Human Senses in HCI

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Class 1: Foundations of Human Senses in HCI

Objective: Introduce how human senses (vision, hearing, touch) shape interaction design.

1. Introduction to HCI and Human Senses (30 mins)

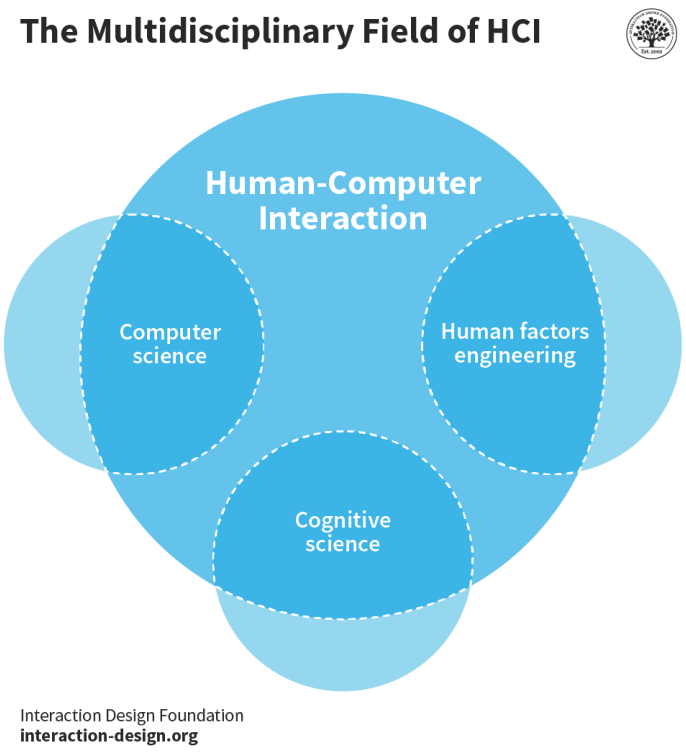
- What is HCI? Overview of Don Norman's contributions (e.g., *The Design of Everyday Things*).
- Why human senses matter in interaction design.
- Key principles: Affordances, signifiers, feedback, visibility, mapping.
- Fitts's Law (Paul Fitts): Time to target based on distance/size (e.g., button placement).
- Gestalt Principles: Proximity, similarity, continuity (visual perception).
- Activity Theory (Vygotsky/Engeström): Interaction as goal-driven, context-aware activity.

What is Human-Computer Interaction (HCI) ?

Human-computer interaction (HCI) is a multidisciplinary field of study focusing on the design of computer technology and, in particular, the interaction between humans (the users) and computers. While initially concerned with computers, HCI has since expanded to cover almost all forms of information technology design.

The Meteoric Rise of HCI

HCI surfaced in the 1980s with the advent of personal computing, just as machines such as the Apple Macintosh, IBM PC 5150 and Commodore 64 started turning up in homes and offices in society-changing numbers. For the first time, sophisticated electronic systems were available to general consumers for uses such as word processors, games units and accounting aids. Consequently, as computers were no longer room-sized, expensive tools exclusively built for experts in specialized environments, the need to create human-computer interaction that was also easy and efficient for less experienced users became increasingly vital. From its origins, HCI would expand to incorporate multiple disciplines, such as computer science, cognitive science and human-factors engineering.



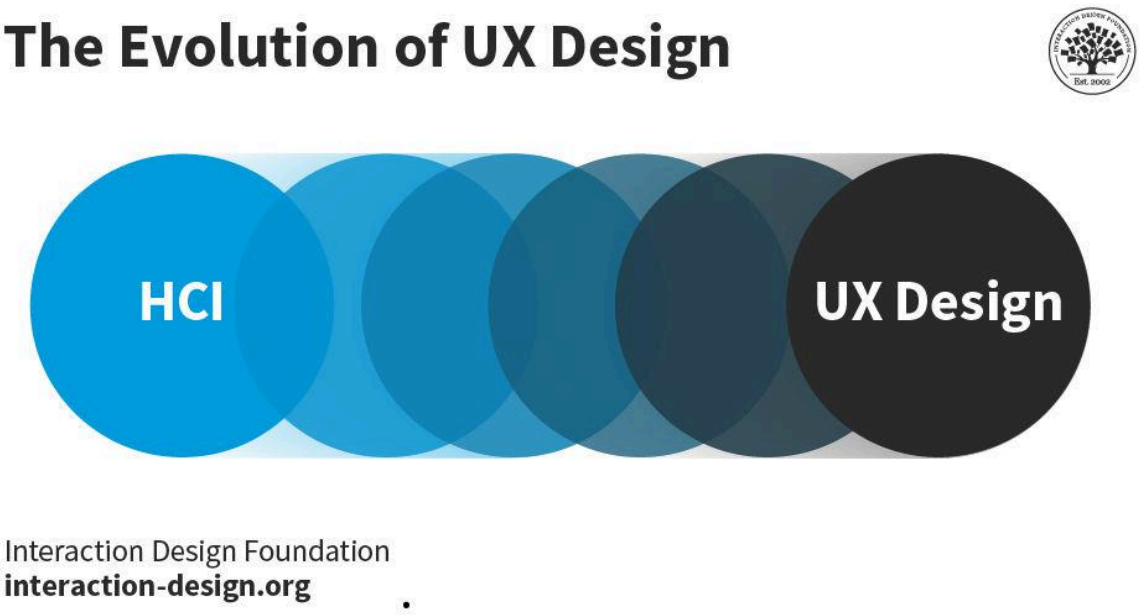
HCI soon became the subject of intense academic investigation. Those who studied and worked in HCI saw it as a crucial instrument to popularize the idea that the interaction between a computer and the user should resemble a human-to-human, open-ended dialogue. Initially, HCI researchers focused on improving the usability of desktop computers (i.e., practitioners concentrated on how easy computers are to learn and use). However, with the rise of technologies such as the Internet and the smartphone, computer use would increasingly move away from the desktop to embrace the mobile world. Also, HCI has steadily encompassed more fields:

"...it no longer makes sense to regard HCI as a specialty of computer science; HCI has grown to be broader, larger and much more diverse than computer science itself. HCI expanded from its initial focus on individual and generic user behavior to include social and organizational computing, accessibility for the elderly, the cognitively and physically impaired, and for all people, and for the widest possible spectrum of human experiences and activities. It expanded from desktop office applications to include games, learning and education, commerce, health and medical applications, emergency planning and response, and systems to support collaboration and community. It expanded from early graphical user interfaces to include myriad interaction techniques and devices, multi-modal interactions, tool support for model-based user interface specification, and a host of emerging ubiquitous, handheld and context-aware interactions."

– John M. Carroll, author and a founder of the field of human-computer interaction.

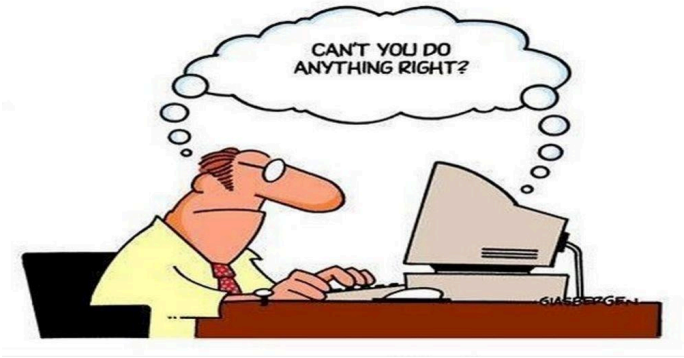
The UX Value of HCI and Its Related Realms

HCI is a broad field which overlaps with areas such as user-centered design (UCD), user interface (UI) design and user experience (UX) design. In many ways, HCI was the forerunner to UX design.



Despite that, some differences remain between HCI and UX design. Practitioners of HCI tend to be more academically focused. They're involved in scientific research and developing empirical understandings of users. Conversely, UX designers are almost invariably industry-focused and involved in building products or services e.g., smartphone apps and websites. Regardless of this divide, the practical considerations for products that we as UX professionals concern ourselves with have direct links to the findings of HCI specialists about users' mindsets. With the broader span of topics that HCI covers, UX designers have a wealth of resources to draw from, although much research remains suited to academic audiences. Those of us who are designers also lack the luxury of time which HCI specialists typically enjoy. So, we must stretch beyond our industry-dictated constraints to access these more academic findings. When you do that well, you can leverage key insights into achieving the best designs for your users. By "collaborating" in this way with the HCI world, designers can drive impactful changes in the market and society.

A Brief History of Human-Computer Interaction



Human Computer Interaction is the academic discipline that most of us think of as UI design. It focuses on the way that human beings and computers interact to ever increasing levels of both complexity and simplicity.

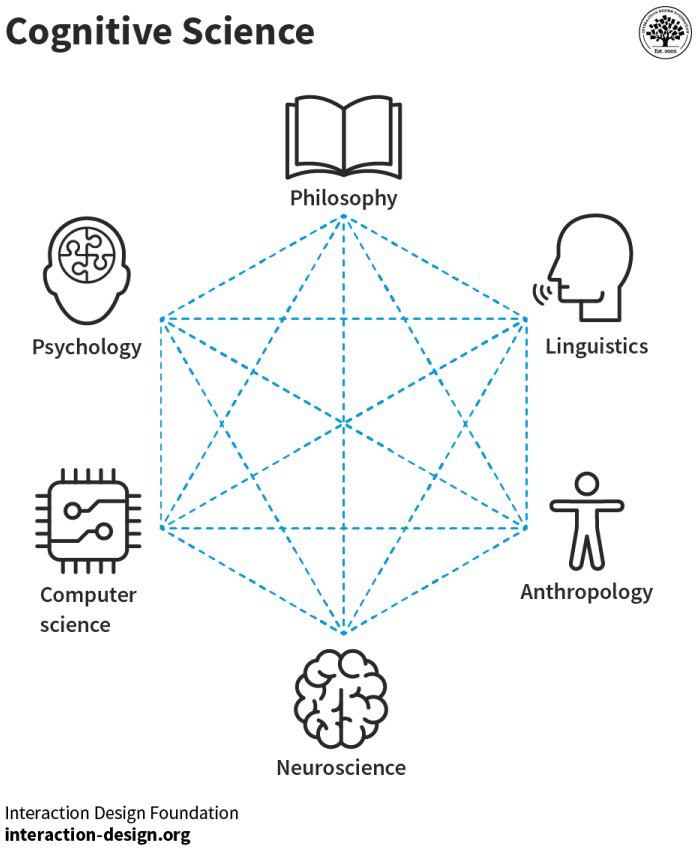
It's a Very New Discipline

It's perhaps easy to see that until the mid to late 1970s this discipline wasn't particularly important. The few people who had access to computers were academics or professionals with a few incredibly dedicated (and wealthy) hobbyists thrown into the mix. Without a broad base of users; it wasn't necessary to focus on how those users interacted with computers – they just made do with whatever was to hand or created what they needed themselves.

Then with the dawn of personal computing; the flood gates opened. The masses wanted computing and they didn't want to go through complicated rigmarole to do what they wanted with a computer. They weren't prepared to build and program their own joysticks for the games they bought, they didn't expect to design the mouse before they could use a word processor and so on…

Cognitive Sciences

Luckily, for the masses, there was a discipline waiting in the wings to help with the tasks that lay ahead. Cognitive sciences (a broad and heady mix which includes psychology, language, artificial intelligence, philosophy and even anthropology) had been making steady progress during the 1970s and by the end of the decade they were ready to help articulate the systems and science required to develop user interfaces that worked for the masses.



Engineering

This is known as “cognitive engineering” e.g. building things that work with our thoughts. And once again the engineering discipline had also come on leaps and bounds during the 1970s in order to support this change. In aviation, for example, engineering had already started to simplify the user interface of complex airplanes. It was natural for some of this work to move into the UI field for computing devices.

Documentation

It’s also important to recognize the challenge of documenting these developments. New systematic approaches needed to be taken in order to record developments and to share these

with other practitioners of the new discipline worldwide. There really is, after all, no advantage in reinventing the mouse over and over again.

Don Norman's Principles of Interaction Design

The first started learning about product design, one of the most influential books I read was The Design of Everyday Things by Don Norman. In this classic work, Don Norman sheds light on the design of every day objects like doors, stoves, thermostats, and more. He then applies these universal design principles to designing technology products. Don Norman is one of the leading thinkers on human-centered design and the principles he writes about are required reading for every product designer. I still reference these principles daily in my work designing Notejoy. So I wanted to walk through each of Don Norman's six principles of designing interactions and how they remain relevant to designing digital products today.

1. Visibility

Visibility is the basic principle that the more visible an element is, the more likely users will know about them and how to use them. Equally important is the opposite: when something is out of sight, it's difficult to know about and use.

As simple as this principle is, designers still struggle with adopting it. The trade-off between hamburger side-bar menus and tab-bar menus in mobile applications is a very recent design debate centered around this very principle of visibility. While the hamburger menu provides a convenient place to store a variety of menu items in a mobile app, it comes at a huge disadvantage: the lack of visibility of the contained menu items. We've seen a shift in major apps like Facebook away from hamburger menus and back toward tab-bar menus to improve the visibility of their key experiences.

The skill in applying this principle is realizing that you can't make everything visible, because it'll ultimately clutter the interface but instead need to prioritize what interface elements are by far the most important for the user experience and prioritize their visibility.

2. Feedback

Feedback is the principle of making it clear to the user what action has been taken and what has been accomplished. Many forms of feedback exist in interaction design, including visual, tactile, audio, and more. The key is to design the experience to never leave the user guessing about what action they have taken and the consequence of doing so.

We've established a variety of design patterns for providing feedback to the user and these feedback patterns are constantly evolving as move interfaces emerge. Here's a brief video showing the many ways that Google's Material design pattern encourages you to provide feedback to the user on the actions they are taking in a mobile app.

3. Constraints

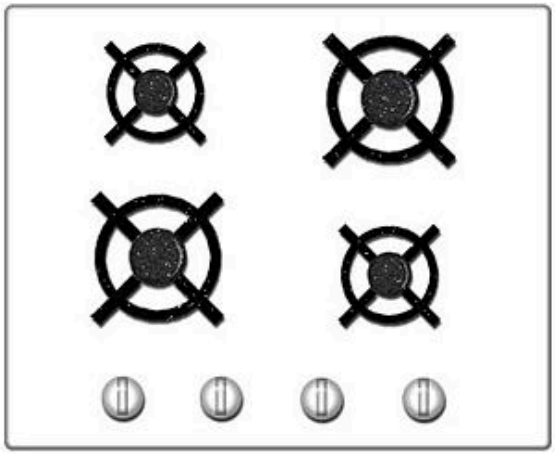
Constraints is about limiting the range of interaction possibilities for the user to simplify the interface and guide the user to the appropriate next action. This is a case where constraints are clarifying, since they make it clear what can be done. Limitless possibilities often leave the user confused.

Conversational interfaces are all the rage these days because they provide the opportunity to speak to a computer via our natural language, which feels far more natural than the traditional user interface methods. However, to-date these interfaces have struggled with a lack of constraints: with limitless possibilities of what you could potentially say to the conversational interface, it becomes impossible to know what kind of queries the interface actually supports. And given the technology today fails to be able to answer every possible query, the endless possibilities are frustrating to the user since it becomes difficult to even know how to use it.

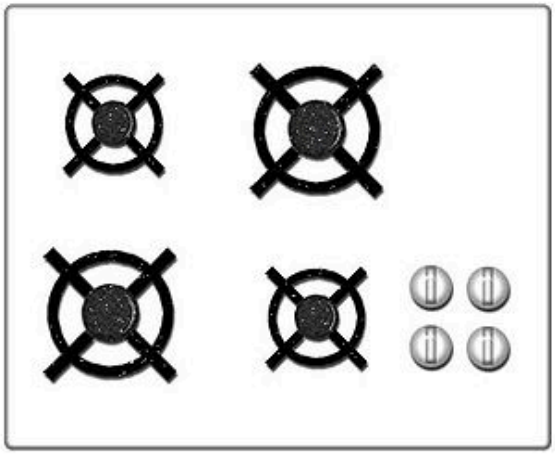
4. Mapping

Mapping is about having a clear relationship between controls and the effect they have on the world. You want this mapping to feel as natural as possible. Stove tops are a great example here. When you see the first image, the mapping is not very clear because it's difficult to determine which control operates each burner. Versus the second image, it's far clearer the control that controls each burner, which has a better mapping.

Poor mapping



Good mapping



This slider also has a strong mapping, since it's clear moving it to the right will increase it's value versus moving it to the left will decrease it.

Apple shook up the world in 2011 when it introduced natural scrolling to Mac OS X Lion. This reversed the familiar pattern of scrolling a page down by holding your fingers on the trackpad and dragging them downward. Instead this was reversed such that you would drag your finger up on the trackpad to scroll the page down. This reversal more closely mapped with the way we used iPhones and iPads. The controversy here is really about a mapping. Was the new mapping too jarring because it changed the conventional mapping that had been used across Mac and Windows for decades? Or was it more natural because it mapped to how you would push a piece of paper up to move it down and also matched the new behavior created on mobile phones. There's no easy answer here, though I'd say I myself turn off natural scrolling on my Mac because I, like many others, prefer the convention established decades ago.

5. Consistency

Consistency refers to having similar operations and similar elements for achieving similar tasks. By leveraging consistent elements throughout your entire experience, you make your experience far easier to use. This consistency is important not only within your interface, but across the many interfaces users are using across their devices.

This is a simple example of poor consistency when you are using so many different styles for actions within your interface.

One of the best ways to drive consistency across applications is to make ample use of Google's Material Design Guidelines and iOS's Human Interaction Guidelines when designing mobile applications.

6. Affordance

Affordance refers to an attribute of an object that allows people to know how to use it. Essentially to afford means to give a clue. The physical button on a mouse gives a clue that it

can be clicked to perform an action. When an object has strong affordances, it's very clear how to use it.

Don Norman talks at length about how doors often have poor affordances. When you come up to a door, it's not always clear do you push or pull the door? One convention used is to put a sheet of metal at around arm height on the side of the door that needs to be pushed to make it clear that it must be pushed instead of being pulled. When you do this, you are giving the door a strong affordance to indicate it should be pushed instead of pulled.

As web and mobile design has been evolving to more modern interfaces, in some ways we have been removing many of the common affordances we have classically used. For example, the blue underlined link used to be the strongest affordance for knowing something was a clickable link on the web. Many web experiences have moved away from this in an attempt to allow link elements to better match with the overall design aesthetic they are trying to achieve across the interface. While that's a helpful goal, we have to ensure that it's still clear what in fact are clickable links on the page using alternative affordances, like showing the underline on hover. When we remove all such affordances, the interface becomes meaningfully harder to use.

As you can see, all six of Don Norman's principles of interaction design remain as relevant today as they did when he originally authored his classic work, The Design of Everyday Things.

Learn the Role of Perception and Memory in HCI and UX

Have you ever wondered how your brain makes sense of the world? It's a fascinating process! If you want to design helpful products and services that people love, you must first understand how they think. A large part of human interaction relies on perception, our ability to see, hear and feel our surroundings. But we also need to be able to connect these things. That's where memory comes in—it helps us connect the dots. Learn about the role of perception and memory in design through the IxDF Perception and Memory in HCI and UX course.

We often design the world based on how we experience it, but this limits our solutions. Diverse people have diverse needs. Age, ability and skill all affect how people use technology.
True universal design is a lofty goal. Yet, we can get close. We must study how people perceive the world and understand how their memory functions. This knowledge can help you build better, more accessible tools.

We gain valuable insights as we focus on how people's senses and minds work (in other words—perception and memory). This helps us support a broader range of users and our solutions can better address the limitations some people face.
Explore how a deeper understanding of perception and memory can enhance your design skills and help you create more inclusive products.

The Basics of Perception and Memory in HCI and UX

Human-Computer Interaction (HCI) and User Experience (UX) are fields that aim to make technology intuitive and enjoyable for people. If you understand perception and memory within these fields, you can create systems that align with how users' minds naturally work.

1. What is Perception?

Perception is how we sense the world around us. We use our senses to notice objects and relationships. This process gives us vital information about our surroundings. Perception needs our brainpower. We use memory to recall a friend's face or a familiar smell. This lets us identify things and react to our environment.

Our five senses help us perceive—sight, touch, hearing, taste and smell. We also have proprioception. This is our sense of body position and self-movement. We face a constant flood of information. Perception filters this to stop us from feeling overwhelmed and helps us understand the world.

How does Perception Work?

Perception increases our awareness of the world. It helps us react.

- We use it in communication: It tells us how loved ones feel.
- It guides our behavior: It shapes our views of people and groups.

We perceive the world constantly but rarely think about it. Light hits our eyes and becomes an image instantly. Our skin senses subtle pressure to let us feel objects. All of this happens without effort.

2. Design Principles on Multi-Sensory Experiences

How you design for the senses goes beyond the obvious—sight, sound and touch. True sensory design weaves various ways users perceive the world to create richer experiences. Let's explore some key principles:

1. Know your senses: Understand how senses work. Research how the brain processes sight, hearing, smell, taste and touch. Consider how sensory disorders and unique sensory experiences might influence your design choices.
2. Senses are a team: Our senses never work alone. Our brains constantly combine information from multiple senses to guide how we react to the world. Test how your sensory design elements work together—they might create unexpected results.
3. Do research: Hunch-based design won't cut it. That's why it's vital to collect user insights on how they interact with your product through multi-sensory methods, and a wealth of scientific literature guides your choices if formal research isn't feasible.
4. Target carefully: Always start with a clear goal for each sensory element. Haptic feedback, distinct sounds or even subtle visual cues should all have a defined purpose.
5. Spark synesthesia-like effects: Our brains naturally seek connections between senses. Words can evoke 'taste' while colors can have a 'feel.' Tap into these associations to make the digital experiences more real and engaging.
6. Uncover hidden effects: Your design choices might trigger unintended sensory responses. Be mindful of this. Words, colors and patterns can all impact some users.
7. Design without sight: Temporarily 'turn off' your focus on sight. How would your product work if users relied on sound, touch or smell? This exercise sparks innovation and reveals how reliant we often are on visuals.
8. Provide balance: Sensory overload is a very real concern, and if you combine too many elements, it may well distract users and ruin their experience. So, always find the right balance—and remember, sensory details should enhance, not obstruct.
9. Create a strategy: Don't treat sensory features as an afterthought—you've got to plan them from the start and align with your overall product vision. These elements are going to have a big impact on how users feel about your brand if done well.

