Feasibility Test of QR Codes for Practical Use by Visually Impaired People

Period: May 2017 to March 2019

A collaborative project between NPO Kobe Light House, NPO i-collaboration Kobe, and Export Japan Inc.

KOBE LIGHT HOUSE
NPO 法人　神戸ライトハウス

i-collaboration Kobe
特定非営利活動法人　アイ・コラボレーション神戸

Export Japan

* “QR Code” is a registered trademark of Denso Wave Incorporated.

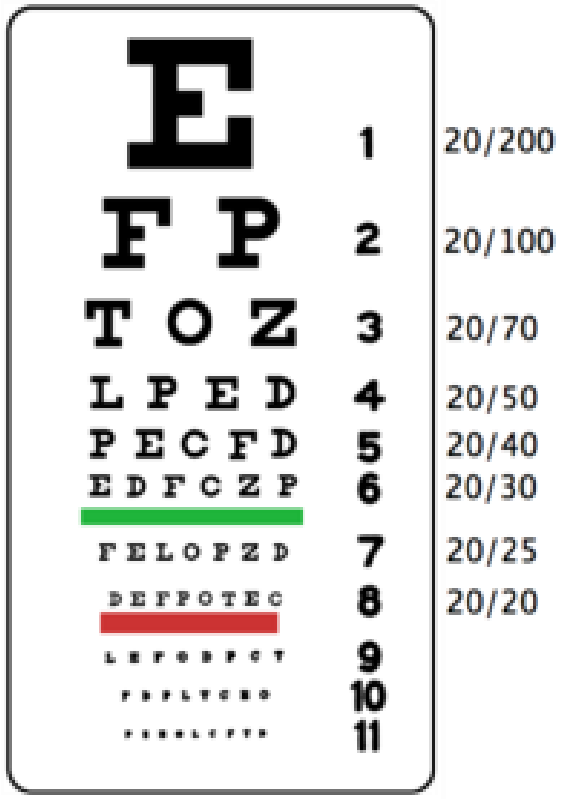
Why did we start this project?

In August 2016, PIJIN, an affiliate company of Export Japan, received an inquiry from Kobe Light House, an organization that helps visually impaired people become more independent.

They wondered whether QR Translator - PIJIN's QR code-related service - could be utilized by visually impaired people to obtain information from printed materials using its text-to-speech function.

From that point on, we learned much about visual impairment.

Who is blind? Who has low vision?



Snellen Eye Chart

- U.S. definition of legal blindness
  1. Visual Acuity (The better-seeing eye with the best conventional correction, such as glasses or contact lenses)
     - Blind: 20/200 or less
     - Low vision: 20/70 or less
     - Unimpaired: 20/20
  2. Visual Field (without moving the eye)
     - Blind: 20 degrees or less
     - Unimpaired: 180 degrees

FACT

Among visually impaired people, only 15% are completely blind (NLP: no light perception)

Statistics

No. of visually impaired people: **1.64 million**
Percentage: **1.3%** of the total population
No. of blind people: **187,800**

According to Japan Ophthalmologists Association (2007)

No. of visually impaired people: **~440 million**
Percentage: **6.0%** of the world's population
No of blind people: **36 million**

According to The LANCET Global Health (2017)

Challenges in Daily Life

- **Challenges**: Visually impaired people face various difficulties in their daily life, such as when traveling, navigating, shopping, and accessing information. However, one of the most critical challenges is the **“Accessible Information”** problem.

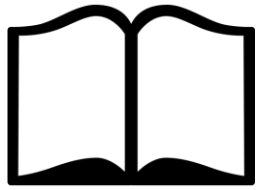
- While the world has been moving towards an information-driven society through improvements and developments in communication and information technology, most visually impaired people still lack access to most of these services. Information plays an important role in social organization as it enables people to participate more fully in public, promotes decision-making in individuals, and encourages equality while simultaneously preventing inequality.

Accessible Information Problem

Much information has been digitalized and put on the internet, where many devices can access it.

Accessibility features on smartphones support people with disabilities in various ways.

Screen Reader, which converts information from text to speech, is available on several platforms.



But it is limited to digital information!

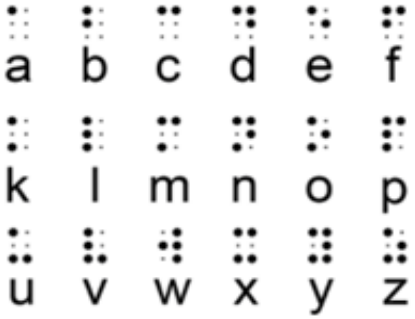
What about printed Information?

Is braille a solution?

- Unfortunately, **braille is not universal.**
- There is a different braille script for each language.
- Approximately only one-eighth of visually impaired people can read braille.
- Braille cannot easily fit in small or limited spaces, such as on product labels.

Japanese Braille

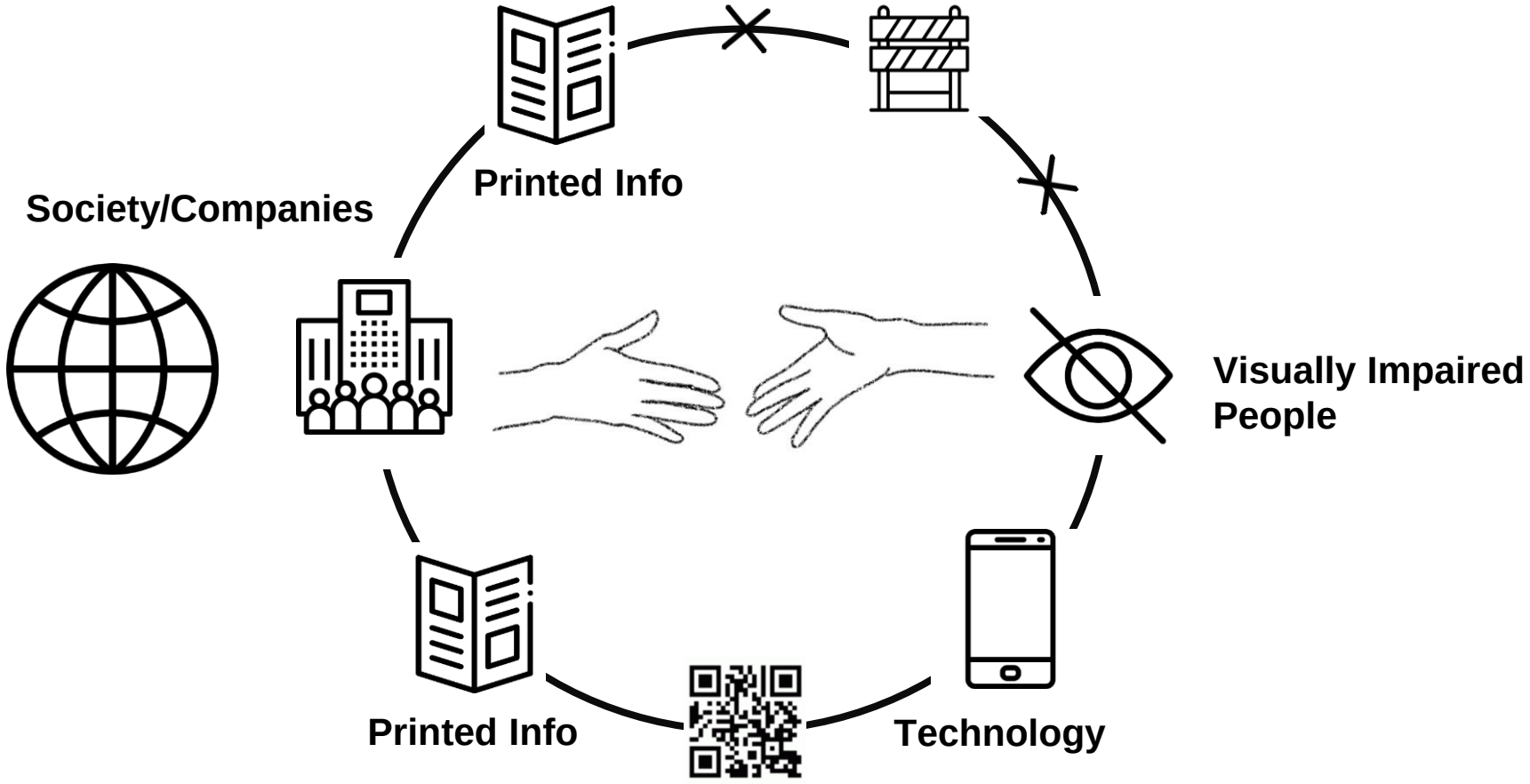
English Braille



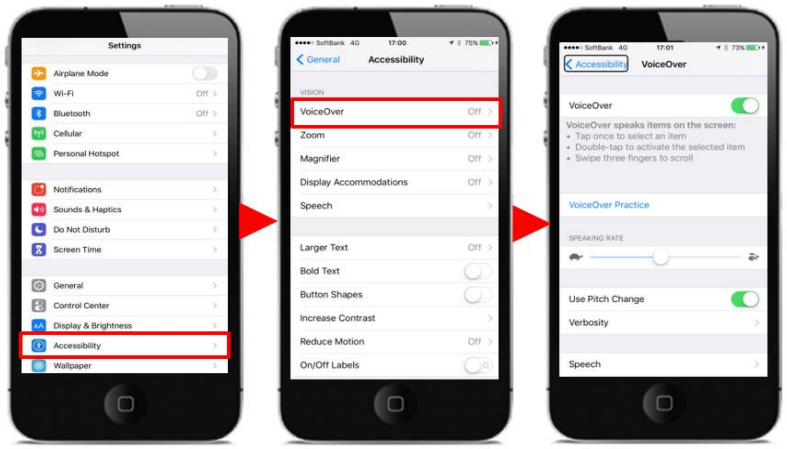
* We are not in any way contesting the importance of braille and understand it is indispensable for a large number of people with visual impairments.

Our Goal

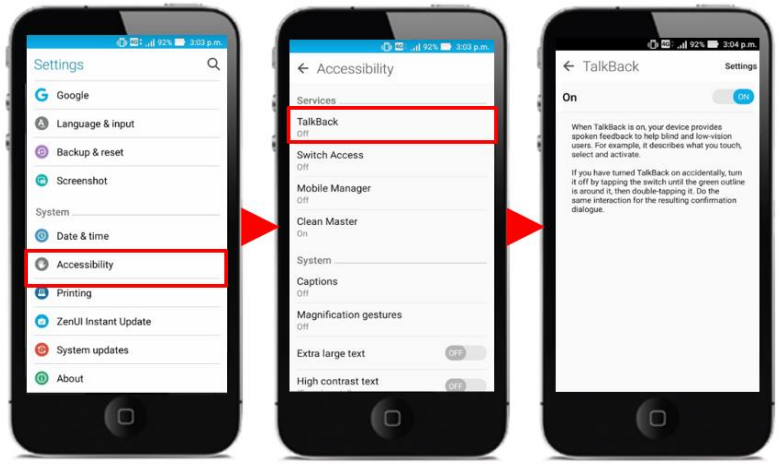
We aim to realize a more barrier-free environment requiring less effort from visually impaired people and society proposing a possible solution.



Voice Over Setting on iPhone



TalkBack Setting on Android



Connecting Bridge – Physical & Digital

Smartphones are useful to everyone. Most modern smartphones have several accessibility features that support the daily life of visually impaired people.
One of the most useful features is “Screen Reader.” It is called “**VoiceOver**” on the iOS platform and “**TalkBack**” on the Android platform.

Question: Is it possible to convert printed texts on physical materials to audio by transferring them to a smartphone to be read by a screen reader?

Hypothesis: QR codes can be a bridge that connects physical and digital information, and they can help visually impaired people access information printed on physical materials.

