Testing the Feasibility of Using QR Codes to Facilitate the Independence of Visually Impaired People

Periods: May, 2017 to March, 2019

A collaborative project between NPO Kobe Light House and Export Japan

Why did we start this project?

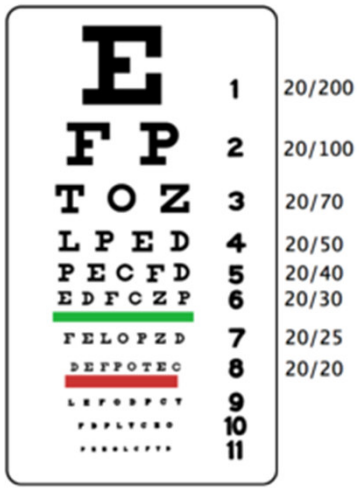
In August 2016, we received an inquiry from Kobe Light House, an organization that helps visually impaired people become more independent.

They were wondering whether QR Translator – our QR code-related service – could be utilized by visually impaired people to obtain information from printed materials by making use of its text-to-speech function.

From that point on, we started to learn a lot about visual impairment....

Who is blind? Who has low vision?

- Definition
  - Blindness is the level of visual impairment that obstructs a person from independent living in everyday life.



Snellen Eye Chart

- U.S. definition of legal blindness
  1. <u>Visual Acuity</u> (The better-seeing eye with best conventional correction such as glasses or contact lenses)
     - Blind: 20/200 or less
     - Low vision: 20/70 or less
     - Unimpaired: 20/20
  2. <u>Visual Field</u> (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

Visually Impaired People: **1.64 million**
Ratio: 1.3% of total population
Blind: **187,800** people

According to Japan Ophthalmologists Association (2007)

Visually Impaired People: **~440 million**
Ratio: 6.0% of world population
Blind: **36 million** people

According to The LANCET Global Health (2017)

Challenges in Daily Life

Challenges: Nowadays, visually impaired people (VIP) face various difficulties in their daily life such as traveling, navigating, shopping, and accessing information. One of the most critical challenges, however, is the **"Accessible Information"** problem.

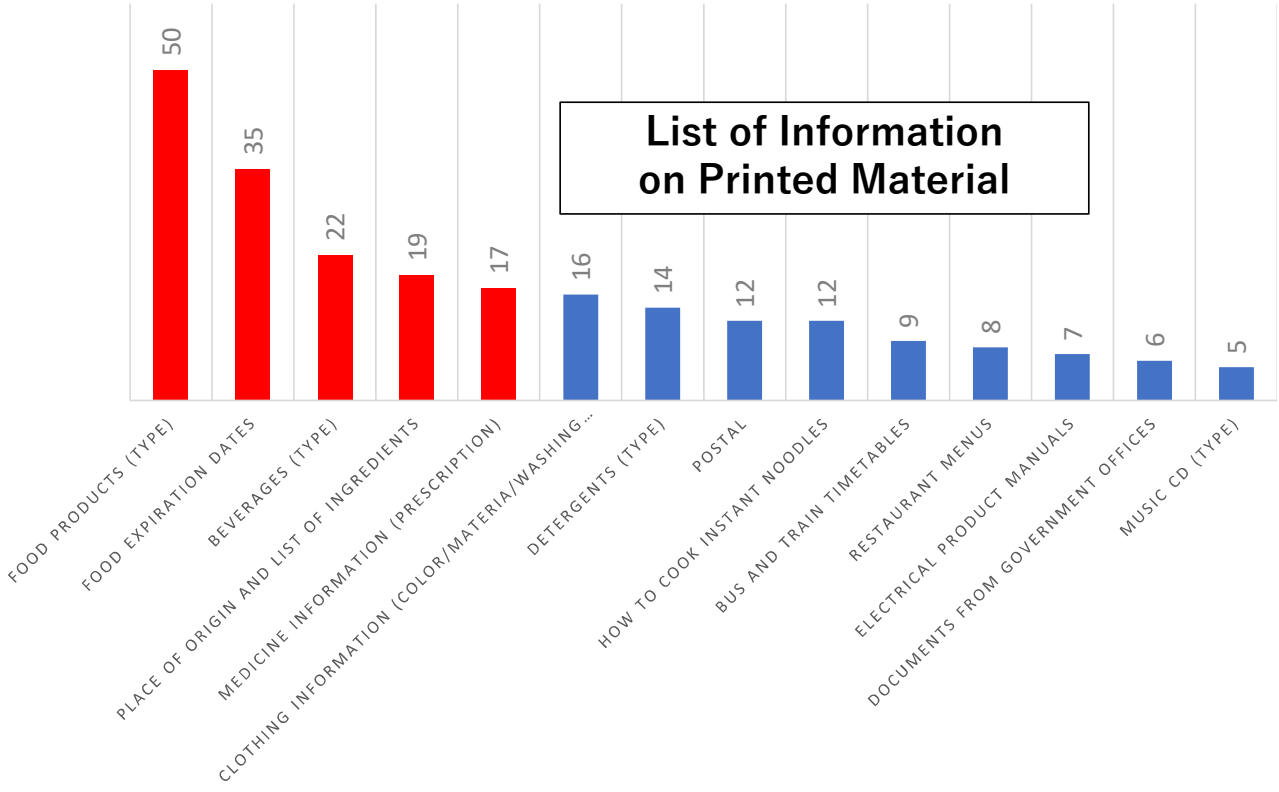
While the world has been moving closer towards an information-driven society through improvements and developments in communication and information technology, most VIP still lack access to the majority of information. Information plays an important role in social organization as it enables people to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

Information	%
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	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

Remark: Multiple Answers

“The kind of information VIP want to obtain"

- that they feel is difficult to access in daily life



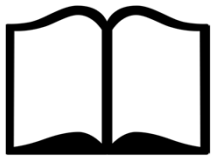
Based on a 2017 survey conducted with 100 Japanese VIP

Accessible Information Problem

Most information has been converted into digital information on the internet and can be accessed by several types of devices.

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 devices!

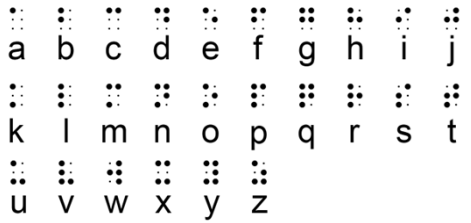
What about printed materials?

Is braille a solution?

- Unfortunately, **braille is not universal.**
- Each language has a different correspondence between characters and braille code.
- It would be unhelpful to put multilingual braille coding on signs due to difficulty in identifying which braille language it is.
- Moreover, braille cannot be easily placed in limited amounts of space, such as on product packaging.

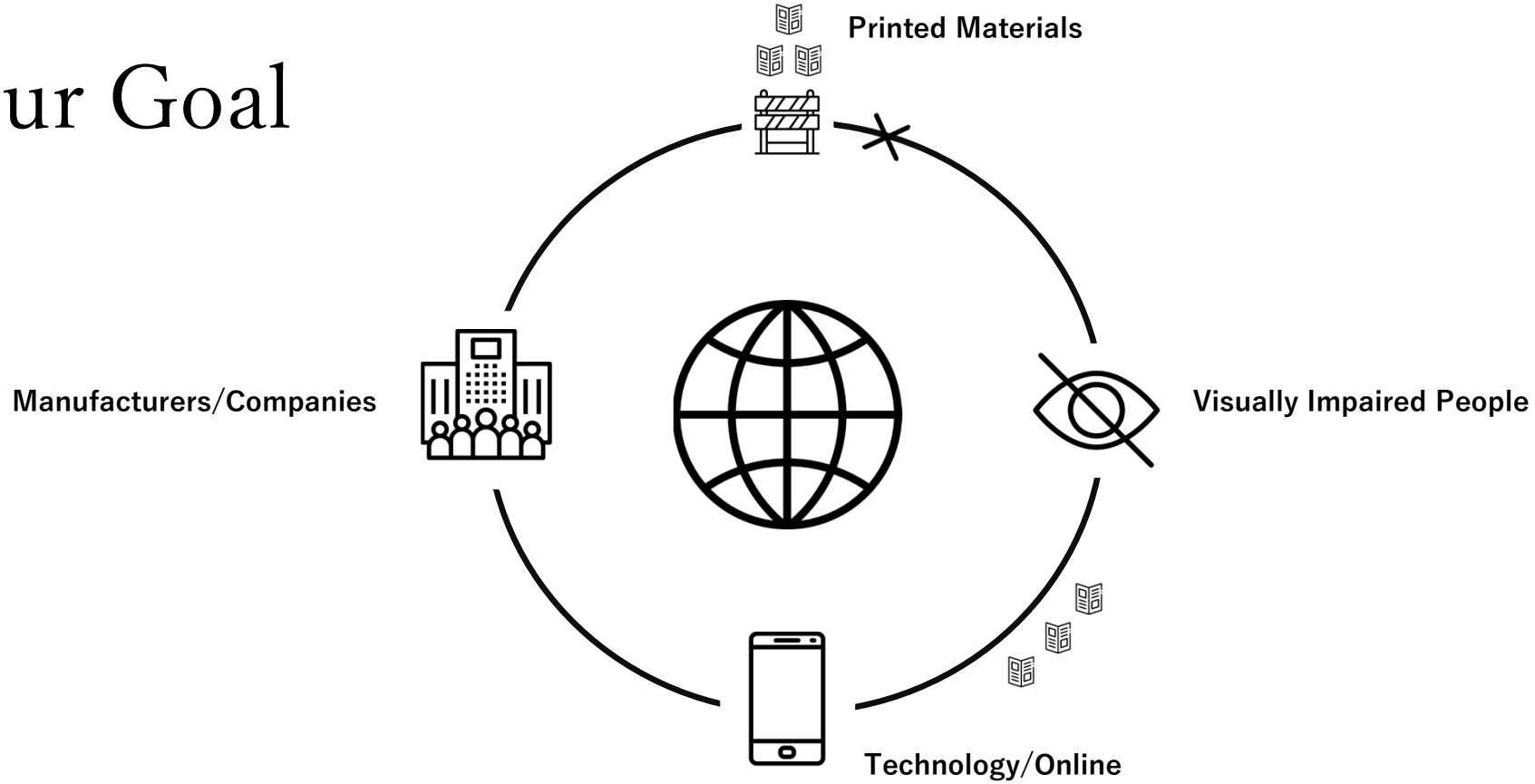
Japanese Braille

English Braille



* Images are subject to copyright.