3. Use Sensation and Perception in Design

Imagine you try to capture the essence of reality through your senses. Sensation and perception play pivotal roles in this process. Sensation gathers raw data from our environment through our senses. Perception interprets this raw data within the brain.

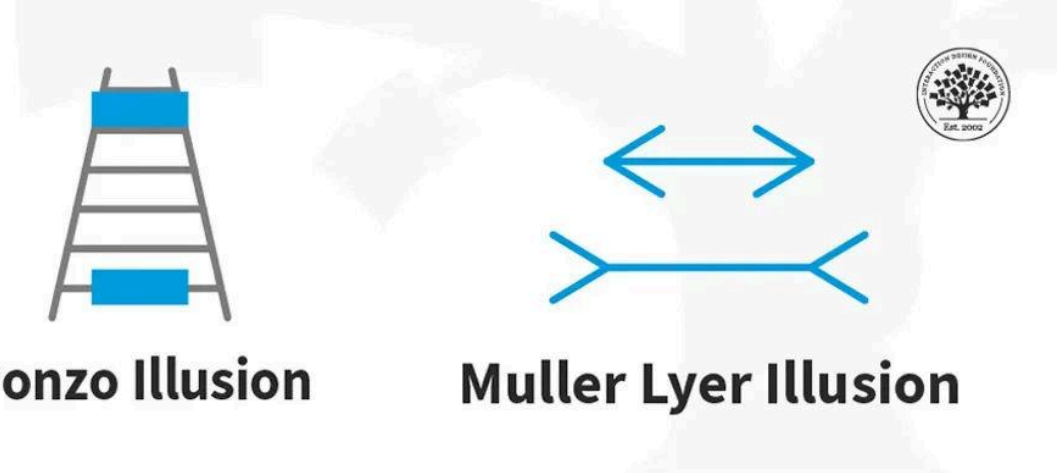
However, perceptions can—sometimes—deceive us. Real-world applications complicate these processes. Our senses interact and our past experiences influence our perceptions. Add the

complexity of processing visual information and it becomes astonishing that observers can agree on a shared experience. Here's an example to help you understand this:

Let's think about a shopping app that highlights sale prices in blue. While effective for most people, users with color vision deficiency well may not notice this, as the blue blends into the background for them. This example shows how design based on one perception can mislead others with different sensory experiences.

There are a few reasons why this matters in design:

- Optical illusions: Illusions like the Ponzo or Müller-Lyer trick make our brains think that we see lines of different lengths or objects of different sizes, when they've actually got the same length and the like. You should be aware of these effects, as visual choices can mislead users unintentionally.



Two popular optical illusions include the Ponzo Illusion and Muller-Lyer Illusion.

- Experience matters: Even seemingly basic perception isn't universal. People raised in different environments might see the world in subtly different ways. Consider the diversity of your audience when you make design choices.
- Our brains seek meaning: We try to find patterns and make sense of things. You can use this to guide user perception and make experiences feel intuitive. However, it also means users can misinterpret seemingly clear visuals if you don't consider alternate viewpoints.

It's vital to be aware of the fluidity of sensation and perception to deliver successful experiences. Consider the potential for misinterpretation due to illusions, personal histories and our pattern-seeking brains—and the users' brains that might misinterpret something are the same brains that can (mis)judge your design. As you understand these complexities and anticipate diverse user responses, you can craft designs that guide perception effectively to create intuitive and inclusive products for all.

4. Use Touch and Haptics in Design

Touch is our sense of feeling things through physical contact—and it can be extremely sensitive. In design, this mainly refers to how users interact with touchscreens. Haptics is the technology that simulates the sense of touch. Think of subtle vibrations or bumps on your phone. Haptics add a physical dimension to digital interactions.

Imagine a map app. A button zooms in on your location. Traditionally, you'd see the view change visually. Now, add a subtle haptic “click” as you press zoom. This adds another sensory layer. It confirms the action and makes the interaction more satisfying.

Use these five guidelines to add touch and haptics to the design:

1. Purposeful: Don't add vibrations for fun. Haptics should have a clear role—to provide feedback, guide actions or enhance immersion.
2. Subtle: Users may feel annoyed if you overdo haptics. Small, precise vibrations usually work best.
3. Make meaningful pair: Match haptic effects to what happens on-screen. A heavier 'bump' might indicate an error, while a light series of taps could mimic typing.
4. Flexible: Provide options to adjust or turn off haptics. Some users might feel distracted or even physically uncomfortable.
5. Device specific: Haptic effects feel different on phones versus smartwatches. Test thoroughly on your target device.

Learn How to Use Vision and Sound Senses

Eyes and ears help us take in most of the world. When we design things, it's important—and then some—to understand how people see and hear. This helps us create websites, products and even spaces that are easy to use and provide a pleasing experience. If you think about color, shape, sound and how they grab attention, you make things work better for everyone.

1. Understand The Science Behind Amazing (but Tricky) Vision

Light enters our eyes and hits special cells at the back. These cells send signals to our brain. Our brain turns them into the images we see. This sounds simple, but our brains do a lot of extra work.

Our brains fill in the gaps of what we see. This is why optical illusions work. People see things differently so you must be careful when you design—your user might be colorblind or have low vision. Shapes and colors can mislead if we don't plan well. Good designers think about these differences. They make sure their work is clear for everyone. For example:

- Color: Color theory explains how colors trigger deep emotions in humans. Reds might mean love or danger, blues calm or sadness—it depends on the person. You must know these complex associations, especially since they shift across cultures.

- Lighting: Our brains respond to light, and soft, warm tones create coziness, while bright, cool light evokes focus. You can use light to set the desired mood for a space.
- Layout: Layout affects us at a subconscious level. Spaciousness, grid systems and natural elements each evoke different feelings. You can use these elements carefully to create a space that supports the desired experience for the user.

Design For Peripheral Vision

Peripheral vision lets you see what's outside your direct focus. It's less sharp than your central vision but helps you spot things in your surroundings and guides your attention.
It's important to understand peripheral vision for a good user experience because users scan interfaces with both central and peripheral vision. Design elements need to consider both to avoid missed content and frustration.

Let's say a user clicks a button and gets an error message on the far side of the screen. They missed it because it was outside their central vision. This is a common problem—and one that can frustrate users a great deal—when the design doesn't consider peripheral vision. So, follow these tips to design for peripheral vision:

- Center important items: Place key elements where users can most likely see them directly—and that means in the screen's center.
- Use visual cues: Employ color, size and contrast properly, to make important items stand out in peripheral vision.
- Use white space: Separate elements to reduce visual clutter and aid peripheral scanning.
- Consider subtle animation: Guide attention to key items with brief flashes or gentle movement.
- Test with users: Verify your design is usable in peripheral vision with real user feedback.
- Maintain consistency: Use familiar design patterns throughout your product for ease of use.
- Offer clear tutorials: Help users learn the interface to maximize efficiency.

2. Use Sound to Shape Design

Sound brings the experience to life in games, movies and virtual reality. But even in simpler apps and websites, the right sound can make the digital world feel more tangible and engaging. Here's a breakdown of how designers use sound in design:

- Feedback and confirmation: Clicks, beeps and swooshes tell us whether an action was successful (or not!). This is essential in digital products where we lack the physical feedback of the real world.
- Emotional connection: Music sets a mood. A suspenseful soundtrack in a game builds tension. A meditation app with gentle, calm music and natural sounds can help users relax and focus on breathing.

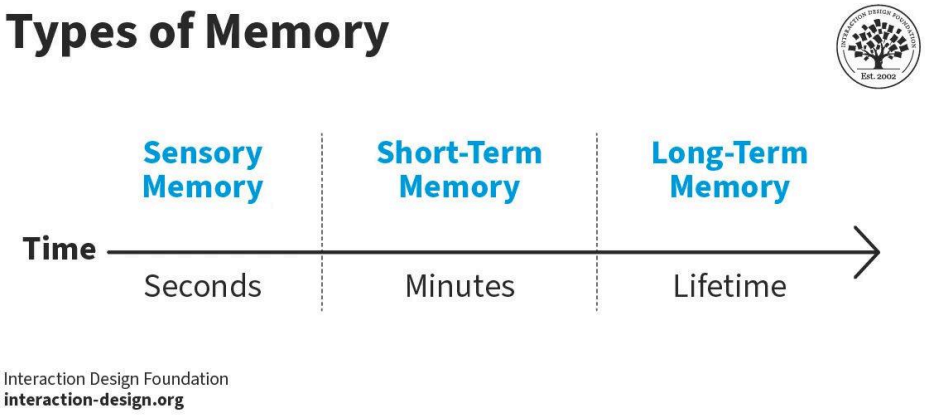
- Alerts and notifications: Unique sounds help users distinguish what needs their attention. Think about how Facebook Messenger uses the distinctive notification tone.
- Accessibility: Sound cues can guide users with vision impairments. Think of a navigation app with a distinct rising tone to indicate "You're heading in the right direction."
- Immersion: Realistic sound effects or spatial audio in games and VR experiences make the world feel believable—and users can get so much more into it, and out of it.

Follow these tips to use sound effectively in design:

- Purposeful: Sound should serve a clear goal—feedback, ambiance, etc.
- Subtle and unobtrusive: Overly loud or repetitive sounds can quickly annoy the users.
- Matches the experience: A playful sound effect might fit a children's app but feel out of place in a banking site.
- User control: Provide options to mute or adjust the sound volume.

Leverage Human Memory to Your Advantage

Our brains aren't perfect memory machines—there's the potential for misremembering things, for instance. But if you understand how memory works, you can create products and experiences that feel more natural and easier to use. This means less frustration for users and better results for your designs.



Human memory has three facets: sensory, short-term and long-term.

1. Understand How to Use Short-term Memory in Design

Short-term memory serves as a vital processing hub—in the short term, indeed. It takes in sensory memories of interest and holds them for up to a minute. This duration can extend to a few hours with rehearsal, such as repetition.

Short-term memory operates on limited capacity. Renowned psychologist George A. Miller explored this in his seminal work, "The Magical Number Seven, Plus or Minus Two." His experiments suggest we can hold between five and nine items in our short-term memory.
"Chunking" is one of the ways to extend this capacity. In this method, you group individual items into larger, more manageable units. For example, if you group the digits into pairs, a 12-digit phone number becomes so much easier to remember. This results in six chunks—a manageable number within the typical memory span—rather than twelve separate digits.

You can also apply chunking to visual and alphanumeric data. Think about a bar chart in a presentation. Each bar represents a chunk of information. It simplifies complex data into digestible pieces. This technique allows visual designers to present information that short-term memory can quickly process.

Chunking Technique	Benefit for User Experience	Examples
Group information into categories	Improves user's ability to process and retain information	Website menu with categories like "Home," "About," Products," and "Contact"
Break down complex data into digestible pieces	Reduces cognitive overload and frustration	Product comparison table with features listed in columns to make selection easier
Allows users to focus on what matters most	Creates a more user-friendly experience	Signup form broken into sections (personal info, address, payment)

2. Understand How to Use Long-Term Memory in Design

Long-term memory serves as our mind's vast storage system—and we retain memories that we make conscious efforts to remember. This effort includes practices like how you study for tests or make meaningful connections. These connections help form long-lasting memories.

For instance, you make a vivid impression if you experience a static shock—it's a painful experience that creates a strong emotional memory after just one occurrence. This shows how potent emotional and physical experiences are for memory retention.

We also use long-term memory to define our identities. It holds our experiences, knowledge and skills that inform who we are. This storage allows us to retrieve important information about our values and past experiences. It plays a crucial role in shaping our behavior and decision-making.

In design, especially in information visualization, the focus often remains on the immediate interaction. Users rarely store the details of a design in long-term memory. Instead, they remember the insights or understanding they gain from it. This selective memory is what makes sure that we keep hold of only the most relevant information.

Follow these five tips to leverage long-term memory in design:

- Emotional design: Create designs that evoke strong emotions for better memorability—we're talking about impressions and feelings here. Products that generate joy, surprise or nostalgia can forge lasting memories and deepen brand connections.
- Storytelling: Use narratives to make complex information so much more relatable and memorable. Stories that resonate with users can enhance recall and engagement with your brand or product—and they'll associate something much more profound than just data with it; humans really do love tales.
- Repetition and familiarity: Employ consistent visual elements, slogans, or sounds across various platforms to reinforce memory. Familiar branding makes it easier for users to recognize and remember your product.
- Priming and cues: Use visual or auditory cues to trigger specific actions or memories. It's an approach that helps users quickly recall their interactions with your interface.
- Personalization: Tailor experiences to individual users so you forge deeper emotional connections and create memorable interactions for them. Platforms that adapt to user preferences or history—like Netflix or Amazon—demonstrate the effectiveness of this strategy to enhance long-term brand loyalty.

Interaction Design: 6 Fundamental Principles

Don Norman, the father of usability and co-founder of the Nielsen Norman Group, stresses the importance of thinking about people and the interaction they will have with the products and systems being developed.

This is why areas such as UX Design are so important within a company. To ensure that the experiences of the end users – and anyone else who interacts with the product – are the best they can be.

But how do you ensure that all these users have a great experience with your design?

With this in mind, Norman wrote – based on the concept of User-Centered Design – 6 fundamental principles of Interaction Design. Check each one out below.

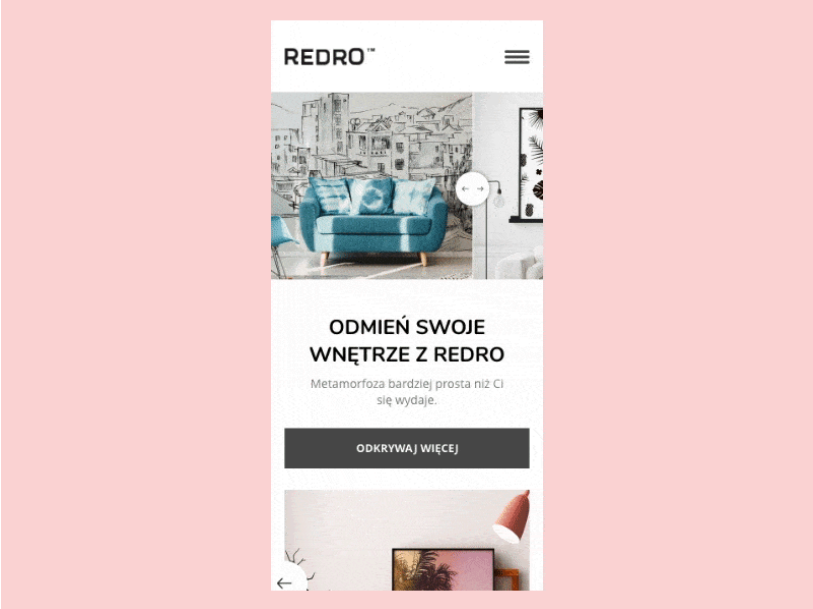
1) Visibility

The principle of visibility brings the matter of discovery.
The user discovers the interface functions by the simple fact that they are visible for interaction. In other words, the more visible a function is, the more the users will notice and use it.
In this regard, visible buttons and menus make the user's journey easier. Whereas if these functions are not visible, they will not be used.

Regarding visibility, it's important to pay attention to the prioritization of functions.
It's not recommended to put buttons and menus for all the functionalities of a system. The screen becomes cluttered and there is no distinction between the most important functions.

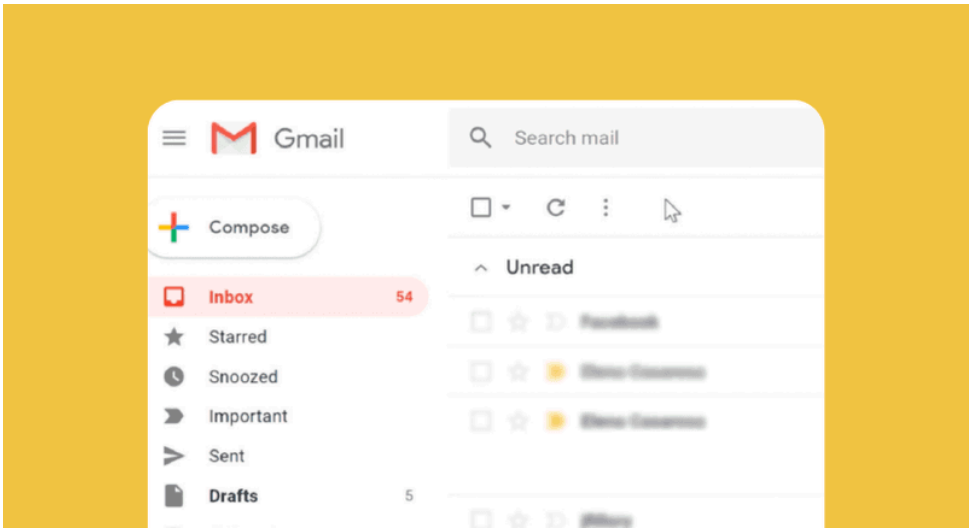
The big challenge is to understand how to prioritize content and functions.

A classic example of visibility and interaction is the Hamburger icon. It represents the function menu on many websites. It's so common that the user already understands that this icon represents a deep dive of the tasks.



Redro / expanded menu by Piotr Swierkowski

Another example of visibility is the button for writing e-mails in the Gmail inbox. With this feature, the user finds the function almost instinctively.



2) Feedback

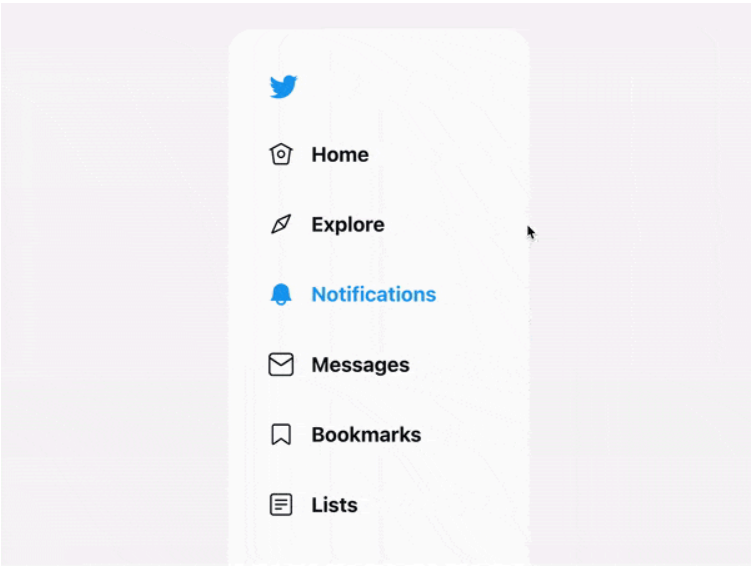
Feedback is the response that the user should receive after performing some action on the interface.

For every interaction with a product, it is natural to create the expectation of a response. Be it confirming the success or failure of the action. If this doesn't happen, the user may have doubts and their experience may be impacted.

A very simple and everyday example is the simple click of a button. If there is no feedback ensuring that the button was clicked, the user will keep on clicking.

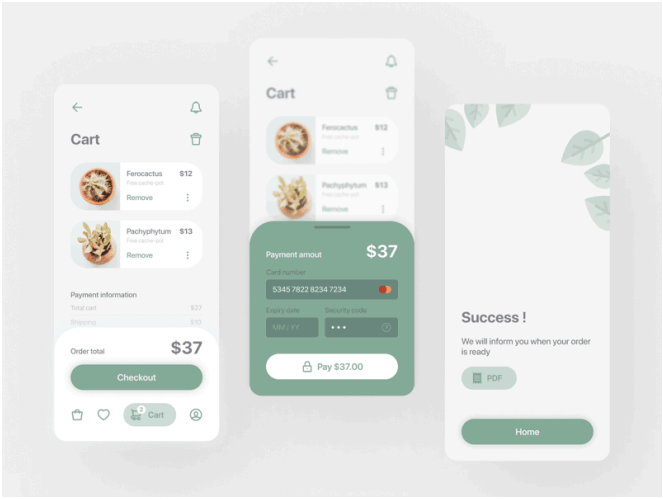
We can classify feedback into two categories:

Activation Feedback: when the response to an action is sensorial, such as a visual or sound effect. For example: when you click on a button, it changes color or emits a sound, confirming that it has been activated.



Twitter Sidebar (Light) by Aaron Iker

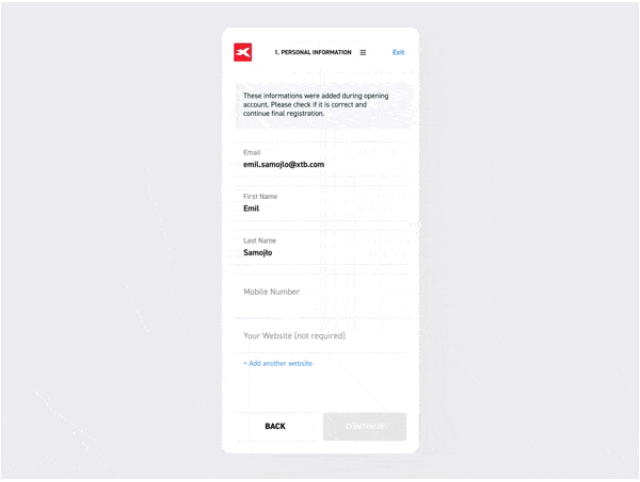
- Behavioral Feedback: when the response indicates that the action had some effect within the system. For example: when you click on a button to finalize your online purchase, a message appears confirming that your action was successfully performed.



Checkout UI [Tatiana Kulgeiko]

3) Constraints

To avoid any invalid or incorrect action by the user, a system must have constraints.
Constraints, within Interaction Design, can be both physical and behavioral.
Physical constraints can be exemplified by the cell phone screen itself. There is no way to have interaction outside of it.
The behavioral constraints, on the other hand, are more related to the user experience and what actions they can or cannot perform within the interface.
An interesting example is the action buttons in any computer program. When an action is restricted to the user, the button usually appears gray and opaque, making it clear that the function is not available at that moment.
This kind of restriction is also common on online forms, where the "submit" button is inactive until the entire form is filled out correctly.