Why QR codes?

- QR codes are a patent-free universal technology we can see worldwide.
- QR codes can be printed anywhere - on documents, product labels, signboards, and even on clothes.
- QR codes are the most common tool for bringing users from conventional print media to digital media.
- QR code scanning applications are built into many modern smartphones by default.

Report on the QR Code Readability Tests by Visually Impaired People with Smartphones #1

Experiment Period: August 3, 2017, to March 16, 2018

NPO Kobe Light House, NPO i-collaboration Kobe, and Export Japan Inc.

The Flow of the Experiments

1. We asked visually impaired participants to sit in chairs with their smartphones in hand. – In case they didn't have their own smartphones, we lent ours to them.
2. We explained the purposes of this test and got their consent signatures.
3. We asked for their profile and wrote them to the test documents.
4. We conducted the experiments following the lists of test documents.
5. We set the time limit of each scanning test as 1 minute. If it takes more than one minute, we judged it as "unsuccessful".

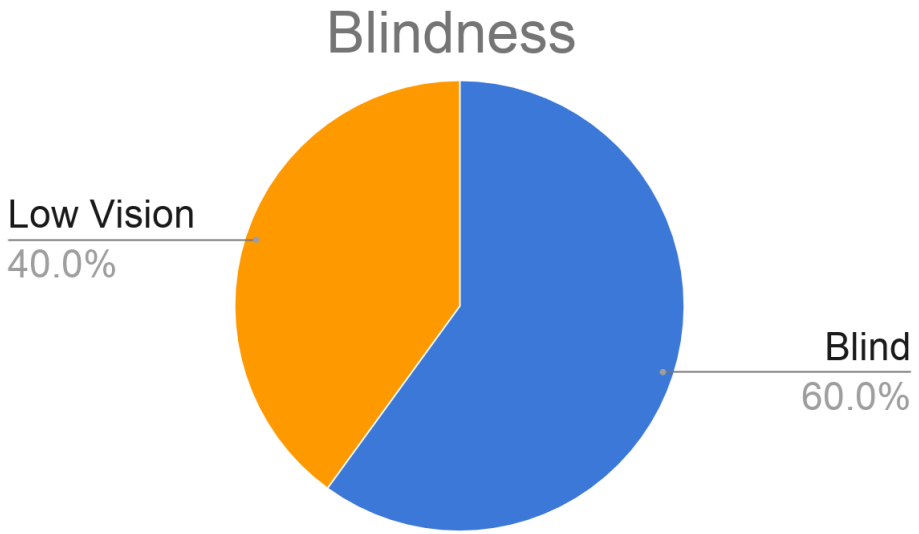
* Note: We provided guidance to the participants who couldn't scan QR codes on their first test only by taking their hands because some had never used smartphones.

Purposes of Experiment 1

- To examine our hypothesis: “QR codes may help visually impaired people acquire information from printed material.”
- To determine how visually impaired people use their smartphones to scan QR codes
- To know what percentage of visually impaired people can successfully scan QR codes
- To discover if there is an obstacle to preventing visually impaired people from successfully scanning QR codes
- To know how visually impaired people feel regarding QR code scanning and the potentiality of it.

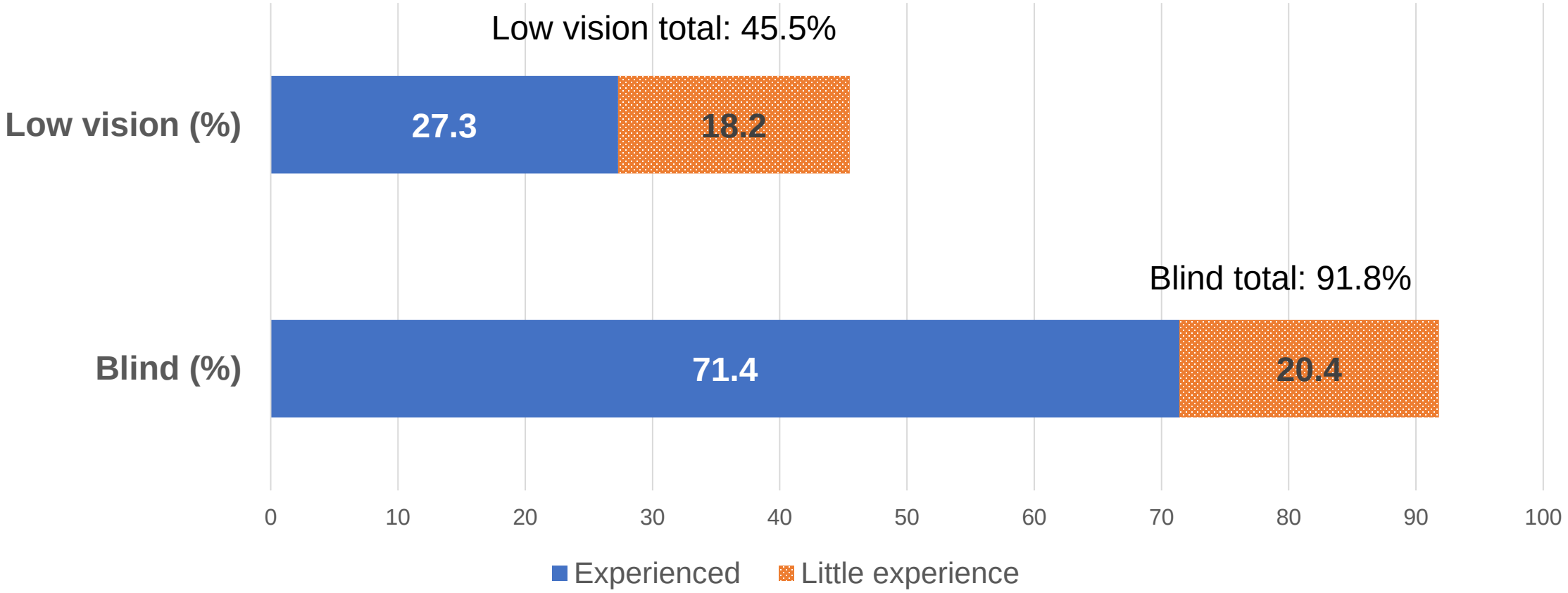
Participants of Experiment 1

Total:	**100 participants** (from 5 different regions)
Average Age:	**55 years old** (out of 43 respondents)
Gender:	64% Male 36% Female
Blindness:	60% Blind 40% Low vision



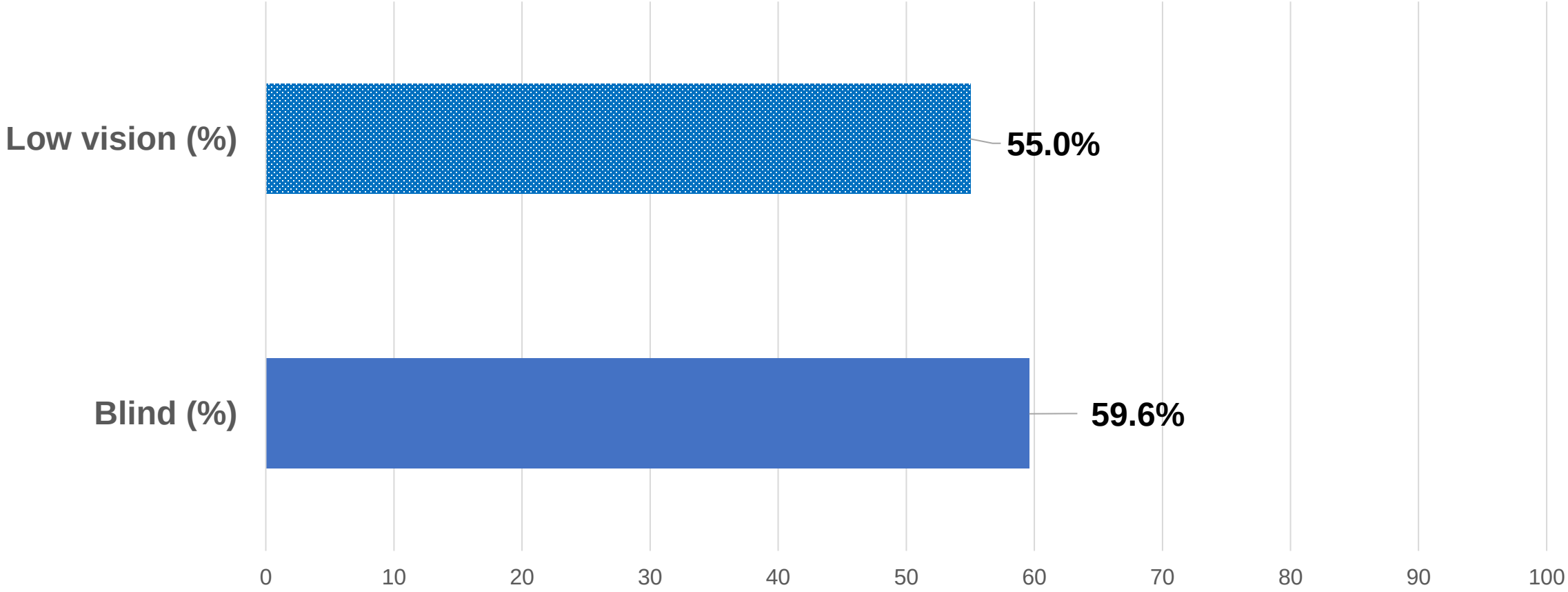
Percentage of Braille Users: 73.2%

(60 out of 82 Respondents)



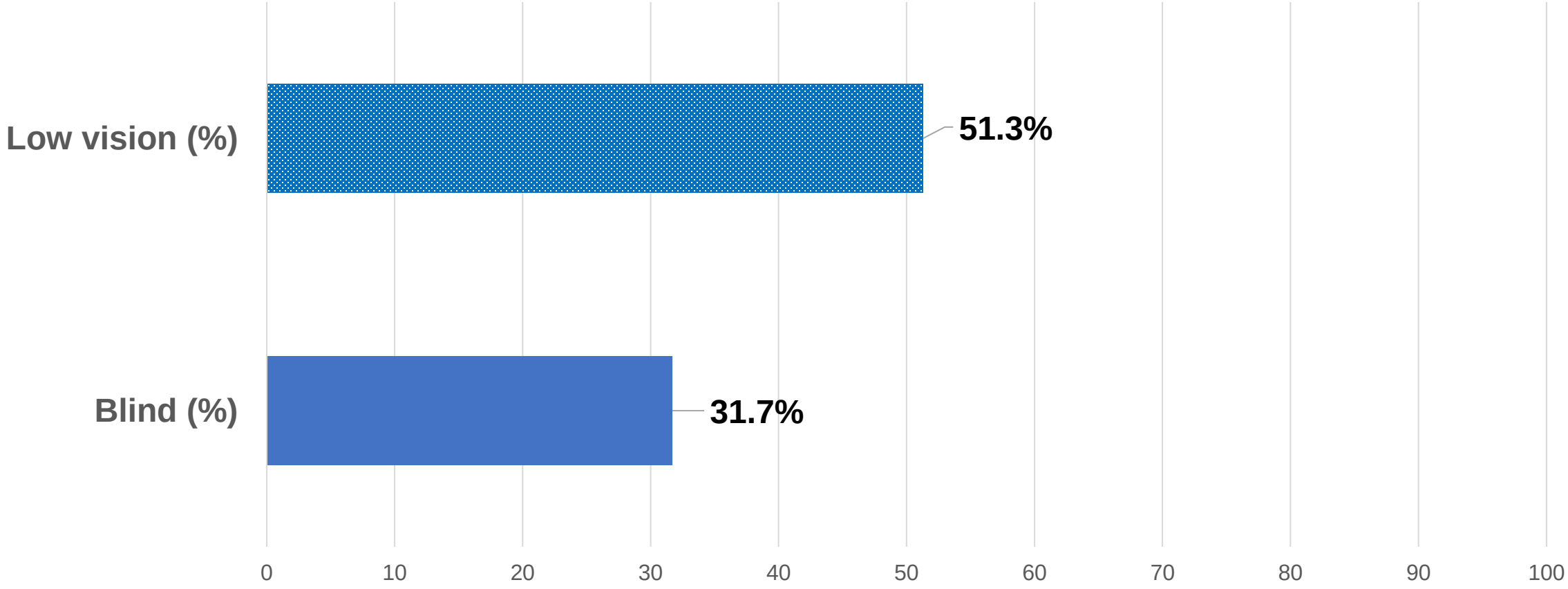
Percentage of Participants Who Have Used Smartphones: 57.7%

(56 out of 97 Respondents)



Percentage of Participants who have used QR code: 39.4%

(39 out of 99 Respondents)



Dimensions of Our Analysis

Through Experiment 1, we tried to know if QR codes are really useful for visually impaired people. If yes, what would be the **critical factors** in determining their practicality? To know them, we picked up the following dimensions:

1. Position of QR code
2. Necessity of guidance (how to scan)
3. Existence of tactile mark(s)
4. Shape of the object
5. Feeling of stress (for participants for scanning QR codes)

Test 1 of Experiment 1

We prepared 4 brochures on which QR codes were printed in 4 different positions. We provided guidance for the participants who failed to scan the code on this test.