Our Goal

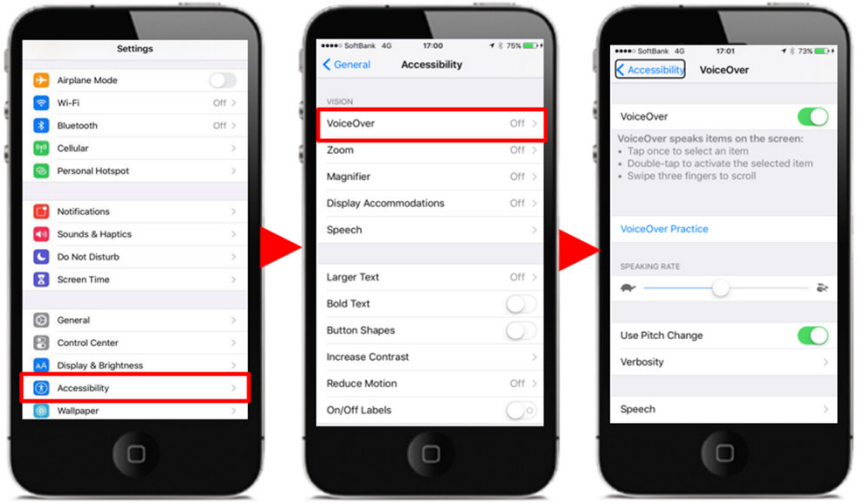


Our goal is to produce a barrier-free environment that requires less effort from both visually impaired people and society by creating a bridge between them.

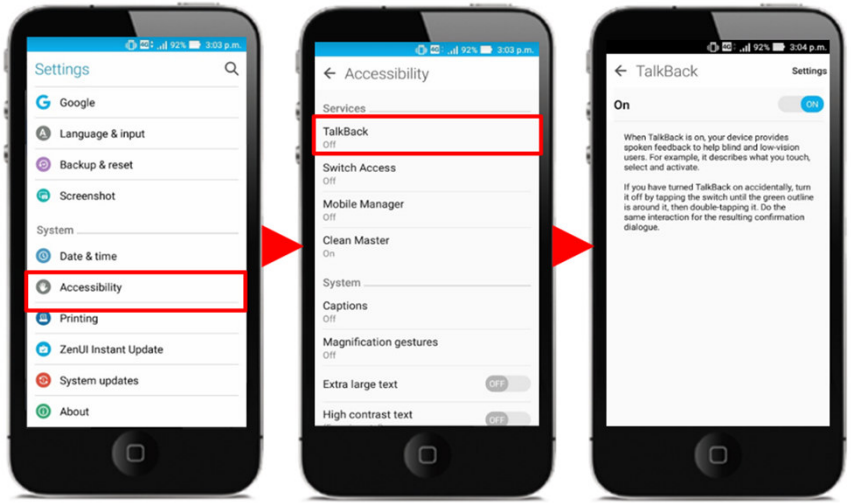
Connecting Bridge – Physical & Digital

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

Voice Over Setting on iPhone



Android OS TalkBack



Question: Is it possible to convert text on printed materials to audio by using a smartphone's screen reader feature?

Hypothesis: QR code can be an effective bridge that connects physical and digital information, and it can help VIP acquire information on printed materials.

Why QR codes?

The application of QR codes is versatile. They are used for advertisements, e-payments, education, and for other public purposes. They can also be attached anywhere such as to documents, product packaging, signboards, and even clothes. They are known as one of the most effective tools to bring customers from conventional print medias to digital medias.

Previously, a QR code scanning application was necessary to read a code, and that made it inconvenient to use QR codes in daily life. Nowadays, however, a QR code scanner comes built into many modern smartphones.

Report on the QR Code Reading Test for Visually Impaired People with a Smartphone

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

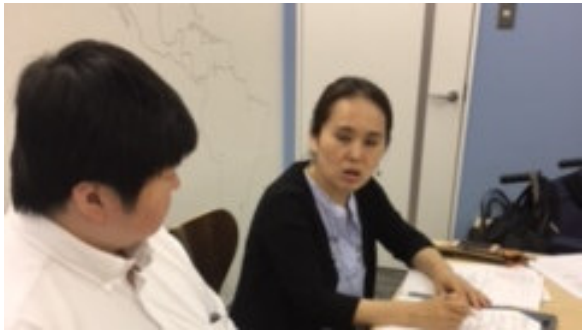
NPO Kobe Light House and Export Japan

Purpose of the First Experiment

- To examine our hypothesis “QR codes may help VIP acquire information from printed materials” (possibility)
- To know how VIP use their smartphones to scan QR codes
- To know what percentage of VIP can successfully scan QR codes
- To discover what difficulties prevent VIP from successfully scanning QR codes
- To study the stress level and feedback from VIP regarding QR code scanning

Flow of the Experiment

1. Have the participants sit on a chair and open the camera on their smartphone
2. Explain the consent form. After the participant has understood and acquiesces, obtain their signature and personal seal.
3. Ask for their profile and fill in the demonstration evaluation form
4. Conduct the experiment following the demonstration checklist
    1. Place the experimental product in front of participants and let them scan it by themselves
    2. If they have not managed to scan it after one minute, the instructor can guide the participant with their hand and give instructions



Profile of Participants

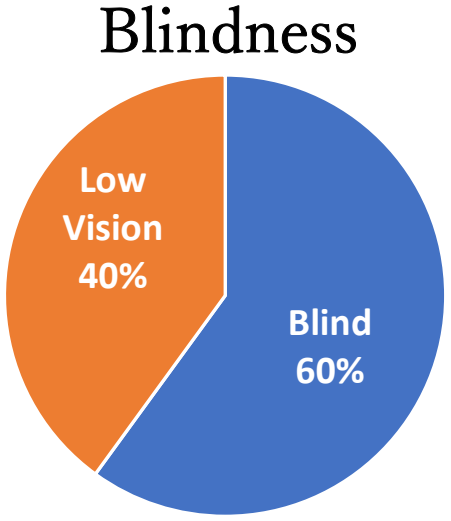
- Age
- Gender
- Blindness
- Braille User
- Smartphone Experience
- QR Code Experience

Total: **100 participants**

Average Age: **55 years old** (43 participants)

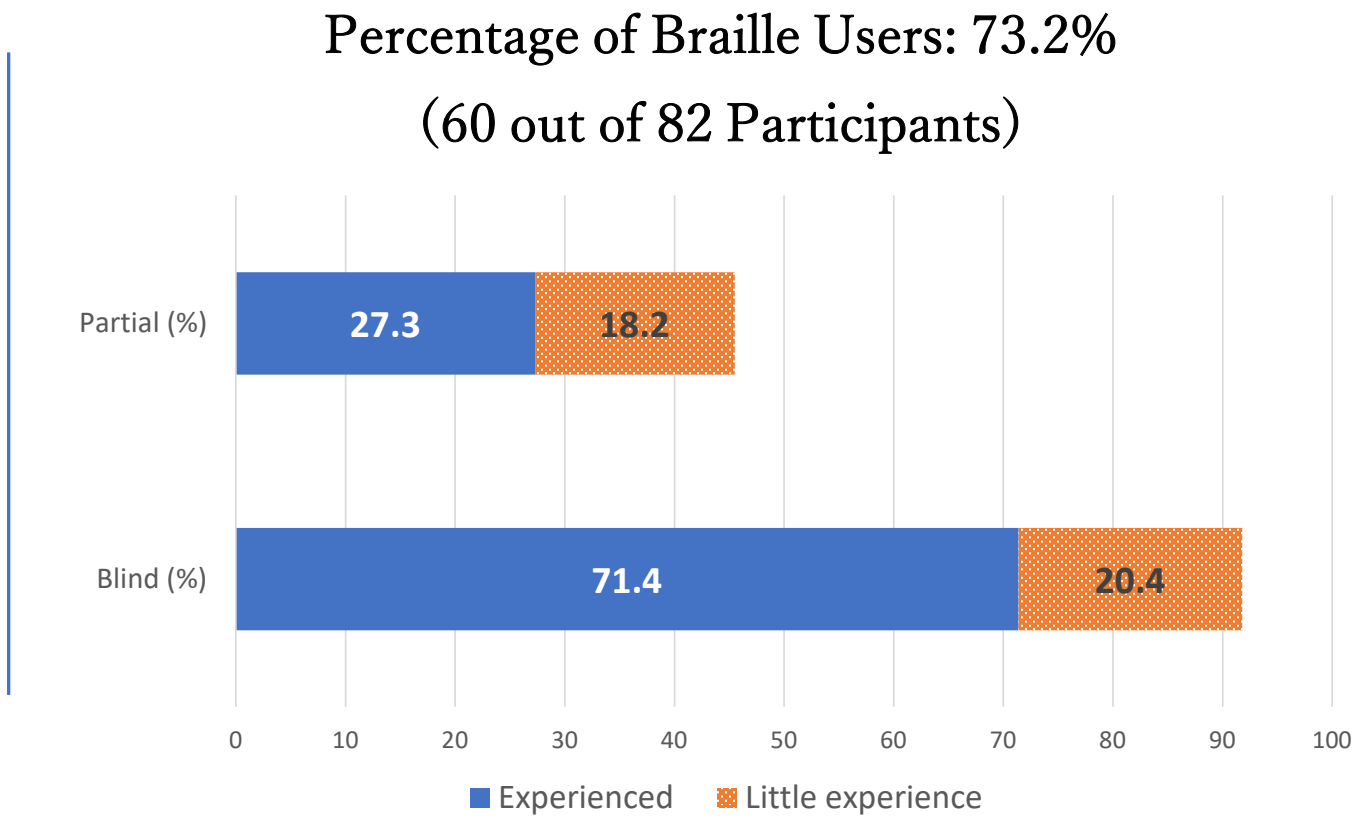
Gender: Male 64%, Female 36%
(100 participants)