Partnership office onboarding – forms by [Emil Samojło]

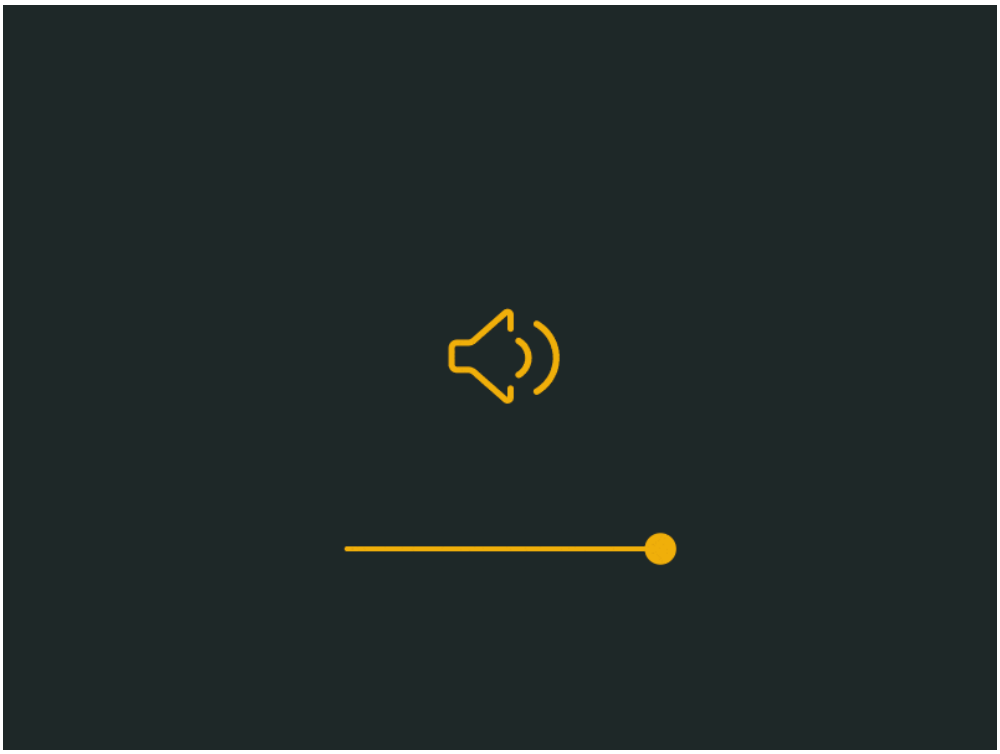
A lack of restrictions can cause confusion and frustration for the users, causing them to click incorrectly on inactive buttons, or submit a form with incomplete information.

4) Mapping

It is clear that any icon, button, or control, when activated, will trigger some function within the system.

But in addition to this, it is important to have a connection between the design and the function linked to it. This connection, within Interaction Design, is called Mapping.
This way, the more the users assimilate the controls with their perception of reality, the better the interaction and the experience.

For example, the volume button shows longer bars as the volume increases and shorter bars as the volume decreases.



Volume Control Micro Animation by Nick Buturishvili

Although mapping may seem straightforward, it requires careful attention and testing with real users.

One useful way to assess the accuracy of mapping is to examine the design of a control and consider the user's expectation for it.

For instance, if a control indicates a gradual increase or decrease, the symbols "+" and "-" may be used. Similarly, if the control is used to start a video, the user would likely expect a button with a triangle symbolizing play

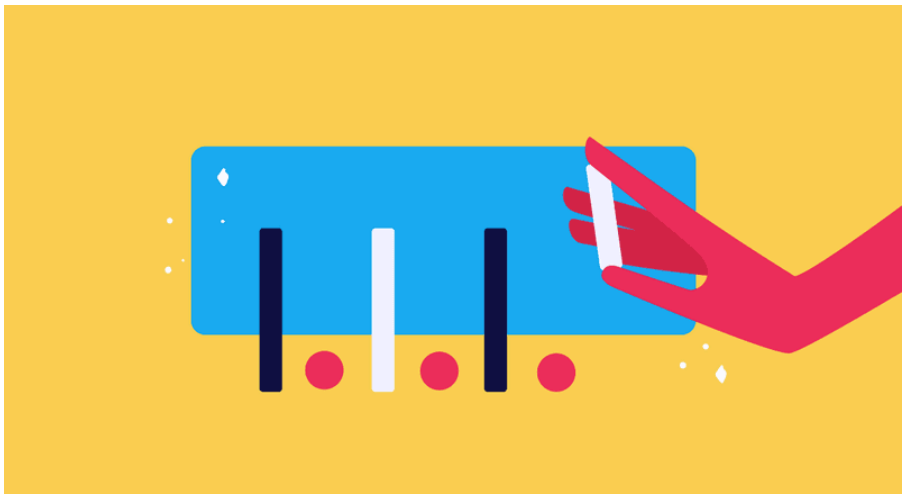
5) Consistency

One of the ways to improve the user experience and ensure a fast learning curve is to use patterns.
Creating patterns helps the user assimilate your system better, making navigation simpler and easier.

Consistency, in interaction design, is nothing more than creating these patterns within the system. Representing controls with similar functions in a similar way, positioning buttons in the same place and in the same way, using the same colors, etc.

A lack of consistency can cause delays in action and confusion for the user. The idea is always to have the user assimilate every function of your system, without having to worry about exceptions.

In addition, it's important to understand if there is consistency with other similar systems.
For example, if on all websites writing and reading are done from left to right, it is not recommended that your website does it any other way. The case is exaggerated, but it helps to understand. Doing something differently is fine if it doesn't interfere with the way the user is used to doing it in other systems.



6) Affordance and Signifiers

Affordances

The concept of affordance is connected to the attributes that an object has and that makes a certain interaction possible.
For example, a glass window has attributes that enable us to see through it. Its hinges have attributes that enable it to open in a particular direction, and the opening of the window enables air to flow through it. These are all examples of affordances – the potential interaction relations between the user and the system.

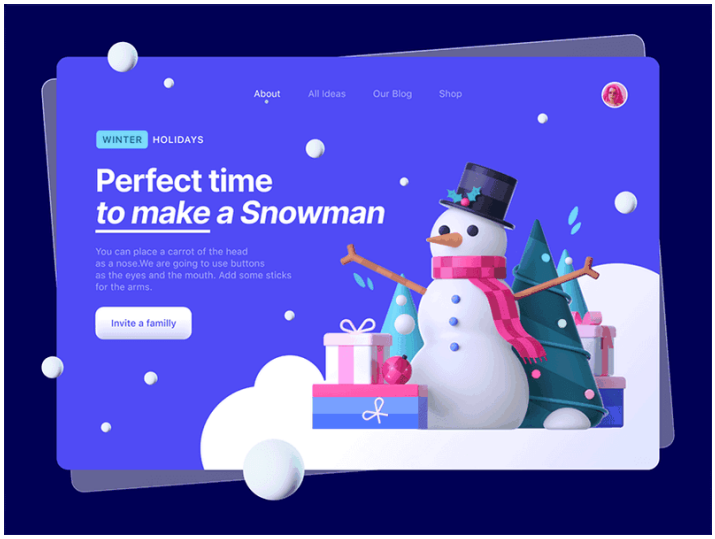
Signifiers

Signifiers are the signs that show that a connection exists and how to use it. They are the visual attributes that indicate how something works.
In the window example, the design of the handle indicates which way it opens, or the shape of the hinges can clearly show whether the window should be pulled or pushed (or both).
Affordances and signifiers are concepts in Interaction Design that go together and are commonly mistaken.

Remember that affordances are the attributes that make interaction possible, while signifiers are the signals that make it possible to identify these attributes and use them.
Everyday examples

It is not uncommon to find, on websites, buttons designed in three-dimensional form. This 3D view indicates that the button must be pressed to perform some function. The 3D is a signifier demonstrating an affordance (click).

Hyperlinks are a common type of signifier in web design. When a word has a link and is clickable, it is typically underlined and blue, indicating its clickability.



Winter Holidays por Varya Panyukova

Affordances and signifiers are crucial in indicating that an object is interactable. However, if these principles are not properly signified and aligned with other design principles (such as Visibility, Constraints, Mappings, etc.), the functions become difficult to use, leading to a poor user experience.
By using all 6 principles correctly, we can ensure an Interaction Design that allows a good user experience.

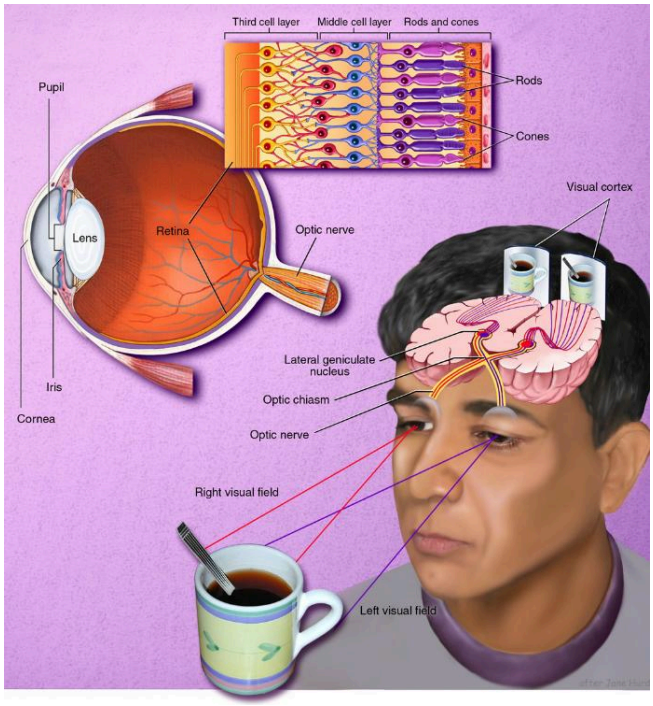
It's important to remember that these concepts aim to provide a simplified and easy user journey, learning, and remembering so that the use of the system flows as automatically as possible.

2. Vision: The Dominant Sense (45 mins)

- How humans process visual information (color, contrast, patterns).
- Implications for design: Visual hierarchy, consistency, affordances (e.g., buttons that "look clickable").
- Case study: Poor vs. effective visual signifiers (e.g., door handles).

Vision: Processing Information

The moment light meets the retina, the process of sight begins. About 60 years ago, scientists discovered that each vision cell's receptive field is activated when light hits a tiny region in the center of the field and inhibited when light hits the area surrounding the center. If light covers the entire receptive field, the cell responds weakly.



Vision begins with light passing through the cornea and the lens, which combine to produce a clear image of the visual world on a sheet of photoreceptors called the retina. As in a camera, the image on the retina is reversed: Objects above the center project to the lower part and vice versa. The information from the retina — in the form of electrical signals — is sent via the optic nerve to other parts of the brain, which ultimately process the image and allow us to see.

Thus, the visual process begins by comparing the amount of light striking any small region of the retina with the amount of surrounding light.

Visual information from the retina is relayed through the lateral geniculate nucleus of the thalamus to the primary visual cortex — a thin sheet of tissue (less than one-tenth of an inch thick), a bit larger than a half-dollar, which is located in the occipital lobe in the back of the brain.

The primary visual cortex is densely packed with cells in many layers, just as the retina is. In its middle layer, which receives messages from the lateral geniculate nucleus, scientists have found responses similar to those seen in the retina and in lateral geniculate cells. Cells above and below this layer respond differently. They prefer stimuli in the shape of bars or edges and those at a particular angle (orientation). Further studies have shown that different cells prefer edges at different angles or edges moving in a particular direction.

Although the visual processing mechanisms are not yet completely understood, recent findings from anatomical and physiological studies in monkeys suggest that visual signals are fed into at least three separate processing systems. One system appears to process information mainly about shape; a second, mainly about color; and a third, movement, location, and spatial organization.

Human psychological studies support the findings obtained through animal research. These studies show that the perception of movement, depth, perspective, the relative size of objects, the relative movement of objects, shading, and gradations in texture all depend primarily on contrasts in light intensity rather than on color.

Perception requires various elements to be organized so that related ones are grouped together. This stems from the brain's ability to group the parts of an image together and also to separate images from one another and from their individual backgrounds.

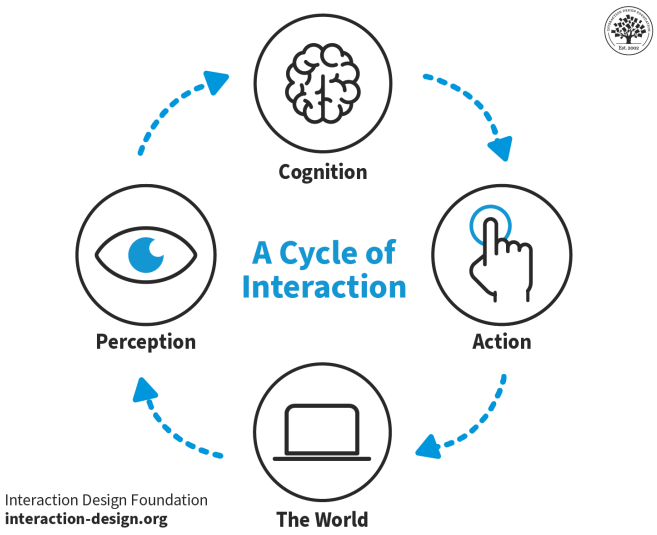
How do all these systems combine to produce the vivid images of solid objects that we perceive? The brain extracts biologically relevant information at each stage and associates firing patterns of neuronal populations with past experience.

What is Visual Perception?

Visual perception refers to the ability to interpret and make sense of visual information from the environment through the process of sight. This complex process involves several steps, beginning with the detection of light by the eyes and ending with the interpretation of visual stimuli by the brain. Visual perception allows individuals to understand and interact with their surroundings by recognizing, organizing, and interpreting shapes, colors, spatial relationships, movement, and other visual attributes.

Physiologically, visual perception happens when the eye focuses light on the retina. Within the retina, there is a layer of photoreceptor (light-receiving) cells which are designed to change light into a series of electrochemical signals to be transmitted to the brain. Visual perception occurs in the brain's cerebral cortex; the electrochemical signals get there by traveling through the optic nerve and the thalamus. The process can take a mere 13 milliseconds, according to a 2017 study at MIT in the United States.

The visual perception of colors, patterns, and structures has been of particular interest in relation to graphical user interfaces (GUIs) because these are perceived exclusively through vision. An understanding of visual perception therefore enables designers to create more effective user interfaces.



Understanding Visual Perception

Visual perception is the brain's ability to interpret and make sense of visual information received from the eyes. This fascinating process transforms raw sensory input into meaningful experiences, helping us navigate our surroundings effectively. For instance, when you glimpse a friend from a distance, your brain rapidly processes their shape, color, and movement, allowing you to recognize them even before you've consciously thought about it.

Visual perception is not just about seeing; it involves a complex interplay between the eyes and brain, enabling us to make informed judgments and decisions based on what we observe. As highlighted in studies, our ability to interpret visual stimuli is crucial for activities ranging from simple tasks like reading a book to more complex ones like driving a car.

The Process of Visual Perception

The journey of visual perception can be broken down into several stages: sensation, organization, and interpretation.

- Sensation: This is the initial phase where light enters the eye. Photoreceptors in the retina capture light and convert it into electrical signals. These signals are then sent to the brain for processing.
- Organization: Here, the brain begins to categorize and organize the incoming information. It discerns shapes, colors, and patterns, establishing relationships between different visual elements.
- Interpretation: Finally, the brain interprets the organized signals, allowing us to recognize objects, faces, and scenes. This stage culminates in our conscious experience of what we see.

Components of Visual Perception

Several key components of visual perception contribute to how we interpret our surroundings:

- Light: Light is the fundamental element that makes vision possible. Variations in brightness and contrast can dramatically alter our perception of objects.
- Color: Colors influence our emotional responses and can change how we perceive an object's size or distance.
- Shape: Recognizing shapes is crucial for identifying objects. The brain uses the outlines and contours of shapes to categorize what we see.
- Depth: Depth perception allows us to perceive the distance between objects and ourselves. This ability is essential for tasks like catching a ball or judging distances while driving.

Theories of Visual Perception

Several theories seek to explain how we perceive visual information, each providing a unique perspective on the process.

Gestalt Principles

Gestalt psychology emphasizes that the whole is greater than the sum of its parts. This approach identifies several principles, such as:

- Figure-Ground: This principle explains how we distinguish an object (the figure) from its background (the ground). For example, in a busy street, a pedestrian might stand out against the blurred images of cars and buildings.
- Similarity: Objects that appear similar are often grouped together in our perception. This helps us make quick judgments about scenes.

Constructivist Theory

The constructivist theory posits that our perception is heavily influenced by previous experiences and knowledge. It suggests that we interpret new visual stimuli based on what we have learned in the past. For instance, if you've had a negative experience with dogs, you might perceive a barking dog as threatening, even if it's friendly.

Direct Perception Theory

In contrast, the direct perception theory focuses on how our environment provides all the necessary information for perception. This theory argues that we do not need to rely on prior knowledge to understand visual stimuli; rather, the objects themselves contain the information needed for interpretation.

Factors Influencing Visual Perception

Biological Factors

Age, health, and eye conditions can significantly affect visual perception. For instance, as we age, our ability to see certain colors may diminish, or conditions like cataracts may blur our vision. Understanding these factors can help mitigate their effects and improve our overall visual experience.

Environmental Factors

Lighting plays a crucial role in visual perception. Bright, well-lit environments enhance visibility, while dim lighting can obscure details. The context in which we view objects also matters—an item might look different on a plain background compared to a patterned one.

Psychological Factors

Our emotions, attention, and cognitive biases can skew our visual perception. For example, if you are anxious about a presentation, you might misinterpret friendly faces in the audience as judgmental. This demonstrates how our mental state can shape what we see.

Applications of Visual Perception

Understanding visual perception is not just an academic exercise; it has practical applications across various fields.

In Education and Learning

In educational settings, insights from visual perception can enhance learning environments. For instance, using diagrams and visuals can help students better grasp complex concepts. Engaging visuals can stimulate interest and aid memory retention.

In Design and Art

Graphic design, art, and user interface design rely deeply on principles of visual perception. Designers harness color, shape, and composition to create effective visual communication. For example, a website's layout can significantly impact user engagement and ease of navigation.

In Everyday Life

Visual perception affects our daily decision-making and interactions. From choosing an outfit that matches to interpreting non-verbal cues in conversations, our ability to perceive visually shapes our experiences. It even influences our shopping choices, as packaging design can affect consumer behavior.

How vision works

Vision is a tricky matter. When we see a pizza, a feather, or a hammer, we are actually seeing light bounce off that object and into our eye. Light enters the eye through the pupil, a tiny opening behind the cornea. The pupil regulates the amount of light entering the eye by contracting (getting smaller) in bright light and dilating (getting larger) in dimmer light. Once past the pupil, light passes through the lens, which focuses an image on a thin layer of cells in the back of the eye, called the retina.

Because we have two eyes in different locations, the image focused on each retina is from a slightly different angle (binocular disparity), providing us with our perception of 3D space (binocular vision). You can appreciate this by holding a pen in your hand, extending your arm in front of your face, and looking at the pen while closing each eye in turn. Pay attention to the apparent position of the pen relative to objects in the background. Depending on which eye is open, the pen appears to jump back and forth! This is how video game manufacturers create the perception of 3D without special glasses; two slightly different images are presented on top of one another.

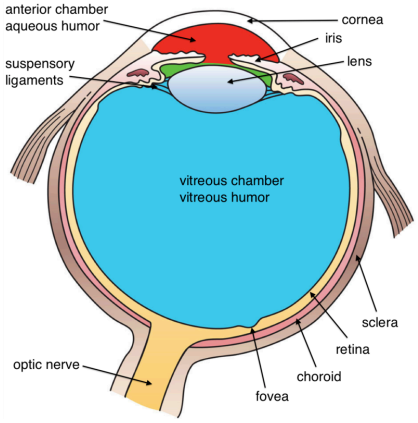


Figure 2. Diagram of the human eye. Notice the Retina, labeled here: this is the location of the Cones and Rods in the eye. [Image: Holly Fischer, https://goo.gl/ozuG0Q, CC BY 3.0, https://goo.gl/TSIsIq]

It is in the retina that light is transduced, or converted into electrical signals, by specialized cells called photoreceptors. The retina contains two main kinds of photoreceptors: rods and cones. Rods are primarily responsible for our ability to see in dim light conditions, such as during the night. Cones, on the other hand, provide us with the ability to see color and fine detail when the light is brighter. Rods and cones differ in their distribution across the retina, with the highest concentration of cones found in the fovea (the central region of focus), and rods dominating the periphery (see Figure 2). The difference in distribution can explain why looking directly at a dim star in the sky makes it seem to disappear; there aren't enough rods to process the dim light!

Next, the electrical signal is sent through a layer of cells in the retina, eventually traveling down the optic nerve. After passing through the thalamus, this signal makes it to the primary visual cortex, where information about light orientation and movement begin to come together (Hubel

& Wiesel, 1962). Information is then sent to a variety of different areas of the cortex for more complex processing. Some of these cortical regions are fairly specialized—for example, for processing faces (fusiform face area) and body parts (extrastriate body area). Damage to these areas of the cortex can potentially result in a specific kind of agnosia, whereby a person loses the ability to perceive visual stimuli. A great example of this is illustrated in the writing of famous neurologist Dr. Oliver Sacks; he experienced prosopagnosia, the inability to recognize faces. These specialized regions for visual recognition comprise the ventral pathway (also called the "what" pathway). Other areas involved in processing location and movement make up the dorsal pathway (also called the "where" pathway). Together, these pathways process a large amount of information about visual stimuli (Goodale & Milner, 1992). Phenomena we often refer to as optical illusions provide misleading information to these "higher" areas of visual processing (see Additional Resources for websites containing amazing optical illusions).

Dark and light adaptation

Humans have the ability to adapt to changes in light conditions. As mentioned before, rods are primarily involved in our ability to see in dim light. They are the photoreceptors responsible for allowing us to see in a dark room. You might notice that this night vision ability takes around 10 minutes to turn on, a process called dark adaptation. This is because our rods become bleached in normal light conditions and require time to recover. We experience the opposite effect when we leave a dark movie theatre and head out into the afternoon sun. During light adaptation, a large number of rods and cones are bleached at once, causing us to be blinded for a few seconds. Light adaptation happens almost instantly compared with dark adaptation. Interestingly, some people think pirates wore a patch over one eye in order to keep it adapted to the dark while the other was adapted to the light. If you want to turn on a light without losing your night vision, don't worry about wearing an eye patch, just use a red light; this wavelength doesn't bleach your rods.

Color vision

Figure 3. Stare at the center of the Canadian flag for fifteen seconds. Then, shift your eyes away to a white wall or blank piece of paper. You should see an "after image" in a different color scheme.