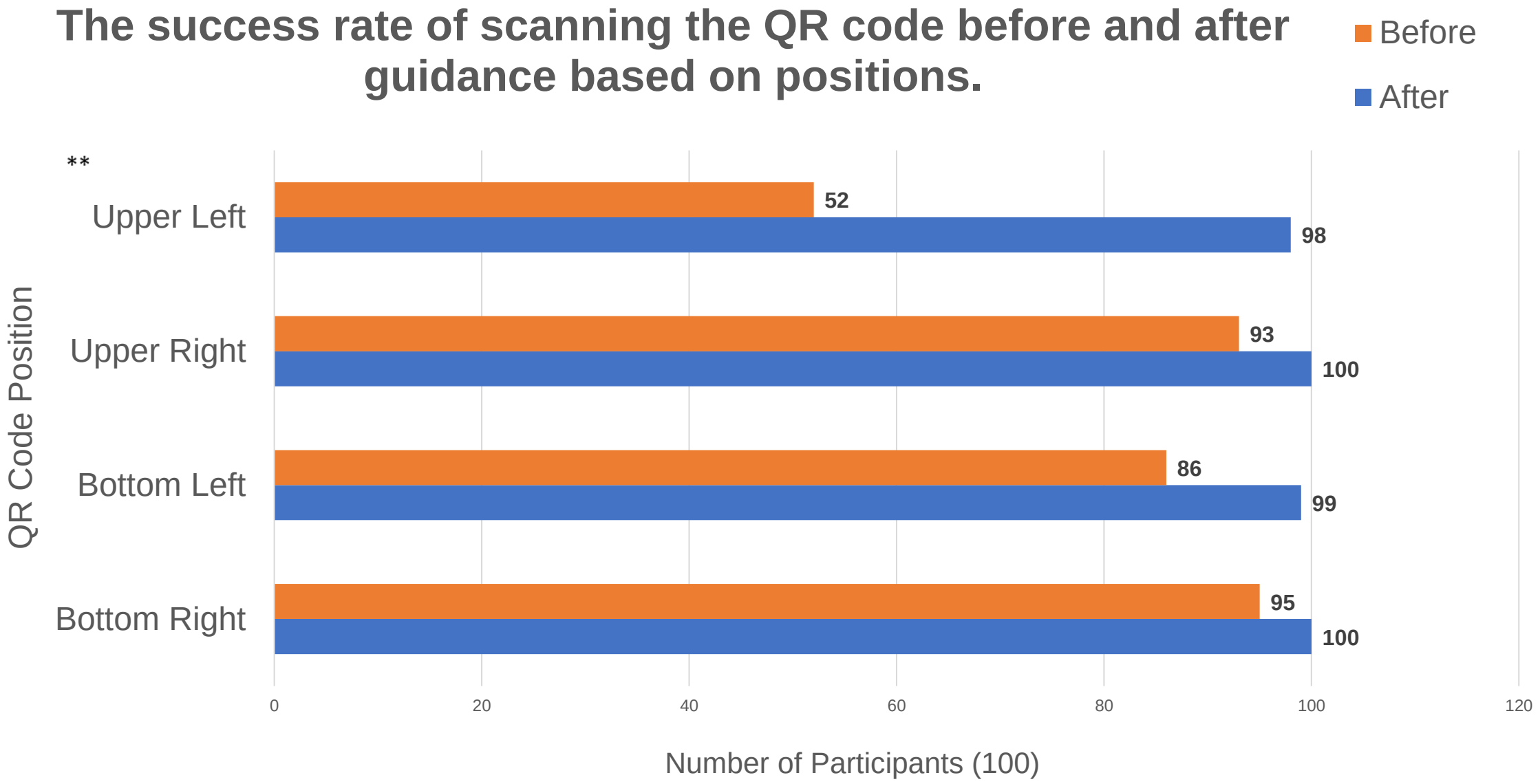
Upper Left

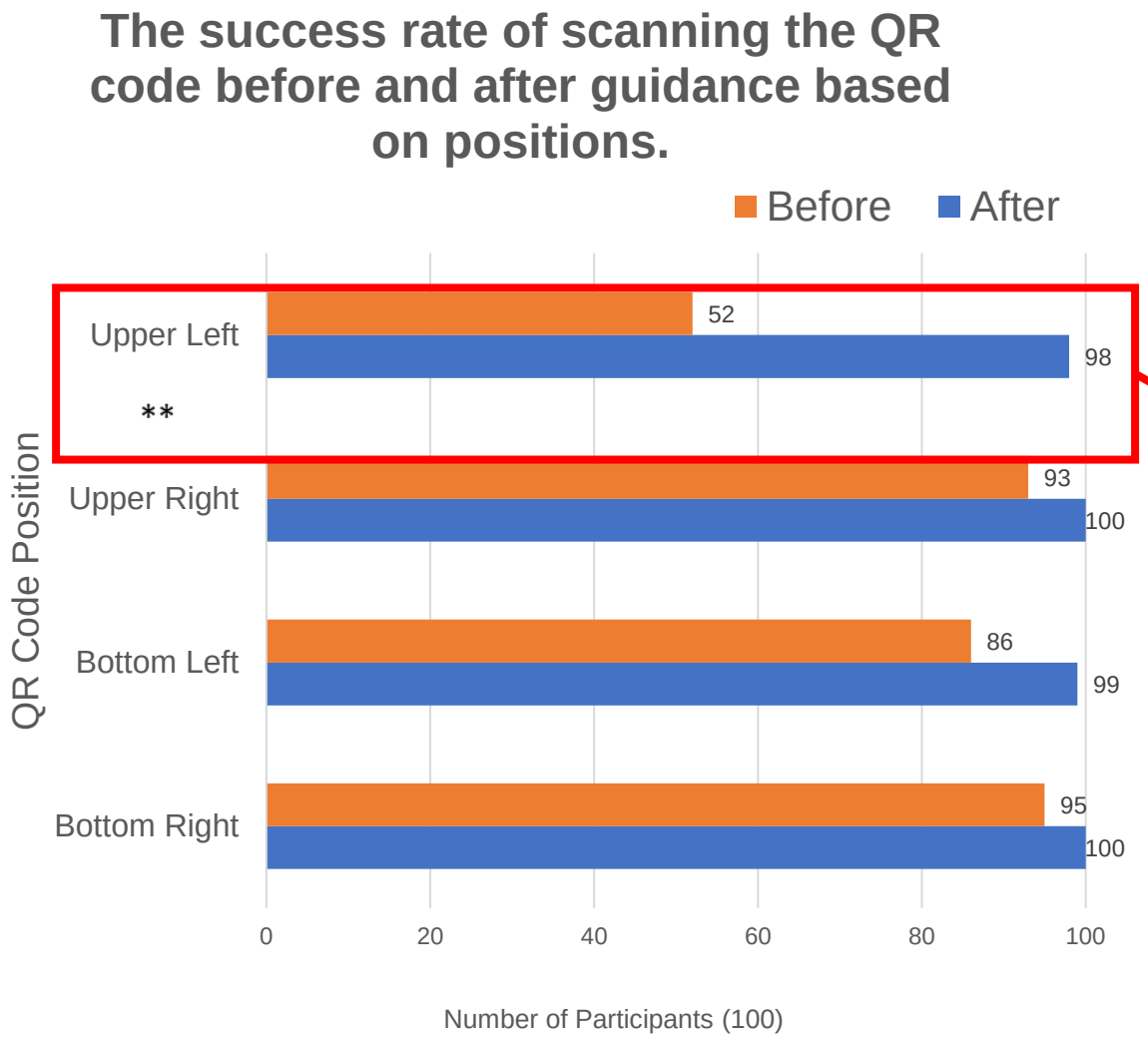
Upper Right

Bottom Left

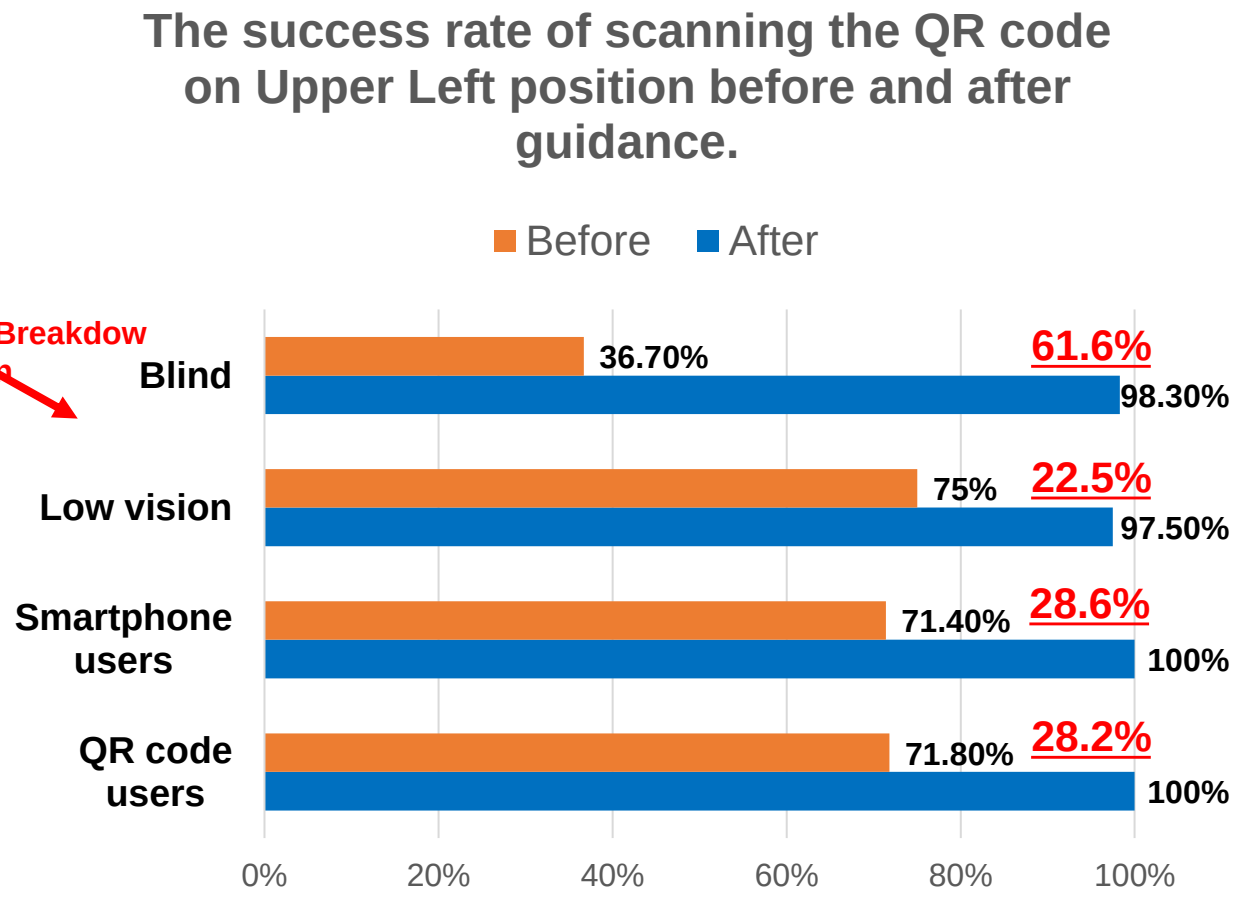
Bottom Right

The success rate of scanning the QR code before and after guidance based on positions.





