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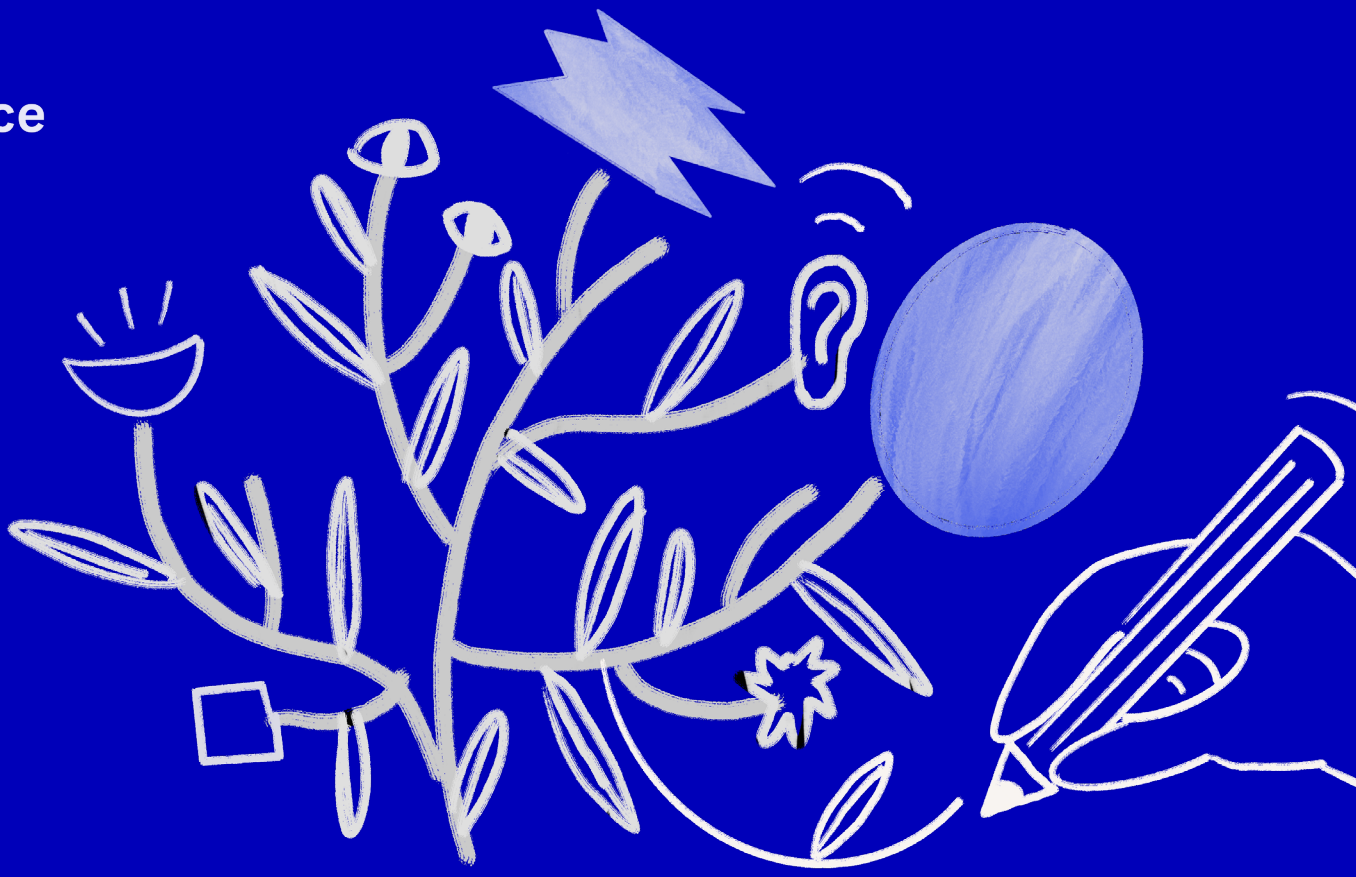

A guide to

Accessible design for connected products and services

Content

A guide to accessible design for connected products and services, 2021

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01 Why it matters

When designing with accessibility in mind, we maximize the chances of everyone being able to properly use a product - regardless of ability, context, or situation. This includes users with permanent or temporary visual, motor, auditory, speech, or cognitive disabilities.

Accessibility affects all of us. A broken arm, a loud environment and many more factors might influence how we interact with a product. A typical example is using high enough color contrast so that content is readable for everybody.

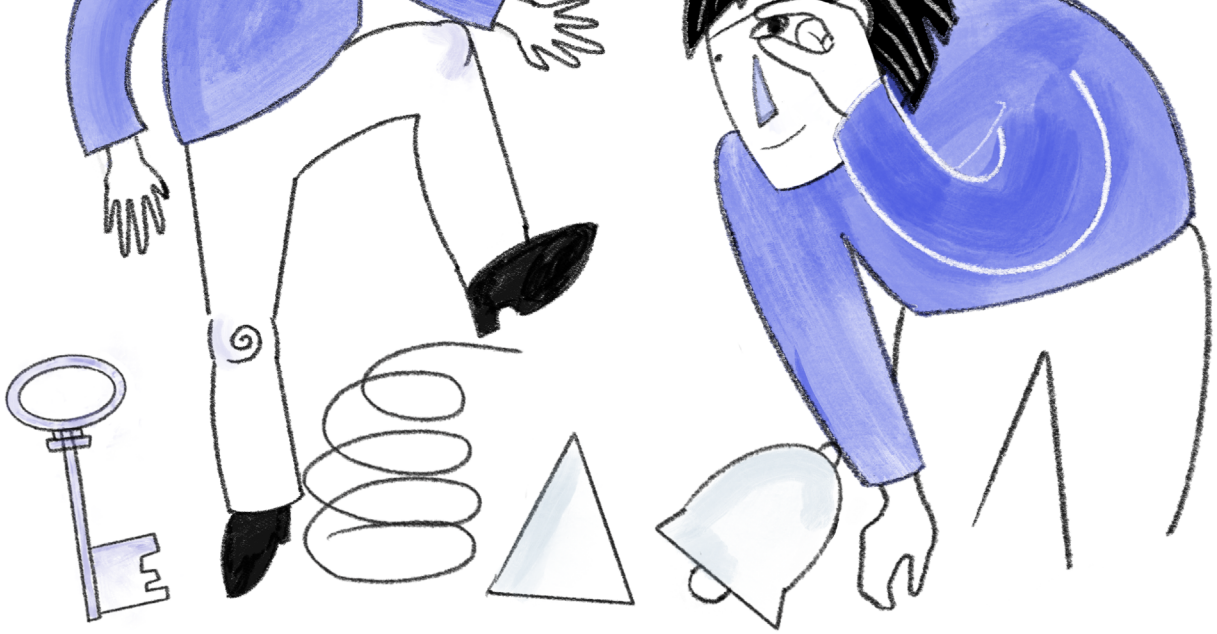
This guide explores the challenges of designing accessible experiences in a connected world. It introduces essential design principles to keep in mind and explains how designers can avoid common accessibility issues by looking at good and bad examples.

