities must be able to live as responsible, respected members of their communities with all the duties and privileges that this entails (Dejong, 1979).

The complexity of needs that individuals with disabilities experience has resulted in increased development of specialized technologies that help them become more independent and more involved at home, in school, and in their communities (Berry, 2003). It is commonplace, for example, for individuals with disabilities to integrate into their lives systems that assist them in performing daily activities that would otherwise be difficult.

Use of assistive technology has had a positive psychosocial effect on feelings of competence, adaptability, and self-esteem among users with disabilities (McNicholl, Desmond & Gallagher, 2023). Studies have also demonstrated that when students with disabilities use assistive devices and apps, they experience heightened feelings of academic self-efficacy (Depountis, Okungu & Molloy-Daugherty, 2019). Assistive tech has been found to "promote participation and inclusion in society and support access to health, social services,

Above: The GoodMaps app use's a device's camera to locate the user based on what it "sees" while a user is in route. The app relies on visually distinct surroundings, such as patterned carpets, ceiling panels, and art to provide accurate location information.

education, work and other important life experiences for persons with disabilities, older people, and those with chronic conditions" (Smith, et al., 2024).

Recently, WHO and UNICEF have called for improved access to assistive tech globally, asserting it is critical to achievement among differently abled people (UNICEF, 2022). When it comes to navigation and wayfinding, inaccessible spaces can have a profoundly negative affect on quality of life, health and safety, independence, and social participation (Kapsalis, Jaeger & Hale, 2024). Specifically, mobility, vision, and neurological impairments may lead to substantial disruptions in the ability to freely and easily move between places.

Users' perceptions of a technology's usefulness and ease of use are the main factors that determine whether they will adopt it (Davis, 1989). Research is necessary to explore how indoor navigation support affects users' perceptions of independence and self-efficacy. This study extends understanding of the relationships among technology acceptance, usability, and user experience.

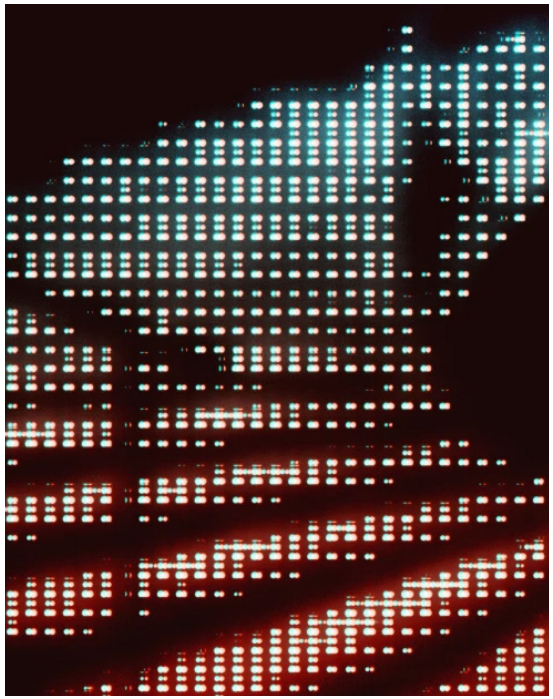
GoodMaps Indoor Navigation

Above: Users get step-by-step routing directions to selected destinations.

GoodMaps is a smartphone app for iOS and Android devices that provides turn-by-turn navigation for indoor spaces. The app is designed to help people navigate safely and efficiently with dynamic routing instructions, orientation aids, and landmark recognition.

To create an accessible building map, a GoodMaps technician scans a facility with a LiDAR camera that captures 360-degree images, measurements, and video. An accurate, detailed map is then created from the scan data. Points of interest–like restrooms, offices, dining, fire extinguishers, exits, etc.–are tagged in GoodMaps Studio, which processes and hosts all map data. Studio generates three map views: a 2D floor plan, a LiDAR point cloud, and a 3D model. Building supervisors can add location names in Studio, update points of interest, and set up access permissions for the map.