Breakdown



** Note: The success rate on the Upper Left position before guidance is much lower than others because, we suppose, it was the very first test of the experiment.

What We Learned from the Test 1 are...

The **position** of QR codes is **not the critical factor**, as all QR code positions achieved a similar success rate except the before-guidance test on the upper left part, which was the very first trial for the participants.

Comparing the results between before and after guidance, It was clear that the success rate increased in every position. Therefore, the critical factor is **guidance** or **experience**.

See the video how they scan QR codes

* Note: We didn't provide the guidance after the test 1 of Experiment 1.

Test 2 of Experiment 1

We prepared 6 kinds of products – all 3-dimensional objects - with 4 different shapes and materials. Among 4 of them, we put tactile marks to compare with 2 other unmarked products.

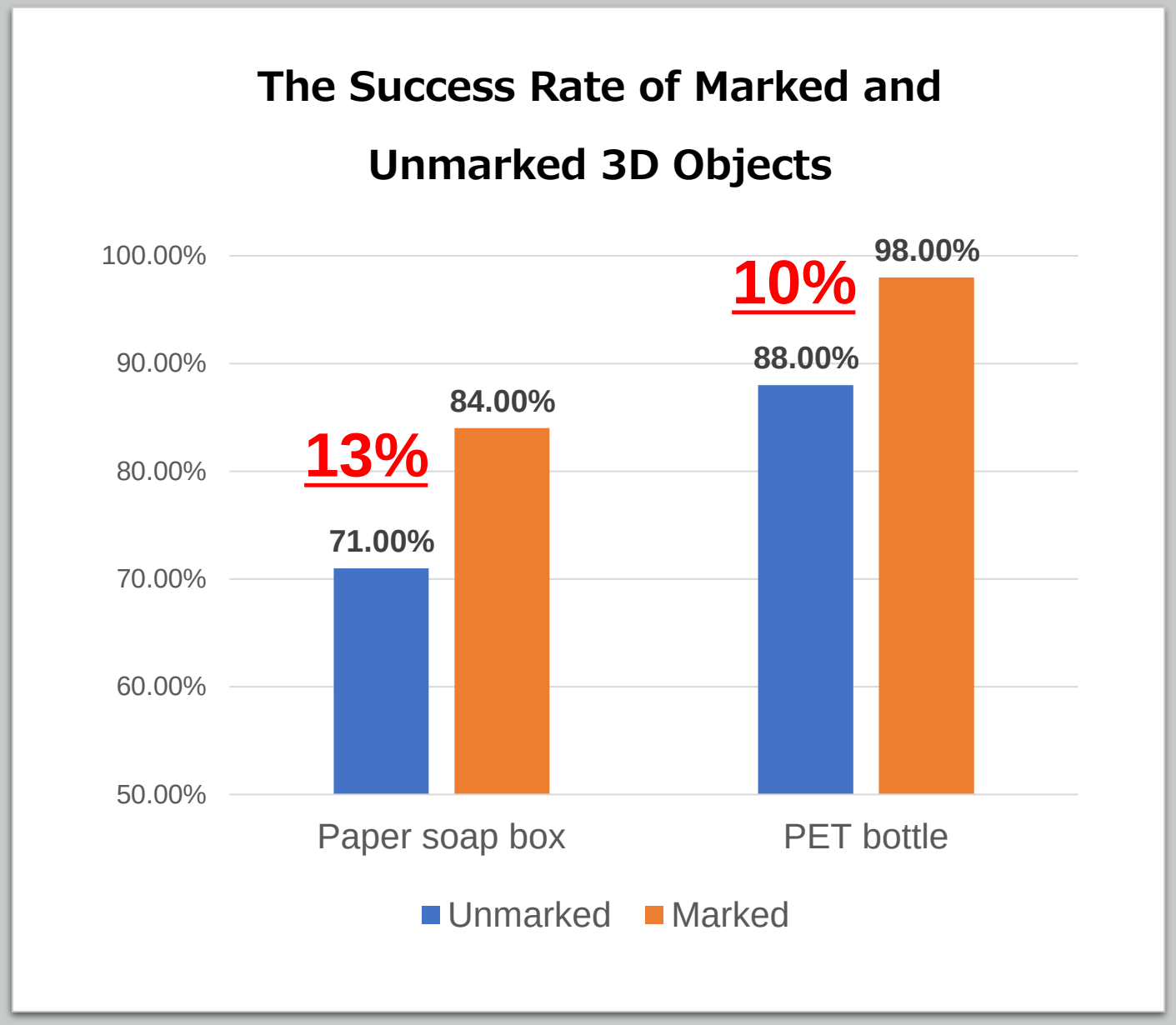
 Paper soap box (Unmarked)	-	 PET bottle (Unmarked)	-
 Paper soap box (Marked)	 Plastic candy bag (Marked)	 PET bottle (Marked)	 Cylindrical can (Marked)

* Those products were bought from retail stores ** Tactile marks were made by us.

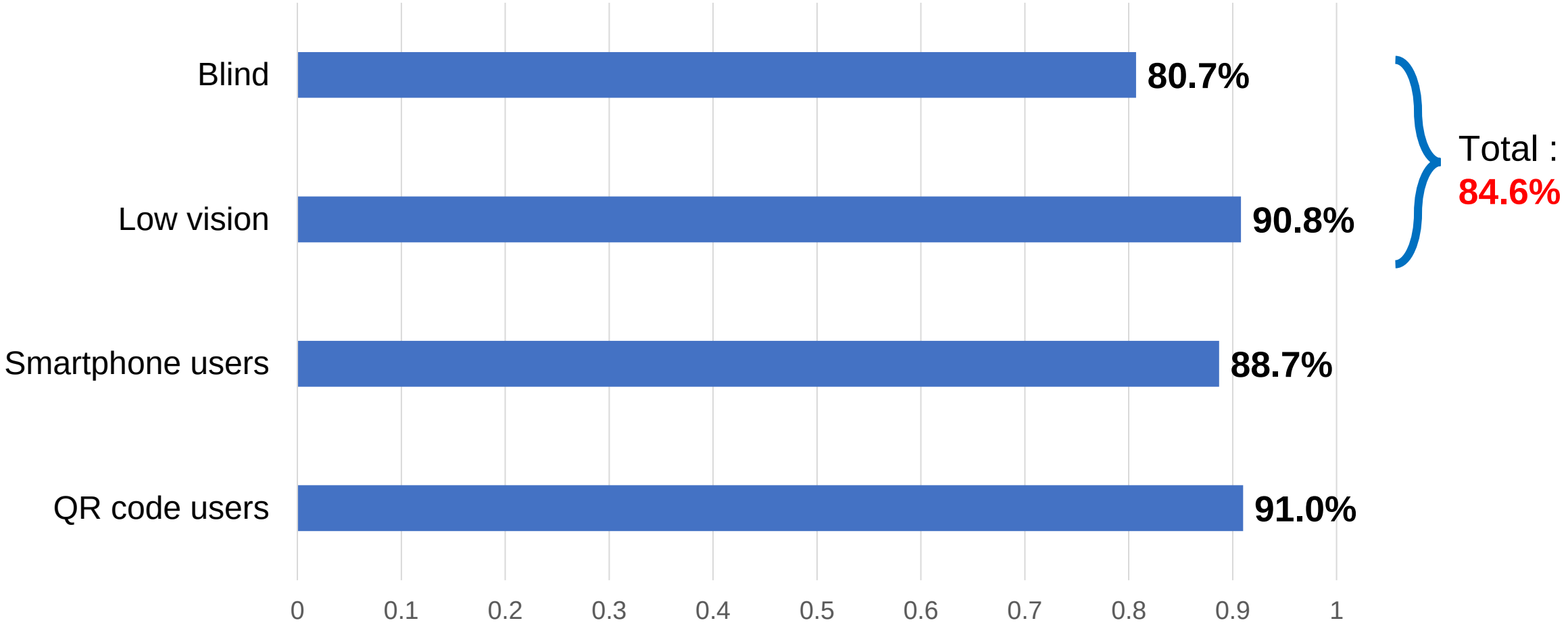
The difference in success rates between marked and unmarked products was 10 to 13%.

Paper Soap Box (6-sided box)

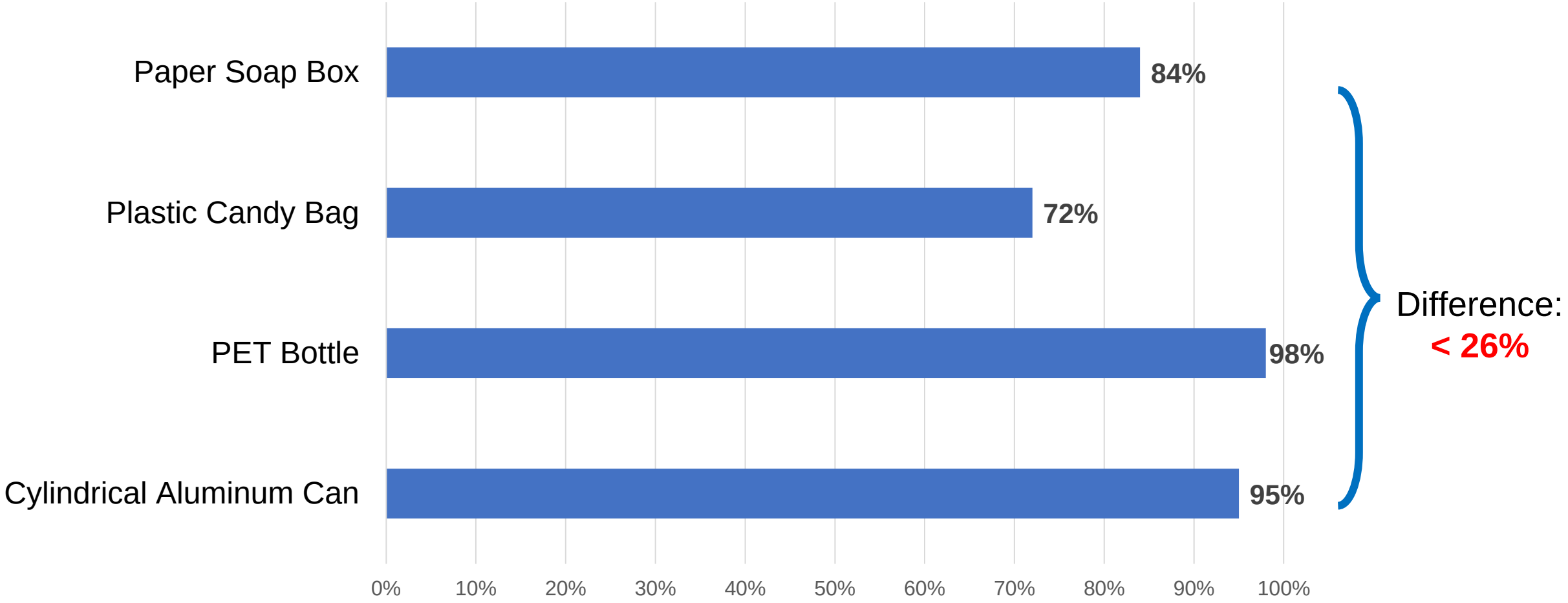
PET Bottle (4-sided plastic bottle)



The Success Rate of Scanning a QR Code on 3D Objects - 6 trials for 6 products - by Participants Profile



The Success Rate of Scanning QR Codes - 1 trial each for 4 marked products – by the Type of 3D Objects



What We Learned from the Test 2 are...