The challenge

Accessibility is often discussed in the context of single or specific technologies like websites and apps.

But today UX and Service designers work on connected products with multiple digital and physical touch points regularly.
Also, products are no longer independent of each other. They exist in the context of bigger ecosystems or service networks. This increases complexity for the end-user.

We can find more and more digital services in all areas of our lives today. We use connected household appliances in our private homes, voice interfaces to interact with our cars while driving, or place our order at a self-serving kiosk in a restaurant instead of speaking to human staff. Designers need to consider the accessibility of individual components within a service and the interaction between these components.



The opportunity

Accessibility is a driver for human-centered innovation.

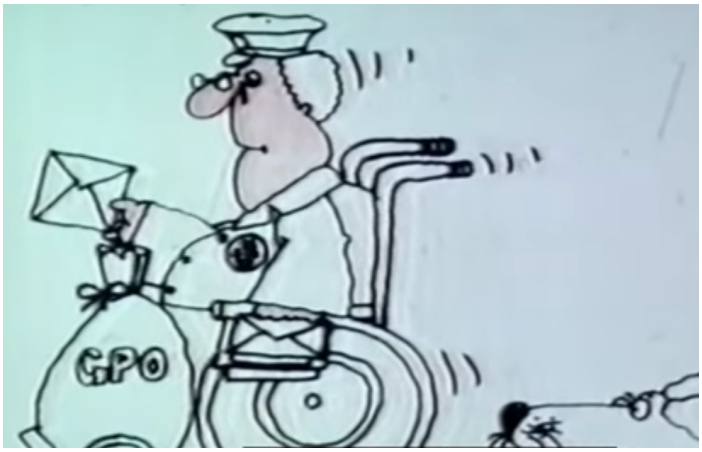
Designing with accessibility in mind forces us to engage with and better understand our users. Accessibility practices make us think in new ways. Therefore it is no surprise that historically accessibility has often benefited all users – including those without disabilities.
Doors, that open automatically for wheelchair users are also beneficial for people who have their hands full when entering a building.
Closed captions on videos are essential for users who are deaf. Nevertheless the feature is also useful and popular amongst all kinds of users, such as older people or those consuming the content in a loud environment.

Besides avoiding legal issues and related costs, accessible design increases the customer base of a product. Disability statistics can be biased and depend on the definition and cultural understanding of disability. Nevertheless we can learn from the numbers that an estimated 10-20 % of people live with one or more disabilities. The estimation ranges from 60-70% among older populations as many people acquire disabilities with age. As today's technology-savvy customers get older, they will want to keep using digital products. Therefore the customer base will increase even further.
Large tech companies like Google, Microsoft, Alibaba or Apple are aware of this need. They are known for investing significant resources to improve the accessibility of their products. Apple is often regarded as an industry leader in this field. The company has been a pioneer for accessibility features and is continuously improving the accessibility of their products.

Social impact

Business impact and driving innovation are positive side effects to keep in mind. But in the end, designing for accessibility is indispensable because ignoring this topic can lead to an unethical or even illegal exclusion of users. Inaccessible digital products block people from benefiting from technology and participating in certain parts of our society.

There are many different theoretical models of how we, as a society, think about disability and what we associate with the term.
Especially valuable for designers to understand is the social model of disability. It points out how disability is a condition caused to a large extent by poor, non-inclusive design:

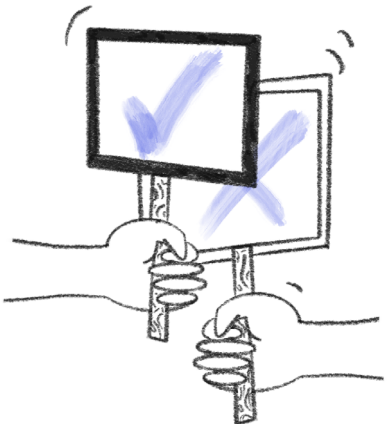


Animated video about the social model of disability

Making our physical world more accessible

In our physical environment, it is an almost impossible task to make every object or service accessible to everybody.
For instance, most traditional thermostats have been inaccessible for users who are blind. Digitalizing such products has the potential to make them usable for a wider audience. We can simply connect a smart thermostat to an app that can be used with a screen reader.
As a result, the thermostat is usable for people who are blind.

Accessible design has the power to create entirely new possibilities for many users, so let's make the most of it.



Guidelines to consider

At the moment, there are no specific guidelines or list of rules for IoT or connected products, as these terms includes a range of different technologies and applications.

Being aware of related, existing guidelines and legislation like WCAG 2.1 or EN 301549 can be a great start, though.
Legislation demonstrates political and societal awareness. It underlines that accessibility is an important topic. But accessibility is not about checking off a list of legal requirements.

Compliance with a set of rules does not automatically equal a good user experience for people with disabilities.

Testing with a diverse group of users and embedding the topic into the entire product development process is equally important. Only then we can avoid creating barriers and make emerging technology truly beneficial and equally valuable for all of us.

WCAG 2.1

Web Content Accessibility Guidelines: these guidelines help to make digital content more accessible. For most countries, legislation regarding accessibility is based on WCAG.

EN 301549

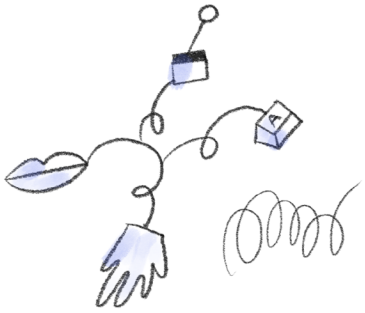
Accessibility regulation for ICT products and services in the EU: those are most relevant for the public sector and go beyond software applications. They consider all kinds of mainstream technology from tablets or e-book readers to ATMs.