Our cones allow us to see details in normal light conditions, as well as color. We have cones that respond preferentially, not exclusively, for red, green and blue (Svaetichin, 1955). This trichromatic theory is not new; it dates back to the early 19th century (Young, 1802; Von Helmholtz, 1867). This theory, however, does not explain the odd effect that occurs when we look at a white wall after staring at a picture for around 30 seconds. Try this: stare at the image of the flag in Figure 3 for 30 seconds and then immediately look at a sheet of white paper or a wall. According to the trichromatic theory of color vision, you should see white when you do that. Is that what you experienced? As you can see, the trichromatic theory doesn't explain the afterimage you just witnessed. This is where the opponent-process theory comes in (Hering, 1920). This theory states that our cones send information to retinal ganglion cells that respond to pairs of colors (red-green, blue-yellow, black-white). These specialized cells take information from the cones and compute the difference between the two colors—a process that explains why we cannot see reddish-green or bluish-yellow, as well as why we see afterimages. Color deficient vision can result from issues with the cones or retinal ganglion cells involved in color vision.

Visual Perception

Visual perception is how humans perceive objects in the surrounding environment using the light reflected by those objects. Visual perception is also known as sight and vision. The information is received by our eyes and then processed by our brains in order to distinguish between similar objects, colors, and relative distances.

Let’s take a closer look at how humans interpret size and depth, color and contrast, and context. All of these play an important role in designing effective interfaces.

Size and depth

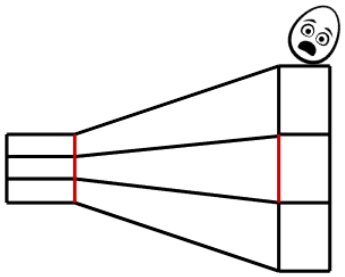
Visual angle is the angle of an object formed on the retina of our eye. It is also called the angular size of an object. Visual angle is affected by both the size of the object and its distance from the eye. There are two proven observations regarding how we perceive visual angle relative to the object’s distance and actual size:

- Two objects of the same size at different distances have different visual angles.
- Two objects of different sizes at different distances may have the same visual angle.

Note: Visual acuity is different from visual angle. Visual acuity is the ability of a person to see fine details clearly.

Law of size constancy: An object’s height and size are perceived as constant regardless of the object being moved away from or towards us.

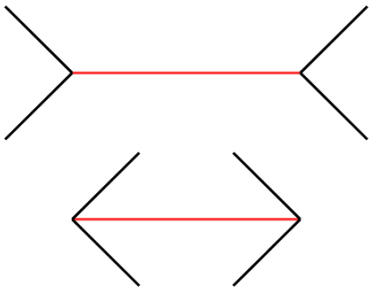
We are going to perform some activities that will solidify our understanding of these observations. Look at the image below. Humpty Dumpty is about to have a great fall because he just learned that both red lines are equal in length.



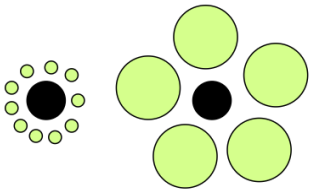
Humpty Dumpty on the wall

Not getting how this is possible? Take a ruler or paper and pen, and measure the length of both lines. They will be equal. The brain uses the converging lines as a source of perception and interprets that the left line is longer than the right one.

Let’s see some more examples. Here are two horizontal lines in Figure 1 and two groups of circles in Figure 2. Observe them keenly!



Gambar 1



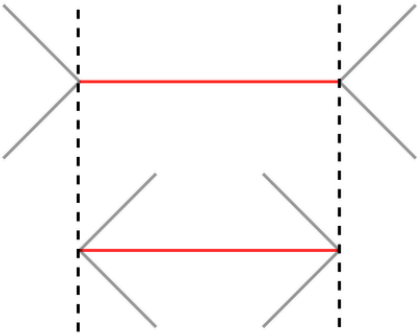
Gambar 2

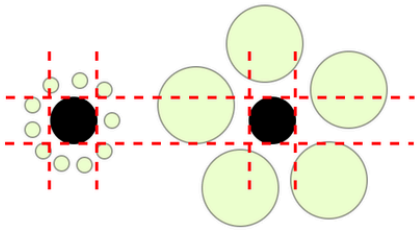
Point to ponder

1. Are the two red lines in Figure 1 the same length? How about the black circles in Figure 2. Are they the same size?

Answer:

Did you answer no to any of the questions? If you did, you are not alone. They are actually the same length and size; however, they appear to be different because the brain perceives cues that provide relative depth and size of the object based on other objects in the environment. In the case of the lines, the arrows on both sides of the lines provide wrong distance cues that lead the user to misestimate lengths. In the case of the black circles, the brain assumes the larger circles to be closer and smaller circles to be farther away. Thus, the brain automatically perceives that the black circles are different sizes. Look at these images below. Comparing them with dotted lines makes perceiving their actual size easier.



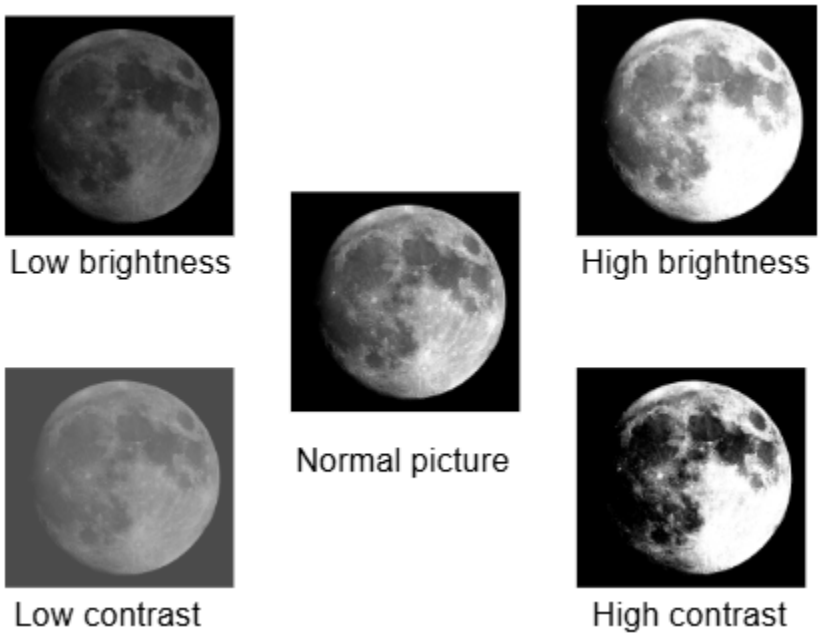


Another cue we use in perceiving the size of an object is our familiarity with that object. If we expect an object to be of a particular size, then, regardless of the surrounding, we see it as that size and judge the distance accordingly.

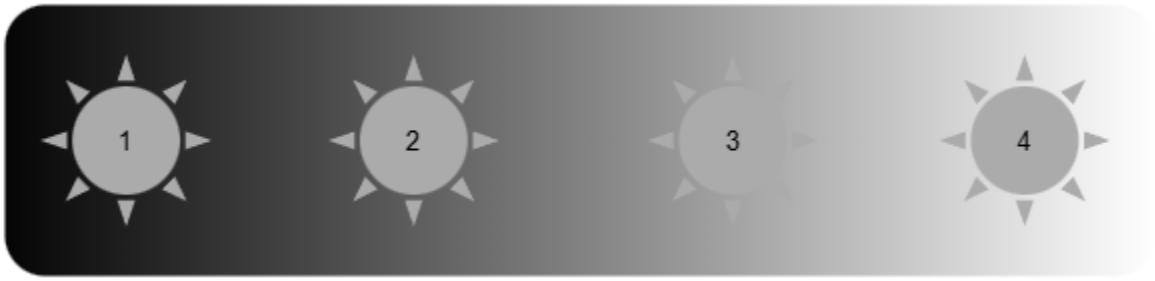
Brightness and contrast

Another aspect of visual perception is how humans perceive color and brightness. Brightness is the perception evoked by the luminance of a visual object. Luminance is the amount of light emitted or reflected by the surface of an object. An object can be differentiated from its

surroundings and background using contrast. Contrast is the difference between the color and brightness of an object and other objects in its surroundings and background.



Brightness and contrast comparison



Are the four suns in the above image the same color?

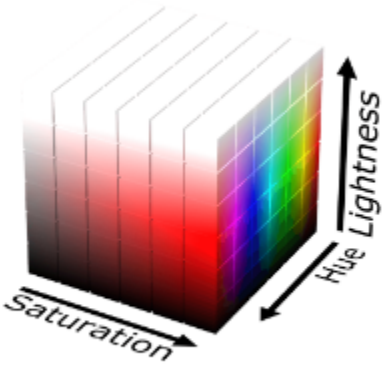
Yes, they are the same color. You might be wondering how this is possible. It's an optical illusion created by our brain perceiving the same color as different colors on different backgrounds.

Color

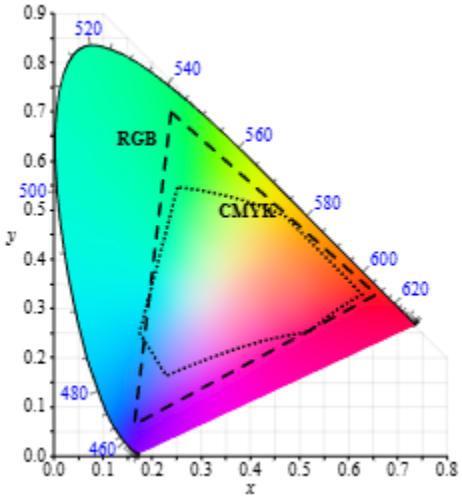
The second factor involved in visual perception is the perception of colors. There are only three main colors; red, blue, and green. Any other color is a combination of these three colors. This is called the RGB model. This model is commonly used to display images in electronic devices such as a television and monitor.
The HSI model is another attractive model, as it represents the colors just like a normal human eye interprets them. According to the HSI model, color is a composition of three components:

- Hue: The purity of color by the wavelength of light, i.e., pure yellow, pure green. Red has long wavelengths, green has medium, and blue has short wavelengths.
- Saturation: The purity of color determined by the amount of white mixed in it.
- Intensity: The brightness of color.

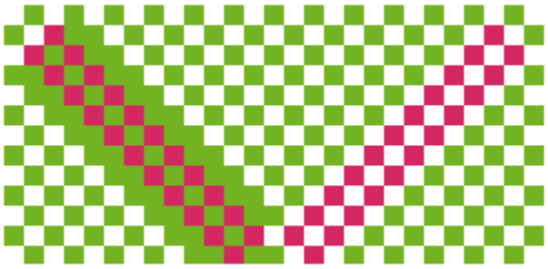
Another widely used model is the CMYK model. It consists of four basic colors: cyan, magenta, yellow, and black. The range of colors produced by this model is less than the RGB model. For example, bright colors such as neons cannot be produced using CMYK. Commercial printing presses use this model.



HSI model



Let's do a small experiment to better understand how the human eye interprets color.



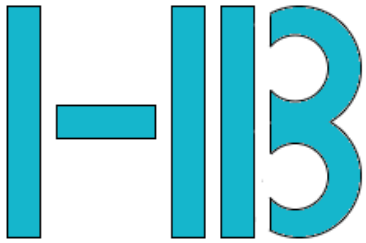
Look at the image above. How many colors does this picture have? Please consider white as the background and not as a separate color.

A. 2 Correct (The pink in the left half appears to be different but there is only one pink used in the picture.)
B. 3
C. 4

Note: The altered perception that occurred in the above picture is due to the fact that the human eye interprets a color by combining adjacent colors.

Context

Visual processing is the interpretation of a complete image. As we discussed above, familiarity with an object's size can help in resolving the perception of size. Similarly, if the context in which an object appears is known, then our ability to exploit and interpret expectations can help in resolving ambiguity.



Is it "1-113" or "HB"?

What do you perceive from the above image: "1-113" or "HB"? It could be either one! It is difficult to tell without knowing the context.

The same image, when used in two different contexts, can be perceived easily. Have a look at these two images.

311-113 MATCHBOX

Another example of how our expectations create illusions is the proofreading illusion, or when we fail to notice errors while reading a typed text. Read the text in the image below quickly.

1 2 3 4 5 6 7 8 9 10

Did you find the mitsake?

The word "mistake" is spelled incorrectly.

Visual perception in a nutshell:
Optical illusions are the differences between how we perceive things and how they actually are. Our perception of the objects that we see depends on the way they are composed together. Hence, while designing and interacting with an interface, we should keep in mind that things do not necessarily appear exactly as they are to the viewer.

Visual Perception and Colour

Data visualisation designers need to understand the laws and limitations of human visual perception. Humans do not directly perceive reality. Vision is our brain's reconstruction of reality put together using neural impulses triggered by light in the photoreceptors of our eyes. Our brains follow well known heuristics in it's construction of vision. Understanding and exploiting these heuristics will help you to understand and design effective data visualisations. Humans can also see in colour. Colour is one of the most powerful visual properties of human vision as it encodes vast amounts of information present in the environment. Therefore, colour is one of the most versatile tools used by data visualisation designers. This chapter will discuss some of the important rules about using colour effectively and responsibly.

Our Visual Information Processing System

In order to design good data visualisations you need to be aware of some of the important theory underlying visual perception. The goal of data visualisation "is to amplify cognition" (Kirk, 2012), but to do so, we need to be able to get a signal (data visualisation) through the human sensory system (eye, retina, optic nerve) and processed correctly by the brain. You might believe this process is simple and instinctual, but I assure you there is a lot going on and there is a lot that can go wrong. Visual perception is an enormous area of research, so, in this chapter we will focus on the big ideas and take home messages related to data visualisation. For the authoritative reference on this area please see Ware (2013).

We will first take a look at an overview of how visual information is processed by the brain. Ware (2013) proposes a simplified three stage model to help explain our eye's and brain's complex visual information processing system (see Figure 3.1). To start the process, our eyes scan a scene, such as a data visualisation. Our eyes convert light into electrical signals that travel along the optic nerve and into the visual cortex of the brain. Visual processing enters stage 1.

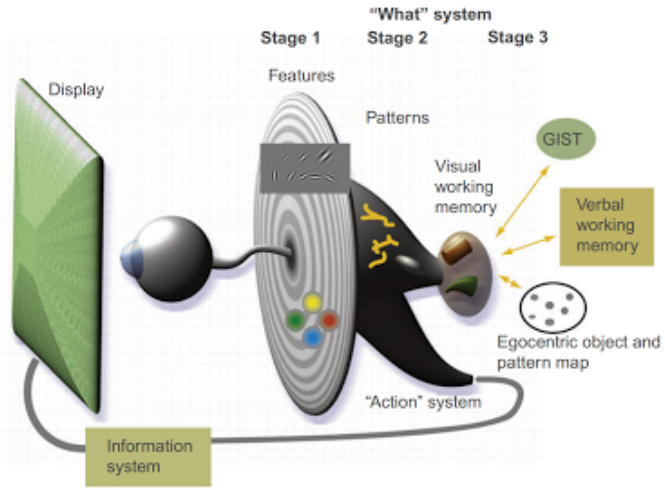


Figure 3.1: Ware's (2013) three stage model of visual information processing, p. 20.

Stage 1: Parallel Processing to Extract Low-Level Properties of the Visual Scene

Once the signal from our neurons in the eye reach the visual cortex, networks of billions of neurons work in parallel to extract low level properties of the visual field, such as colour, texture, orientation and movement. This happens automatically and unconsciously. The results of this process are held temporarily in iconic memory (<1000 ms), which is just enough time for our conscious processes to divert attention if required and move to the next stage. During stage 1, information that is optimised for recognition by the vast neuronal networks in the visual cortex will be readily detected and processed. This will enable efficient interpretation of our data visualisation.

Stage 2: Pattern Perception

During the pattern perception stage, information obtained from stage 1 is further processed in order to identify patterns. Our visual field is broken into regions and our brains analyse contours, regions of colour, texture and motion. Stage 2 starts to involve our attention as we choose to make visual queries of the display. This stage is slower and less automatic than stage 1 but is still very rapid. Patterns perceived in the visual display can be held for a few seconds in our memory. Our brains will also transition between our object perception pathways and our action pathways. Data visualisation mainly concerns the object recognition pathway or the “what” system. The action pathway relates to our body’s reaction to the environment. For example, the action of catching a ball rapidly approaching you.

Stage 3: Visual Working Memory
This is the fully conscious stage of visual information processing. Our attention has been drawn to a visual task, for example, interpreting a data visualisation that has caught our attention in an online news article. Our identification of the data visualisation based on the broad layout of the graphic is referred to as “gist”. We are all familiar with visual gist. Think about how quickly we can identify the scene of a TV show as you rapidly flick through channels. Almost instinctively, we can identify the broad spatial layout of the scene as something like a beach, park, bush, studio, house etc. This suggests another important implication for data visualisation. Using visualisations that have “gist” will lead to more rapid interpretation. For example, most people are familiar with common data visualisations such as bar charts and scatter plots. Using these familiar data visualisation methods will allow the viewer to get the “gist” of the data visualisation very quickly.

Once we get the gist of the visualisation, we commence a series of visual queries driven by stages 1 and 2. We employ visual search strategies to bring the information together. Our working memory allows us to keep a few pieces of the visualisation in mind at any one time, however, we can also exploit our long-term memory stores to help fill in the gaps and activate contextual cues.

With this in mind, Ware (2013) compiled the following list of the costs versus benefits considerations for data visualisation (p. 24 - 25):

- Where two or more tools can perform the same task, choose the one that allows for the most valuable work to be done per unit of time.

- Consider adopting novel design solutions only when the estimated pay-off is substantially greater than the cost of learning to use them.
- Unless the benefit of novelty outweighs the cost of inconsistency, adopt tools that are consistent with other commonly used tools.
- Effort spent on developing tools should be in proportion to the profits they are expected to generate. This means that small-market custom solutions should be developed only for high value cognitive work.

Essentially, however you choose to visualise your data, the benefit (knowledge and insight) must outweigh the cost in your time (creating the visualisation) and your audience's time (in processing and interpretation). Always try to keep it "perceptually" simple, or "kips" for short.

Important Visual Laws

A good data visualisation will allow the viewer to quickly find the important patterns that tell the story behind the data. There are well known rules and laws of human visual processing that allow us to do this job in the most efficient way possible. We are all, innately, but unconsciously familiar with these laws. Through hard-wiring and learning from our environment, our brains are highly tuned to process visual information in certain ways. We will start from the beginning with the most important law related to data visualisation - preattentive processing.

Preattentive Processing

What first draws your attention in Figure below?

Figure: Delicious.

The delicious cherries! Why? Why not the leaves or branches of the tree or the blue sky? Consider another example. What features in Figure below "pop-out" to you?

Figure: Paradise.

The curvature of the beach, the rows of coloured beach chairs, the vibrant blue of the ocean? Why did these things so readily draw our attention? These are examples of preattentive processing.

Let's consider another, more sterile, example. Count the number of 3s in the following sequence of numbers.

45929078059772098775972655665110049836645
27107462144654207079014738109743897010971
43907097349266847858715819048630901889074
25747072354745666142018774072849875310665

It takes a while, doesn't it! You have to visually scan each digit. Now, try again.

45929078059772098775972655665110049836645
27107462144654207079014738109743897010971
43907097349266847858715819048630901889074
25747072354745666142018774072849875310665

Much quicker, I bet. Now you only had to scan the colour red to count all the 3s. Colour is said to be preattentively processed. What exactly does this mean? Researchers discovered long ago that certain visual features appear to stand-out. Preattentive features were so quickly processed by the brain, that researchers originally believed such features were processed prior to conscious attention. This turned out to be not quite true, as attention is still necessary, but the name stuck. Ware (2013) defines preattentive processing as the degree to which a visual object is made available for our attention. Camouflage can be thought of the opposite of preattentive processing. Camouflage seeks to conceal objects by reducing the degree to which an object draws attention. Preattentive processing is a very powerful idea and governs much of "why" we design data visualisations using particular methods.

Colour, and many other features, are known to be preattentively processed. Figure below provides some concrete examples that demonstrate how other visual properties are preattentivelty processed. For contrast, the last two boxes (juncture and parallelism) are examples of features that are not preattentive.

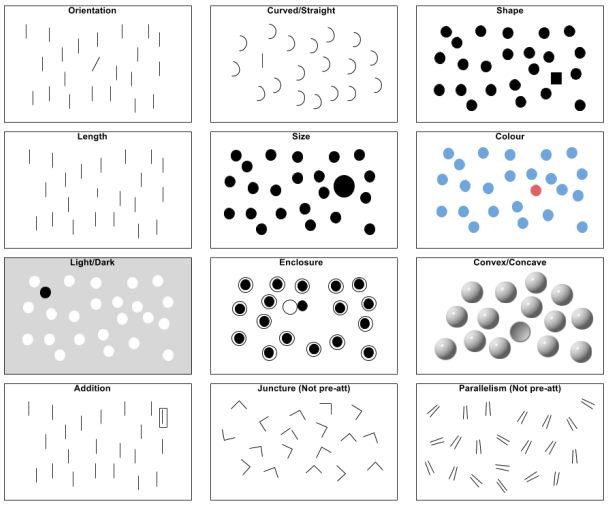


Figure: Examples of preattentively processed features adapted from Ware (2013).

Using preattentive features helps us to design data visualisations that allow efficient processing by the perceiver. For example, we use colour and shape to rapidly distinguish groups, and size, length and colour intensity to allow rapid comparisons. Many common data visualisation methods are based on preattentive principles. When designing your own, heed preattentive theory. Use it to draw the viewer's attention to the most important elements of the visualisation, while ensuring that other features of the visualisation don't detract attention from the story.

Gestalt Laws

The Gestalt (German translation meaning "pattern") school of psychology, founded in 1912, sought to understand the ways in which humans recognise visual patterns. It turns out that our brains are incredible at this task. Let's put ourselves to the test. Can you see the dog in Figure below?

Figure: Our brains fill in the gaps (Boyer and Sarkar 2000).

To someone who has never seen a dog, this image would appear to be a collection of black blobs. However, our brains use what are known as Gestalt laws to “fill in” the perceptual gaps and allow us to see the dog. Beware though, because we are highly tuned to see patterns in our environment, we are also known to get it wrong, sometimes very wrong! Our psychological predisposition to see patterns, where no patterns exist, is referred to as pareidolia. A prime example was the face on Mars (Figure below).