There was a significant difference in the success rate of scanning QR codes on 3D objects that have been marked versus those that have not. As a result, we concluded that the **tactile marks played a crucial role** in serving as a reliable location indicator.

See the video on how difficult to scan unmarked codes.

Comparing the results by the shape of products, the success rate differs by 26%. This showed that the **shape of products greatly influenced** the success rate.

* There were much differences in the size of QR codes on 4 different shapes of products. At this moment, we had not thought of the possibility that the size of QR codes could be a critical factor of the success rate.

Major Causes of Unsuccessful Scanning

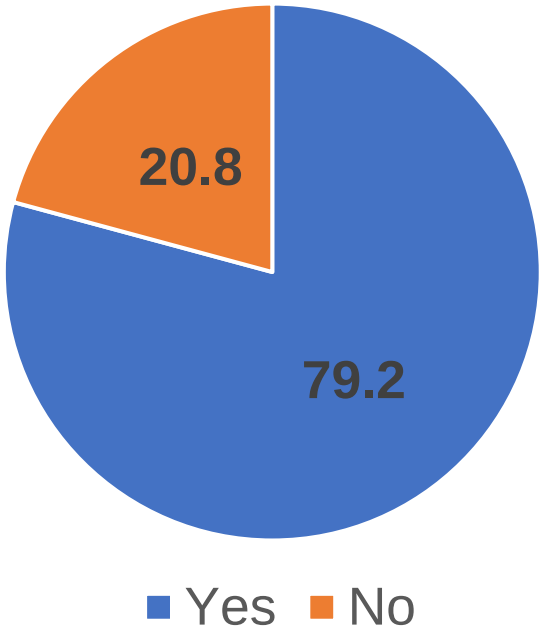
Through the observations of Test 1 and 2, we have identified the major causes of why visually impaired people fail to scan QR codes as follows:

- One hand, while another held the smartphone, overlapped the QR code.
- They moved smartphones too fast to let the lens auto-focus QR codes.
- They couldn’t catch the best distance between the smartphone and the QR code. In most cases, it was too close to capture the wider area.
- They didn’t seem easy to hold the smartphone cameras parallel to QR codes.

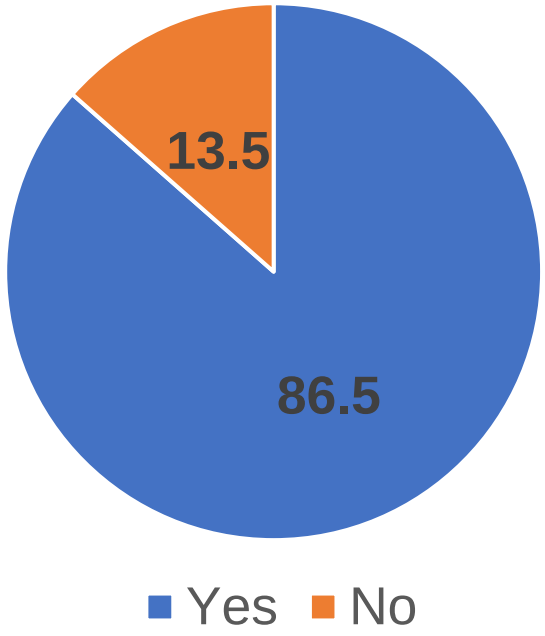
Survey 1 of Experiment 1

- If the participants felt stressed about scanning QR codes -

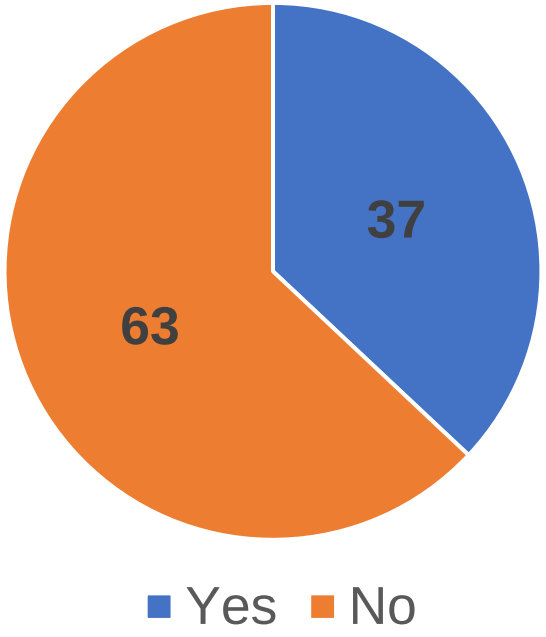
Did you feel stressed if you knew there was a QR code but couldn't scan it?
(96 respondents)



Did you feel stressed if you didn't know whether there was a QR code and couldn't scan it?
(89 respondents)



Did you feel it was difficult to scan QR codes?
(100 respondents)



What We Learned from the Survey 1 are...

Many participants felt stressed if they couldn’t scan QR codes successfully. And the stress became bigger in case they weren’t sure if there were QR codes.

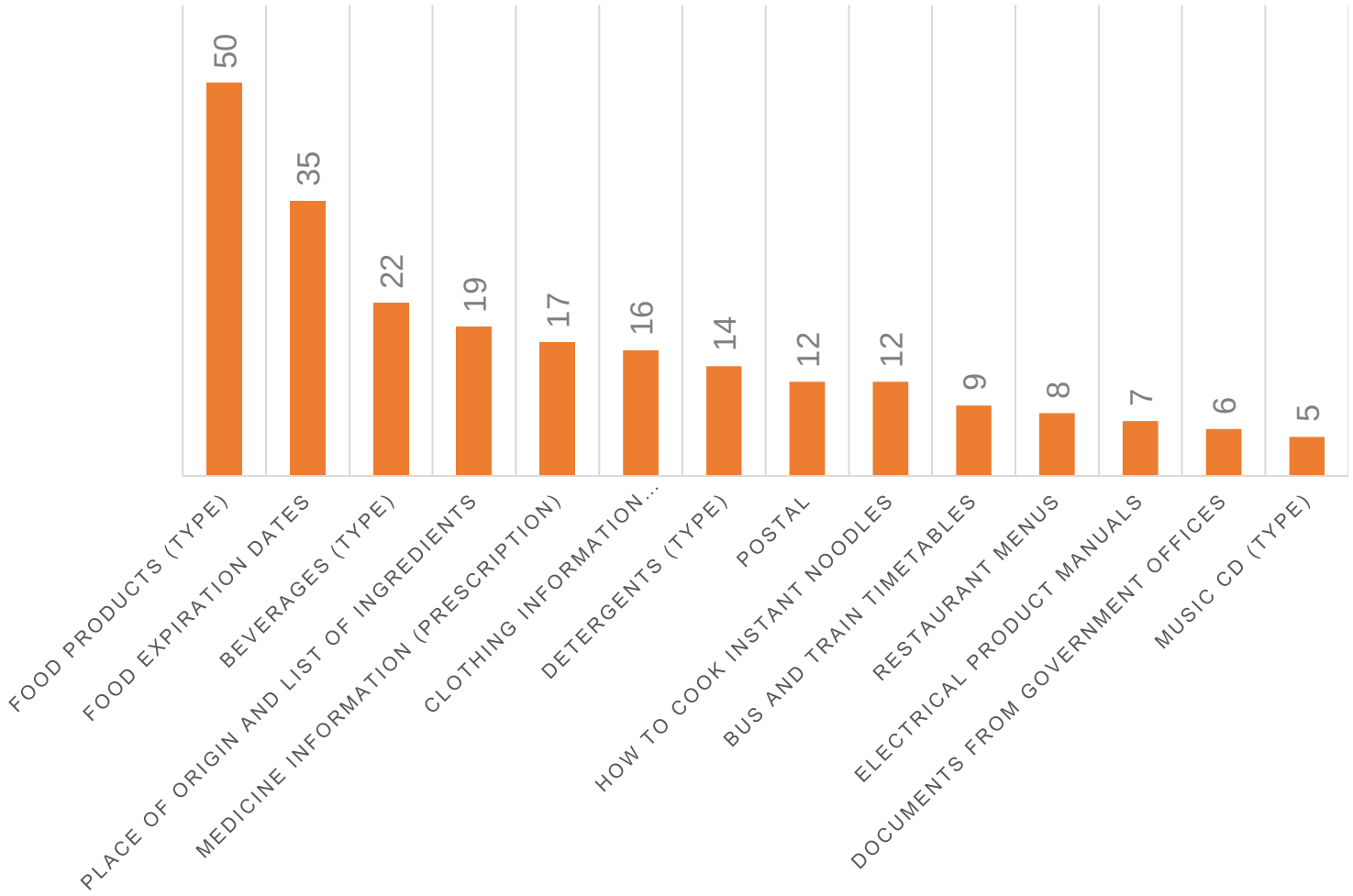
Nearly 2/3 of participants replied that QR code scanning was not difficult. An important factor in reducing their stress is how QR codes are presented for them to be scanned easily.

Survey 2 of Experiment 1

- The kind of information the participants want to obtain through QR codes – That they feel is difficult to access in daily life.

Information	No. of Respondents
Food Products (Type)	50
Food Expiration Dates	35
Beverages (Type)	22
Place of Origin and List of Ingredients	19
Medicine Information (Prescription)	17
Clothing Information (color/material/washing method)	16
Detergents (Type)	14
Postal Information	12
How to Cook Instant Noodles	12
Bus and Train Timetables	9
Restaurant Menus	8
Electrical Product Manuals	7
Documents from Government Offices	6
Music CD (Type)	5

* Multiple Answers



What We Learned from the Survey 2 are...

There are great needs for visually impaired people to access information about foods or medicines which may become fatal in case of mis-ingestion. Those needs are more serious for those who live alone.

Some participants already used QR codes or tactile stickers to distinguish the products they bought in retail stores. At the time of shopping, store staff may help them to choose products. But, the real challenge for those who live alone starts after returning home from the shopping. (through the free conversations during the survey.)

Other Remarkable Feedback from the Participants

- “The most important for me is if the available information is what we really want to know. In case of the important information, I won’t care taking how much time to scan it.”

- “I found it difficult to scan at first. However, after acquiring a sense of appropriate distance, I found scanning them much easier.” -*There seems to be a slight adjustment period for participants to find the correct distance.*

- “I have low vision, so when I’m at a supermarket, I bring items very close to my face to check what they are, and this sometimes makes other people look at me odd. I think the QR codes on products are beneficial for avoiding that.”

Summary of Experiment 1

Understanding of visually impaired people

- Visually impaired people have lots of challenges in their daily lives in accessing necessary information.
- Some visually impaired people already use smartphones or QR codes to obtain information digitally.
- The information that visually impaired people need the most is for their ingestions, such as foods, beverages, and medicines.
- It is not very difficult for visually impaired people to scan QR codes. But, they feel stressed if they are not presented suitably.