Blindness: **Blind 60%,** Low vision 40%
(100 participants)



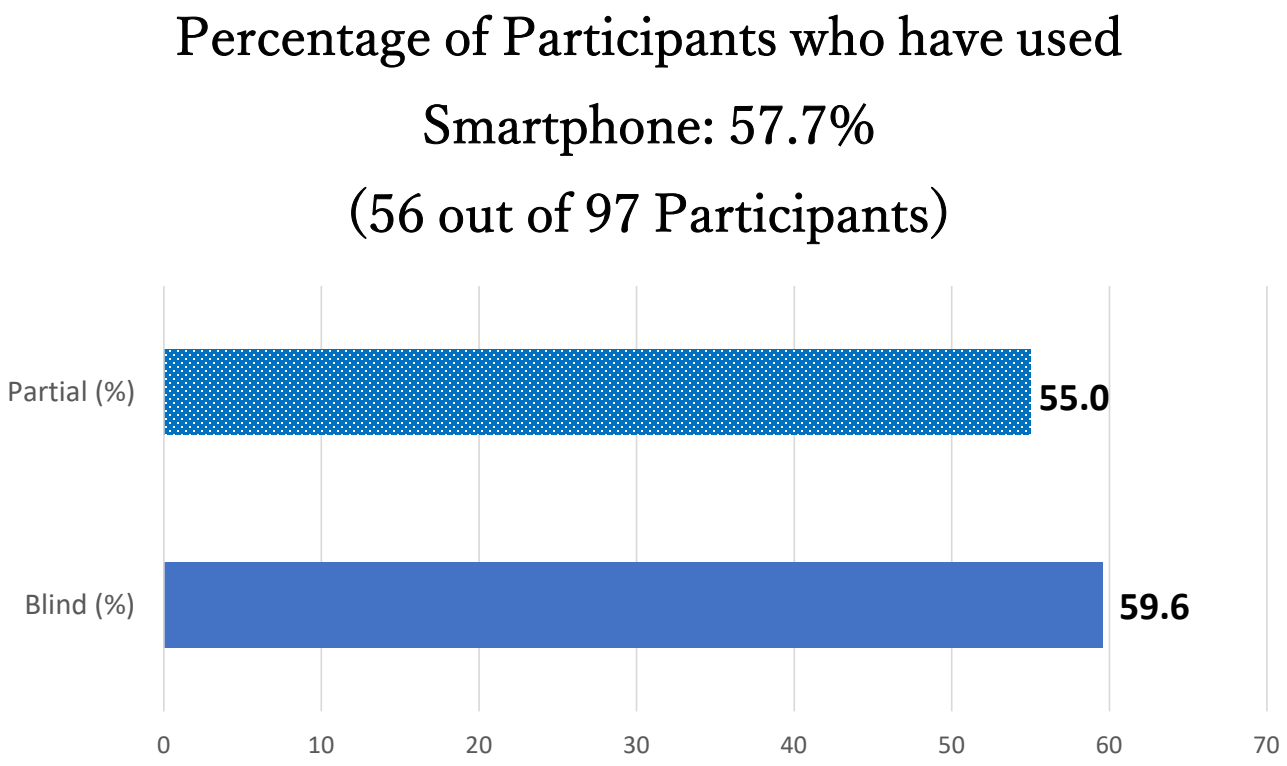
Percentage of Braille Users: 73.2%
(out of 82 participants)

- Blind: 91.8%
- Low vision: 45.5%



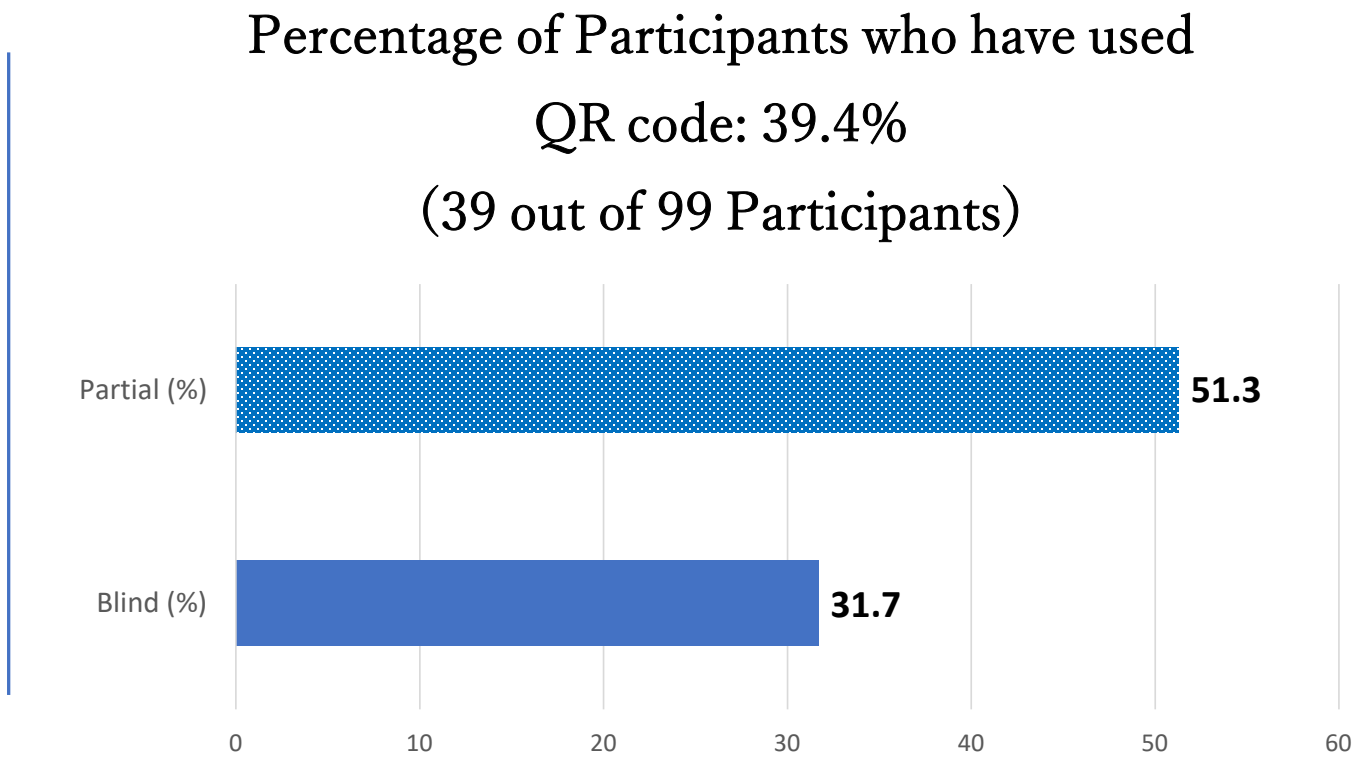
Percentage of participants who have used a smartphone:
57.7%
(out of 97 participants)

- Blind: 59.6%
- Low vision: 55.0%



Percentage of participants who have used a QR code: 39.4% (out of 99 participants)

- Blind: 31.7%
- Low vision: 51.3%



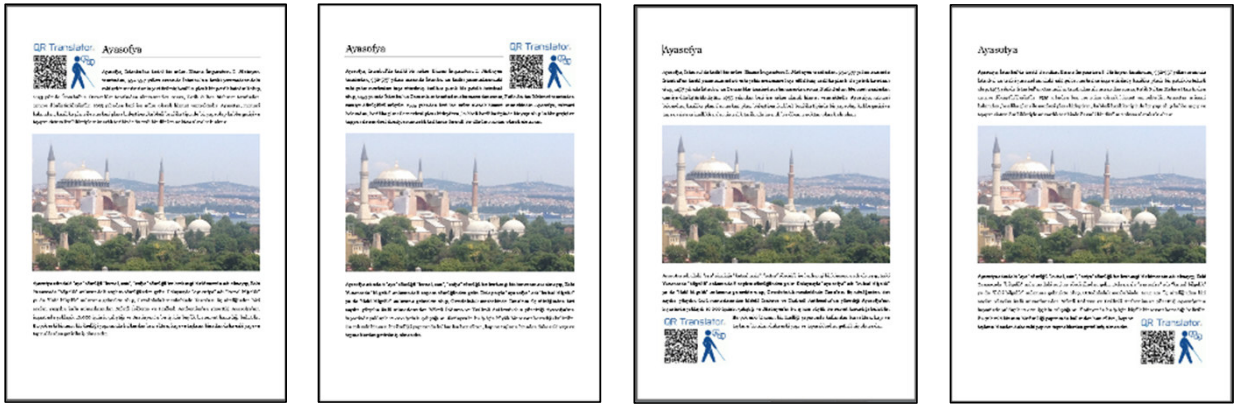
Outline of the Results of the Experiment

We conducted the experiment to answer the hypothesis on each matter in order to figure out the **critical factors** to understand how QR codes can be utilized for visually impaired people.