Once a map is published, app users can navigate indoor spaces using the app, which includes voice, tactile (haptic



vibrations), or text prompts to find their desired destinations. Buildings mapped with this technology are explorable via the app, which also includes step-by-step navigation instructions to selected destinations. CPS determines a users' position in a building, and the app offers information about indoor points of interest. The app relies on visually distinct surroundings, such as patterned carpets, ceiling panels, and art to provide accurate location information.

Methodology

Fourteen individuals with disabilities – including those with low vision, neurodiversity, hearing impairments, and mobility challenges – were recruited for a mixed-methods pilot study.

We first administered the Technology Acceptance Model survey (Davis, 1989) to measure interns' perceptions of independence and self-determination in the use of assistive technology in general. The 29-item instrument suggests that users' perceptions of a technology's usefulness and ease of use are the main factors that determine whether they will accept it. As such, the TAM can help predict how likely a group or organization is to adopt a new technology.

Next, participants engaged in a moderated, in-person user experience session at a GoodMaps-enabled building, during which they were asked to provide feedback after completing several tasks while using the app. Tasks included exploring a first-time user experience tutorial, the app interface, the destination directory, and search. Participants also engaged in three distinct routing tasks in which they were able to experience GoodMaps-supported indoor navigation.

After completing the moderated session, participants were asked to use the app at least two more times at the same building on their own. This approach allowed us to ensure feedback was also based on independent use. Finally, participants were asked to complete a modified TAM survey in which reference to assistive technology use in general was replaced with reference to GoodMaps specifically.

Results

Response to the overall user experience was generally positive. In addition to open-ended feedback, we also asked participants to rate certain aspects of the app on a scale of 1 to 5. The following sections provide a brief overview of how participants responded to key app features and functionality.

Tutorial

Participants noted that the interactive

tutorial designed to instruct first-time users on how to use the app was helpful. Some participants indicated they would like more detail on why the app requires certain actions to function properly. Wheelchair users also noted some of the language used in the app is biased toward users who can walk. For example, one set of instructions encourages users to "take a few steps to a different location" if the app is having trouble finding their position in the building. Revisions to address these discrepancies are underway.

TABLE 1 – Interactive Tutorial

Statement	Rating
The tutorial effectively explains how to use the app.	4.23
The tutorial design is easy to understand.	4.54
There is enough color contrast in the visual illustrations/animations.	3.23
The text-based explanations are easy to understand.	4.31
The text is sized appropriately.	2.54
I like the ability to practice certain functions using the tutorial.	4.62
I have a better understanding of how to hold the phone while routing.	4.85
I understand how to pan the phone to find my position.	4.15
The tutorial helped me understand what to do if GoodMaps can't find my position.	3.85
The tutorial makes me more confident about using the GoodMaps app.	4.38

Table 1 indicates that while most of the tutorial scored positively among most users, low-vision users shared some concerns about color contrast and text size. Likewise, several users voiced concern about the clarity of instructions provided about what to do if GoodMaps can't find a user's position.

Building & destination information

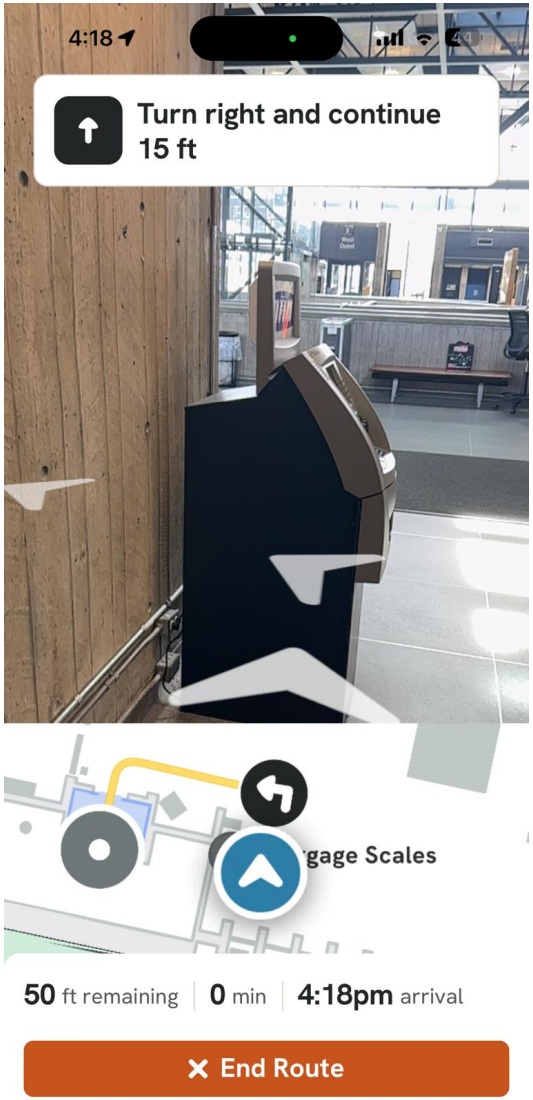
Unsurprisingly, most participants also noted that the building and destination information cards found in the app don't provide valuable information. Recent revisions to GoodMaps Studio–the app venue owners use to manage their maps–allows for more robust building and destination descriptions within the app.