Understanding of possible factors to decide the successful scanning of QR codes

- Guidance or experience is a critical factor for successfully scanning QR codes.
- Positions of QR codes do not have much influence on the success rate.
- The presence of a tactile mark raises the success rate.
- The shapes or materials of products greatly impact the success rate.

Conclusion

- QR codes can potentially help visually impaired people acquire necessary information from printed objects.
- There seem to be many factors to consider to increase the success rate of scanning QR codes by visually impaired people.
- The contents of the information is another key to increasing the practicality of QR codes.
- We need to do more research to determine any other critical factors.

Report on the QR Code Readability Tests by Visually Impaired People with Smartphones #2

Experiment Period: October 1, 2018, to November 2, 2018

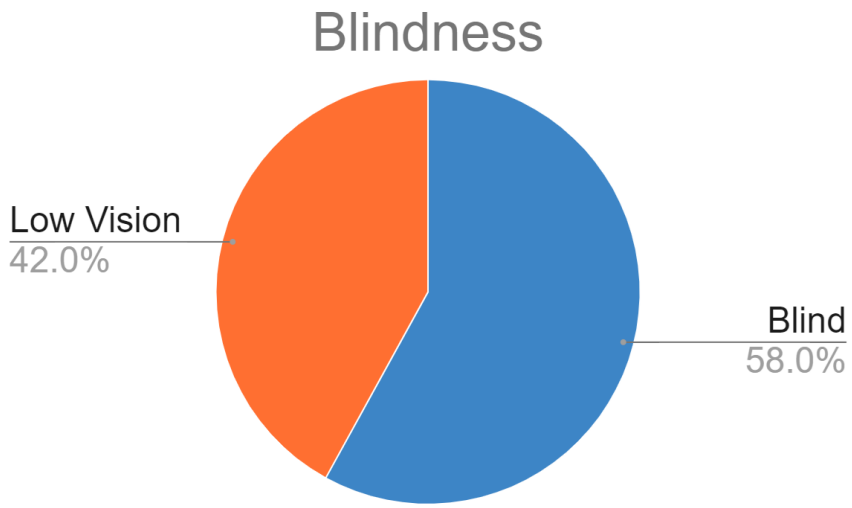
NPO Kobe Light House, NPO i-collaboration Kobe, and Export Japan Inc.

Purposes of Experiment 2

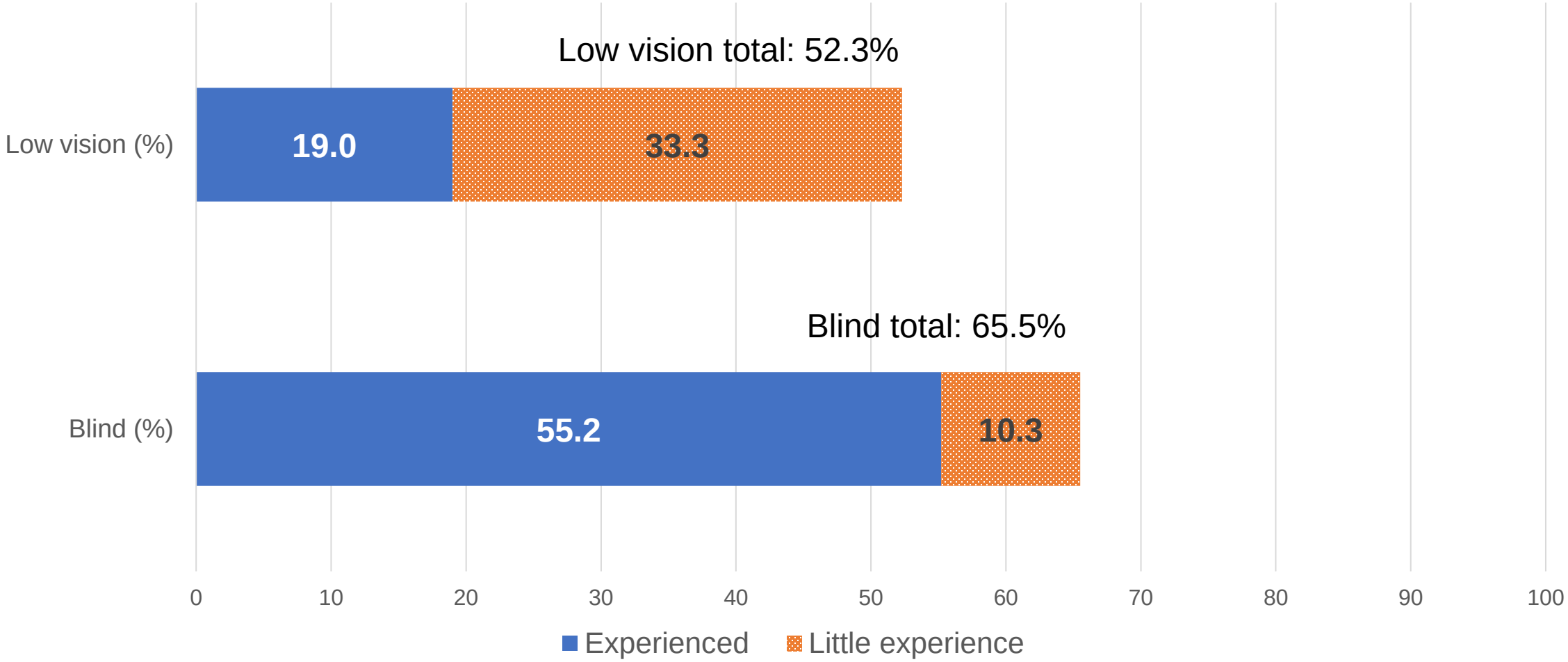
- To validate our assumptions obtained in Experiment 1
- To further analyze critical factors that determine the success rate of QR code scanning, such as tactile marks or sizes of QR codes
- To find out the indispensable features for designing visually impaired people-friendly QR codes
- To receive further feedback from visually impaired people regarding QR code scanning

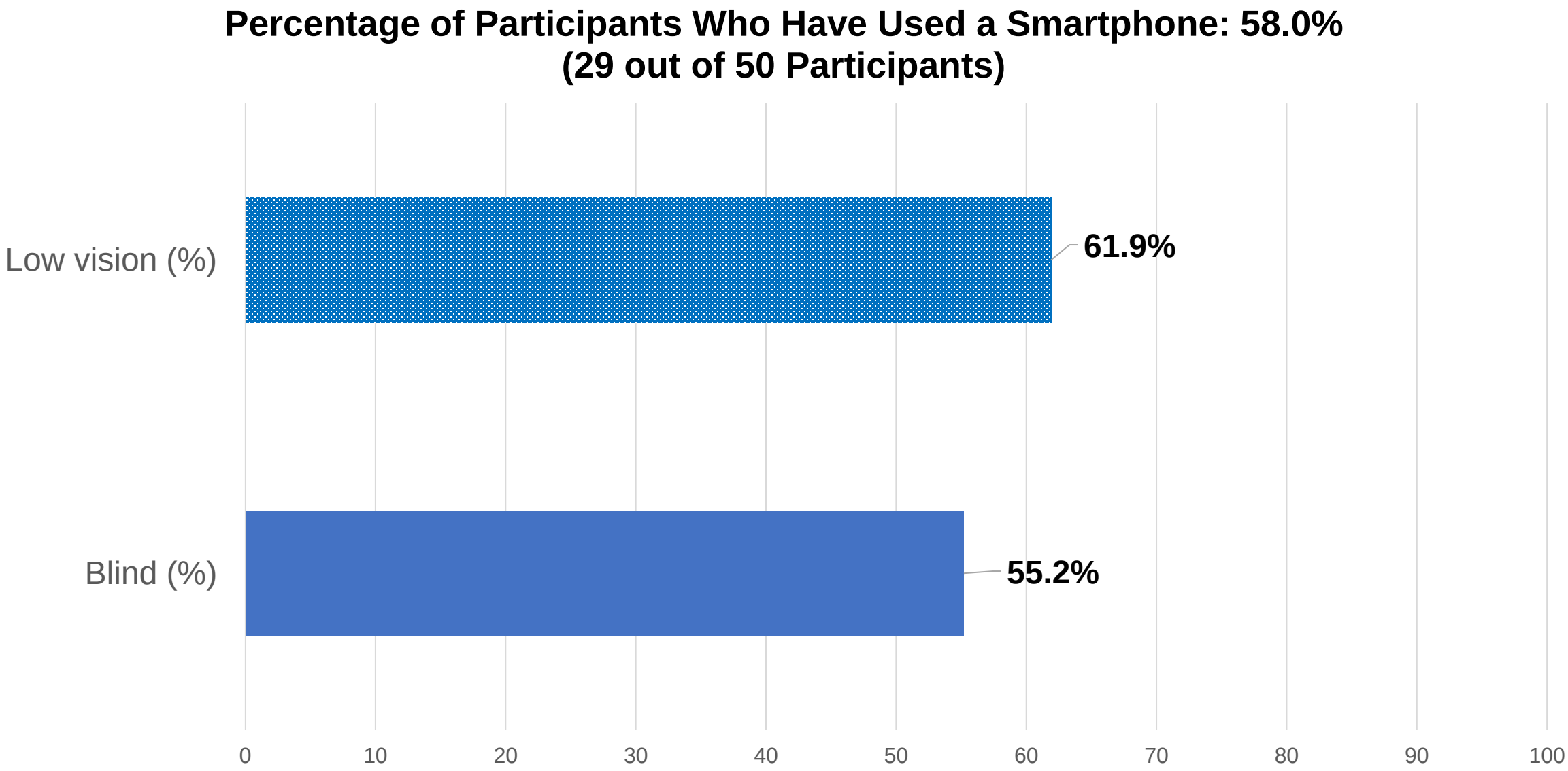
Participants of Experiment 2

Total:	**50 participants** (Living in 3 different regions)
Average Age:	**52.9 years old**
Gender:	72% Male (36 people)
	28% Female (14 people)
Blindness:	58% Blind (29 people)
	42% Low vision (21 people)

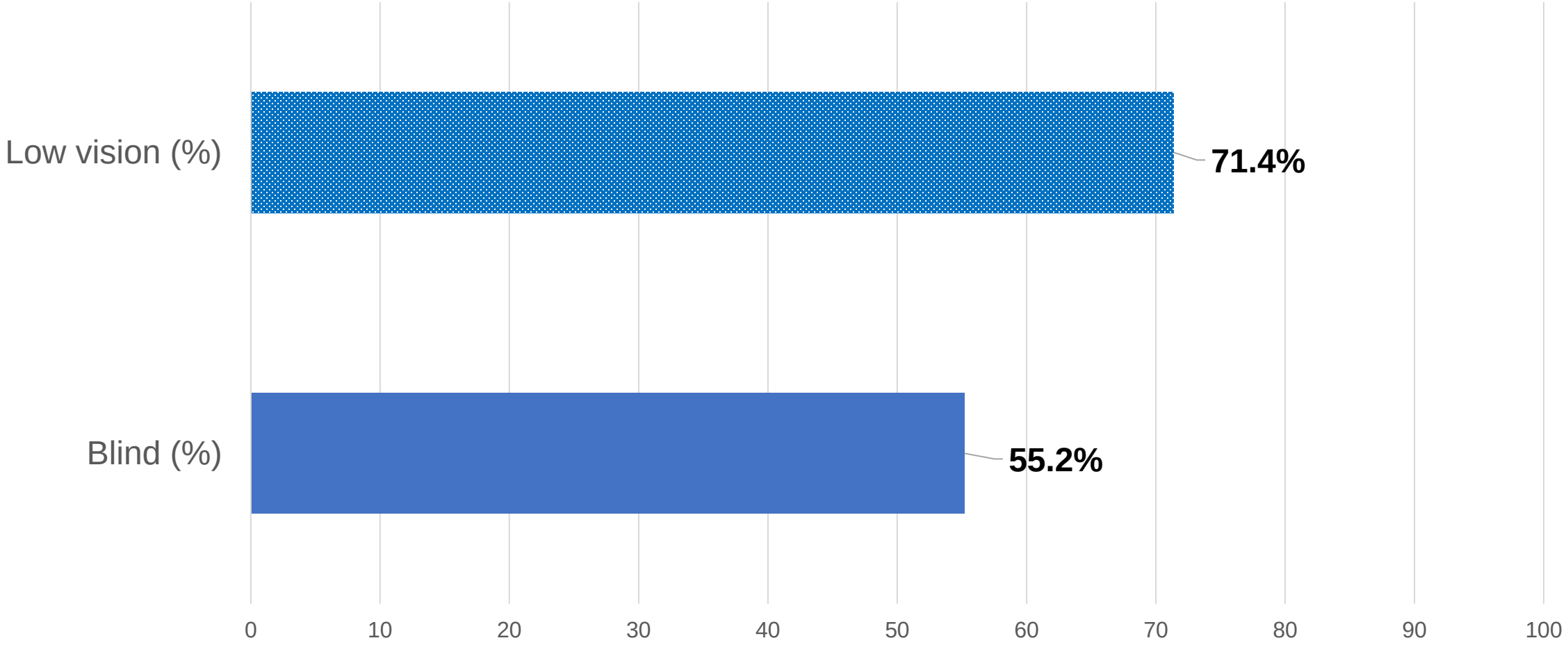


Percentage of Braille Users: 60.0%
(30 out of 50 Participants)