1. Positions of the code on 2D material (upper left, upper right, bottom left, bottom right)
2. Before and after explanation (how to use, 2D material)
3. Marked and unmarked code on a 3D object
4. Products of different shapes
5. Stress survey

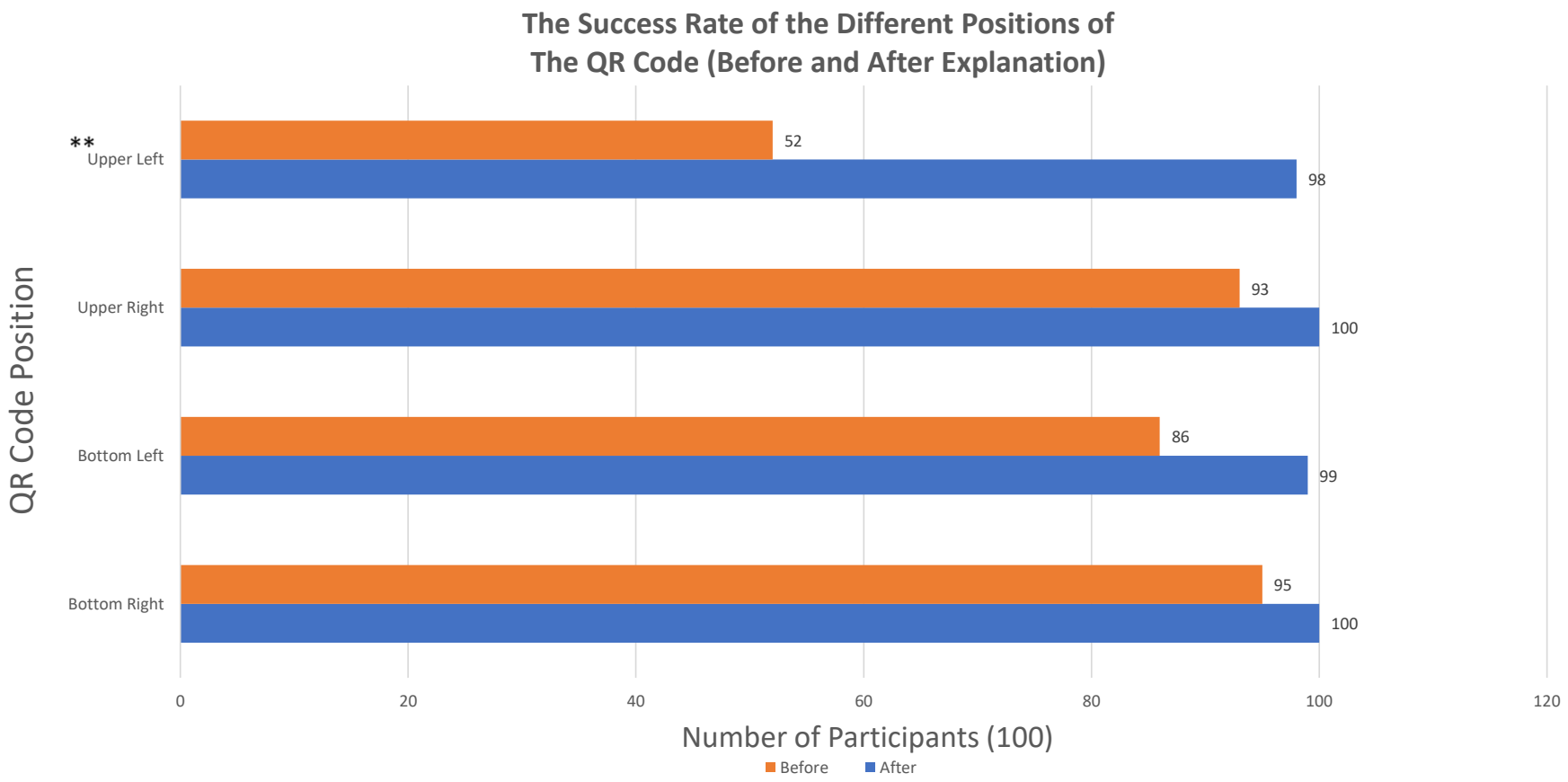
Experiment Results

(1) Positions of the code on 2D material (bottom right, bottom left, upper right, upper left)
(2) Before and after explanation (how to use, 2D material)

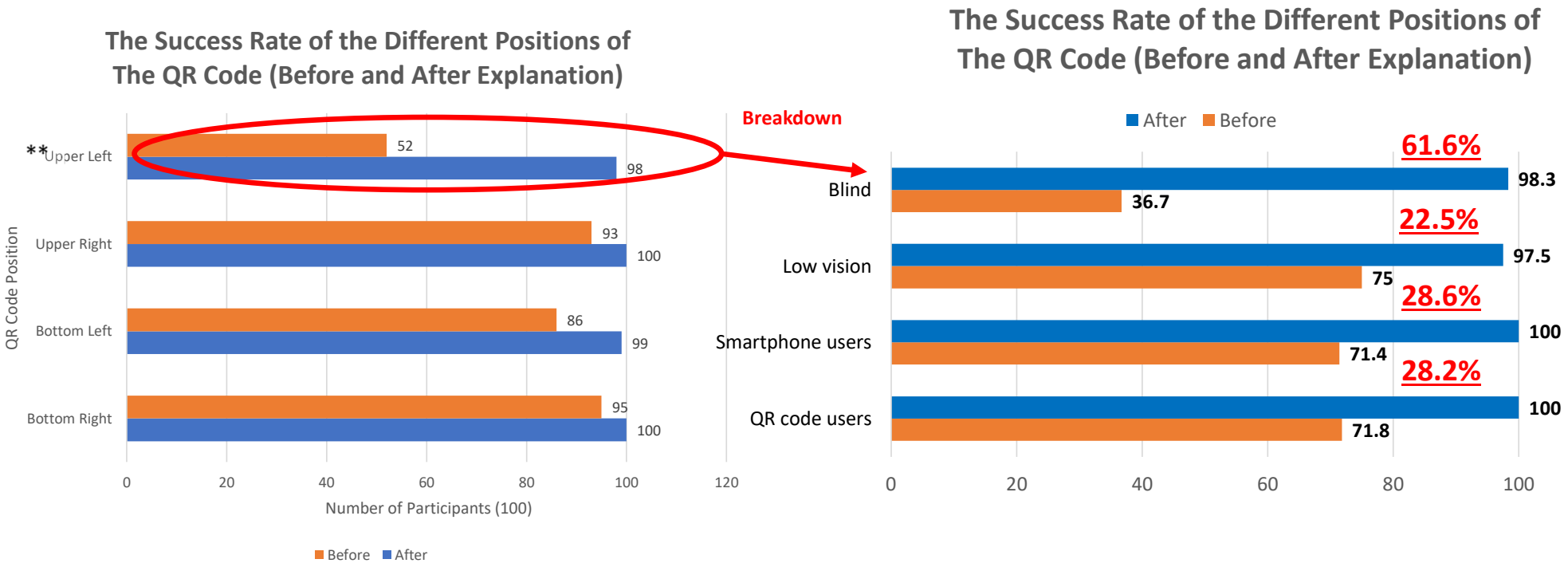


Upper Left → Upper Right → Bottom Left → Bottom Right

4 sheets of experiment paper (the QR code is printed in different positions)



**Note: Results for Upper Left are lower than expected due to participants never having used smartphones, QR codes etc.



**Note: Results for Upper Left are much lower than others because, as we can guess, it was the very first test of this experiment.

First and Second Assumptions

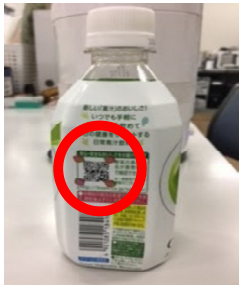
We discovered that **the position** is not a critical factor since all positions achieved a similar success rate of over 85% (except the upper left which was first to be tested and therefore includes participants who had never used a smartphone or QR codes before.)

Comparing the results from before and after explanation, we found that the success rate increases in every position. Therefore, the critical factor is **the explanation** and **the experience**.