Destination directory & search

Directory and search also performed well, with a few notable issues. Users want to sort and filter destinations in the Directory. Additionally, low-vision users noted that the directory is difficult to navigate with magnification turned on due to the spacing of elements. Also, some logical search terms weren't supported. For example, when users were asked to route to Human Resources, many entered "HR" into the search field, which did not generate results. All three of these issues are currently being addressed by app designers. Table 2 illustrates that Directory and Search ratings were generally positive. However, some users were less clear on the actions they can take from the directory. The GoodMaps design team is currently updating app design to address this concern.

Map & augmented reality views

In route, sighted users can view a dynamic map and augmented reality view that includes directional arrows superimposed on a live view of the environment. It's worth noting that this pilot study was GoodMaps' first opportunity to test



Above: Augmented reality + map view in route; **Right:** Map view.

TABLE 2 – Directory & Search

Statement	Rating
The directory makes sense to me.	4.54
The directory is well designed.	4.46
The actions I can take from the directory are clear.	3.92
The search bar is easy to use.	4.85
Search worked as expected.	4.54

augmented reality view with real users, and participants overwhelmingly rated it one of the best app features. However, several participants wanted the option to change the color of arrows based on the floor color to control contrast. Future iterations of the app will allow for this type of customization. Likewise, participants said they want to be able to turn off map or AR view so that only one is visible at a time. This revision has already been implemented.

Routing

Participants engaged in three unique routing tasks during these sessions. In general, they noted they would like to be reminded to pan the phone left and right sooner so the camera can scan their surroundings when the app is slow to find a user's position. They also shared some confusion when the app goes silent during

a pause in instructions when a route involves using an elevator. They also noted frustration when the app was sometimes slow to find the users' position when they come out of elevators or off the stairs. These issue are currently being addressed as GoodMaps developers work to optimize app performance in these scenarios. Finally, wheelchair users shared that it can be difficult to hold the phone and maneuver their chairs at the same time. GoodMaps is exploring hands-free routing alternatives to address this problem.

Responses to routing experiences were generally positive, with a few recommendations for improvement. During the first route (Table 3), some participants felt routing instructions were confusing. Specifically, some explained that when users are slightly off track, app instructions for getting back on the route were difficult to understand. Likewise, some participants were slightly apprehensive during the first route, sharing that they weren't entirely confident in the app's accuracy.

The second route (Table 4) included use of an elevator, which was confusing for

TABLE 3 – Route #1

Statement	Rating
It was easy to find and select the destination.	4.54
The scanning process used to find my location took too long.	2.69
I understood how to start a route.	4.62
It was easy to start a route.	4.31
The verbal routing directions were easy to understand.	3.85
The routing instructions are too wordy.	2.54
I like the augmented reality view.	4.31
The route I travelled was accurate.	4.08
I felt confident while routing.	3.92
The route was efficient.	4.31

TABLE 4 – Route #2

The scanning process used to find my location took too long.	2.85
It was easy to start a route.	4.46
The information that was delivered when I was on the stairs/in the elevator made it clear that I was on the stairs/in the elevator.	3.38
The verbal routing directions were easy to understand.	4.31
The routing instructions are too wordy.	2.00
I like the map view.	4.09
The route I travelled was accurate.	3.92
I felt confident while routing.	3.69
The route was efficient.	4.00
I prefer the augmented reality view (sighted users only).	3.27
I prefer the map view (sighted users only).	2.73
I like seeing both augmented reality and map view (sighted users only).	3.00

some. The fact that the app was sometimes slow to find their position out of the elevator also affected users' perceptions of route accuracy and their general confidence while routing. After this task, we also asked about augmented reality and map views, and it's worth noting that participants were relatively split on which view they liked best.