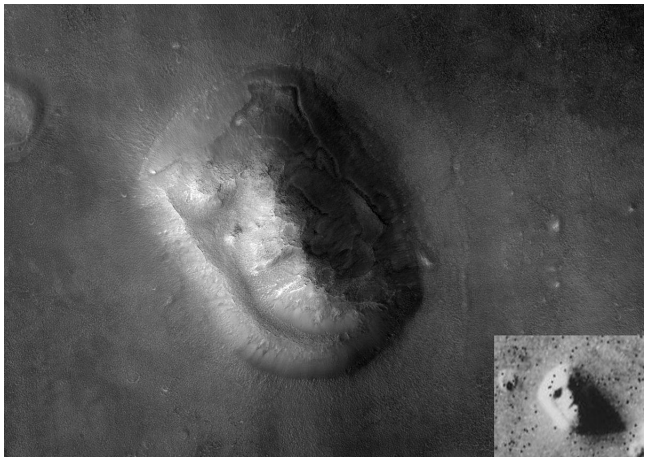


Figure 3.6: Face on Mars (NASA 2007).

There are heaps of other hilarious examples to be found on the internet. As long as you don’t actually believe that Jesus is appearing in your food, enjoy this human tendency. There are eight common Gestalt laws that you need to know about. These laws are introduced in the following sections. We will also consider how these laws apply to data visualisation.

Proximity

Objects close or clustering together are perceptually grouped (Figure below). Data visualisations use proximity to highlight relationships between categories and trends in the data. This also means that spacing can be used to visualise no relationship.

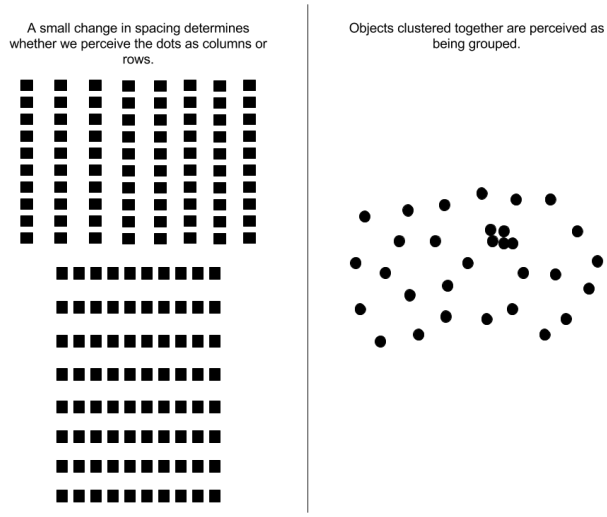


Figure 3.7: Proximity examples.

Similarity

Objects of similar characteristics (e.g. size, shape, colour) are grouped (Figure below). Visualisation implication: Use colour, size, shape and other attributes to group related objects or to differentiate between categories.

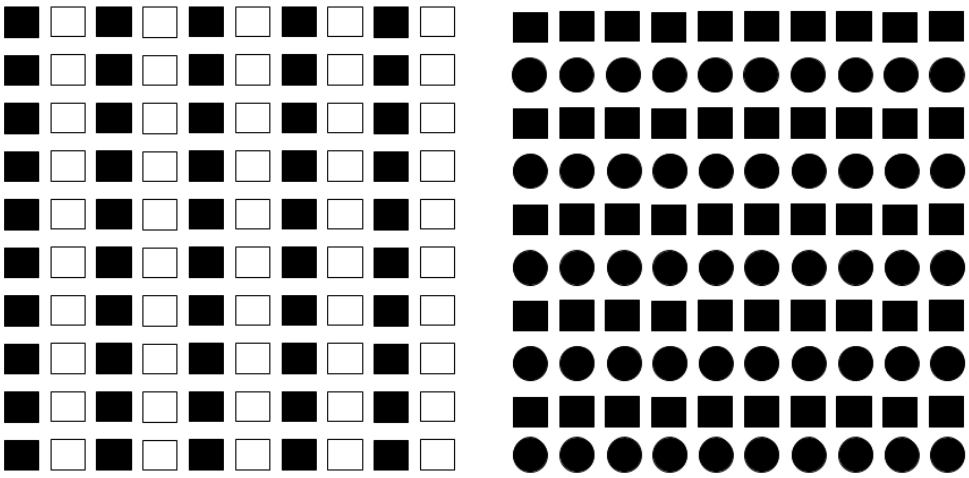


Figure 3.9: Similarity examples.

The choropleth map of the 2019 Australian Federal Election results by the Guardian demonstrates this law (Figure below). Colour is used to represent political parties. Electorates sharing the same colours are grouped together so the viewer can quickly see which seats belong to Labour, the Coalition and other parties.

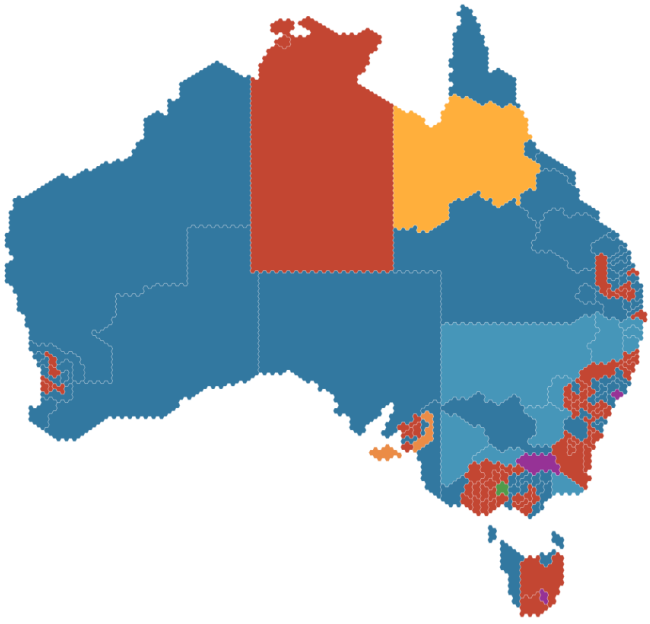


Figure: The 2019 Australian Federal Election results (The Guardian 2019).

Inattentional blindness shows us that human beings have a limited ability to hold information in short-term memory. If we over-burden the viewer with unnecessary visual complexity or too many irrelevant/redundant objects, we run the risk of the viewer missing important details. To avoid inattentional blindness ruining our data visualisations, Kirk's process (Chapter 1) cautions us to exercise editorial focus and narrow down on the salient features of the data.

How Does Visual Perception Affect UX Design

Visual perception plays a crucial role in user experience (UX) design as it fundamentally influences how users understand and interact with digital products. It encompasses the way our brain interprets visual information from the environment, which impacts decision-making, usability, and overall satisfaction with a product. Here's how visual perception impacts UX design:

1. First Impressions and Aesthetics

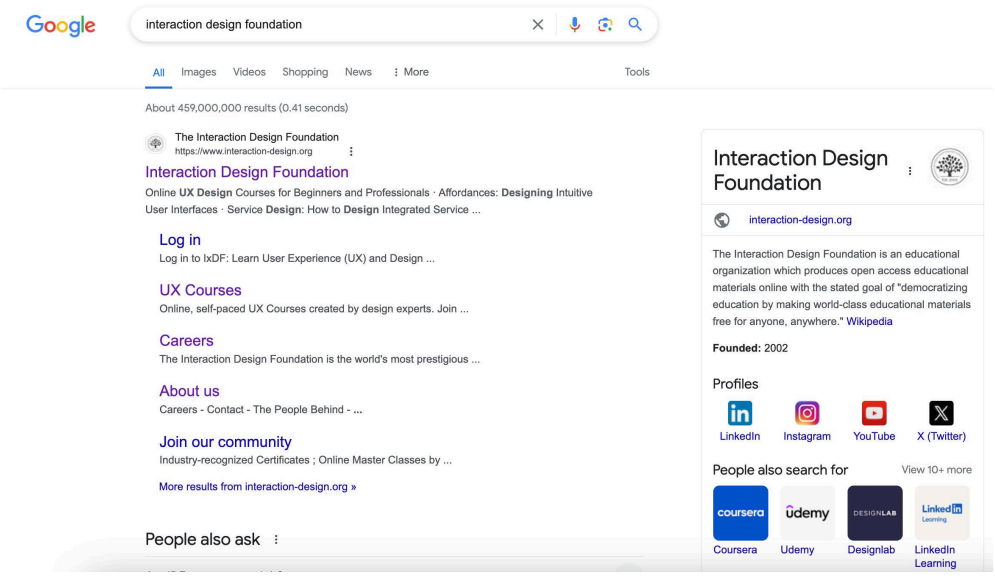
Visual perception shapes the first impressions users have of a product. Attractive designs are perceived as more usable and trustworthy. This aesthetic-usability effect means that visually appealing interfaces can positively influence user satisfaction and loyalty from the moment they encounter the product.

Since its launch in 2007, The Apple iPhone's sleek design, intuitive interface, and overall aesthetic appeal significantly influenced its market success. Consumers perceived it as not only a symbol of innovation but also as a highly usable and trustworthy device, which contributed to strong user satisfaction and brand loyalty. This demonstrates how first impressions based on visual perception can have a lasting impact on product success.

2. Hierarchy and Structure

Through the use of visual hierarchy, designers can guide users' attention to important elements first. Size, color, contrast, and placement all play roles in how users perceive the importance of various elements on a page. This helps to create a structure that aligns with users' natural scanning patterns, such as the F-pattern or Z-pattern, improving the effectiveness of information presentation and navigation.

Google's search engine uses size, color, contrast, and placement strategically to differentiate between types of results (e.g., ads, organic results, featured snippets) and to highlight key information. The design ensures users quickly see the most relevant results and additional helpful features like questions related to their search. This structure aligns with natural scanning patterns, which enhances the user's ability to find information efficiently and navigate the page effectively.



3. Simplicity and Clarity

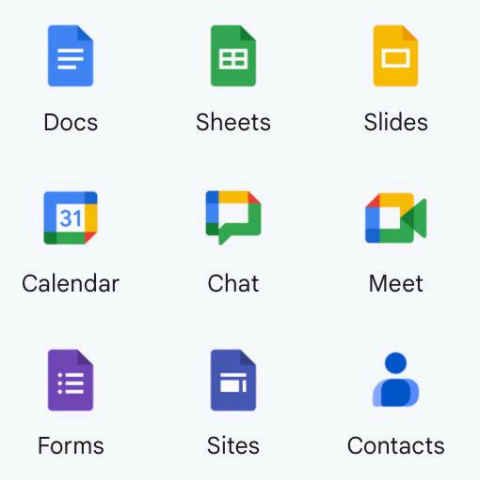
Visual perception underlines the importance of simplicity in design. Overly complex or cluttered interfaces can overwhelm users, which leads to confusion and frustration. Designers can create clear and concise interfaces that communicate more with less when they leverage users' visual perception which enhances usability and reduces cognitive load.

WhatsApp's design avoids clutter by using a clean layout, straightforward navigation, and intuitive icons, which makes it easy for users of all ages and tech-savviness to communicate effectively. This simplicity ensures users can focus on their primary task—messaging—without unnecessary distractions or complications. This demonstrates how leveraging visual perception to create clear and concise interfaces can significantly enhance usability and user satisfaction.

4. Consistency and Familiarity

Consistent visual elements across a product, such as color schemes, typography, and iconography, leverage users' visual memory and perception, making interfaces more intuitive and learnable. Familiar design patterns and conventions, like the placement of a logo at the top left corner or navigation menus at the top of a webpage, play into users' pre-existing visual perceptions, facilitating smoother interactions.

Google's suite of products, including Gmail, Google Drive, and Google Docs are consistent and familiar. Google maintains a consistent color scheme, typography, and iconography across these services, which leverages users' visual memory to make navigation and interaction more intuitive. Additionally, the familiar placement of key elements, such as the app launcher icon in the top right corner and the search bar prominently displayed at the top, aligns with users' expectations based on prior web experiences, facilitating smoother and more efficient interactions across different Google products.



Several of Google's product icons—the consistency of their visual design help make them recognizable.

5. Color Psychology and Accessibility

Colors have psychological effects that can influence how users feel and behave. For example, blue can convey trust and security, while orange might be used for calls to action due to its high visibility and association with action. Additionally, understanding visual perception is crucial for designing accessible interfaces, ensuring that color choices and contrasts accommodate users with visual impairments, such as color blindness.

Bank of America's online platform predominantly uses blue hues throughout its interface, leveraging the color's association with trust, security, and stability, which are crucial in the context of financial transactions. For calls to action, such as submitting forms or proceeding to the next step in a transaction, the platform often employs colors like green or orange, which are visible and convey a sense of progress or action. Furthermore, Bank of America's online platform is designed with accessibility in mind, offering high contrast options and color schemes that are considerate of users with color vision deficiencies to ensure that all users can navigate and use the services effectively, regardless of their visual abilities.

6. Motion and Interaction

Visual perception influences how users perceive and react to motion within an interface. Well-designed animations can direct attention, indicate actions, and provide feedback, enhancing the interactive experience. However, it's important to use motion thoughtfully to avoid distracting or disorienting users.

Slack incorporates thoughtful animations and transitions for activities such as switching between different chat channels, sending messages, and receiving notifications. For instance, when a message is sent, users see a smooth transition that visually confirms the message's delivery, and notification animations are designed to catch the user's attention without being intrusive. These subtle motions help in making the digital workspace feel more dynamic and responsive, fostering a more engaging and intuitive user experience.

3. Hearing and Auditory Interaction (30 mins)

- Role of sound in feedback (e.g., error alerts, notifications).
- Designing auditory cues without overwhelming users.
- Example: Voice interfaces (Alexa/Siri) and sound in gaming.

The Role of Sound Design in UX Design: Beyond Notifications and Alerts

Sound is an integral part of people's daily experiences, shaping their perceptions and experiences in ways that they often don't even notice. From the hum of city traffic to the rustling of leaves in a breeze, sound adds a layer of richness to our world, giving it color and depth.
However, in the digital world, designers often relegate sound to a supporting role—a functional necessity or a mere afterthought. In software user experiences, sound is often limited to the pings and beeps that alert users to incoming messages or system updates. These auditory cues certainly serve their purpose, but they barely scratch the surface of sound's true potential in enhancing the user experience.

What if sound could do more than just tell us when to pay attention? When thoughtfully crafted, sound can transform digital experiences into immersive, multisensory environments. Just as a movie's soundtrack can evoke people's emotions and heighten their engagement, carefully curated sounds can guide users through an app or Web site, evoking desired moods and creating a deeper connection with the digital experience.

In this article, I'll consider some transformative ways in which UX designers can use sound to craft a sensory experience that elevates user engagement and satisfaction.

Enhancing Accessibility

Sound plays a crucial role in helping users who have visual impairments to navigate digital environments with confidence and ease. By providing auditory cues for navigation and feedback, it becomes possible for these users to interact with digital content more effectively.

Apple's VoiceOver feature, for example, uses distinct sounds to distinguish between different types of content, helping visually impaired users quickly grasp the structure of a page. Similarly, Microsoft's Narrator includes customizable auditory feedback to help users understand page layouts and interact with controls. These examples illustrate how sound design can break down barriers, transforming digital interfaces into inclusive digital experiences in which everyone can engage more fully.

Creating Emotional Connections

Sound wields an incredible power to evoke emotions, influence people's mood, and shape how they perceive the world around them. Likewise, it's no secret that sound shapes a person's perception of a brand. But you don't need a psychology degree to connect the emotional intent

of a UX element to a corresponding tone. In digital user interfaces, sound can help create memorable and engaging experiences that build a distinctive identity and resonate deeply with users.

Consider the comforting warmth of Netflix's iconic ta-dum that ushers viewers into its familiar world of entertainment or the triumphant chime that accompanies reaching a new level in a favorite game. These audio cues have become synonymous with their respective brands, immediately evoking excitement or satisfaction.

Such strategic use of sound can amplify brand recognition and reinforce messaging while creating consistent emotional experiences that leave lasting impressions. Whether it's an upbeat jingle that energizes the checkout process or a soothing tone that rewards task completion, using sound to merge brand strategy and the user experience is a great way to enhance user satisfaction and help people connect with a brand's core values.

Guiding User Interactions

Beyond its emotional impact, sound is a powerful navigational tool that can subtly and effectively engage the audience throughout their user journey. When you thoughtfully integrate auditory feedback into the user interface, it provides users with real-time confirmations and helps them better understand the outcomes of their actions. This instant feedback is critical to reinforcing correct behaviors, reducing errors, and enhancing overall usability.

A well-placed click or tone reassures users that a button press was successful or a transaction was completed, while error beeps signal the need for corrective action. These sound cues can also offer contextual information. For instance, adjusting the volume on a device often includes a distinct series of beeps that increase or decrease in pitch or volume, giving immediate and easy-to-understand feedback.

Google Maps exemplifies sound design that supports navigation, offering clear audio directions that help drivers stay on track without the distraction of checking their screen. Similarly, Apple's iOS keyboard provides subtle clicks with each keystroke, ensuring that users know when they've successfully input some text. In gaming, the directional sounds in first-person shooter games let players pinpoint enemy locations, enhancing gameplay strategy.

Likewise, completing more complex actions such as financial transactions or signing a document with a digital signature can also be acknowledged with imposing, but not overbearing sounds that emphasize trust and security. These examples demonstrate how smart sound design can clarify interactions, making digital experiences more fluid and enjoyable. The right mix of sounds can elevate even small actions such as opening a menu or logging in or out of an app. By providing users with auditory confirmations and context, sound can guide them effortlessly through the most complex tasks, improving their overall experience.

Crafting Immersive Experiences

Sound also plays a vital role in crafting immersive experiences, anchoring users in digital environments with a sense of depth and presence. The right blend of sounds can transport

people into vivid, believable worlds where every footstep echoes and ambient sounds shift as they move through different spaces. This auditory immersion engages users' imaginations and blurs the lines between the physical and virtual worlds. The power of sound to evoke a sense of immersion is particularly evident in virtual reality (VR) and augmented reality (AR) environments.

For these simulated worlds, sound design becomes an essential tool in establishing a convincing, believable reality. From the subtle rustling of leaves in a virtual forest to the hubbub of a simulated marketplace, meticulously crafted audio elements can heighten the user's sense of presence, making them feel as though they've been transported to another realm.

Sound design can also establish continuity and rhythm, creating a seamless flow across different scenes or interactions. In storytelling games such as The Last of Us, audio helps convey the tense emotions of characters through carefully orchestrated ambient sounds and music. Meanwhile, fitness apps such as Supernatural VR use rhythm-based audio cues to guide users through their workouts, keeping them motivated and focused.

Gamification and User Engagement

Incorporating sound effects for achievements and rewards can transform mundane digital tasks into rewarding experiences through gamification. The satisfying chime the user hears after completing a level of a game, the upbeat jingle celebrating a goal achieved, or the triumphant fanfare marking a personal milestone all provide auditory affirmations that keep users motivated and engaged. These rewarding sounds can reinforce positive behaviors and encourage users to continue progressing, a hallmark of successful gamification.

In combination with other sensory elements such as haptics or visual effects, sound can deepen user engagement. For instance, vibrant animations accompanied by a complementary audio track can create dynamic responses that capture the user's attention. In AR games such as Pokémon GO, the sound of a Pokémon appearing is paired with a vibration and an on-screen visual effect, providing a multisensory cue that enhances the excitement of the encounter.

Practical Considerations for Integrating Sound in UX Design

While sound design can significantly enhance the user experience, its integration requires thoughtful planning to ensure that it complements the broader user interface.

A well-crafted auditory experience considers users' needs and preferences while balancing the impacts of other sensory elements. Let's consider some practical guidelines to follow when incorporating sound into your UX designs:

- Establish a sound strategy. When creating a Web site or an app, don't forget your sound strategy. Start by defining the goals of sound design. Is it intended to confirm actions, provide feedback, or set a mood? What is the overarching auditory language for a digital product? A clear strategy ensures that each sound serves a meaningful function within the overall user experience.

- Balance sound design with other UX elements. Audio should harmonize with the user interface's visual layout, haptic feedback, and navigation to create a cohesive user experience. Consider how sound would complement these other components without overwhelming the user interface.
- Consider accessibility and user control. Offer customizable settings so users can adjust or disable sounds according to their preferences and needs. Ensure that you design auditory cues with accessibility in mind, providing clear guidance for users with visual or auditory impairments.
- Choose subtlety over intrusiveness. Sound should enhance users' interactions without being too prominent or distracting. Avoid overwhelming users with loud or excessively intrusive sounds. Instead, prioritize subtlety and moderation to create a more refined auditory experience.

Wrapping Up

In UX design, sound can be a transformative element that does much more than notify and alert the user. When it is executed well, sound design turns everyday tasks into memorable journeys and creates multisensory interactions that captivate users on deeper levels. By experimenting with sound, you can create digital worlds that are not only seen but truly felt.

Sounds in User Experience: The Invisible Power of Auditory Design

Sound was the catalyst that initially sparked my interest in technology. Back when I was attending a multimedia class at university 25 years ago, one of the docents mentioned something that stuck with me — the notion that nearly anything could be stored in a database, even sound. Given my passion for sound engineering and music, this idea immediately captivated me. It did take me several good years to fully grasp the intricacies of managing audio within a database. However, throughout this journey, I discovered a multitude of exciting opportunities for incorporating sound into my career as a human interface designer.

User experience (UX) design is a multifaceted discipline that seeks to create seamless, enjoyable interactions between humans and digital products. While visual elements often take the spotlight in UX discussions, the role of sound in shaping our experiences is equally crucial and often overlooked. In this article, we'll explore the psychology of sound, the principles of sound design, its impact on UX, and the future trends in this fascinating field.

The Psychology of Sound

Before delving into the world of sound design, it's essential to understand the psychology behind how we perceive and react to sounds.

Sound is a multi-sensory experience, and our brains process auditory information in conjunction with visual, tactile, and even olfactory cues. This integration of sensory inputs shapes our overall perception of the world around us. Here are some key aspects of auditory perception:

1. Soundscape: Our brains use auditory cues to determine the direction and distance of sounds. This is essential for spatial awareness and can be crucial for survival.

2. Emotional Responses: Sounds have the power to evoke strong emotions. For example, the sound of a baby laughing is universally associated with joy, while a sudden loud noise can trigger fear or startle reactions.

3. Cognitive Processing: Auditory information is processed rapidly in the brain. It often takes less time to recognize and respond to sounds than visual stimuli. This quick processing can influence our behavior and decision-making.

4. Associations and Memories: Sounds are strongly linked to memories and associations. Hearing a particular song may transport you back in time to a specific moment in your life, eliciting emotions associated with that memory, one of true instances of synesthesia.