The video how they scan qr codes

(3) Marked and unmarked code on a 3D object
(4) Products of different shapes

・Types of 3-dimension objects with QR codes (4 types, 6 items)

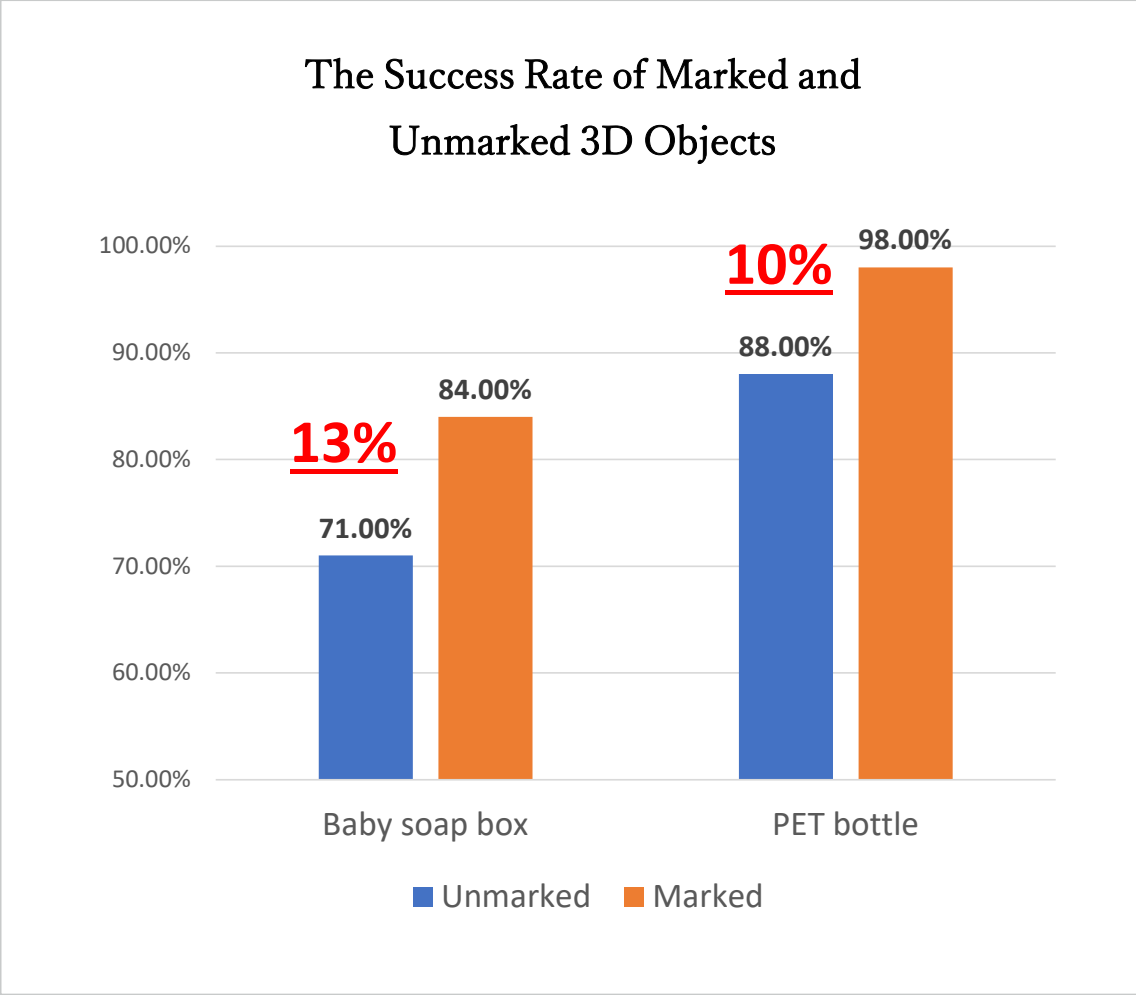
 Baby Soap (Unmarked)	-	 PET bottle (Unmarked)	-
 Baby Soap (Marked)	 Candy bag (Marked)	 PET bottle(Marked)	 Cylindrical can (Marked)

* Products were bought from retail stores ** Mark was made by the staff

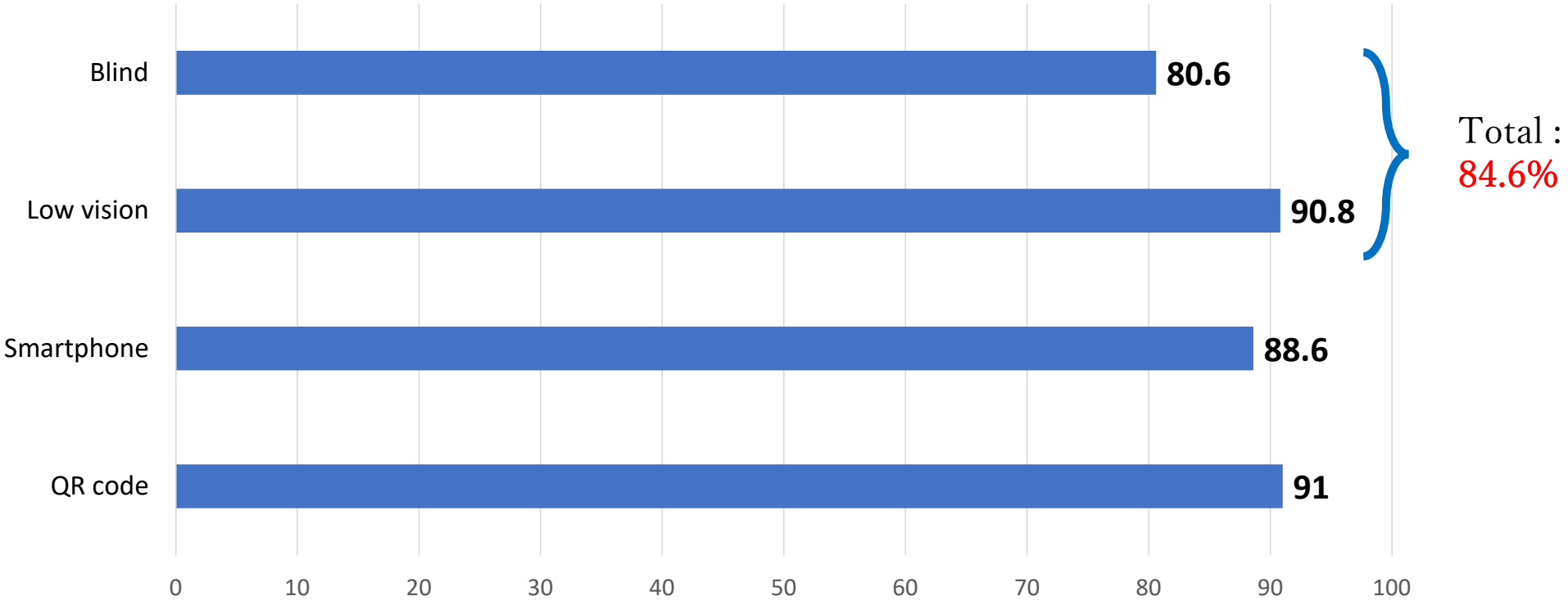
The difference in success between marked and unmarked 3D objects is 10～13%

Baby Soap Box (6-sided box)

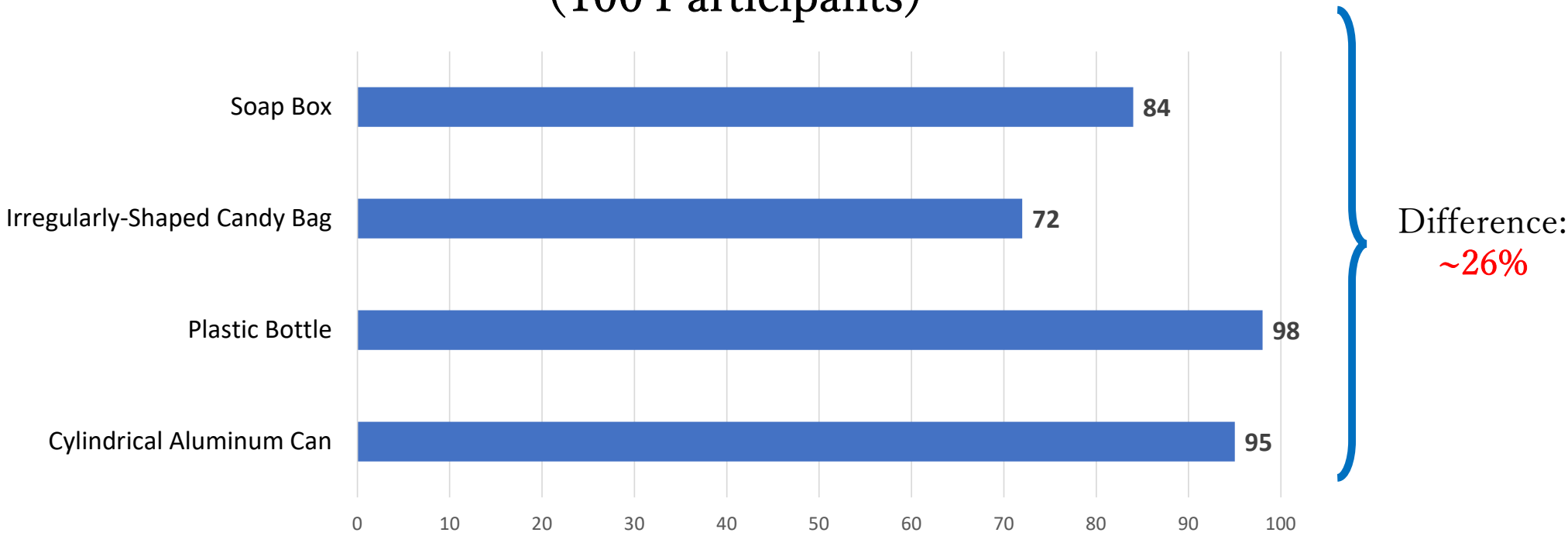
Plastic Bottle (4-sided plastic bottle)