Interestingly, participants rated the third routing experience (Table 5) positively across the board, suggesting that it doesn't take long for users to get comfortable with app functionality and use.

Tones & haptics

At the time of this test, tones were used to indicate when users were successfully pointed in the right direction, as well as when their position is found and when they arrive at their destination. Vibrations (or haptics) were also used to indicate when a user veers off track. Participants noted that definitions of tones and haptics should be added to the tutorial so their purpose is clearer from the start. Low-vision users were sometimes frustrated with tones indicating a user is pointed in the right direction because they chime any time users hold the phone up. However, low-vision users often raise the phone to see it better, and chimes were annoying when this was the case. Neurodiverse users also want to turn tones/haptics off to avoid feelings of "sensory overload."

TABLE 5 – Route #3

Statement	Rating
It was easy to select a destination.	4.77
The scanning process used to find my location took too long.	2.23
It was easy to start a route.	4.62
The verbal routing directions were easy to understand.	4.46
The routing instructions are too wordy.	1.69
I like the map view.	4.54
The route I travelled was accurate.	4.46
I felt confident while routing.	4.23
The route was efficient.	4.46

Pre- and post-session surveys

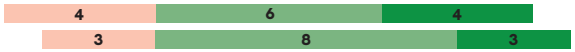
Ultimately, participants' responses to the GoodMaps user experience aligns with their baseline perceptions and opinions of assistive tech in general. Likewise, in some cases, the GoodMaps experience scored slightly better than opinions about assistive technology in general.
Of course, with only 14 participants, we can't find any statistical significance in these results. However, we hypothesize that a broader study with a greater number of participants would find that when it comes to feelings of independence, ease of use, usefulness, and confidence navigating indoors, GoodMaps will continue to perform well and even generate statistically significant results.

Charts on the following pages illustrate comparisons of how participants responded to pre- and post-session surveys.

Using assistive technology in my job enables me to **accomplish tasks more quickly.**

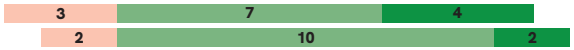
Using **GoodMaps** in my job would enable me to accomplish tasks more quickly.

Using assistive technology **improves my job performance.**



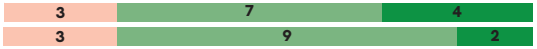
Using **GoodMaps** will improve my job performance.

Using assistive technology in my job **increases my productivity.**



Using **GoodMaps** in my job will increase my productivity.

Using assistive technology enhances my **effectiveness at work.**



Using **GoodMaps** will enhance my effectiveness at work.

Using assistive technology makes it **easier to do my job.**

Using **GoodMaps** will make it easier to do my job.

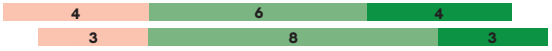
I would find the use of **assistive technology useful at work.**

I would find the use of **GoodMaps** useful at work.

Learning to use assistive technology is easy for me.

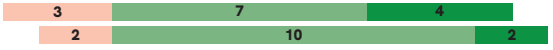
Learning to use **GoodMaps** was easy for me.

It is easy for me to become skillful at using assistive technology.



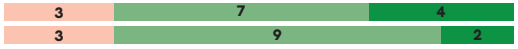
It was easy for me to become skillful at using **GoodMaps** .

Using assistive technology **at work makes me feel more independent.**



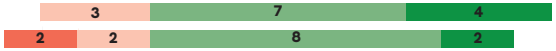
Using **GoodMaps** at work made me feel more independent.

Using assistive technology **in my personal life increases my feelings of independence.**



Using **GoodMaps** in my personal life will increase my feelings of independence.