Device specific guidelines

There are existing guidelines for products in the physical world (like telephones or washing machines) that remain relevant if such devices are digitally enhanced.

European accessibility act

(Legislation will fully apply by 2025).
The goal of this new regulation is to remove barriers that are being created by divergent rules around accessibility in different countries. Many affected companies will be held to higher standards; for example, those providing banking or transportation services.



How to make good design decisions when there are no guidelines?

Not every component of an IoT service needs to be fully accessible as long as the overall system is accessible and can provide the same quality of experience to all users.

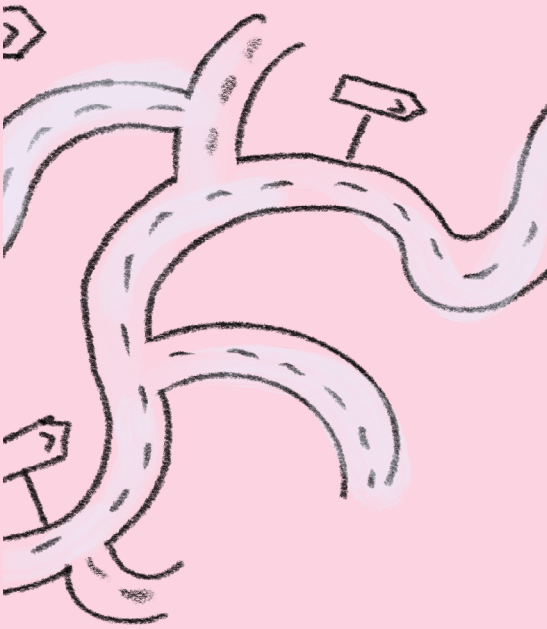
Think back to the previous example of the smart thermostat that is connected to an accessible app. The device itself is still mostly inaccessible for people with low vision. A designer might wonder: Does the app alone provide an equally valuable experience? Perhaps user research reveals that there is a strong need to have some essential functionality accessible on the actual device in case there is no internet connection.
So maybe a quality experience in this case requires haptic buttons or vibration feedback on the device.

Often there is more than one way to provide access.
For this reason, designers and other stakeholders need to evaluate the quality of experience, feasibility and desirability of different accessibility solutions in their project.
In this context, it becomes more important for designers to understand the basic principles of accessibility, develop skills to identify accessibility problems and match them with a solution. It will be increasingly hard to rely on simple checklists once products get more complex.

Designers can use the POUR principles for guidance.

POUR principle

POUR is an acronym for four principles: Accessible technology according to the **Bureau of Internet Accessibility** is



Perceivable

"Information and user interface components must be presented to users in ways they can perceive. This means that users must be able to comprehend the information being depicted: It can't be invisible to all their senses."

Operable

"User interface components and navigation must be operable: The interface cannot require interaction that a user cannot perform."

Understandable

"Information and the operation of a user interface must be understandable: Users must be able to understand the information as well as the operation of the user interface."

Robust

"Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies: As technologies and user agents evolve, the content should remain accessible."

Designers can apply these high-level principles to any kind of product or service no matter the underlying technology. The principles can give guidance in the design process when trying to make decisions, that a set of guidelines or rules can not fully answer.

Perceivability

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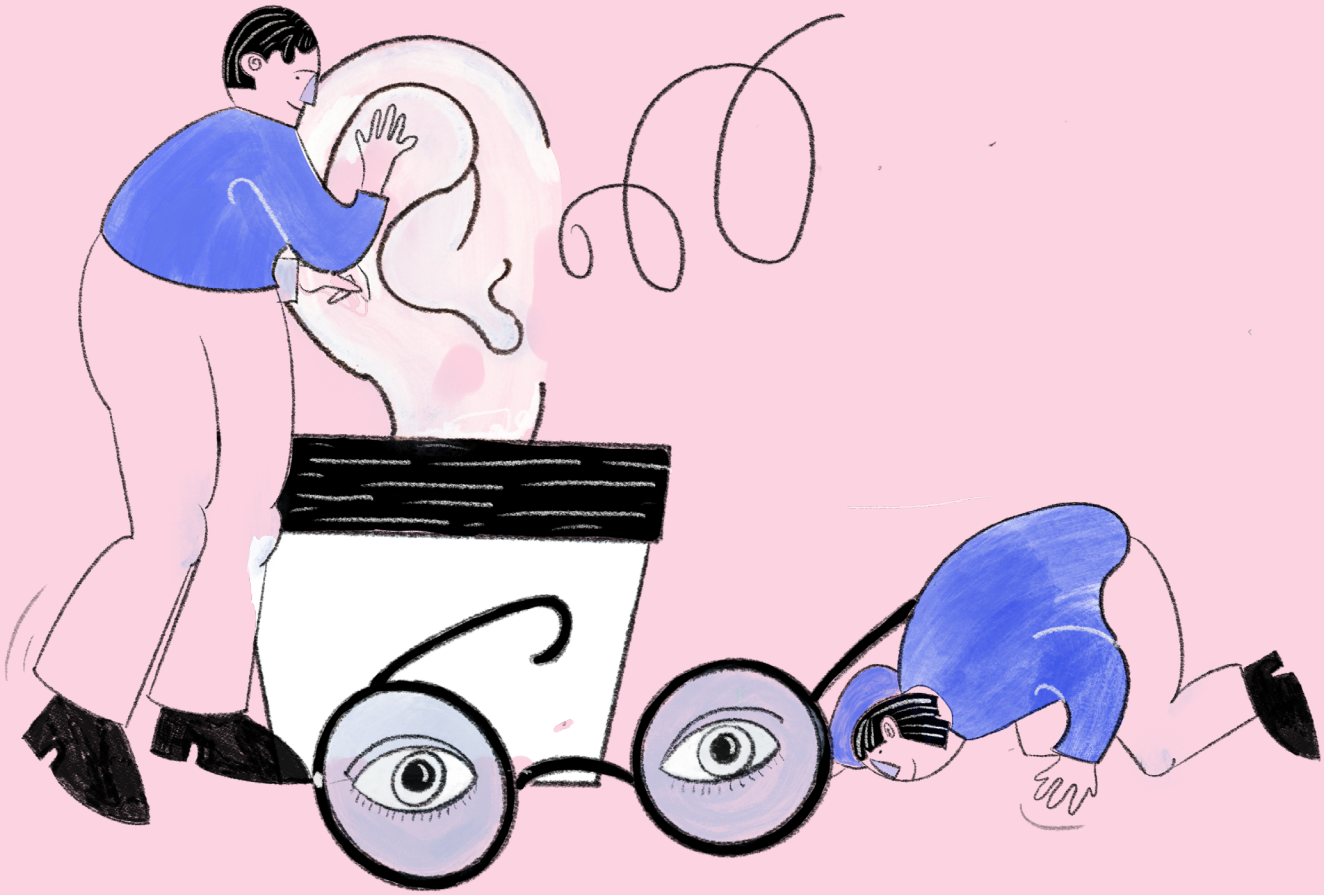


“Information and user interface components must be presented to users in ways they can perceive. This means that users must be able to comprehend the information being depicted: It can’t be invisible to all their senses.”