The Success Rate of Reading a QR Code on 3D Objects (6 items) of Each Participant Group



The Success Rate of Reading a 2D Code according to the Shape of Marked 3D Objects (100 Participants)



Third and Fourth Assumptions

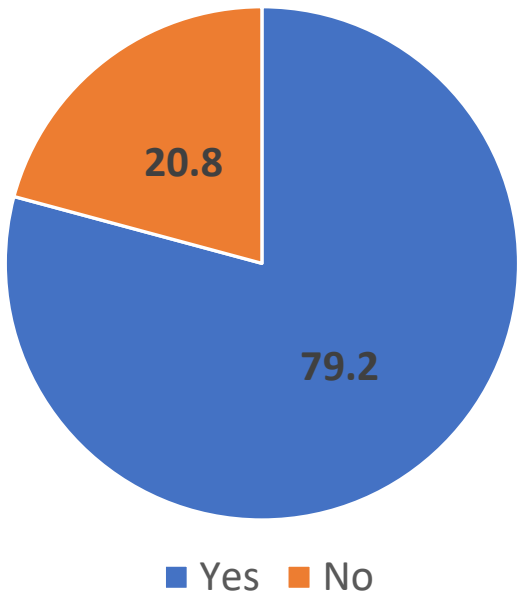
See how they feel it difficulty to scan unmarked codes

The difference of success between marked and unmarked 3D objects is 10-13%. Therefore, we found that **the presence of the mark** is as significant as the location indicator.

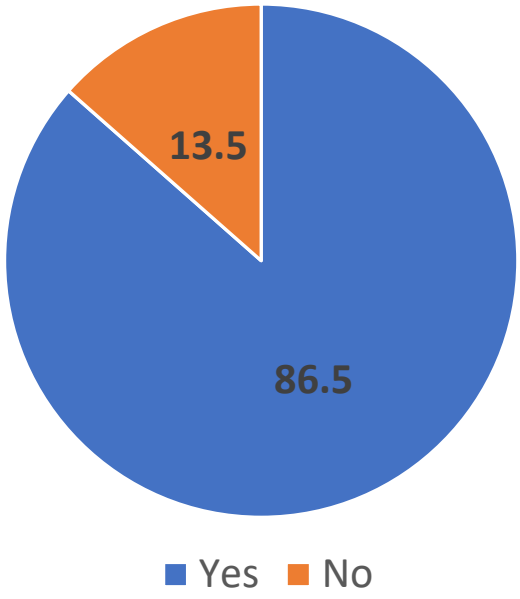
Comparing the results between the shape of marked products, the success rates differ by 26%; the irregularly-shaped candy bag had a 72% success rate, and the plastic bottle had one of 98%. This result showed that **the shape of product** has an influence on the success rate.

(5) Stress Survey on the QR Code Recognition

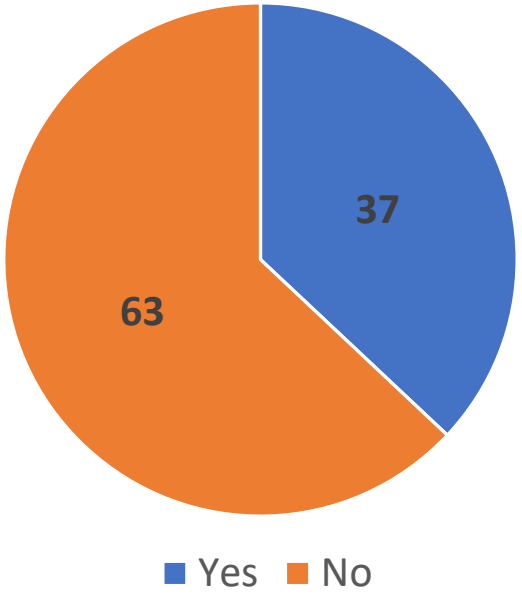
Do you feel stressed if you know that there is a QR code but you cannot read it? (96 participants)



Do you feel stressed if you do not know whether there is QR code or not and cannot read it? (89 participants)



Is it difficult to use QR codes? (100 participants)



Major Causes of Failure (from observation)

- One hand covered the object to be scanned
- The smartphone was moved too fast/too frequently (the lens could not auto-focus)
- Difficulty approximating the distance between the smartphone and QR code

Feedback from Participants

Feedback

- 一番重要なのは、読取る情報が本当に知りたい情報かどうか。もし、必要としている情報であれば、時間がかかっても読取りたいと思う。

- 最初はわからなかったが、途中から距離感が分かったので、そこからは使いやすくなった。

- 弱視だらかスーパーの食品に顔をつけて確認すると誤解を受ける時がある。このアプリがあれば便利だと思う。

≒

Translations and Implications

- “The most important issue is whether information to be scanned is information that VIP actually want to know. If it is necessary information, I think that people will be willing to spend more time to scan it.”

- “I didn’t understand how to do it at first, but eventually I got a feel for how much distance was necessary, and after that it was easier to use.”

→There is a slight adjustment period for users to find out the correct distance.

- I have low vision, so when I’m at the supermarket I bring the items very close to my face to check what they are, and this has led to misunderstandings a few times. I think this application is very practical.

→VIP sometimes feel embarrassed in public places, so this application can help them to feel comfortable and avoid misunderstandings.

Summary

2D Material (paper)

- We can conclude that the position is not a critical factor since all positions achieved a similar success rate of over 85% (except the upper left without explanation).
- The critical factor is the explanation and the experience.

3D Object (soap box, candy bag, plastic bottle, and can)

- The difference between marked and unmarked codes is around 10-13%. The presence of the mark is as significant as the location indicator.
- The shape of the product also has an influence on the success rate.

Feedback

- The most preferable products that users want QR to be on are "types of food and beverages," "expiration dates," "ingredients," and "medicine information."

Conclusion

- There is a strong probability that QR code reading can help VIP acquire information from printed materials such as 2D and 3D objects.

Report on the QR Code Reading Test for Visually Impaired People with a Smartphone #2

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

NPO Kobe Light House and Export Japan

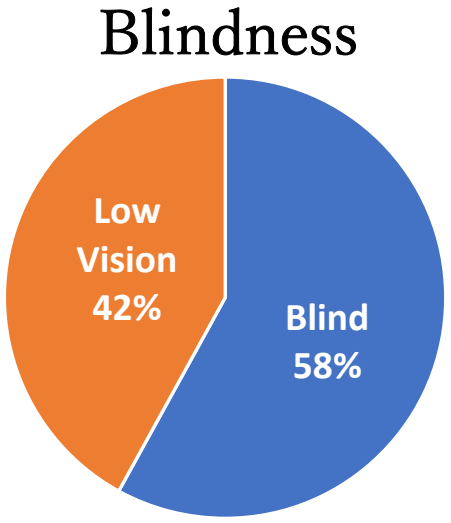
Purpose of the Second Experiment

- To analyze important factors that determine the success rate of QR code scanning such as marked/unmarked and size
- To analyze the prominent features for designing QR codes for VIP
- To discover what difficulties prevent VIP from successfully scanning QR codes
- To receive and analyze feedback from VIP regarding QR code scanning

Profile of Participants

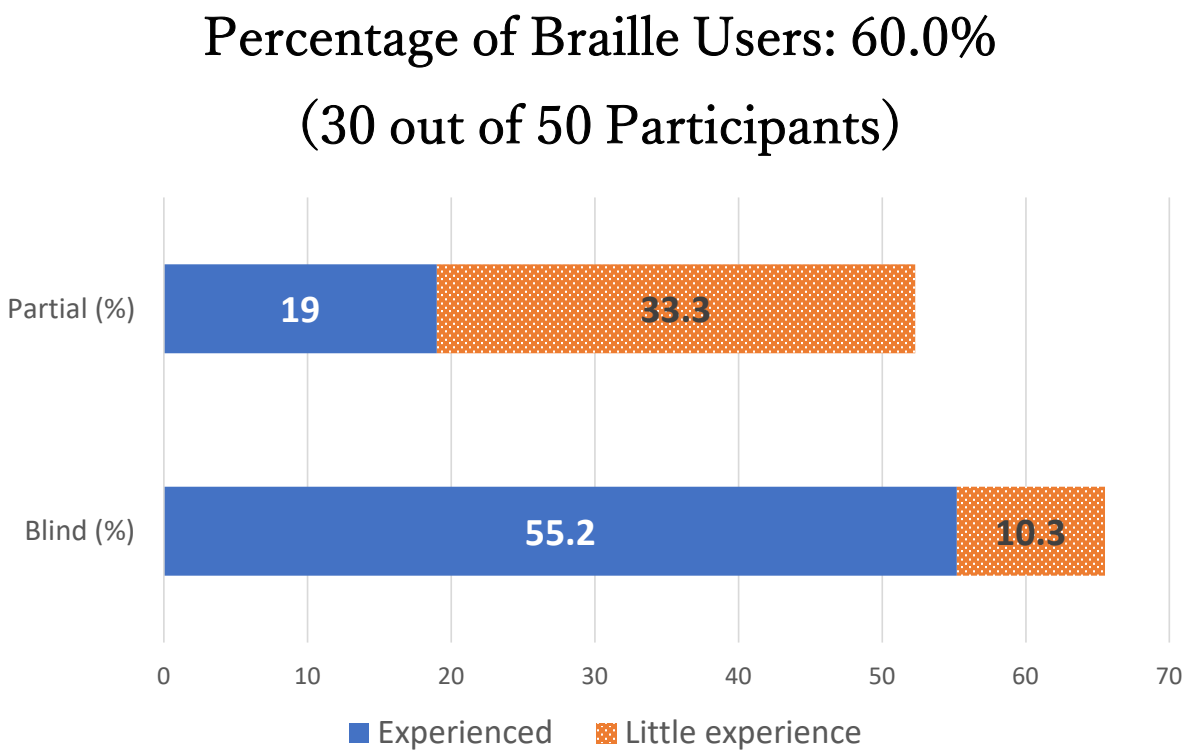
- Age
- Gender
- Blindness
- Braille User
- Smartphone Experience
- QR Code Experience