Using assistive technology **helps me get and do what I want at work.**



Using **GoodMaps** will help me get and do what I want at work.

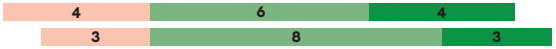
Using assistive technology helps me **accomplish my goals at work.**

Using **GoodMaps** will help me accomplish my goals at work.

Using assistive technology **increases my confidence at work.**

Using **GoodMaps** will increases my confidence at work.

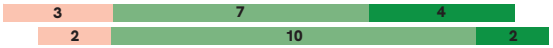
Using assistive technology helps me be **more efficient at work.**



Using **GoodMaps** will help me be more efficient at work.

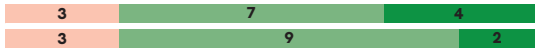
Strongly Disagree **Disagree** **Neither Agree, Nor Disagree** **Agree** **Strongly Agree**

Using assistive technology **increases my sense of calm while at work.**



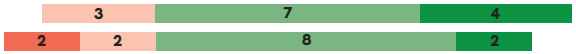
Using **GoodMaps** will increase my sense of calm while at work.

I use assistive technology because **other people want me to use it.**



I will use **GoodMaps** because other people want me to use it.

I use assistive technology **because it is interesting to use.**



I will use **GoodMaps** because it is interesting to use.

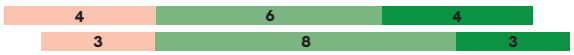
I use assistive technology because **I believe it could improve my life.**

I will use **GoodMaps** because I believe it could improve my life.

I use assistive technology because it **helps me do something important to me.**

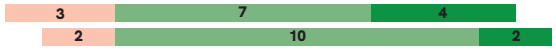
I will use **GoodMaps** because it helps me do something important to me.

I want others to know I use assistive technology.



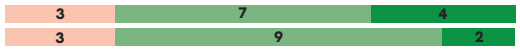
I want others to know I use **GoodMaps** .

I will feel bad about myself if I didn't try to use assistive technology.



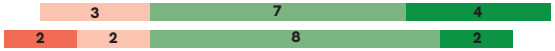
I will feel bad about myself if I didn't try to use **GoodMaps** .

I use assistive technology because **I think it is enjoyable.**



I will use **GoodMaps** because I think it is enjoyable.

I would only use assistive technology **if I am required to use it.**



I would only use **GoodMaps** if I am required to use it.

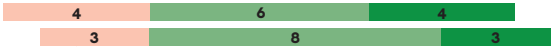
Using assistive technology **is of value to me in my life.**

Using **GoodMaps** is of value to me in my life.

I use assistive technology because **it is fun to use.**

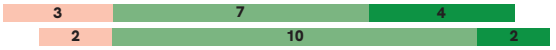
I will use **GoodMaps** because it is fun to use.

I only use assistive technology **if I feel pressured to use it.**



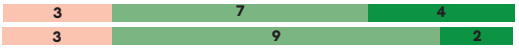
I will only use **GoodMaps** if I feel pressured to use it.

It will look good to others if I use assistive technology.



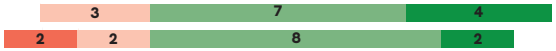
It will look good to others if I use **GoodMaps** .

I feel confident that I will be able to use assistive technology effectively in the future.



I feel confident that I will be able to use **GoodMaps** effectively in the future.

Assistive technology is **generally easy for me to use.**



GoodMaps is generally easy for me to use.

Key Takeaways

Again, response to GoodMaps as an assistive tool in the workplace was generally positive. Participants provided valuable feedback for app improvements that have already been integrated in the GoodMaps development backlog. Response to GoodMaps user experience aligns with participants' baseline perceptions and opinions of assistive tech in general. Results also suggest indoor wayfinding support is of interest to individuals with disabilities, and GoodMaps represents a positive user experience. Finally, results from this pilot study suggest there are opportunities for a larger study with more participants and a variety of venue types.

As a result of this work, we are planning an expanded study to include larger participant pool across multiple venue types, including:

- University campuses
- Transit stations
- Healthcare settings
- Entertainment venues
- Office buildings

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