Emotional Impact of Sounds

The emotional impact of sounds is a fascinating area of study within auditory psychology. Different types of sounds can evoke a wide range of emotions:

1. Positive Emotions: Uplifting music, laughter, and nature sounds like birdsong often evoke positive emotions such as happiness, contentment, or relaxation.

2. Negative Emotions: Harsh or dissonant sounds, as well as sudden loud noises like alarms, can trigger negative emotions like stress, anxiety, or annoyance.

3. Emotionally Neutral Sounds: Some sounds, like white noise or background chatter, may not elicit strong emotions but can still affect our mood and concentration levels.

Auditory Cues and Decision-Making

Sounds also play a role in guiding our decision-making processes. In many situations, we rely on auditory cues to make judgments and choices:

1. Safety: We use sounds to assess our environment for potential threats. The sound of footsteps approaching from behind, for instance, can trigger a fight-or-flight response.

2. Trust and Familiarity: Familiar sounds can instill a sense of trust and comfort. For instance, the sound of a well-designed car engine can convey reliability and quality.

3. Productivity: In work and study environments, background sounds like ambient music or white noise can enhance focus and productivity by masking distractions.

Sound Design Principles

Good sound design in UX is rooted in several fundamental principles:

1. Affordances

Affordances refer to the perceived action possibilities of an object or interface. In sound design, this principle involves making sounds match their associated actions or functions.

Users should intuitively understand how to interact with a digital product based on the sounds it emits. For example, a soft “click” sound when pressing a button indicates that an action has been taken. This auditory cue provides a clear affordance, helping users understand the functionality of the interface.

2. Feedback

Feedback in sound design involves providing users with immediate and informative responses to their actions.

Auditory feedback is crucial for confirming that an action has been successfully executed. It can also serve as error alerts, guiding users in correcting their actions when something goes wrong. Effective feedback enhances the user’s sense of control and comprehension of the system.

3. Consistency

Consistency in sound design ensures that similar actions or elements produce similar sounds throughout a digital product.

Maintaining a consistent auditory language across an application or website is essential for user comprehension and predictability. Users should be able to rely on sound cues to navigate and interact with the interface confidently. For example, buttons of the same type should produce the same sound when clicked, creating a sense of familiarity.

4. Hierarchy

Hierarchy in sound design involves assigning different levels of importance or prominence to various auditory elements.

In complex digital products or multimedia experiences, not all sounds are equal in significance. Hierarchy helps users focus on the most critical auditory cues while filtering out less important ones. For example, in a video game, the sound of an approaching enemy might take precedence over ambient background noise.

5. Context Sensitivity

Context sensitivity means that sound design adapts to the user’s context or situation.

Sound should respond to the user’s actions and the context in which they occur. For instance, in a messaging app, the notification sound for a new message may vary depending on whether the

user is in a quiet meeting or a noisy café. Context-sensitive sound design ensures that the auditory experience is appropriate and non-disruptive.

6. Accessibility

Accessibility in sound design involves making auditory elements inclusive and usable by individuals with disabilities.

Sound is not just about hearing but also about conveying information. Considerations for accessibility include providing alternative auditory cues for those with hearing impairments, ensuring compatibility with screen readers, and offering customization options for volume and pitch.

7. Aesthetic Appeal

Aesthetic appeal in sound design relates to creating sounds that are pleasant, engaging, and aligned with the overall design aesthetics.

The auditory experience should complement the visual and functional aspects of a product. Well-designed sounds can enhance the user's emotional connection to the product and contribute to an enjoyable and memorable experience. For example, a beautifully composed theme music can set the tone for a video game or app.

8. User Testing and Iteration

User testing and iteration involve collecting feedback from users and refining the sound design based on their preferences and responses.

Sound design is not a one-time task but an ongoing process. User testing helps identify what works and what needs improvement. Iteration ensures that the auditory experience aligns with user expectations and preferences.

Auditory Feedback

Auditory feedback, also known as audio feedback or sonic feedback, is a fundamental aspect of sound design in various fields, including user experience (UX), technology, and human-machine interactions. It involves the use of sound to provide users with real-time information about the outcomes of their actions or the state of a system. Let's delve into the details of auditory feedback:

The Role of Auditory Feedback

1. Confirmation of User Actions

Auditory feedback confirms to users that their input or action has been successfully executed. It's akin to a reassuring nod that tells users, "Yes, your command was received and acted upon." This confirmation is particularly crucial in situations where visual feedback may be limited, such

as when interacting with voice-activated systems or while using touchscreens without tactile feedback.

2. Error Detection and Alerts

Auditory feedback also serves as a tool for error detection and alerts. When something goes wrong or if the user's action is not permitted, distinct auditory cues can inform them about the issue. These error sounds can range from gentle warning tones to more attention-grabbing alarms, depending on the severity of the problem. This helps users quickly identify and address errors, improving the overall user experience.

3. State Changes and Updates

In complex systems or applications, auditory feedback is used to convey changes in the system's state. For instance, in a navigation app, users may receive voice instructions to turn left or right. These spoken directions serve as auditory feedback, keeping users informed about their progress and the next steps to take.

4. Progress and Completion Indicators

Auditory cues are also used as progress indicators or signals of task completion. Consider a file download; the sound of a completed download is a form of auditory feedback that tells the user the task has finished successfully. Similarly, during video editing, audio feedback can indicate the completion of rendering or exporting a video project.

Designing Effective Auditory Feedback

Creating effective auditory feedback requires careful consideration of various design principles:

1. Clarity: Auditory feedback should be clear and distinct, ensuring users can easily differentiate between different cues. Consistency in sound design is essential so that users can develop an understanding of what each sound represents.

2. Relevance: Feedback sounds should be contextually relevant. They should match the user's action and the situation. For example, a camera shutter sound confirms taking a photo, while a "whoosh" sound can signify sending a message.

3. Customization: In many applications, users appreciate the ability to customize feedback sounds. Allowing users to choose from a range of sound options or adjust volume settings can enhance their overall experience.

4. Accessibility: Consider the needs of users with disabilities. Provide alternative forms of feedback for individuals who may have difficulty hearing, such as visual cues or vibrations.

5. Non-Intrusiveness: While feedback sounds should grab the user's attention when necessary (e.g., for error alerts), they should generally be non-intrusive and not disrupt the user's focus.

6. User Testing: Iterative design involving user testing is vital to ensure that the chosen auditory feedback elements align with user expectations and preferences.

Examples

To illustrate the concept, consider the following real-world examples:

- Smartphone Keystrokes: The subtle click sound when typing on a smartphone keyboard confirms each keypress, enhancing the typing experience.
- Car Safety Alerts: Modern vehicles often include auditory feedback for safety features like lane departure warnings, ensuring drivers are aware of potential dangers.
- E-commerce Checkout: The satisfying “ding” sound after successfully completing an online purchase provides a sense of accomplishment and security to the user.

Sonic Branding

Sonic branding, also known as audio branding or sound branding, is a strategic approach used by businesses and organizations to create a distinctive and memorable auditory identity. Similar to visual branding, which involves logos, colors, and visual elements, sonic branding focuses on creating unique and recognizable sounds or music to represent a brand. Let’s delve into the details of sonic branding:

The Importance of Sonic Branding

Sonic branding is essential for several reasons:

1. Brand Recognition: Just as a well-designed logo helps consumers instantly recognize a brand, distinctive sonic elements can achieve the same effect. When consumers hear a specific sound or piece of music, they should immediately associate it with a particular brand.

2. Emotional Connection: Music and sound have a powerful impact on emotions. Sonic branding allows brands to evoke specific feelings and emotions in their audience. For example, a soothing melody can create a sense of calm, while an upbeat tune can inspire energy and enthusiasm.

3. Consistency: Sonic branding ensures consistency across various touchpoints. Whether it’s in advertising, on websites, in apps, or in physical stores, consistent sound elements reinforce brand identity and messaging.

4. Memorability: Memorable jingles or sonic cues can stay with consumers long after they’ve encountered them. This can lead to increased brand recall and loyalty.

Elements of Sonic Branding

Sonic branding involves several key elements:

1. Audio Logo: An audio logo, also known as a mnemonic or audio signature, is a concise and distinctive sound that represents a brand. It's often used at the beginning or end of commercials, videos, or other brand-related content. Famous examples include the Intel jingle or the McDonald's "I'm Lovin' It" jingle.

2. Brand Theme Music: Some brands create original theme music that becomes synonymous with their identity. Think of the Intel "Intel Inside" theme or the NBC chimes, which have been in use for decades.

3. Soundscapes: Some brands develop a unique soundscape that represents their brand. This can include ambient sounds, nature sounds, or other auditory elements that create a specific atmosphere associated with the brand.

4. Voice and Tone: The choice of voice actors and the tone of voice in audio advertising or brand content also play a role in sonic branding. Familiar voices or a consistent tone can reinforce brand identity.

5. Sound Effects: Even specific sound effects can become part of a brand's identity. For example, the "swish" sound in Nike's commercials has become iconic.

The Process of Creating Sonic Branding

Creating effective sonic branding involves a structured process:

1. Brand Analysis: Understand the brand's values, mission, target audience, and overall identity. Consider how sound can convey these elements.

2. Creative Development: Work with composers, sound designers, and musicians to create sonic elements that align with the brand's identity and objectives.

3. Testing and Refinement: Test the sonic elements with focus groups or target audiences to ensure they evoke the desired emotional response and brand association.

4. Implementation: Integrate the sonic branding elements across all relevant touchpoints, including advertising, digital platforms, phone systems, and physical locations.

5. Consistent Use: Continually use and reinforce the sonic branding elements to build recognition and association over time.

Successful Examples of Sonic Branding

Several brands have achieved success with sonic branding:

- Intel: The five-note Intel jingle is one of the most recognizable audio logos in the tech industry.

- McDonald's: The "I'm Lovin' It" jingle is heard worldwide in McDonald's advertising.
- Nokia: The Nokia ringtone is iconic and instantly associated with the brand.
- Microsoft: The Windows startup sound is a well-known example of sonic branding.

Accessibility and Inclusivity

Sound is also a crucial element for making digital products accessible to all users. It plays a significant role in providing information to those with visual impairments. Features like screen readers and haptic feedback rely on sound to convey information.

Usage

To illustrate the real-world impact of sound in UX, here are few samples:

1. Mobile Banking App: The use of a subtle "cha-ching" sound when a financial transaction is successful provides users with a sense of accomplishment and reassurance.
2. Video Streaming Service: The distinct sound that plays when a video is paused or resumed helps users easily track the status of their content.

Challenges and Pitfalls

While sounds can significantly enhance the user experience (UX), they also present challenges and potential pitfalls that designers must carefully consider. Let's explore these challenges and pitfalls:

Challenges of Using Sounds in UX

1. Overwhelming Users:
    - Challenge: Too many sounds or overly complex auditory feedback can overwhelm users, leading to a negative experience.
    - Approach: Prioritize essential sounds and use them sparingly. Ensure that sounds are relevant and not excessive.
2. Intrusiveness:
    - Challenge: Sounds can be disruptive, especially in quiet or public settings, potentially annoying users.
    - Approach: Provide options for users to control or mute sounds. Use non-intrusive sounds when possible, and avoid auto-playing audio.
3. Inconsistent Interpretation:
    - Challenge: Users may interpret sounds differently based on cultural or personal backgrounds, leading to potential miscommunication.
    - Approach: Conduct user testing to ensure that sounds convey the intended meaning universally. Use culturally neutral sounds when possible.
4. Accessibility:
    - Challenge: Not all users can hear or interpret sounds, which can exclude individuals with hearing impairments.

- Approach: Offer alternative forms of feedback, such as visual cues or vibrations. Ensure compatibility with screen readers for auditory information.

5. Distracting from Key Tasks:
   - Challenge: Sounds that are too attention-grabbing can divert users' focus away from their primary tasks.
   - Approach: Design sounds that enhance, rather than detract from, the user's main objectives. Avoid using overly flashy or distracting sounds.

Pitfalls of Using Sounds in UX

1. Poorly Designed Feedback Sounds:
   - Pitfall: If auditory feedback is poorly designed, it can confuse users rather than provide clarity.
   - Prevention: Test feedback sounds with users to ensure they understand their meaning and purpose.
2. Inconsistent Branding:
   - Pitfall: Inconsistent use of sounds can dilute a brand's identity and create confusion.
   - Prevention: Maintain a consistent auditory language across all brand touchpoints and products.
3. Complex Soundscapes:
   - Pitfall: Complex or layered soundscapes may overwhelm users, making it difficult to process information.
   - Prevention: Keep soundscapes simple and avoid overloading users with multiple auditory elements simultaneously.
4. Ignoring User Preferences:
   - Pitfall: Failing to allow users to customize or control sound settings can lead to frustration.
   - Prevention: Provide options for users to adjust sound volume, disable specific sounds, or choose from a range of feedback options.
5. Lack of Testing:
   - Pitfall: Implementing sounds without user testing can result in unexpected negative reactions.
   - Prevention: Conduct usability testing with representative users to gather feedback on sound design choices.

Future Trends

The field of sound design in UX is evolving rapidly, and several exciting future trends are shaping how sound will be integrated into user experiences. These trends leverage advancements in technology and a deeper understanding of human perception. Here are some future trends of sounds in UX:

1. Spatial Audio for Immersive Experiences

Trend: Spatial audio is gaining prominence in UX, especially in virtual and augmented reality (VR/AR) applications. It allows designers to create immersive 3D soundscapes, enhancing the sense of presence and realism in virtual environments.

Impact: Users will experience more realistic and engaging interactions in VR/AR environments, such as games, training simulations, and virtual tours. Sounds will be spatially positioned, giving users a sense of direction and depth, which is crucial for navigation and situational awareness.

2. AI-Generated Sounds

Trend: Artificial intelligence (AI) is being used to generate and adapt sounds dynamically based on user interactions and environmental factors. AI-driven sound synthesis can create unique and contextually relevant auditory experiences.

Impact: AI-generated sounds can provide personalized and responsive feedback to users. For example, an AI-driven voice assistant can adapt its tone and responses based on the user's mood or context, making interactions more natural and empathetic.

3. Sonic Personalization

Trend: UX designers are exploring ways to personalize sound experiences for individual users. This involves tailoring sounds to match a user's preferences, habits, and sensory abilities.

Impact: Users will have the option to customize soundscapes, feedback tones, and voice interfaces to suit their preferences. This personalization enhances user comfort and engagement while ensuring accessibility for individuals with varying auditory needs.

4. Multimodal Experiences

Trend: The integration of sound with other sensory modalities (such as touch and sight) is becoming more prevalent. This trend aims to create richer, multimodal user experiences.

Impact: Users will encounter digital products and interfaces that seamlessly combine sound, haptic feedback, and visual elements to provide comprehensive and engaging interactions. For example, a gaming controller may provide synchronized haptic feedback and sound effects for a more immersive gaming experience.

5. Minimalist and Subtle Sound Design

Trend: In contrast to the early days of digital interfaces filled with attention-grabbing sounds, there's a trend towards minimalist and subtle sound design. Designers are prioritizing non-intrusive auditory feedback.

Impact: Users will appreciate digital products and applications that use sound sparingly and thoughtfully. Subtle sounds will enhance the user experience without being distracting or disruptive.

6. Cross-Platform Consistency

Trend: Brands are recognizing the importance of consistent sound identity across various platforms and devices. This trend involves creating unified auditory branding that extends seamlessly from mobile apps to smart speakers.

Impact: Users will associate consistent auditory cues with a brand, regardless of the device or platform they use. This reinforces brand identity and improves user recognition and trust.

7. Voice User Interfaces (VUIs) Evolution

Trend: VUIs, like voice assistants, are becoming more sophisticated and context-aware. They are evolving from basic command-response systems to conversational interfaces with nuanced auditory interactions.

Impact: Users will enjoy more natural and conversational interactions with voice assistants. Improved voice recognition, understanding of context, and emotional intelligence will make VUIs feel more like knowledgeable companions.

8. Sustainability and Eco-Friendly Soundscapes

Trend: As environmental consciousness grows, there's a trend toward creating eco-friendly soundscapes in UX. These soundscapes aim to reduce auditory pollution and promote calm and sustainable auditory environments.

Impact: Users will encounter digital products and public spaces designed with acoustic sustainability in mind, contributing to reduced stress and improved well-being.

These future trends in sound design for UX reflect the growing importance of auditory experiences in digital interactions. Designers will need to adapt to these trends to create more engaging, personalized, and context-aware soundscapes that enhance user satisfaction and usability.

Audio Signifiers for Voice Interaction

Good voice interfaces require not only excellent natural language comprehension, but also strategies for helping users understand the universe of actions and commands available in voice interactions — in other words, we need to bridge the Gulf of Execution. This interaction design challenge is present in all systems, but is inherently more difficult for voice interfaceS.

The Gulf of Execution

To successfully interact with any system, people must be able to (1) figure out what actions to take in order to achieve a specific goal, and (2) understand the results of those actions. In his seminal book, The Design of Everyday Things, our colleague Don Norman described these needs as the Gulf of Execution and the Gulf of Evaluation, respectively. Both are important, but in this article, we'll focus on the Gulf of Execution, and how voice-interaction systems can help users understand what commands are possible.

In graphical user interfaces (GUIs), designers can help people bridge the Gulf of Execution by providing visible signifiers, like distinctive colors for clickable text. When used appropriately, these techniques enable users to understand at a glance what actions are possible; conversely, research shows that diminished graphical signifiers lead to slower task times and cause click uncertainty in a GUI.

In the absence of visual signals, users must either imagine or try to remember possible commands — both of which increase the cognitive load and difficulty of using the interface. Designers of voice-interaction systems can help minimize these problems by including signifiers for important system commands.

Definition: A voice-interaction signifier is a user-interface cue that the system provides to users in order to help them understand what verbal commands they can make.

Either sound or visual cues can be used to signify possible voice commands. If a screen is available, it's usually best to include a visual signifier, but not all UIs have screens. This article focuses on audio signifiers, which are used by both smartphone-embedded personal assistants such as Siri, Google Now, and Cortana, and by standalone voice-interaction systems such as Amazon's Echo and Google Home.

Types of Sound Signifiers

There are three types of sound-based signifiers or cues which can prompt user actions and inform users about possible commands:

1. Nonverbal sounds, or earcons (auditory icons), which are distinctive noises generated by the system, usually associated with specific actions or states. For example, Siri emits a 2-tone beep after detecting its activation phrase, to signal that it is now 'listening' for a command.

2. Explicit verbal signifiers, when the system verbalizes a suggestion or request to let the user know what commands are available. For example, if you tell Google Home to "Set a timer," it responds with "Ok, for how long?"

3. Implicit verbal cues, when the system hints that an action is possible, without fully articulating the suggestion. For example, when Amazon's Echo detects its wake word while it is speaking, it pauses its own speech to let the user know that it is 'listening' for a new command. This behavior mimics human speech patterns, where people pause briefly to cue conversational partners that they are willing to stop speaking and listen.

Nonverbal Sounds

Earcons, or interface sound cues, are similar to visual icons found in graphical user interfaces because both attempt to communicate with users more efficiently by eliminating words. Just as an icon of a trashcan requires less screen space than a button labeled Delete, playing a beep takes less time than speaking the words "You have a new message."

But the efficiency gains of both icons and earcons depend on users actually understanding the meaning of the signal. Visual icons often have usability problems due to the ambiguous nature of the imagery; auditory icons are even less understandable, because they can't use words or images to convey meaning. This problem quickly becomes obvious when you attempt to generate earcons with the same meaning as common visual icons.

For example, visual icons can be classified as resemblance, reference, or arbitrary, depending on how the symbol relates to with the action it represents. Resemblance icons look like the function they perform: a drawing of a trashcan has the same shape as a physical garbage container. A resemblance earcon for the action of deleting could be a "clunk" sound, to resemble the noise made when dropping an object into a can. But a "clunk" also sounds like many other noises—such as two objects colliding, or an object being placed on a shelf.

Earcons become even more obscure when they attempt to reference a concept. For example, the sound of a cow mooing could be a reference earcon for the concept 'milk'. (The "moo" in this case refers to something related to a cow, instead of representing an actual cow.) But requiring users to guess a specific action based solely on a "moo" sound would be more appropriate for a game than for a shopping list.

Because of the ambiguity of nonverbal sounds, most earcons function as arbitrary sounds, even if they are intended to resemble a specific action. Arbitrary sounds can attract attention, but can only convey specific meanings under certain conditions:

- Within a task context: Immediately after the user has made a command, they may be primed to recognize earcons as related to that command. For example, playing a "clunk" sound can serve as a confirmation after the user has indicated that an object should be deleted.
- After repeated exposure: Over time users may learn that one arbitrary sound indicates an incoming phone call, while a different sound indicates a new text message.

Even repeated exposure is no guarantee that people will be able to uniquely identify arbitrary sounds. Most of us have heard the tones generated by dialing numbers on a telephone thousands of times, but would be hard-pressed to tell you which tone is associated with a particular digit.

Auditory icons are also a one-way form of communication: the system can play a "clunk" or a "beep" sound to the user, but users cannot accurately produce specific nonverbal sounds as commands.

Due to these limitations, earcons are effective primarily in narrow, repetitive contexts (for example, when serving as confirmations for frequent tasks) or as a generic attention getters. But, in most situations, they do not convey enough information and need to be accompanied (or replaced) by verbal signifiers.

Verbal Signifiers: Balancing Explicit and Implicit Cues

Explicit verbal cues, in the form of questions or suggestions, are the most understandable type of sound signifier. But explicitly stating every possible command would be incredibly tedious — just ask screenreader users. Besides being annoying, long verbal lists are ineffective, because people are unlikely to remember them all. (Think of telephone menus which list 10 different departments, and how often you forget the first choice by the time you get to number 5.)

Explicit signifiers are essential for irreversible actions like making a purchase. But in many other instances, the need for strong signifiers can be balanced with the need for quick interaction by using a few specific techniques:

- Guess and confirm the user's intent
- Provide implicit cues instead of explicit statements
- Separate explicit cues into sequential, distinct dialogues
- Progressively disclose cues so they are stated only at the point of need

Guess and Confirm

Guessing the user's intent leads to the most efficient interactions — but only if the system has enough information to make a good guess. For example, if you tell Echo to play the music-streaming service Pandora, rather than asking which station, the device automatically plays the most recently used Pandora station. Since that station was previously selected by the user, there's a pretty good chance it will be ok.

On the other hand, inaccurate guessing can slow down the interaction, because after a bad guess, users have to figure out how to correct the system's assumptions.