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



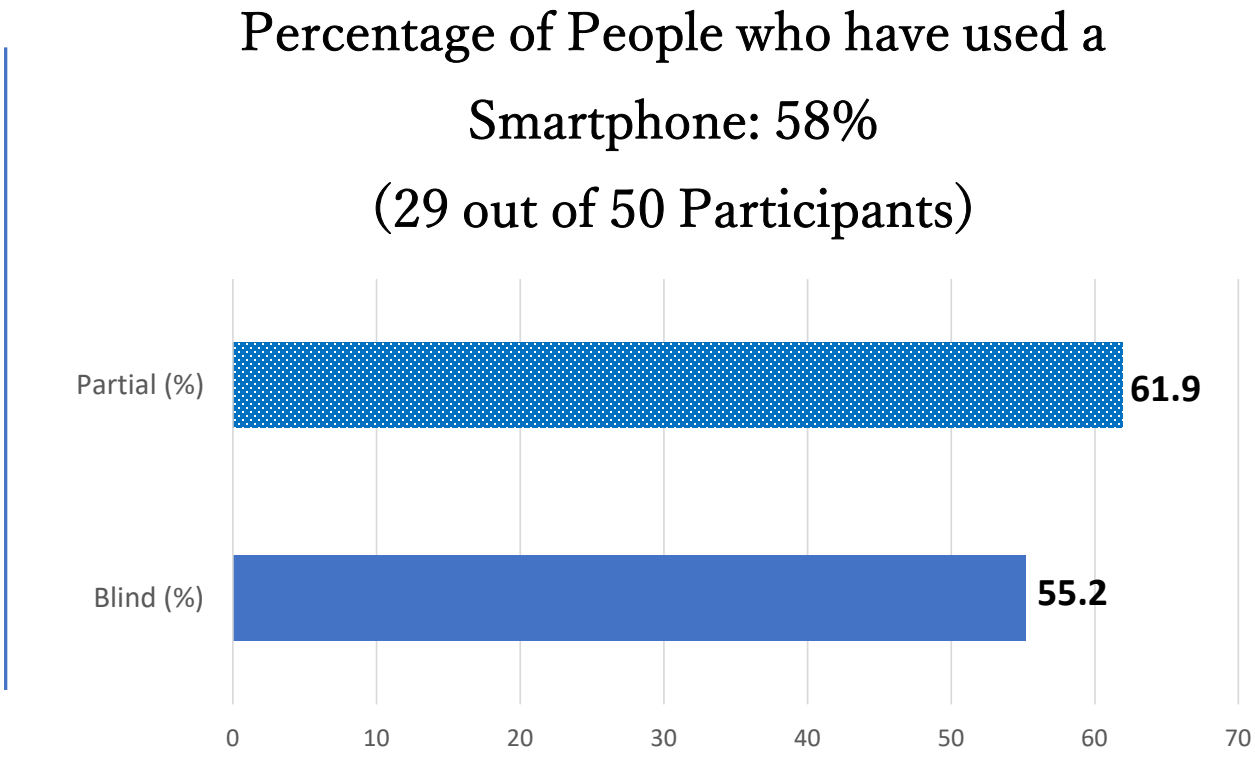
Percentage of Braille Users: 60%

- Blind: 65.5%
- Low vision: 52.3%



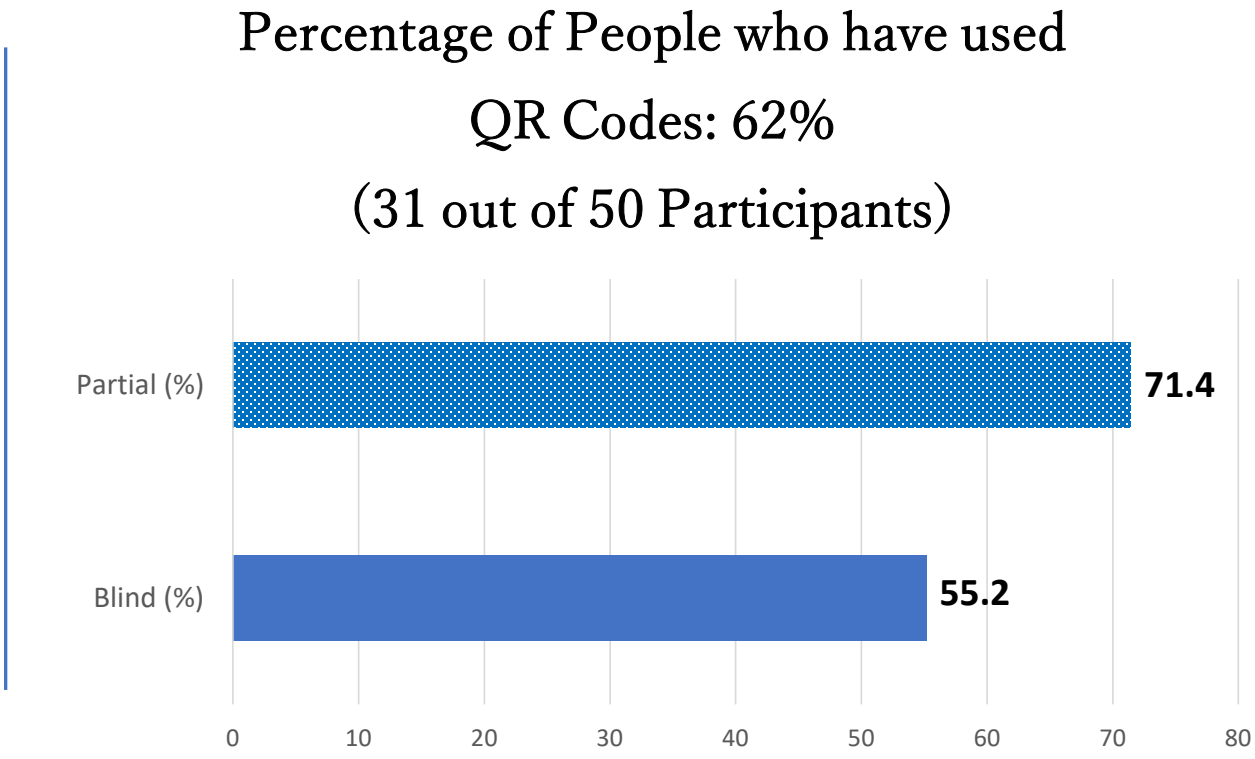
Percentage of participants who have used a smartphone: 58%

- Blind: 55.2%
- Partial: 61.9%



Percentage of participants who have used QR Codes: 62%

- Blind: 55.2%
- Partial: 71.4%



Outline of the Experiment Results

1. Marked and unmarked (corner cut) on 2D printed material
2. Size of QR code (0.6, 0.8, 1.0, 1.2 cm)
3. Type of mark (no mark, concave, convex, seal, dot) on a 3D object (rectangular box)
4. Type of mark (no mark, seal, dot) on a 3D object (cylindrical can)

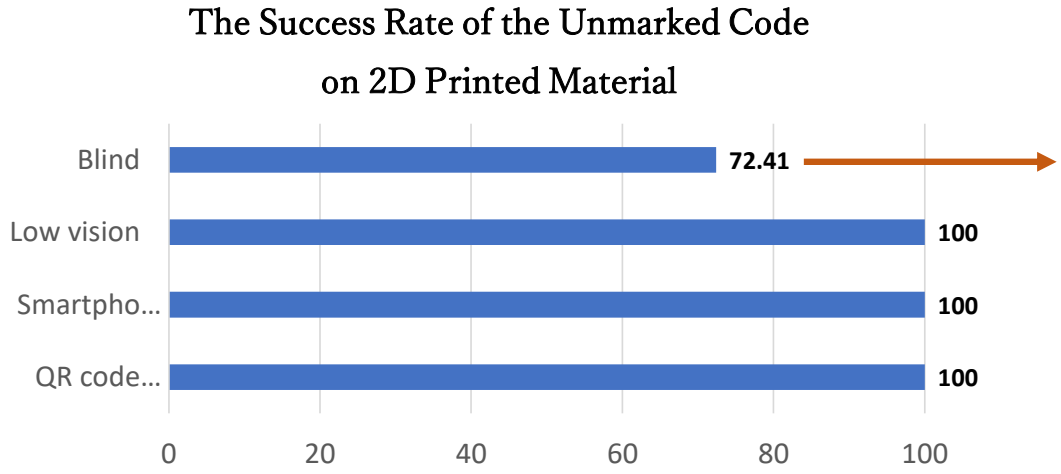
1. Marked and unmarked (corner cut) on 2D printed material

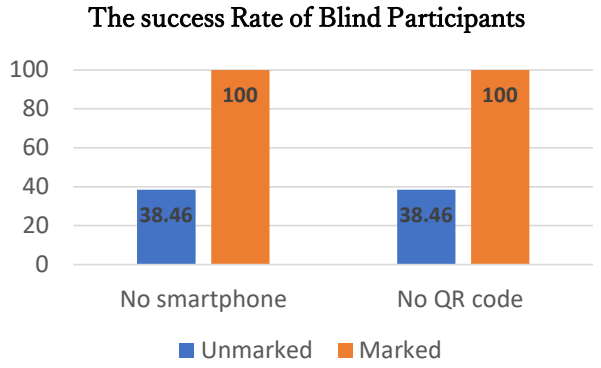
A comparison of printed materials that each have a QR code, but the bottom right corner of one is cut off.