Percentage of Participants Who Have Used a Smartphone: 58.0%
(29 out of 50 Participants)
Low vision (%)
61.9%
Blind (%)
55.2%
0
10
20
30
40
50
60
70
80
90
100

Percentage of Participants Who Have Used QR Codes: 62.0% (31 out of 50 Participants)



Dimensions of Our Analysis

Through the Experiment 2, we tried to figure out what kind of factors determine the success rate for visually impaired people scanning QR codes. To know them, we picked up the following dimensions:

1. Existence of tactile marks on paper (2D printed material)
2. Size of QR code (0.6, 0.8, 1.0, 1.2 cm)
3. Existence of tactile marks on products (3D objects)
4. Types of tactile marks on products (3D objects)

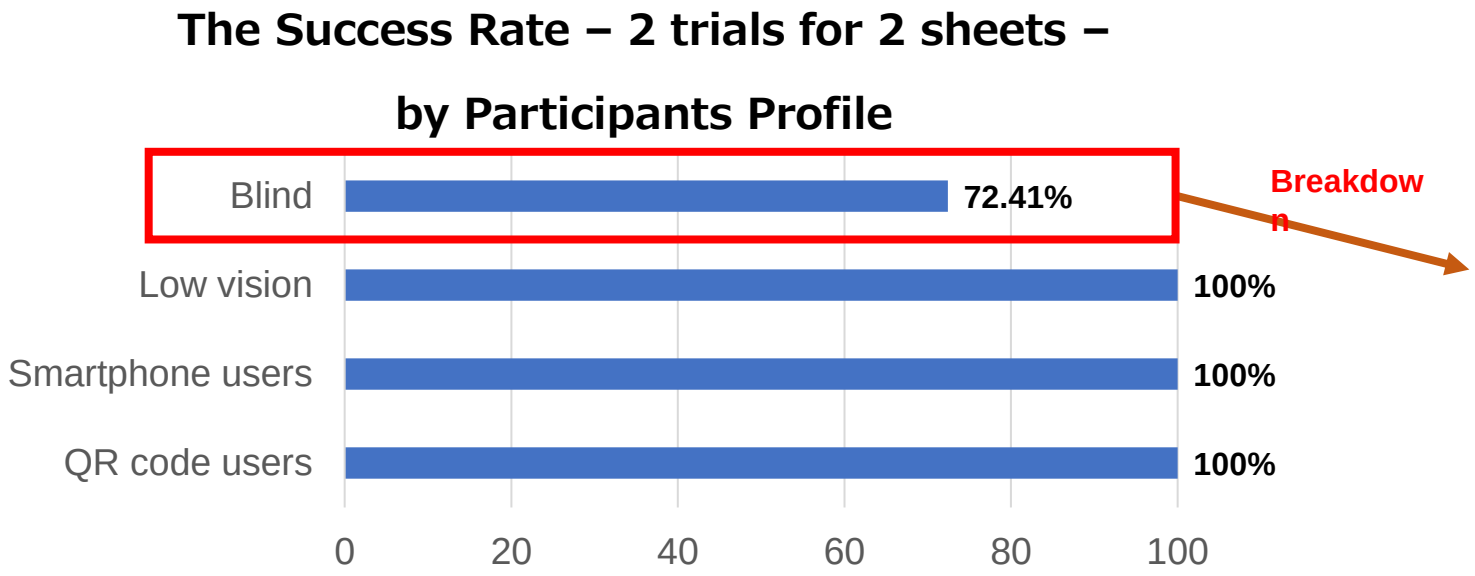
Test 1 of Experiment 2

We prepared 2 brochures with QR codes printed in the same position. However, One of them had one corner cut off to inform the participants that there was a QR code around.

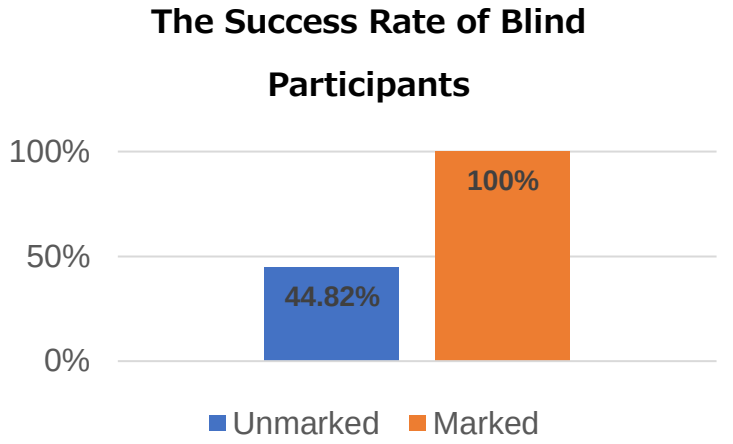
- Success rate for the unmarked sheet: 84% (42/50 participants)
- Success rate for the marked sheet: 100% (50/50 participants)

Normal Paper (Unmarked)

Corner Cut Paper (Marked)



Breakdown



What We Learned from the Test 1 are...

For low-vision participants, a tactile mark of a QR code on a 2D object (e.g., paper) didn’t seem as important as for blind ones because the success rate by the low-vision group was 100% on this Test, both for marked and unmarked papers. However, the tactile presence of a QR code seemed important for blind people as the success rate of the blind group dropped significantly in the case of no tactile mark.

From the observations, in the case of no tactile marks, the blind participants seemed worried if there was a QR code, while some low-vision participants could easily identify the location of a QR code because it was black-and-white, the two strongest contrast of colors.

Prepared Materials for the Tests 2-4 of Experiment 2

	0.6 cm x 0.6 cm	0.8 cm x 0.8 cm	1.0 cm x 1.0 cm	1.2 cm x 1.2 cm
				
Unmarked 	Convex (凸) 	Concave (凹) 	Sticker 	Dots 
Unmarked 			Sticker 	Dots 

* Note: Tactile marks were made by our staff.

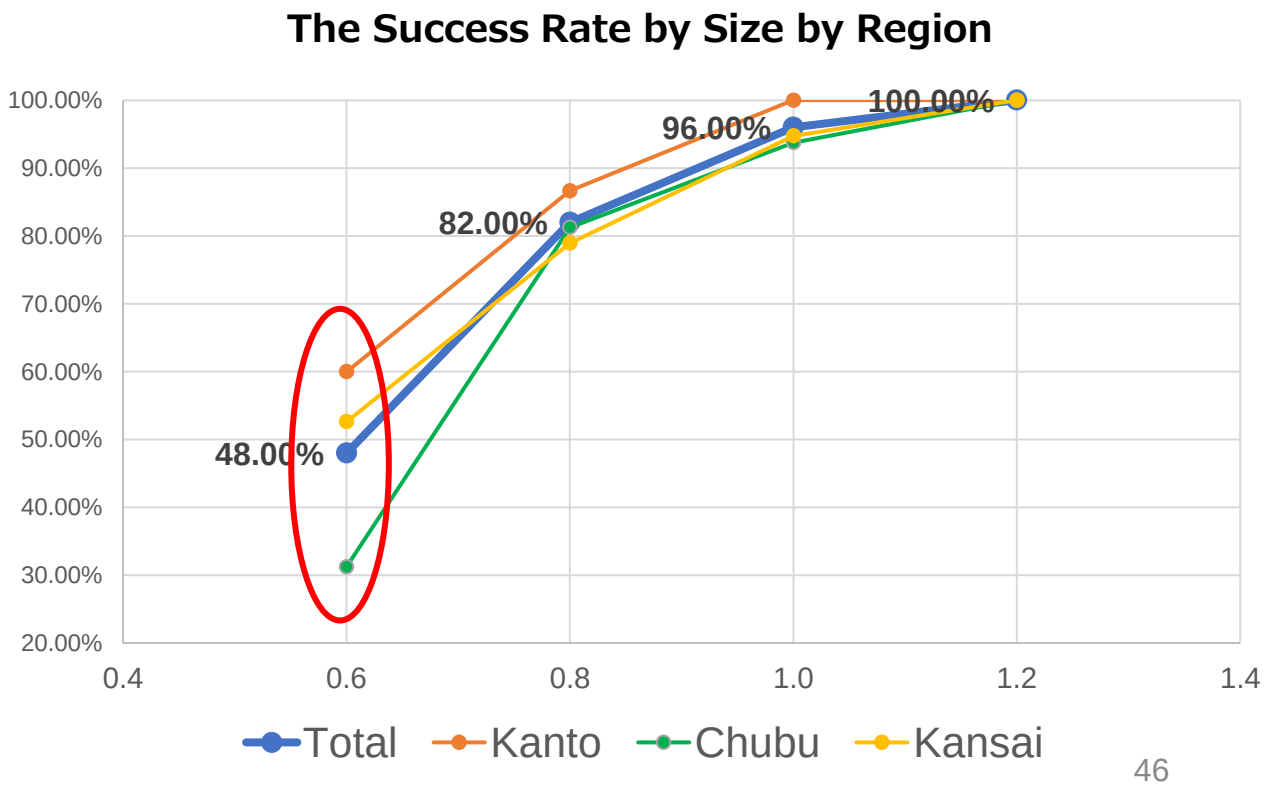
Test 2 of Experiment 2

We prepared 4 brochures with QR codes printed in the same position but in 4 different sizes. We also analyzed the results by Japanese regions in which we conducted the test on different dates to see if this experiment had other hidden factors or biases.

- 0.6 cm×0.6 cm 48% (24/50 participants)
- 0.8 cm×0.8 cm 82% (41/50 participants)
- 1.0 cm×1.0 cm 96% (48/50 participants)
- 1.2 cm×1.2 cm 100% (50/50 participants)

Size	Total (50)	Kanto (15: 12-3)*	Chubu (16: 9-7)	Kansai (19: 8-11)
0.6	48.00%	60.00%	31.25%	52.63%
0.8	82.00%	86.67%	81.25%	78.95%
1.0	96.00%	100.00%	93.75%	94.74%
1.2	100.00%	100.00%	100.00%	100.00%

* Region (Total participants: Blind-Low vision)



What We Learned from the Test 2 are...

The size of QR codes has a strong impact on the success rate of scanning QR codes. The rate dropped significantly if the size become less than 1.0 cm square.