For example, consider a scenario where the user has asked a voice-interaction system to "Set up a meeting at nine." This seemingly simple task necessitates several different followup questions and commands, such as specifying the name, date, and time of day (morning or evening) for the appointment, as well as editing any of these values, and finally saving the appointment. The table below illustrates how four different voice-interaction systems handle this task, with system statements in bold:

Voice system responses to the user command "Set up a meeting at nine."			
Google	Echo	Cortana	Siri
What's the title of the event? Haircut **Sure, Haircut tomorrow at 9 am. Do you want to save this?** Yes **All right, I saved your event.**	**Is that nine o'clock in the morning or in the evening?** In the morning **On what day?** Thursday **And what's the name of the event?** Haircut **I'll schedule Haircut on Thursday, August 24th at 9 am, ok?** Ok **Ok, I've added that.**	**What do you want to call it?** Haircut **I'll add Haircut to your calendar for today at 9 pm. Sound good?** No, change it to 9 am tomorrow **Sorry, should I add this to your calendar?** No **Did you want to change the title or the time?** Time **When is your event?** Nine am tomorrow **All right, I'll add Haircut to your calendar for tomorrow at 9 am. Sound good?** Yes **Sure thing.**	**Ok, I set up your meeting for today at 9 pm. Shall I schedule it?** No, change it to 9 am tomorrow **To continue, you can confirm, cancel, change the time, or change the title.** Change the time **What time is your appointment?** 9 am tomorrow **Ok, I set up your meeting for tomorrow at 9 am. Shall I schedule it?** Change the title **Ok, what's the new name for this meeting?** Haircut **Ok, I set up your meeting for tomorrow. Shall I schedule it?** Yes **It's on your calendar for 9 am tomorrow.**

Guessing the name of the event is doomed to failure, and only one system makes the attempt: Siri, which creates an appointment named 'meeting.' All the other systems use an explicit signifier in the form of a question to prompt users for the event name. For the date and time of day, 3 of the 4 systems attempt a guess. Siri and Cortana guess the closest future day and time, while Google guesses the following day. While these are reasonable guesses, they could each easily be incorrect, and therefore require users to figure out how to edit the information. As it happens, Google was right in this case, and so its interaction sequence was the shortest, but it could almost as easily have been wrong, leading to a more clunky dialogue. (Machine learning techniques run across vast masses of meeting requests presumably lead to a higher probability of correct guesses under various circumstances.)

Unfortunately, neither Siri nor Google provide any signifiers about how to edit the event details; instead they skip straight to explicit prompts to save the appointment. This is problematic because "Shall I schedule it?" and "Do you want to save this?" are questions that suggest a yes-or-no answer, rather than the possibility of editing the event information. Both systems allow editing, but it's up to users to realize that this option exists. The editing command could be signaled by asking another question — such as "Do you want to change this event?" — but that would also add an extra step to the task.

Implicit Signifiers

Substituting an implicit signifier instead of an explicit signifier can effectively prompt people to edit without making the interaction (much) longer. Implicit signifiers suggest actions by mimicking speech patterns that humans have developed to exchange information more efficiently. One such pattern is adding a question word to the end of a statement. For example, both Cortana and Echo include a brief implicit cue at the end of the confirmation prompt:

Question Words as Implicit Cues
Cortana: I'll add Haircut to your calendar for today at 9 pm. **Sound good?**
Echo: I'll schedule Haircut on Thursday, August 24th at 9 am, **ok?**

Implicit interrogatory cues at the end of a system-produced utterance help users understand that they can change the appointment.

These statements ask for permission to proceed with saving the event. But interrogatory confirmation words ("Sound good" and "ok") are placed in the same sentence, immediately after the event details. This placement, coupled with the broad terminology, suggests that the system is asking not only about whether to save, but also about the accuracy of the entire preceding sentence. (Unfortunately, Cortana only accepts yes or no answers to this question. Only after saying "no" and waiting for another explicit editing prompt can users change the information.)

Sequential Explicit Signifiers

Theoretically, combining several prompts into a single exchange could save time, for example by asking "What is the name, day, and time of day for this event?" In actual practice, however, this type of prompt increases the users' cognitive load, because they have to remember 3 different questions and answer them all at once. In practical terms, the mistakes and corrections that result from increased cognitive load are likely to equal or exceed the time needed to ask each question separately.

Echo's dialogue in the table above illustrates an alternative sequential approach to explicit signifiers: the name, date, and time of day prompts are 3 separate questions with 3 separate answers. As illustrated in the example, this strategy may end up being more efficient than one which requires editing due to incorrect guesses — especially if there are errors or false starts due to missing editing signifiers.

Also, keep in mind that not every user will be asked all questions. People who provide more detailed commands such as "Set up a meeting on Thursday at 9 AM named Haircut," can complete their task successfully after just one confirmation question on any of the systems:

Detailed Commands = Fewer Steps

User: Alexa, set up a meeting on Thursday at 9 am named Haircut.

Echo: That's Haircut on Thursday, August 31st at 9 am, right?

User: Yes.

Echo: Ok, I've added that.

The Echo event dialogue does not include sequential followup questions if the user includes all necessary information in the initial command.

Progressive Disclosure of Cues

Progressive disclosure provides infrequently used options only after users' behavior indicates a need for those commands. For example, Siri at first explicitly prompts users to save the event. Only after a user declines to save does Siri suggest several alternative commands, with the statement: "To continue, you can confirm, cancel, change the time, or change the title."

Prioritization is essential for good progressive disclosure, in order to determine which features should be exposed as primary features vs. hidden as secondary features. Prioritization is even more critical for voice-interaction systems than for graphical user interfaces, because exposed voice options require people to listen to them being read aloud while deferred voice options are even more hidden, due to the lack of visible see more indicators. (A universal "See more" earcon would be handy for voice interfaces, but doesn't exist yet.)

Considering that Siri's event-creation dialogue guesses the name, day, and time of day for the event based on very little data, most users would need to edit those guesses for this task. So, in this case, deferring a frequently used command to a secondary choice, without offering even an implicit cue, is likely to cost more time than it saves.

For complex tasks with branching paths, progressive disclosure helps keep the user focused on exactly what is relevant for the current step. Google Home uses this technique to provide step-by-step cooking instructions. During this task, the system asks, "Would you like to prepare the ingredients, or skip to the instructions?" If users ask to prepare the ingredients, they receive another more specific prompt explaining options for hearing the ingredients: "There are 7 in total. Should we go through them in groups of three, or one by one?" However, this offer is presented only to users who have opted in to the ingredients task, as the question is irrelevant for those who want to skip to the instructions.

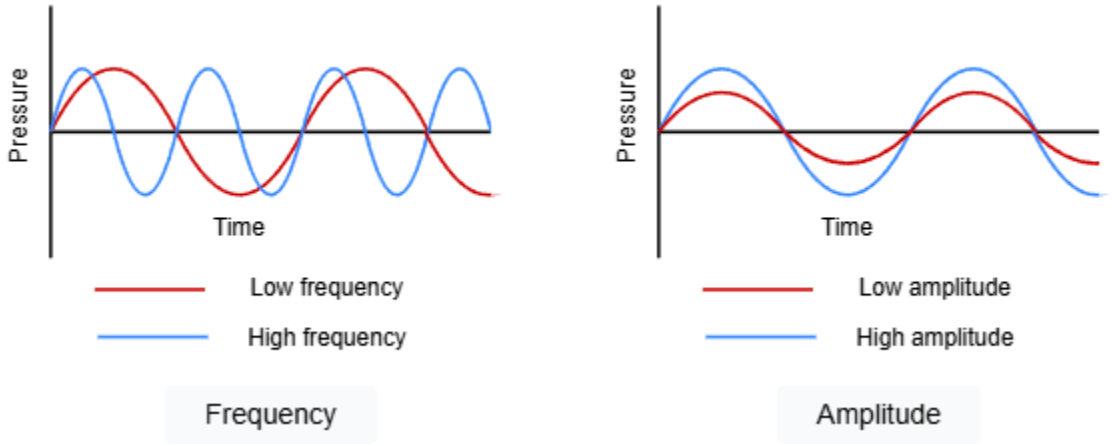
Auditory Perception

Auditory perception is the ability to perceive and detect sounds in the surrounding environment using the auditory system. Ears detect sounds as vibrations through a medium. The medium can be air, water, glass, wood, etc.

Characteristics of sounds

Humans can differentiate between sounds on the basis of the following characteristics:

- Pitch: The number of vibrations of sound waves per unit of time, also known as the frequency of the sound waves. Higher frequency means higher pitch, and lower frequency means lower pitch.
- Loudness: The expansion and compression experienced by the vibrating particles of the medium, also known as the amplitude of the sound waves. Higher amplitude means louder sound and lower amplitude means quieter sound.
- Timber: The tone quality or tone color that differentiates two sounds of the same frequency and amplitude.



Auditory localization

Auditory localization is the ability to locate or identify the origin or location of a sound. Humans detect locations by comparing the sounds coming into both ears. Time difference and loudness are the key factors in locating the sound. For example, a sound coming from your right side will enter your right ear earlier than the left, and loudness will be higher on the right side.

In order to better demonstrate human auditory perception, let's listen to this audio. This audio creates an illusion. You will feel like you are sitting in a barber shop with the barber moving around you and cutting your hair.

Note: Please use earphones for a better demonstration. Close your eyes and enjoy your virtual haircut. We hope you like it.

Note: The ear is not the only organ that can detect sounds. Some sounds can be perceived by other parts of the body as well. Low-frequency and loud sounds can be perceived through the sense of touch as vibrations. An example of this idea being implemented in new technology is Soundshirt, a shirt with haptic technology and the most advanced smart textiles that brings music to life allowing the wearer to feel the music on their skin.

4. Touch and Haptic Feedback (30 mins)

- Tactile sensitivity and haptic interfaces (e.g., vibrations, force feedback).
- Applications: Touchscreens, VR controllers, Braille keyboards.

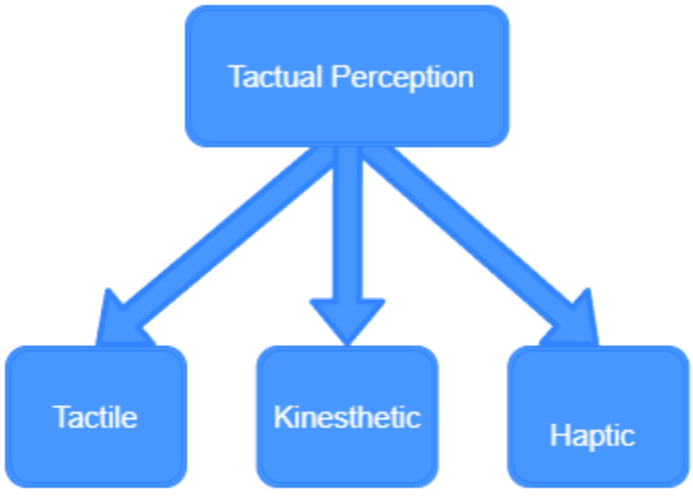
Tactual Perception

Tactual perception or touch is how humans perceive objects in the surrounding environment using sensations created by the physical contact of the human body with the objects. This perception can help us in acquiring loads of information about the object we touch. We can immediately find the object's size, weight, temperature, material, and shape.

A well known use of touch in the world of communication is Braille, an alphabet reading system for people who are blind. It consists of patterns of raised dots indicating letters that can be read by moving fingers over them.

Braille

Tactual perception is an umbrella term referring to three forms of perception; tactile, kinesthetic, and haptic.



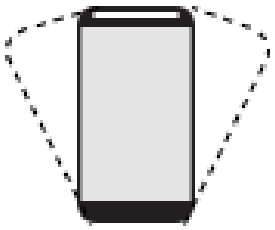
Tactual perception

Tactile perception

Tactile perception is the ability to interpret the object being touched via receptors on our skin that are sensitive to temperature, pain, and pressure. This sensory information is sent to the brain and the brain can interpret what the object is, its features such as shape, texture, and size, and how it should be handled and used.

In human-computer interaction, we are concerned mainly with the receptors of pressure in the form of vibrations. Pressure can be felt on our whole body but with varying sensitivity. For example, our fingers and thumbs are most sensitive to pressure compared to any other body part.

The vibration function of mobile phones was the first large scale application of tactile perception in the field of HCI. In recent years, the interest and development in vibrotactile displays has increased rapidly. These displays convey messages by producing vibrations that can be felt on the user's skin.



Vibrating phone

Kinesthetic perception

Kinesthetic perception is the ability to have awareness of body position and movements of body parts using sensory organs present in body muscles and joints, i.e. without the use of the five senses. We are using our kinesthetic perception whenever we are involved in physical activity.

Kinesthetic learning style refers to learning new things better by actually performing them rather than reading instructions or watching someone perform.

The same concept is used by mobile phones for a more intuitive interaction with the user. One well known functionality is rotation. By turning this function on, you can rotate the phone from portrait to landscape, the mobile device senses the changed direction of the gravitational force and then rotates the screen display automatically.

Haptic perception

Haptic perception is the ability to recognize objects through touch. It is the combination of both tactile perception and kinesthetic perception. For example, to check the quality of a sofa, you run your hands on its surface to check the upholstery's quality and put pressure on it to check the cushion filling's quality. Another widely used application of haptic perception is video games, especially arcade or racing games. For example, force feedback wheels used in arcade games provide a realistic resistance while rotating the wheel, giving users a feeling of a real steering system.

Player uses haptic perception to rotate the wheel.

Laptops use haptic perception in the form of a touchpad. They sense the movement of fingers and pressure on the pad and the associated function is implemented.

Haptic Interfaces

Haptic interfaces enable people to interact with computers using force feedback and vibrations to simulate tactile sensations like texture and movement. These sensations are created by applying forces or vibrations to the user's skin, which can mimic the feel of touching natural objects.

Haptic interfaces have applications in various fields, from gaming to medicine. For example, they can give surgeons better control when performing delicate operations or give gamers an immersive experience. They can also help people with disabilities interact with computers in ways that were not previously possible.

A Comparative Analysis of Haptic Feedback Technologies

Various types of haptic feedback exist to simulate tactile sensations, and each type has its own strengths and weaknesses. The effectiveness of haptic feedback depends on the context in which it is used. Here's a comparison of different kinds of haptic feedback and their effectiveness in different contexts:

- Vibration Feedback: Vibration feedback is the most common type of haptic feedback used in digital devices. It uses small motors or actuators to create vibrations that mimic real-world sensations. Vibration feedback provides simple alerts or notifications, such as when receiving a text message or an email. However, vibration feedback has limitations when it comes to more complex interactions; for example, it cannot provide precise force information, making it less effective for tasks that require fine motor control or manipulation.

- Force Feedback: Force feedback gives users a sense of resistance or pressure when they interact with digital objects. It uses motors or other mechanisms to apply forces to the user's skin, simulating the sensation of touching natural things. Force feedback benefits applications that require precise control over physical interactions, such as surgery simulation and virtual assembly training. In these contexts, force feedback can help trainees develop muscle memory and improve performance.

- Tactile Feedback: Tactile feedback provides a sense of texture and surface properties. It uses arrays of small pins or other mechanisms to create patterns on the user's skin, simulating the sensation of touching different textures. Tactile feedback is helpful for applications where surface properties are essential, such as product design and prototyping. It can also enhance the realism of VR/AR experiences.

The choice between different types of haptic feedback depends on the specific application and user needs. Different types may be necessary to create a fully immersive and realistic experience.

Examples of Haptic Interfaces in Real-World Applications

Haptic interfaces have a wide range of applications in various industries. They are used in gaming, virtual reality, healthcare, automotive, and many other fields to improve the overall experience and create a more immersive environment.

In the automotive industry, haptic feedback can alert drivers of potential hazards on the road, such as lane departure or collision avoidance systems. This technology provides tactile feedback through vibrations or pressure changes in the steering wheel or seat to help drivers avoid accidents.

In healthcare, haptic devices are used for surgical training and simulators. These devices provide realistic touch sensations to trainees, enabling them to develop their skills without putting actual patients at risk.

In gaming and virtual reality, haptic feedback can simulate physical sensations like touch, texture, and temperature.

How to Enhance User Experience in VR/AR with Haptic Feedback

Haptic feedback is essential to virtual reality (VR) and augmented reality (AR) environments. It adds a new dimension to the user's experience by providing tactile sensations that mimic real-world interactions. For example, when you touch a virtual object, haptic feedback can simulate the feeling of its texture, weight, and shape.

Moreover, haptic feedback can help users navigate complex environments more efficiently. In VR/AR simulations with no physical reference point for orientation, haptic feedback can provide subtle cues to guide users through their surroundings. For instance, it can indicate the direction of movement or warn users about obstacles in their path.

Ultrasound Haptics: The Future of Tactile Simulation

Ultrasound haptics enables the creation of tactile sensations in mid-air using ultrasonic waves. Focused ultrasonic waves exert pressure on the skin, creating a sense of touch without requiring users to wear gloves or hold on to physical devices. This technology could guide surgeons during delicate procedures or enhance immersion in virtual environments. While still in its early stages, ultrasound haptics could revolutionize how we interact with digital devices and the world around us.

What Is Haptic Feedback?

Haptic feedback refers to the use of touch and vibrations to communicate sensations or feelings to a user, providing a more immersive experience. It's brought about by software that responds to a user's interaction, like when a controller vibrates during certain actions performed in a video game or when a smartphone provides a button-clicking sensation as the user presses their screen.

Haptic feedback is the use of physical stimuli, like vibration patterns, to simulate tactile experiences. Products that offer haptic feedback often provide different kinds of sensations to correspond with different visual and audio stimuli, such as a smartphone giving a "clicking" sensation as a user types on the screen.

What Are Haptics?

Haptics is a broad term that describes technologies that engage users' tactile senses. Haptic technology targets users' sense of touch and is sometimes seen as a novelty because so few digital products provide intentional tactile experiences.

Since the 1990s, companies have been trying to create consumer products that allow users to receive tactile feedback from devices and “feel” virtual objects, which would come to be known as haptics.

Haptic research company Immersion Corporation began developing a haptic technology in the 2000s for virtual reality gameplay, which consisted of an exoskeleton structure users could wear around their hands. Immersion’s vice president of research and user experience, Manuel Cruz, said the cost of manufacturing the product prevented the company from moving forward with it, because only universities and research labs could afford it.

“It is always about cost, the power it’s going to use and how big it is,” Cruz said about haptic tech. “Those are the main problems that we always have in pushing this technology into the market — because at the end of the day, the devices need to sell.”

Because of this hurdle, haptic technology still seems to be waiting for its breakthrough moment.

How Does Haptic Feedback Work?

Haptic devices use tools like motors, sensors and speakers to create haptic feedback. Devices are programmed to output haptic feedback when a particular action is performed. The mechanical stimulus the user feels can be created by different technologies like skin indentation devices, exoskeleton devices or vibrotactile technology.

Skin indentation devices can be found in a variety of haptic technology like haptic gloves or other wearables. These mechanisms compress skin to imitate a sensation like touching or moving an object.

Exoskeleton devices are typically found in the gaming industry and use active force feedback to create stimuli. These devices rely on electromechanical motors that target specific body parts and correlate to a game experience.

Vibrotactile technology is commonly used in VR haptic devices. Haptic devices equipped with vibrotactile technology use piezoelectric actuators and linear resonant actuators to create rumble and shaking sensations as well as vibrational patterns.

Haptic Feedback Types

Vibrotactile Feedback

Vibrotactile feedback applies vibrations to stimulate a user’s skin, and is one of the most common types of haptics. This feedback is often used for mobile phones, touchscreens, wearable electronics and video game controllers. Vibrotactile feedback is simple to create and control, but isn’t able to emulate a large range of physical sensations.

Force Feedback

Force feedback stimulates the skin, muscles and ligaments of a user to emulate realistic pressure and weight against the body. Force feedback is applied deep enough to activate the musculoskeletal system, being able to move entire body parts like a hand or finger. This is unlike most haptics that only affect the top layer of the skin.

Force feedback haptics are designed as either biomimetic or non-biomimetic, meaning they're shaped to imitate parts of the human body or they're not shaped as such. Biomimetic force feedback devices can include wearables like exoskeletons and haptic gloves. Non-biomimetic devices can include steering wheels found on arcade racing game machines or driving simulators.

Electrotactile Feedback

Electrotactile feedback administers electrical pulses to stimulate the skin and its nerves, down to the nerve endings. It works by placing electrodes directly onto the user's skin, and doesn't require any mechanical or moving hardware parts to function. This feedback can also emulate various types of sensations by adjusting the pulse current, voltage, electrode size or electrode material. Electrotactile feedback may be applied to scenarios like medical training, teleoperation or gaming and VR.

Ultrasonic Tactile Feedback

Ultrasonic tactile feedback, or ultrasound tactile feedback, mimics the sensation of real-life objects by emitting high-frequency, ultrasound waves into the air. This feedback utilizes time reversal acoustics, where sound waves are directed toward a specific area in space, creating turbulence and simulating pressure. Wearable devices aren't required to feel ultrasonic tactile feedback, allowing more natural movement for users.

Thermal Feedback

Thermal feedback haptics simulate temperature changes on the skin, as if a user is touching something hot or cold. This is done by applying a grid of actuators onto the skin, which converts energy to heat and moves it across parts of the body. Unlike vibrotactile feedback, thermal feedback doesn't require a great amount of actuators to work, as humans aren't able to pinpoint the location of thermal stimuli as accurately as tactile stimuli. That said, thermal feedback requires heat energy to move around quickly enough to feel realistic, so it can take more power for thermal feedback to equate to the sensations of tactile feedback.

Haptic Feedback Benefits

Immersion

Haptic feedback provides users an immersive experience by having tactile sensations coincide with what they're seeing, hearing or interacting with. Think about when you're typing on a

touchscreen device, and how pressing a button on-screen triggers a “clicking” effect, as if the button were a 3D object. This can also apply to entertainment experiences, where a player’s controller can vibrate when steering a vehicle or hitting a target in-game, or how a movie watcher’s seat could shake while watching a 4D film.

User Accessibility

Having specific haptic feedback occur for certain scenarios can provide cues into what’s happening on-screen. Feel a long rumble from your phone? You might be getting a phone call. A short rumble? This could be an app notification.

Haptic movements increase accessibility for all users, but especially so for users who have visual or hearing disabilities, as they alert people to key actions or moments without even having to look at or listen to the device.