- Success rate within 1 minute
  - Success rate for the normal printed material: 84% (42/50 participants)
  - Success rate for the printed material of which the bottom right corner is cut off: 100%

Normal QR Code (Unmarked)

Corner Cut QR Code (Marked)





2. Size of QR code (0.6, 0.8, 1.0, 1.2 cm)

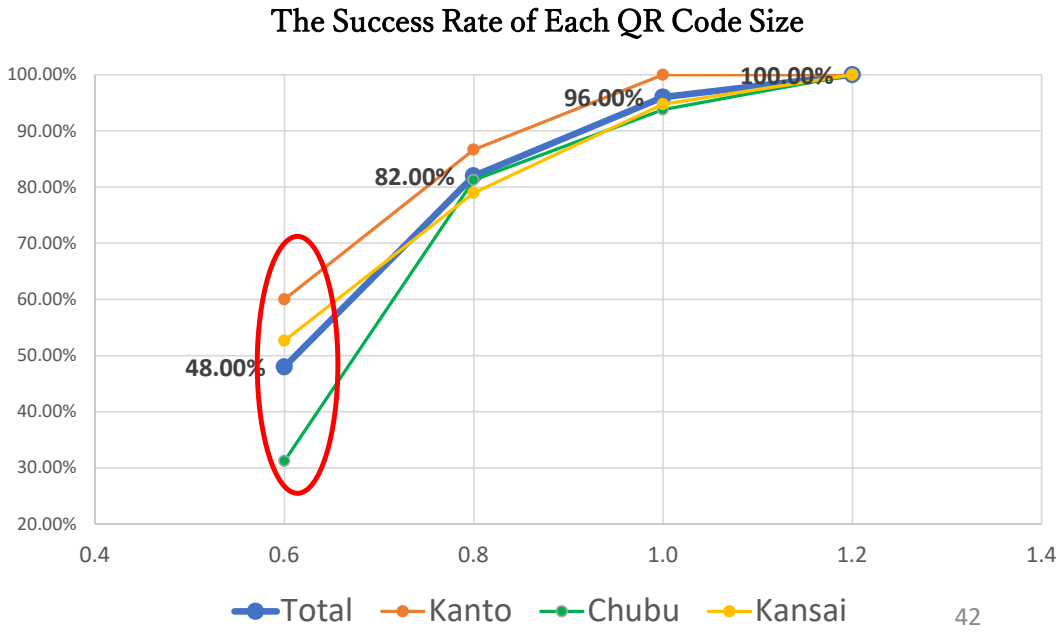
A comparison of the difference in size of a QR code on a printed material (paper.)

- 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)

Participants from Chubu had the least success with the 0.6 cm code. They remarked that they could not find the right position or distance between the camera and the code >> It may take time to get used to it.

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 ppl: Blind-Partial)



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

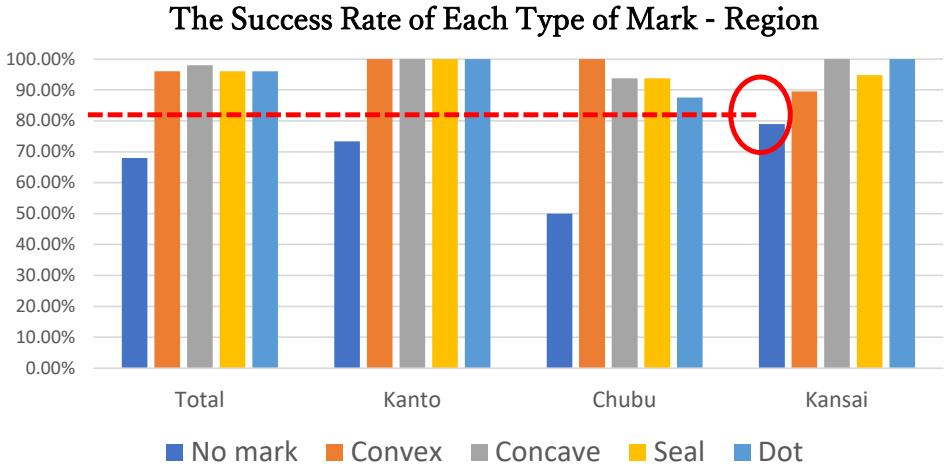
3. Type of mark (no mark, concave, convex, seal, dot) on a 3D object (rectangular box)

A comparison of the difference in the type of mark for a QR code on a 3D product.

- No mark 68% (34/50 participants)
- Convex (凸) 96% (48/50 participants)
- Concave (凹) 98% (49/50 participants)
- Seal 96% (48/50 participants)
- Dot 96% (48/50 participants)

Surprisingly, around 80% of participants from Kansai can successfully scan the code even if there is no mark

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	96.00%	100.00%	100.00%	89.47%
Concave	98.00%	100.00%	93.75%	100.00%
Seal	96.00%	100.00%	93.75%	94.74%
Dot	96.00%	100.00%	87.50%	100.00%

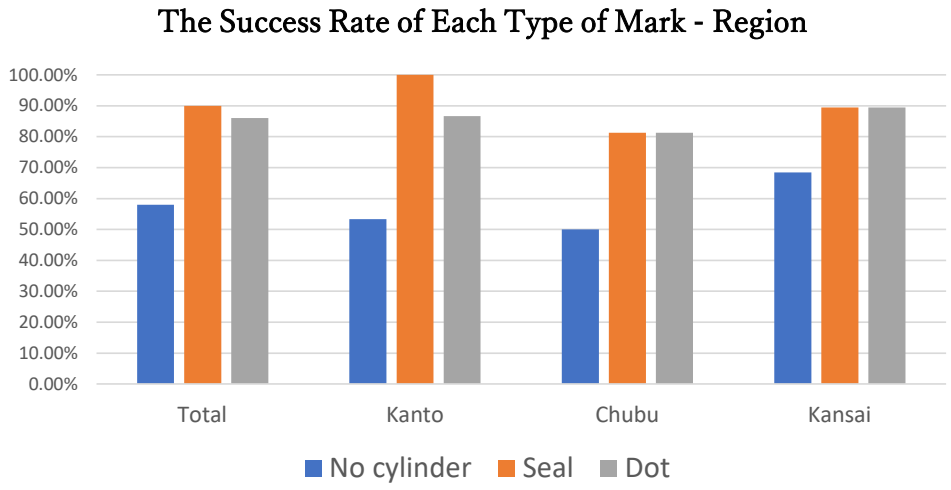


4. Type of mark (no mark, seal, dot) on a 3D object (cylindrical can)

A comparison of the difference in the type of mark for QR code on a cylinder product

- No mark 58% (29/50 participants)
- Seal 90% (45/50 participants)
- Dot 86% (43/50 participants)

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



- In experiment three, both seal and dot have similar success rates (96%)
- In experiment four, seal is at 90% and dot at 86%

Feedback from Participants

Feedback

- スマートフォンのカメラが水平になっているかどうかを確認しづらい。
- スマートフォンを持つ手を頻繁に動かしすぎてしまう（オートフォーカスができなくなる）

- 印があった方が見つけやすい。
- 目印があるとよくわかる。(複数)
- 紙の場合、QRコードの場所が固定されているとよい。商品に目印をつけてくれていたのは助かった。

- 実現したら良いと思う。点々で統一できれば良いと思う。シールは他にもある。

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Translations and Implications

- “It was difficult to know whether the camera was level or not.”
- “The hand holding the smartphone moved too much (meaning that the camera could not auto-focus).”

→ There is still difficulty in scanning due to camera instability.

- “It’s easier to find the code if it is marked.”
- “It’s much easier to find with a mark.”
- “It’s a good idea to standardize where the QR code is on paper. It is very helpful to mark the location of the QR code on food products.”

→ Having some sort of mark and standardizing its location is better.

- “I think this should be implemented. It would be good if it were standardized. There are also various types of marks.”

→The type of mark should be considered in order to make it easily recognizable.

Summary

2D Material (paper)

The corner cut plays a very important role in increasing the success rate, especially for the blind participants who had no experience with smartphones or QR codes.

- The difference between 1.2 cm and 0.6 cm is more than 50%. The size of QR codes is a critical factor.

3D Objects (carton box, and can)

- The results between marked and unmarked codes are significantly different – up to 30% – but the difference between each type of mark is very low at just 2%.
- The existence of a mark does matter, but the type of mark is not a critical factor.

Conclusion

- There are several important factors which need to be considered in order to develop the most efficient and easy-to-understand solution.