Bureau of Internet Accessibility

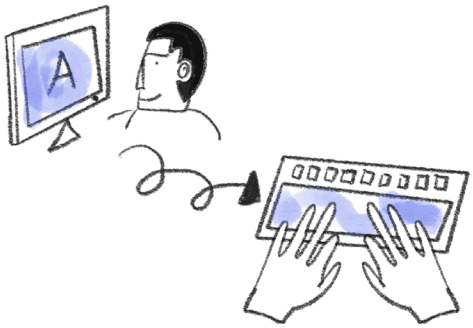
The challenge

Making experiences in the IoT perceivable can be tricky due to the diversity of interfaces. Within one service, users might interact with:

- Visual interfaces like touchscreens
- Audio interfaces like smart speakers
- Wearables that communicate with vibration or haptic feedback

These technologies must be considered with users' varying abilities in mind like limited vision, hearing or motor disabilities.

A general rule to remember is that designers should not rely on one sense alone when displaying information.
Instead, there should always be an alternative form of representation. By sticking to this so-called "Two-sense rule", designers can avoid a range of issues.



Alternative presentation of text

Text can usually be converted into other representation types without human intervention. Text can be read aloud by a screen reader (like Apple's VoiceOver) for low vision users. It can also be transferred into haptic output on a refreshable braille keyboard for users who are Deafblind.
But many custom IoT devices do not offer the option to attach assistive technology or use accessibility features in the way we are used to from established technologies like websites or smartphone apps.

Therefore designers might need to ideate, evaluate and test to figure out the best method to provide an alternative presentation of text.

Fictional example

Max is blind and wears an activity tracker during their workout.
Checking the display for visual information is not an option for them. They check the app that is connected to the wearable.
To monitor their heart rate, Max has the information read out loud by their screen reader.

Another option can be making sure the device connects well with third party devices like smart speakers. Then Max can use a voice command to ask their Google Home for the measurement.

Alternative presentation of non-text information

Non-text information is sometimes harder to convert into an alternative format, depending on the complexity of the content.

Product example

A simple case is Amazon Alexa. Previously the device used a light ring to communicate when it was collecting audio data.
Blue light meant the device is listening. Red meant the microphones on the device are turned off. No light meant the device is waiting for a request.
People with visual disabilities were excluded from knowing when the device is collecting their data.

Now Amazon devices offer a setting that allows users to turn on auditory clues as an alternative. Different sounds indicate the changes in state.

Fictional example

Sara, who is deaf, has installed a connected doorbell. She will not be able to hear it ring.

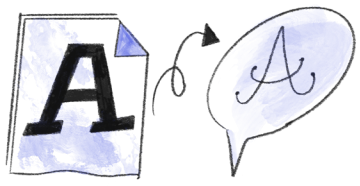
As an alternative, she can receive a visual notification with a vibration signal to her smartwatch or another preferred device.

More complicated information to transfer into another mode of presentation is, for example:

- The video of a surveillance camera
- Generated images that contain essential information
- Real-time voice output

From case to case, this kind of information can require a custom solution to offer an equally valuable experience for all users. Luckily, advances in technology give us more and more new options to create such alternatives.
Voice and image recognition can turn complex visual or audio material into a text format. Just think of automatic captioning features in video-calls. Most of these technologies are far from perfect yet, but hopefully they will mature, become more accurate and can help us to create better experiences.

Designers and developers have to work hand in hand to identify a feasible way of making information available at relevant touchpoints. It is a good idea to explore early on in a project where accessibility problems could arise for which group of users.
For example, if a product relies heavily on audio information, it can be essential to work with users who are Hard of Hearing in the research stage to figure out how to avoid barriers and develop solutions for their experience.



Viewing distance

When using a smartphone, people can adjust the settings of their phone to increase the size of elements on the screen. Looking at a website in the browser, a user might adjust the window size with their keyboard for zooming.
Like many traditional physical devices IoT devices with a custom UI can be perceived from various angles and distances but lack these mechanisms in many cases.

Product example

Google implemented an ultrasound sensing feature for the Nest Displays. The display shows only the most important information in large size when far away and more details in a smaller size if the device detects the user nearby.

As a result, those with low vision can get the most out of the device no matter where they are in the room. There is also the option to use a 3-finger tap gesture to magnify the screen.

Fictional example

A smart scale displays information with insufficient font size. Depending on the user's height and level of vision, they might face problems reading the measurement. They could also miss other valuable feedback like when the measurement has been completed, and data has been synced with the mobile app or different touch-points.

Therefore using sufficient font size considering the users viewing distance is crucial to make sure most users with low vision can read the content.

Another option is implementing mechanisms to increase the font size - like on this website from Deutsch Bahn (German railway). Buttons for different font sizes provide a high level of control to the user.

Here you can see the relationship between maximum design viewing distance and minimum character height at the limit of subtended angle:

Minimum subtended angle	Maximum design viewing distance	Minimum character height
0,7 degrees	100 mm	1,2 mm
	200 mm	2,4 mm
	250 mm	3,1 mm
	300 mm	3,7 mm
	400 mm	4,3 mm
	450 mm	4,9 mm
	450 mm	5,5 mm
	500 mm	6,1 mm
	550 mm	6,7 mm
	600 mm	7,3 mm

Color contrast in various environments

A lack of color contrast is one of the most detected accessibility issues within websites and apps and a massive problem for users with limited vision.

Connected products might be installed or used in various environments that could be dirty, sunny, rainy, windy or dark and therefore it is crucial to be mindful about contrast.

Even a person with perfect vision may have trouble interacting with a screen when the sun is shining directly onto it. Or perhaps the device is full of scratches because it is placed at a busy train station and has been used for years.

Color contrast checkers are helpful to choose a suitable contrast for UI elements. Stark is one example for such a tool. But also testing a product in real environments can identify problems.