There weren’t many differences in the success rate between blind and low-vision participants as every region has the same tendency even though the ratio of blind to low-vision participants was quite different by region.

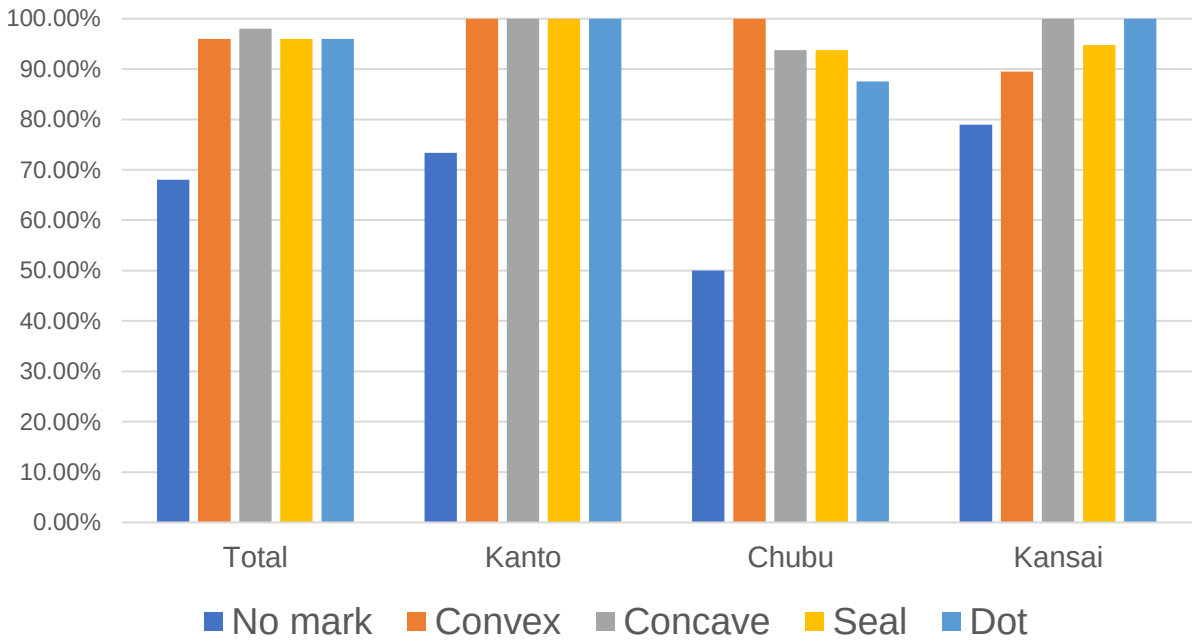
Test 3 of Experiment 2

We prepared 5 boxes of the same product with QR codes printed on the same position of each box in the same size and with 4 different tactile marks around the QR code, except 1 with no mark. The 4 different types of tactile marks are convex, concave, seal sticker, and dots. We also analyzed the results by Japanese regions in which we conducted the test on different dates to see if this experiment had other hidden factors or biases.

Type	Total (50)	Kanto (15: 12-3)	Chubu (16: 9-7)	Kansai (19: 8-11)
No mark	68.00%	73.33%	50.00%	78.95%
Convex (凸)	96.00%	100.00%	100.00%	89.47%
Concave (凹)	98.00%	100.00%	93.75%	100.00%
Seal Sticker	96.00%	100.00%	93.75%	94.74%
Dots	96.00%	100.00%	87.50%	100.00%

* Region (Total participants: Blind-Low vision)

The Success Rate by Mark by Region



What We Learned from the Test 3 are...

The QR code scanning success rate was quite high, even for the 6-dimensional objects, if tactile marks were provided. But, the rate dropped significantly if a tactile mark was not provided.

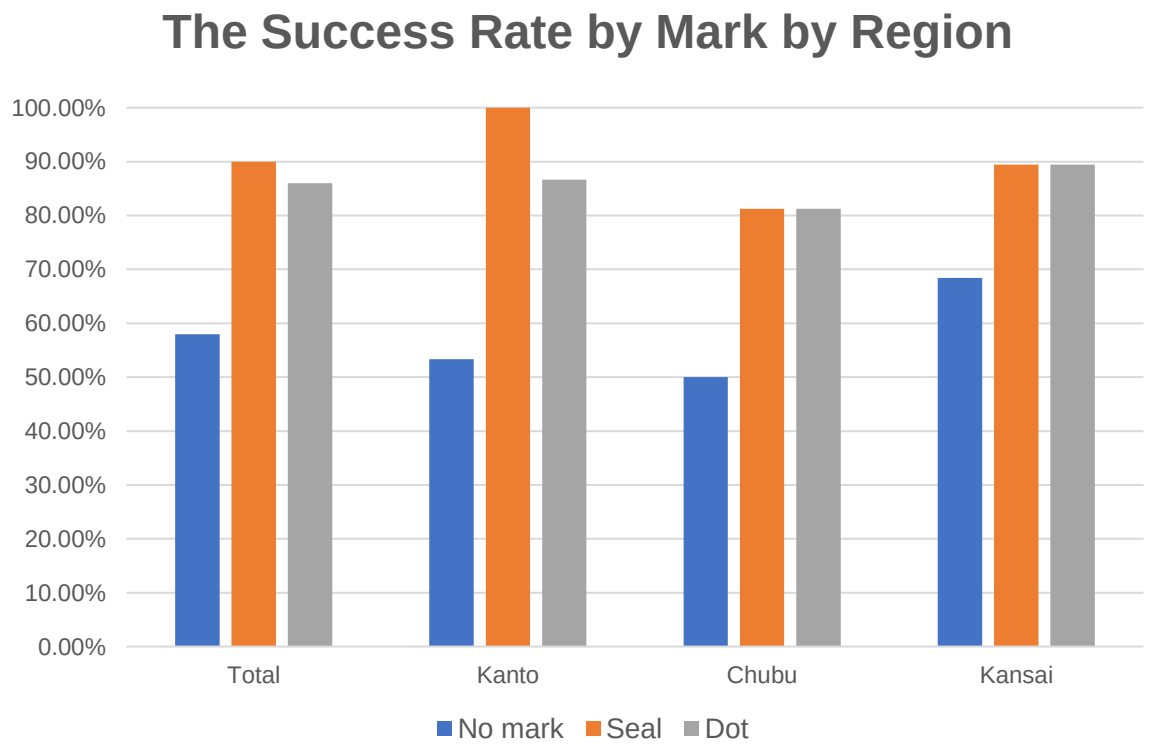
There weren’t any significant differences in the success rate among the types of tactile marks. So, the critical factor influencing the success rate of QR code scanning for visually impaired people is the existence of tactile marks and not the type of them.

Test 4 of Experiment 2

We prepared 3 cans of the same product with QR codes printed in the same position of each can in the same size and with 2 different tactile marks around the QR code, except 1 with no mark. The 2 different types of tactile marks are seal sticker and dots. We also analyzed the results by Japanese regions in which we conducted the test on different dates to see if this experiment had other hidden factors or biases.

Type	Total (50)	Kanto (15: 12-3)	Chubu (16: 9-7)	Kansai (19: 8-11)
No mark	58.00%	53.33%	50.00%	68.42%
Seal Sticker	90.00%	100.00%	81.25%	89.47%
Dots	86.00%	86.67%	81.25%	89.47%

* Region (Total participants: Blind-Low vision)



What We Learned from the Test 3 are...

The QR code scanning success rate was quite high, even for the round 3D objects (cylindrical cans), if tactile marks were provided. However, the success rate dropped significantly when a tactile mark was not provided for both blind and low-vision participants.

There weren’t any significant differences in the success rate between two types of tactile marks. So, the critical factor influencing the success rate of QR code scanning for visually impaired people is the existence of tactile marks, not the type.

Summary of Experiment 2

Understanding the critical factors of the success rate

- From the results of Tests 1, 3, and 4, it's undoubtful that a tactile indication of a QR code is the critical factor for increasing the success rate for visually impaired people to scan QR codes.
- From the results of Test 2, it seems that the smaller a QR code becomes, the more difficult it becomes to be scanned for visually impaired people.
- From the results of Tests 3 and 4, it seems obvious that the type of tactile marks is not the critical factor, but their presence is.
- From the results of Tests 2, 3, and 4, there didn't seem to be any differences among the results of regions where we conducted the Experiment on different dates.

Conclusion

- With Experiment 2, we could confirm that some assumptions made from Experiment 1 were correct. There seem to be many interrelated factors that may affect the successful scanning of QR codes by visually impaired people. We should continue trying to discover other factors we might have missed.

Notes

- The room brightness is an essential factor for successful QR code scanning. We didn’t set any numerical criteria but requested it as “bright enough.” We did not see any significant differences among regions even though we conducted the tests on different dates and in different rooms for each region.
- We did not include any analysis of participants’ gender and age because we assumed they weren’t specific factors to visually impaired people. (They must be the same as sighted people.)
- We collected data on participants’ smartphones’ OS and the versions the participants used. We lent our smartphones only to those who did not have their own. More than 90% of the participants used iPhones for the tests. Thus, we didn’t give any analysis regarding the difference in OS.
- We used only black-and-white QR codes for the tests. Nowadays, there are colored QR codes in the market. People with low vision find it easier to identify black-and-white QR codes because those two colors have the highest contrast. Hence, the color of QR codes may affect the success rate for some visually impaired people.
- No person participated twice or more in the same test. But some of the participants of Experiment 1 also took part in Experiment 2. Less than 30% of Experiment 2 comprised the participants in Experiment 1.

What we might have missed

After Experiment 1&2, we found other critical factors when considering visually impaired people-friendly QR codes.

1. QR code version (https://www.qrcode.com/en/about/version.html)

The smaller a QR code version is, the easier it is to scan because smaller versions have fewer cells. This means that each cell has more interspace to be read by a QR code reader. Version 5 QR codes were used in Test 2 of Experiment 2.

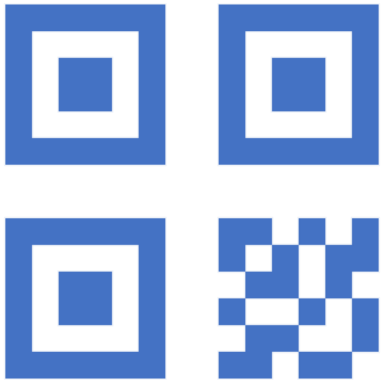
2. Printer resolution

The higher the printer resolution is, the finer the cells of QR codes can be printed. A 600 dpi resolution printer was used for scanning Test 2 of Experiment 2. Nowadays, many commercial printers have finer resolution than our testing environment.

3. Smartphone camera's resolution

The higher the resolution, the further away people can scan the QR code from. In our experiments, we guided participants to scan the QR codes from a distance of around 20 to 30 cm so that the cameras could capture a wider area. Most smartphones nowadays have higher-resolution built-in cameras than we used in our experiments.

After the Experiments



- We’ve become more confident that QR codes can be an alternative to braille for visually impaired people to gain more information on physical matters such as products, signs, or documents.
- The experiments were conducted only in Japan this time. So we wish we could verify if similar results can be obtained in other countries, regions, or languages.
- Thinking of the practical use of QR codes for visually impaired people in society, there must be many other factors we have to consider. However, we can gradually increase their practicality by focusing on controllable factors, such as their sizes, tactile presentations, or useful content.
- We also must consider the differences in available resources, such as devices and Internet connections, from the universal perspective.
- Google Camera may be somewhat of an alternative – At this moment, QR codes are much easier to scan than physical text paragraphs, though.
- Above all, we must hear many more voices of visually impaired people to know what they need or want.

Thank you.

Tell us your opinions

Email: pvip@export-japan.co.jp

Website: https://accessible-code.com/