03

Operability

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“User interface components and navigation must be operable: The interface cannot require interaction that a user cannot perform.”

Bureau of Internet Accessibility

The challenge

Especially in the public space, more and more human touch points like cashiers or receptionists are being replaced with technology to save time, money and reduce friction for customers.
Instead of standing in a long line at the cinema, people can purchase a ticket and pick a seat online while still on their way.
Or they can use a self-serving machine at the cinema. We can see similar developments at train stations, supermarkets, airports and more.
If these new touchpoints are not designed with accessibility in mind, they create barriers for people instead of making life more comfortable.

User reach in the physical world

For products that are installed in our physical environment interactive elements need to be within reach of the user.
Designers often fail to consider people who use wheelchairs and the diverse body sizes of their users.
Children, small people and users in wheelchairs might not be able to reach a device that is placed in a at the eye level for an average adult person.
Wheelchair users also need space to navigate and place their wheelchair.

Alternative input mechanism

User input should not require actions the user can not perform. A majority of issues can be avoided by not relying on one form of input alone but always providing an alternative.
For instance, there are many reasons why a person might be unable to use their hands for interaction (e.g. shaking to complete loss of movement).
As an alternative, people can use a variety of different assistive technologies like mouth sticks, head sticks or eye-tracking to give input.
Speech-enabled components are also a popular solution.

Fictional example

Tom, who has a motor disability owns connected light bulbs.
He has difficulties with the remote control and the physical buttons on the wall that require him to lift his arms.
He prefers to control the lights with his voice by talking to a smart speaker. When he does not feel like talking, he uses his smartphone and can adjust the lights with simple gestures like tapping, which he can perform without discomfort.

Product example

To track activity levels, the Apple Watch allows selecting wheelchair pushes as input instead of collecting data about steps.

Biometrics

Technologies like facial or voice recognition are on the rise. They can make user input more convenient, which is amazing news. Nevertheless, designers should not assume that these new input mechanisms are automatically solving accessibility issues. Still, a product should not rely on one of these mechanisms alone. Products should not use one particular biological characteristic like a fingerprint or facial features as the only way of identification or control.

Fictional example

Due to Covid-19 we are all temporarily disabled when wearing a face mask. Anna wants to unlock their phone at the supermarket. Facial recognition on their phone is not working since half of her face is covered. She can also input a pin to unlock her phone.

Real life example

The disability rights advocate Victor Pineda describes:

"If a kiosk is the only way I can buy a train ticket or pay for a service or get information, I'm excluded from that."

For users like him, who sit in a wheelchair and have limited use of hands and arms, touchscreen displays without voice control or a human staff to support are a barrier.

Touchscreens

Touchscreens are truly everywhere today, so they are worth mentioning specifically. They are now a part of our microwaves, ovens, cars, train stations and coffee machines. But touchscreens are causing problems for many people with disabilities.

Real life example

Harrison Tu, an accessibility engineer, explains in one of his blog post:

"A few months ago, I went to a Texas convenience store: the convenience store to end all convenience stores. There was amazing food all over and I, as a blind person, could order exactly nothing. The reason? To place an order, you must use an inaccessible touchscreen kiosk. To cut costs, there is no staff to help, so if you have a disability, you are completely out of luck."

First of all, the designer should reflect if a touchscreen is truly the right choice for an interface in the first place. Haptic buttons, for example, are much more accessible to a larger group of people. But also touchscreens can become more accessible with vibration feedback, audio output, voice control or the possibility to connect assistive technology.

Tricky gestures, and interactions

As we digitalise our physical surroundings, gesture control and tangible interactions are becoming more popular. For instance, BMW introduced gestures to control some features of the in-car system.
These interactions can create problems for people with motor disabilities, limited manipulation or strength. When tricky gestures are needed to perform an action it is important to provide an accessible alternative. BMW offers voice control and allows users to customize gestures.

Common difficult gestures are:

- Those that require a fine motor path
- Grasping
- Twitching of the wrist.
- Actions that require both hands simultaneously like pressing two buttons at the same time
- Actions that require a lot of physical effort or strength from the user

Product example

An easy example from web accessibility is zooming in the browser (e.g. Chrome or Safari).
Users who have trouble using the two-finger pinching gesture on a track pad for zooming can use their keyboard or enter the menu in the browser to perform the same action.

04

Understandability

“Information and the operation of a user interface must be understandable: Users must be able to understand the information as well as the operation of the user interface.”

Bureau of Internet Accessibility

The challenge

Connected products usually consist of several components that are scattered across different locations.
An action that is being performed at one touch point might influence several other touchpoints. The same piece of data or content might be displayed in multiple places and formats. As a result, products can be more complicated, unpredictable and harder to understand for users. Sometimes systems will act autonomously without users having to perform an action. That is especially challenging for people with limited cognition, problem-solving skills, language and learning abilities or those with little tech literacy.

Cognitive disabilities are the most common form of disability. But often we are not aware of this fact and tend to forget those users, because cognitive disabilities are largely "invisible" compared to more noticeable, physical conditions.

Meaningful feedback

All users benefit from clear, meaningful notifications. Like any other content, feedback messages should be perceivable in multiple ways and should be brought to the user's attention. Success, confirmation and error messages or information about state changes guide the user and prevent confusion. Especially in the complexity of an IoT environment, proactive communication with the user is vital.
Error messages should make users aware of problems or malfunctions. Ideally, they indicate where in the system the issue is coming from and how to resolve it.
For users, it can be very complicated to solve problems in a larger system without technical knowledge or guidance.

Fictional example

Kai is trying to unlock their car with their smartphone without success.
They are confused and wonder: Is the problem their phone, their car, the internet connection or the car companies' server? And more importantly - how to solve the problem?
To move on, they should receive an error message specifying the source of the problem and a step by step guidance on how to resolve the issue.

Contextual feedback can also make services in the real world (such as public transport) more accessible to people with cognitive disabilities.

Real life example

John Blascovich, who is the president of a nonprofit that seeks to improve the lives of people with Down syndrome, points out in an article:

"Cities could also use technology to make commuting safer and more predictable for people who have cognitive disabilities. Typically, these folks have memorized what bus to get on and how many stops to go, and if the route changes or the bus isn't operating, they run into problems."

When it comes to public transportation users can be actively informed about delays and detours in real-time and they should be advised how to handle the route changes. For example, by sending notifications to smartphones or wearables.
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Consistency across different touchpoints

In a connected world, the same piece of information or action can be presented to the user at various touchpoints.
To create an understandable and predictable experience, consistency is key. Otherwise, users will be left confused and disoriented. Those with cognitive disabilities might even be unable to use the product at all.

Navigational elements should be identified consistently across a product. Wording and iconography should be the same across different interfaces. If data is being synced across multiple touchpoints, it needs to be clear to the user, where the information is distributed and when it was last updated.

This becomes especially challenging once a service is connected to third parties in a bigger ecosystem.

Fictional example

Let's get back Kai, who owns a connected car. They can save their favorite addresses in their in-car system. Those are automatically synced with the respective companion app.

The interface in the vehicle is using a slightly different visual language because it is harder to update than the app interface.
As a result, the car's favorite addresses are marked with a star icon. But in the app, a heart icon is used. Kai might not understand that this is the same feature and the data is being synced across both touchpoints.

Simple language

When setting up an IoT system, adding a new device to it or restoring an error, we ask our users to understand complicated, technical systems. Simple language is essential to explain these systems.
As designers, we sometimes tend to leave text to a copywriter. Or we work with placeholders until late in the process. But good UX writing can make or break the accessibility of a product. There are some simple things to remember:

- Use active instead of passive voice
- Avoid long, complex sentences.
- Put the relevant information at the front of a sentence
- Provide definitions for technical terms or abbreviations (e.g. terms like "Internet Bridge", "Firmware Update"), considering less tech-savvy users
- Be mindful about the usage of metaphors. In many cases, this can be a great way to communicate complicated information to users. Designers should keep in mind though that users with limited comprehension might be unable to understand metaphors or very abstract language.
- Images or video in addition to text can help to make content more understandable for some users.

Product example

The banking company Monso has set the goal for themselves to remove barriers from digital banking. Therefore they use simple and clear language wherever possible like in their onboarding.
They keep the paragraphs and sentences short and avoid complex terms.

With voice interactions on the rise, there is a new layer to the topic of simple language. Written and spoken language are not the same. Especially building an interactive conversation requires careful consideration.

Product example

"Pepper" is a humanoid robot that can interact with people via speech. A potential use case for the robot is to greet customers and provide guidance at a shopping mall.

Pepper is carrying a tablet to display additional information when talking to people.
The guidelines for voice interactions with Pepper recommend:

- Use short sentences and get straight to the point to not lose the user's attention. When giving the user different choices to pick from, display them visually also in case the user can not keep them in their mind
- Use pauses. When speaking for too long without a break, people can not retain the information
- Training the system to use correct pronunciation and rhythm of words and sentences is important to make the information as easy to process as possible

Robustness

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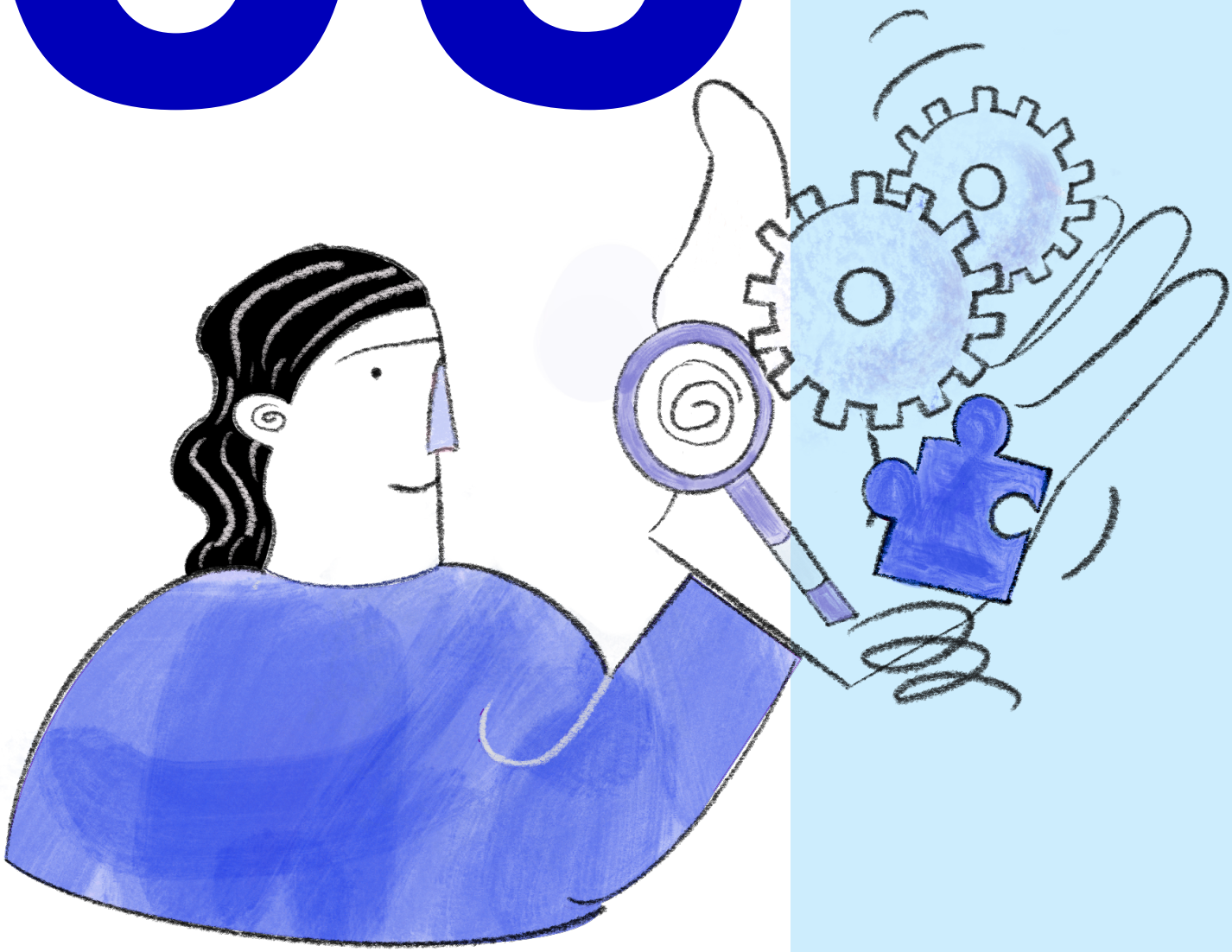


“Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies: As technologies and user agents evolve, the content should remain accessible.”

Bureau of Internet Accessibility

The challenge

Accessibility APIs (Application Programming Interfaces) have evolved with traditional desktop computer systems over many years. That means assistive technologies can easily talk to these applications and access information. APIs allow This information can then be transferred into another way of presentation. For example, turning written text into audio output.
A screen reader can access an article on a website and read it out loud to a user, who is blind.
A braille display can detect that a pop-up has shown up on the screen and alert the user.

In addition, most operating systems come with powerful, already built-in accessibility features. Such an accessibility feature is, for example the option to customize haptic feedback in iOS.
The world of IoT is full of less mature devices without these features or APIs.

Accessibility features and assistive technology

Currently, a lack of interoperability makes it hard for assistive technologies to tap into IoT systems. Many products are not compatible with assistive technologies and might even interfere with them. That is true for hardware components like special joysticks or keyboards as well as software components like screen readers.

Designers need to be aware of these limitations and think of other ways to interact with the product across the user journey. Also, information about compatibility with assistive technology should be available for users. Right now this information is not typically a part of onboarding flows or documentation material, which users can access before a purchase.
There is a ton of assistive technology out there.

Every user is unique and different people prefer different tools and solutions when it comes to assistive tech.

For screen-based products the four most important input methods to consider are: mouse, touch, keyboard and voice

Designers can include the topic in the user research phase to understand what devices their target group uses and take these insights into the design stage to optimize the experience for those.

Fictional example

It is becoming increasingly popular for users, who are blind or have motor disabilities to use voice assistants like Alexa or Google Home to control all kinds of devices.

Tim is designing an IoT Service. He wants to optimise the service for being used on popular voice assistants to make it accessible for people with disabilities in the target group.

During the research stage the team learns, that there is a large group of people in the userbase who do not own smart speakers. Tom suggest to focus on building a great built-in screen reading functionality and on making the product compatible with other standard assistive technology like braille keyboards.

The first-time use & set-up experience

Setting up connected devices can be a challenging task, especially for non-technical users.
People with disabilities might also require additional installation processes to set up accessibility profiles before the first usage of a new product. That can include screen resolution adjustments, personalizing settings for captioning, setting up screen readers or connecting other assistive technologies.

Often the set-up and first-time use of a product can turn out to be a barrier if it is not compatible with assistive technology. In these cases, users are forced to rely on assistance from other people to make the product usable for them in the first place.

Fictional example

Many fitness wearables are accessible for people with limited vision once the user has paired them to an app with a screen reader or magnifier.

Nina wants to set up her fitness bracelet. But the pairing step requires her to read a code on the wearable and input it into the app. Due to her limited vision she is stuck in this step. She needs to ask a sighted person for help.

Product example

The Google Home set-up experience considers users who are blind or have low vision.
The whole set-up process can be performed with a screen reader. Google also provides tutorials on how to do this, so users do not depend on help to start using their new product.

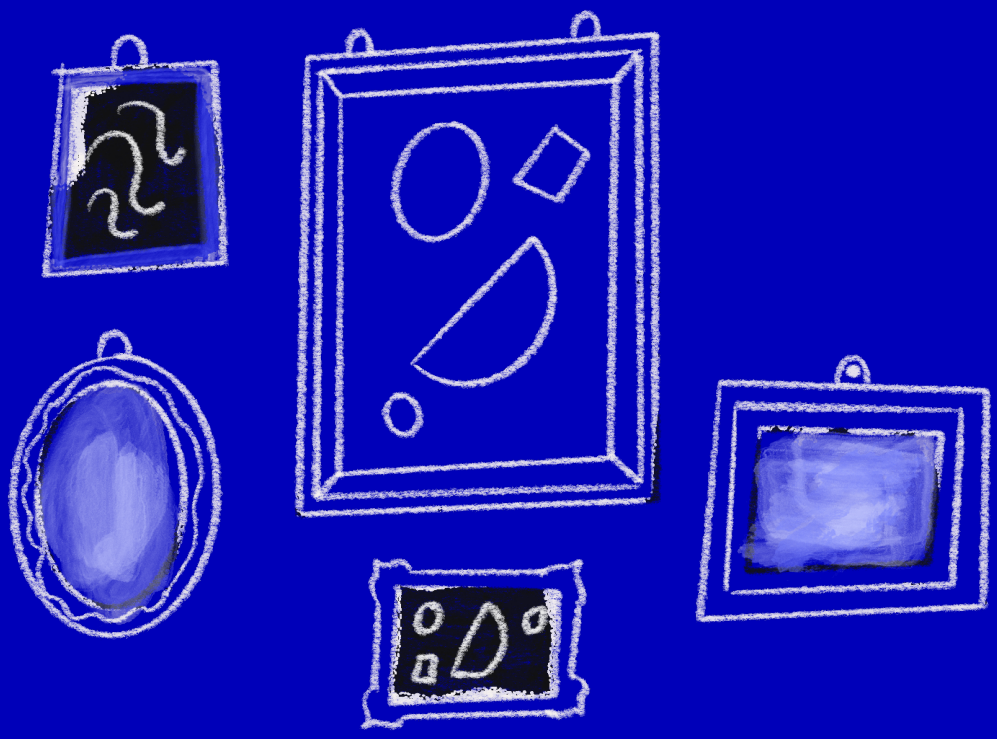
Product example

Samsung's Smart TV offers a "Learn Remote Control" mode. The TV enters a teaching mode. When the user presses a button on the remote, the TV explains what the button does.
Therefore a user with limited vision or a user with a cognitive disability can quickly learn the location and function of the different buttons without having someone explain it to them or affecting regular TV operation.

Responsiveness

Responsive design is essential for a good user experience across a vast array of devices. In a connected world, users expect a seamless experience at all touch points no matter if they are using a phone, a tablet or a smart TV.

Thinking in terms of art boards and breaking points can be increasingly tricky as it can be hard to predict what device users will consume the content. Fluid designs with a realistic minimum and maximum size for all elements that work across all screen sizes prevent broken experiences on different devices.



The long-term experience

People might use services with physical components like smart thermostats, cars, doorbells or fridges for years and years to come. That is quite a commitment. Any software update that does not consider accessibility standards could cause a product to be suddenly unusable. And that is in no way an uncommon issue. Just check out this list of accessibility issues, that were resolved but also newly introduced by iOS 13.

An excellent foundation for reducing issues is maintaining an accessible design system from the start. But it is equally important to have an understanding of the user base, for example, what assistive technology and version people use as well as which devices and operating systems.

A common risk is neglecting users with older phones or operating systems. A conscious decision has to be made at what percentage the team is willing to cut things off. It is the designer's job to advocate for the user, but accessibility, in the end, is a shared responsibility between development, design and management.

Fictional example

Sam, who is blind, buys a wearable sensor to monitor physical symptoms between their doctor visits. They use it for several years to check on the information and interact with the sensor using it's accompanying desktop application. For example, to share relevant data with their doctor.

Sam uses a braille keyboard to do so, as they can not see the visual interface. At some point, the application receives an update. The new update introduces a lot of bugs for braille keyboard users. They can, therefore, no longer use the product smoothly. The application contains sensitive information so Sam feels uncomfortable when the software does not give clear feedback or reacts in confusing ways.

Designers need to consistently keep accessibility in mind and be aware of the impact different functionaries may have on users depending on their abilities.

Product example

When the German Corona tracing app was released many people with older phones or operating systems complained, because they could not download the app.

It was only available for iOS 13.5 and Android 6.0 or newer due to several reasons concerning feasibility. But especially for many older people, who owned older devices or felt reluctant to update their phones, because they got used to their current operating system, this ended up as an issue.

06 Privacy

The Challenge

The ubiquity of connected devices increases the amount of data that is being created. When using IoT products with several touch points, consent mechanisms can become more complicated and harder to understand. The complexity increases once several services interact with each other and third parties are involved.
In an ecosystem or service-network, it is not an easy task to communicate to users how their data is being used.
Privacy can be more granular for different groups of people, for example, those with permanent disabilities or health conditions.
Designers have to be mindful about protecting the privacy of users who use assistive technology, accessibility features or require assistance from other people.

Private usage of accessibility features

When offering audio output as a text alternative, enable users to attach headsets or other devices for private listening. This is especially important if a product might be used outside of a person's private space or if the content is especially sensitive.

Sensitive information and private data like personal or financial information should be excluded from audio output unless there is a way to let the user confirm the output first.

Fictional example

Ella forgot her glasses at home and wants to check-in at a self-serving kiosk at the airport.
The kiosk provides a standard audio connection so she can plug in her headphones for audible instructions and talk back, that make it easier for her to check in without her glasses. Her interactions with the kiosk and the information she enters are now private and can not be heard by the other people waiting in line.

Real life example

Dot Watch is a wearable watch and communicates with haptic braille output.
A happy user describes how the product solves a major pain point for them in a post on AppleVis, a community-powered page for blind and low-vision users.

"The reason I bought one, (...), has everything to do with the ability to silently check incoming calls and alerts. During meetings or when I'm teaching a class, it's invariably my phone that goes off; and, frankly, I sometimes need to know what it is, rather than leaving my phone in my office.
My Braille skills are regrettably very poor, but one-line messages on a four-cell display are within my meagre power, particularly when much of the text is boiler-plate like "message received from..."

Decrease the need for human intermediation

It is not uncommon for people with disabilities to require the assistance of a caregiver, an interpreter, or other aids.
This reliance on others can produce differing baseline privacy expectations for people with disabilities.
Accessible design can help to decrease the need for human intermediation for those users who desire it. When users can operate a product on their own from the start without further assistance, greater privacy can be achieved.

Fictional example

John has a developmental disability. It can be challenging to provide meaningful consent for him, as many privacy policies and permission forms are written at an eighth-grade reading level or higher, which may not accommodate his comprehension levels.

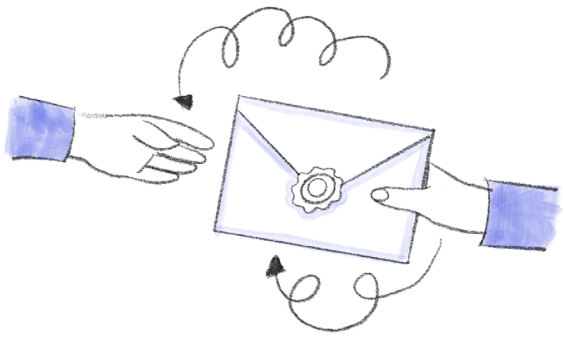
As a consequence, sometimes John is not able to give meaningful consent without support. Images and easy-to-read summaries of crucial privacy practices help him to make decisions on his own.

Handling sensitive personal data responsibly

It is a part of the designer's role to create a solid understanding of the user. User information is collected in many stages of the design process for different reasons: user research studies, interviews, field visits, user tests and tracking the usage of the end-product.

Therefore designers usually have a powerful voice in the topic of data generation within a company and can remind the team to be mindful when working with sensitive user data.

For example, there is still an ethical debate about tracking assistive technologies or other data that can identify users with disabilities or health conditions. Some argue that tracking this information helps to improve the user experience. But it is important to keep in mind that as soon as technology can be used to detect people with



disabilities or illnesses, it can also be used to discriminate.
The United Nations (UN) Convention on the Rights of People with Disabilities (CRPD) Article 22 has stressed the importance of privacy for people with disabilities:

> "No person with disabilities, regardless of place of residence or living arrangements, shall be subjected to arbitrary or unlawful interference with his or her privacy, family, home or correspondence or other types of communication or to unlawful attacks on his or her honor and reputation."

Designers have to make sure all users can understand privacy practices and interact with the related controls by making them easily accessible and understandable.

With iOS 14, Apple added promising new privacy features. They aim to help users understand the privacy practices of every app before downloading.
Privacy is an important topic to address in the user research stage of a product to understand what sorts of privacy users value, what data they feel comfortable sharing and for what purpose.

Real life example

John Rochford (University of Massachusetts Medical School) describes his interactions with Amazon Alexa:

"As a legally blind person, I rely heavily on technology to help lead an independent life.
I have 14 Alexa devices in my home.
With these devices, I can use my voice to control the dozens of other IoT devices that I possess and cannot otherwise use because their designers did not develop them to be accessible to people with disabilities.

However, these devices come with a significant downside. I have traded privacy for convenience. The Alexa devices upload my commands and conversations to Amazon's cloud infrastructure to analyse and, thus, improve my interactions with the Alexa devices."

As with many topics, the sole responsibility is not on the designer when it comes to privacy.
But designers, as the advocate of the user, are in an excellent position to share a user-centered and ethical perspective with other team members.
The same is true for accessibility as a whole.
Creating products that everybody can use and love is a challenge that can only be solved by involving users early and continuously and making their needs understood by all stakeholders.

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