Touchscreen and Device Navigation Accuracy

Having tactile feedback helps guide users toward what actions are “correct” or produce a desired output from their device. When using a digital keyboard or dashboard, if you don’t feel the distinct “click” from hitting a certain key, this may indicate you have mistyped. Haptic feedback has been seen to improve accuracy for some touchscreen actions and even for robotic surgery training.

Haptic Feedback Applications

Haptic feedback has become a crucial feature for a variety of technologies, making it a mainstay in various industries.

Gaming

Gaming controllers use haptic feedback to make various actions seem more life-like. Players can feel different sensations when a character is navigating a terrain, getting punched or building up energy to deliver an attack. These responses contribute to a more realistic experience that draws users into the game.

Metaverse

Haptic feedback can be integrated into VR and AR tools, so users can feel pressure and vibrations. While this can be used to enhance VR and AR games, it can also support more immersive training simulations. In all cases, the physical aspect haptics bring to VR and AR can better connect users to the metaverse and the technologies they’re wearing.

Aerospace

The forces exerted on objects in space act differently than on Earth, but haptic feedback can bridge this gap. For example, NASA and the European Space Agency have collaborated on the

METERON Project to explore remotely operating robots in space. Humans can use haptics to inform how they design human-robot interfaces and understand the forces acting on robots as they maneuver in space.

Healthcare

Haptic feedback enables simulations of medical procedures, both improving operations and training sessions. For example, surgeons performing robotic-assisted surgeries can use haptics to better control robotic tools and reduce operation times. Meanwhile, dental students can practice teeth and gum procedures through simulations.

Automotive

Many car models feature steering wheels outfitted with haptic feedback technology. Vibrations can be used to assist with steering and keeping drivers alert while making touchscreens feel more intuitive. As a result, haptics can eliminate unnecessary distractions and ensure the driver remains focused on the road.

Mobile Technology

A range of mobile technologies integrate haptic feedback into their functions. Phones can deliver specific vibrations to communicate to users that they've received text messages and notifications. In addition, iPads and laptops can use haptic feedback to signal when a user presses on a screen or keyboard, contributing to a more convenient user experience.

Haptics Examples

Haptic Controller

PlayStation 5's DualSense controller is capable of precise vibrations that complement in-game scenarios. The DualSense uses electricity to vibrate small metal coils, which allows game

developers to match vibrations more closely to in-game situations. It also has adaptive triggers, which game developers can program to provide resistance under certain circumstances when players engage the triggers. For example, the controller can mimic a gun jamming or give the right resistance when an avatar is pulling an object.

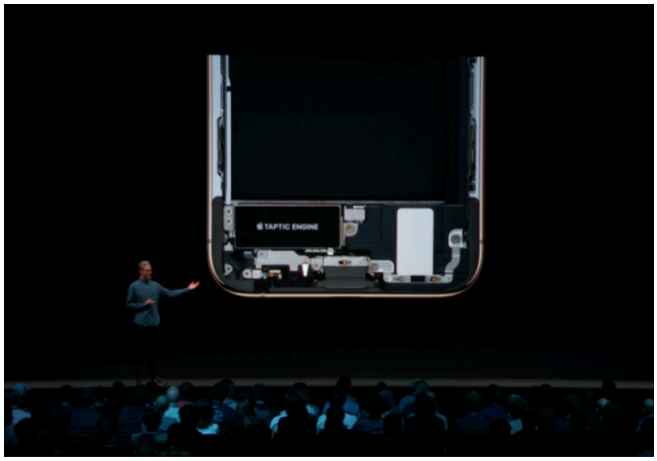
Haptic Suit

Korean startup bHaptics creates a line of haptic suits that can be paired with compatible VR games for an added layer of realism. The suit includes a vest, armbands, controllers and a headset, all of which have components that transmit vibrations to the player. When the player is hit during first-person shooter games, for instance, the suit vibrates accordingly.

Ultrasonic Speakers

Ultraleap sells haptic hand-tracking technology that uses ultrasound instead of vibrations to transmit haptic sensations. These devices are made of an array of small ultrasound speakers, which send ultrasonic waves through the air to collide at specific focal points. Users can move their hands through the space in front of the device and feel the landscape of focal points, which are experienced against the skin as pressure, creating the haptic sensations.

iPhone Haptics



Apple's Taptic Engine was originally introduced in 2015 in the Apple watch, and incorporated later into the iPhone. It uses the same technology as PlayStation's DualSense controller, with electric currents feeding a resonating coil that creates precise and easily controllable vibrations. Games on iOS, such as the racing game GRID Autosport, uses the feedback to transmit realistic sensations to the user.

Haptics in Touchpads

Lenovo has joined Apple in rolling haptic trackpads out to its laptops. Although Apple's patent on this innovation prevented other companies from quickly creating their own versions, Lenovo's ThinkPad now shares this capability, thanks to hardware company Sensel, which supplies the trackpad for the laptop. This technology can mimic the sensation of a click through vibrations, saving more space to add other physical features to the ThinkPad.

Wearable Wellness Devices

The Apollo device uses haptics for haptics' sake — to create a soothing sensation that helps users feel calm and relaxed. Apollo can be worn on the wrist or ankle, and it uses vibrations to help users feel relaxed and energized. The device is designed to address issues like sleep quality, social anxiety and stress. It is controlled from a phone, where users can select from a suite of vibration patterns and intensities.

Headphones

Razer's Nari series haptic headphones turn intense sounds, such as in-game explosions or a strong bass, into vibrations felt against the device. While technically a gaming headset, it doesn't require special programming to use, and works just as well for listening to music on Spotify. The haptic feedback used in Nari headphones may not work well with all types of media, but they can contribute to a more engaging gaming experience.

Haptics in Steering Wheels

Audi has incorporated haptic feedback technology into a couple of features for its electric vehicles, including the touchscreen and buttons on the steering wheel. Audi's MMI touch response system helps drivers keep their eyes on the road while using other features. Touchscreens are especially difficult to navigate while driving, but haptic feedback can let the driver know if a button was successfully selected, saving an extra glance back at the screen.

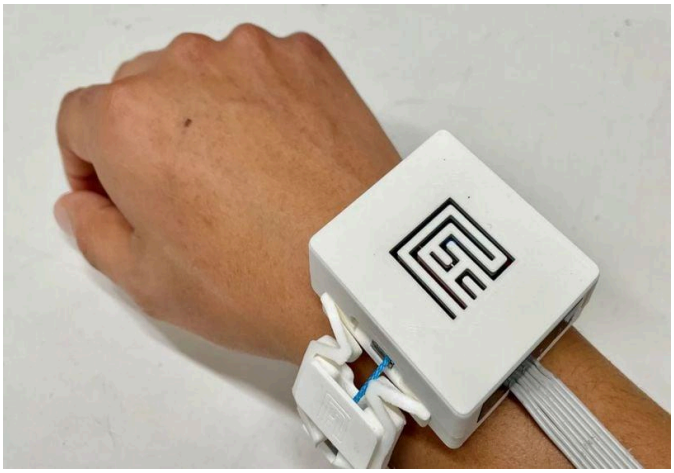
Haptic Braille Displays

University of Bayreuth in Germany has developed HaptiRead, a device that uses ultrasonic waves to project Braille onto users' fingertips, and the University of Washington has developed V-Braille, an infrastructure that can be applied on smartphones that uses vibrations to simulate braille. While neither technology is available to the public, these foundations have the potential to make braille a good alternative to other types of assistive technology.

Haptic Movie Seats

D-BOX designs movie seats equipped with haptic feedback technology to produce "immersive cinematic motion." The seats' movements can be synced with onscreen sequences, so users can experience vibrations during a film's action-packed moments. Each seat comes with a control panel as well, enabling a user to customize their seat's settings.

Haptics in Robotic Surgery



Medical and engineering experts at Johns Hopkins University have teamed up to develop a tactile sensor device that emits vibrations during robotic surgical training. This addresses the

need for surgeons to know how much pressure they're exerting while wielding robotic tools during operations. The tactile sensor can help trainees improve this ability, especially when experienced surgeons are unavailable to train them.

Haptic Feedback vs. Haptic Touch

Haptic feedback is the physical reaction the user receives from a device, while Haptic Touch is a specific form of haptic feedback. Haptic Touch is a feature present on the iPhone SE, iPhone XR, iPhone 11 and later models that activates a small vibration on the device and opens a menu when long-pressing on an app.

Class 2: Designing for Human Perception and Cognition

Objective: Explore cognitive processing and apply sensory principles to HCI design.

1. Multi-Sensory Interaction (30 mins)

- Combining senses for richer experiences (e.g., VR/AR).
- Synesthesia-inspired design (e.g., using color to represent sound).

Overview

Multi-sensory systems use more than one sensory channel in interaction

E.g. sounds, text, hypertext, animation, video, gestures, vision etc.

Used in a range of applications: particularly good for users with special needs, and virtual reality

Topic Summary

We will cover
• general terminology
• speech
• non-speech sounds
• handwriting
• text and hypertext
• animation and video
considering applications as well as principles

Usable Senses

The 5 senses (sight, sound, touch, taste and smell) are used by us every day
• each is important on its own
• together, they provide a fuller interaction with the natural world

Computers rarely offer such a rich interaction. Can we use all the available senses?

ideally, yes
practically - no

We can use
• sight
• sound
• touch (sometimes)

We cannot (yet) use
• taste
• smell

Multi-modal versus Multi-media

Multi-modal systems

• use more than one sense (or mode) of interaction
• e.g. visual and aural senses: a text processor may speak the words as well as echoing them to the screen

Multi-media systems

• use a number of different media to communicate information
• e.g. a computer-based teaching system may use video, animation, text and still images: different media all using the visual mode of interaction. It may also use sounds, both speech and non-speech: two more media, now using a different mode.

Speech

Human beings have a great and natural mastery of speech

• makes it difficult to appreciate the complexities, but
• it’s an easy medium for communication

Structure of Speech

• phonemes - 40 of them: basic atomic units, which sound slightly different depending on the context they are in; this larger set of sounds are
• allophones - all the sounds in the language: between 120 and 130 of them. These are formed into
• morphemes - smallest unit of language that has Meaning.

Other terminology:

• prosody - alteration in tone and quality: allows variations in emphasis, stress, pauses and pitch to impart more meaning to sentences.

• co-articulation - the effect of context on the sound; co-articulation transforms the set of phonemes into the set of allophones.
• syntax - structure of sentences
• semantics - meaning of sentences

Speech Recognition Problems

Different people speak differently: accent, intonation, stress, idiom, volume and so on can all vary.
The syntax of semantically similar sentences may vary.

Background noises can interfere.
People often “ummm.....” and “errr.....”

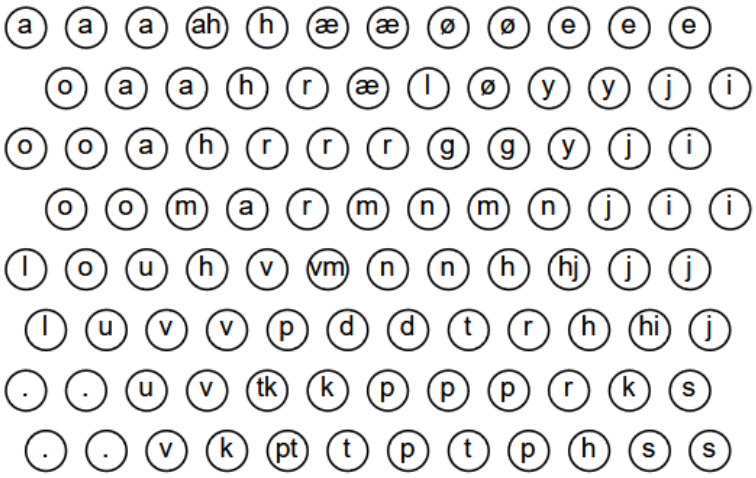
Recognising words is not the ultimate goal of a speech recognition system: the semantics have to be extracted as well. It often requires intelligence to understand a sentence: the context of the utterance often has to be known, as does information about the subject and sometimes the speaker.

Example:
Even if
“Errr.... I, um, don’t like this”

is recognised, it is a fairly useless piece of information on it’s own

The Phonetic Typewriter

Developed for Finnish (a phonetic language, written as it is said).
Trained on one speaker, will generalise to others. A neural network is trained to cluster together similar sounds, which are then labelled with the corresponding character.



When recognising speech, the sounds uttered are allocated to the closest corresponding output, and the character for that output is printed.
• requires large dictionary of minor variations to correct general mechanism
• noticeably poorer performance on speakers it has not been trained on

Speech Recognition: currently useful?

Single user, limited vocabulary systems can work satisfactorily No general user, general vocabulary systems are commercially successful, yet

Large potential, however
• when users hands are already occupied - manufacturing, for example
• for users with physical disabilities
• lightweight, mobile devices

Speech Synthesis

Speech synthesis: the generation of speech

Useful - natural and familiar way of receiving information
Problems - similar to recognition: prosody particularly

Additional problems
• intrusive - either requires headphones, or creates noise in the workplace
• transient - harder to review and browse

Successful in certain constrained applications, usually when the user is particularly motivated to overcome the problems and has few alternatives

• screen readers - read the textual display to the user: utilised by visually impaired people
• warning signals - spoken information is sometimes

presented to pilots whose visual and haptic skills are already fully occupied

Non-Speech Sounds

Boings, bangs, squeaks, clicks etc.
• commonly used in interfaces to provide warnings and alarms Evidence to show they are useful
• fewer typing mistakes with key clicks
• video games harder without sound

Dual mode displays: information presented along two different sensory channels
Allows for redundant presentation of information - the user can utilise whichever they find easiest
Allows resolution of ambiguity in one mode through information contained in the other
Sound especially good for transient information, and background status information. It is also language/culture independent, unlike speech

Example: Sound can be used as a redundant mode in the Apple Macintosh; almost any user action (file selection, window active, disk insert, search error, copy complete, etc.) can have a different sound associated with it.

Auditory Icons

Use natural sounds to represent different types of object or action
Natural sounds have associated semantics which can be mapped onto similar meanings in the interaction

• e.g. throwing something away can be represented by the sound of something smashing
Problem: not all things have associated meanings:
e.g. copying

Application: SonicFinder for the Macintosh
Items and actions on the desktop have associated sounds

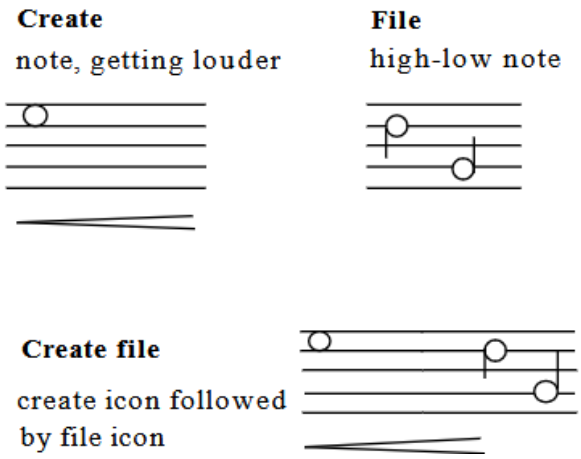
• folders have a papery noise
• moving files is accompanied by a dragging sound
• copying (a problem one) has the sound of a liquid being poured into a receptacle; the rising pitch indicates the progress of the copy
• big files have a louder sound than smaller ones

Additional information can also be presented:
• muffled sounds indicate the object is obscured or an action is in the background
• use of stereo allows positional information to be Added

Earcons

Synthetic sounds used to convey information
Structured combinations of notes, called motives , used to represent actions and objects

Motives combined to provide rich information
• compound earcons
multiple motives combined to make one more complicated earcon: for example



• family earcons
similar types of earcons represent similar classes of action or similar objects: the family of “errors” would contain syntax and operating system errors
Earcons easily grouped and refined due to compositional and hierarchical nature
Harder to associate with the interface task since there is no natural mapping

Handwriting recognition

Handwriting is another communication mechanism which we are used to

Technology

Handwriting consists of complex strokes and spaces. Captured by digitising tablet - strokes transformed to sequence of dots

• large-scale tablets available, more suitable for digitising maps and technical drawings
• smaller devices, some incorporating thin screens to display the information, becoming available
E.g. those produced by Apple as personal organisers

Recognition

Problems
• personal differences in letter formation
• co-articulation effects

Of limited success are systems that are trained on a few users, with separated letters
Generic multi-user naturally-written text recognition systems are not currently of significant accuracy to be commercially successful

Text and Hypertext

Text is a common form of output, and very useful in many situations

• imposes a strict linear progression on the reader, according to the author's ideas of what is best - this may not be ideal

Hypertext structures blocks of text into a mesh or network that can be traversed in many different ways

• allows a user to follow their own ideas and concepts through information
• hypertext systems comprise:
• a number of pages, and
• links, that allow one page to be accessed from another

Example
A technical manual for a photocopier may have all the technical words linked to their definition in a glossary. It may be possible to follows links so that one reads all the information on a particular aspect of the system, such as all the electronics, or to follow a different route through the data to solve a problem with, say, the copying to double-sided documents. Many of the pages visited will be identical in both cases, but will be encountered in a different order

Hypermedia

Hypermedia systems are hypertext systems that incorporate additional media, such as illustrations, photographs, video and sound

Particularly useful for educational purposes
• animation and graphics can allow user to see things happen as well as read
• hypertextual structure allows users to explore at their own pace following threads that interest them

Problems
1
• “lost in hyperspace” - users can be unsure as to where in the hypertext web they are Maps of the hypertext are a partial solution, but since hypertexts can be large these can be daunting too
• incomplete coverage of information. As there are so many different routes through the hypertext, it is possible to miss out chunks, by taking routes that avoid these areas
• difficult to print out and take away. Printed documents require a linear structure; it can be difficult to get the relevant information printed out in a neat manner

Animation

Animation refers to the addition of motion to images; they change and move in time

Simple examples:
• clocks
  Digital faces - seconds flick past
  Analogue face - second hand sweeps round constantly
  Salvador Dali clock - digital numbers warp and melt, one digit into the next
• cursor
  hourglass/watch/spinning disc indicates the system is busy
  flashing cursor indicates typing position clearly
  different types of cursor pointer indicate different
  functionality available, or different mode

Animation used to great effect to indicate temporally- varying information.
Useful in education and training: allow users to see things happening, as well as being interesting and entertaining images in their own right

Example: data visualisation

Abrupt and smooth changes in multi-dimensional data can be visualised using animated, coloured surfaces that ripple and fluctuate.
Complex molecules and their interactions can be more easily understood when they are drawn and moved on the screen, rotated and viewed from arbitrary positions.

Video and Digital Video

Compact disc technology is revolutionizing multimedia systems: large amounts of video, graphics, sound and text can be stored and easily retrieved on a relatively cheap and accessible medium

Different approaches, characterised by different compression techniques that allow more data to be squeezed onto the disc
• CD-I: excellent for full-screen work. Limited video and still image capability; targeted at domestic market
• CD-XA (eXtended Architecture): development of CD-I, better digital audio and still images
• DVI (Digital Video Interactive)/UVC (Universal Video Communications): support full motion video

Example: Palenque - a DVI-based system

Multimodal multimedia prototype system, in which users wander around a Mayan site. Uses video, images, text and sounds.
QuickTime from Apple represents a standard for incorporating video into the interface. Compression, storage, format and synchronisation are all defined, allowing many different applications to incorporate video in a consistent manner.

Utilising animation and video

Animation and video are potentially powerful tools
• notice the success of television and arcade games

However, the standard approaches to interface design do not take into account the full possibilitiesof such media. We will probably only start to reap the full benefit from this technology when we have much more experience.

We also need to learn from the masters of this new art form: interface designers will need to acquire the skills of film makers and cartoonists as well as artists and writers.

Applications

Users with special needs have specialised requirements which are often well-served by multimedia and/or multimodal systems

• visual impairment - screen readers, SonicFinder
• physical disability - speech input, gesture recognition, predictive systems (e.g. Reactive keyboard)
• learning disabilities (e.g. dyslexia) - speech input, output

Virtual Reality
Multimedia multimodal interaction at its most extreme, VR is the computer simulation of a world in which the user is immersed.

• headsets allow user to “see” the virtual world
• gesture recognition achieved with DataGlove (lycra glove with optical sensors that measure hand and finger positions)
• Eyegaze allows users to indicate direction with eyes alone

Examples:
VR in chemistry - users can manipulate molecules in space, turning them and trying to fit different ones together to understand the nature of reactions and bonding
Flight simulators - screens show the “world” outside, whilst cockpit controls are faithfully reproduced inside a hydraulically-animated box

VR / AR Fundamentals — 3) Other Senses (Touch, Smell, Taste, Mind)

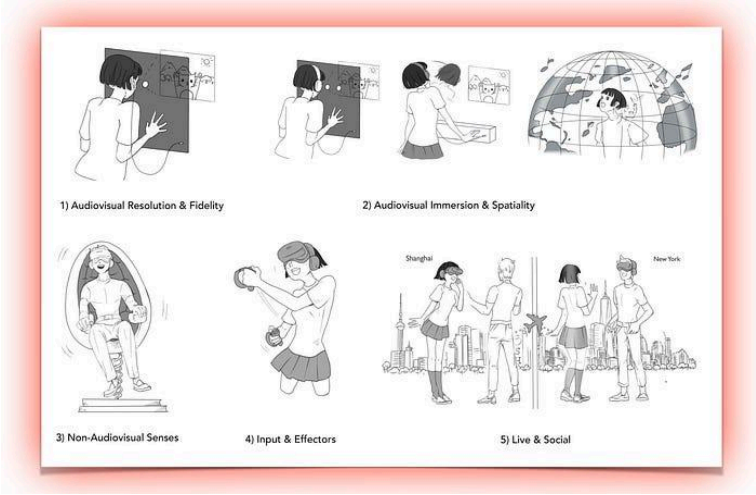
It’s hard to hear panels, presentations, pitches, or cocktail chatter about VR and AR without the topics of touching, smelling, and tasting coming up. Indeed, this is part of “real reality.” Today we’ll overview the non-audiovisual senses, including “Mind as sensor.”
Let’s begin though, with the most ubiquitous non-audiovisual sense.

Haptics
- Haptics & Force-Feedback
- Seats & Motion Platforms
- “4D”
- Skin as Input
- Hands & Controllers
- Touching Real Things / MR
- Non-Contact Haptics

Smell & Taste
- Smell-O-Vision & the Food Simulator
- Current Work

Mind
- Remote Viewing (ESP), Brainstorm (the movie), & Science
- Hacks

Issues
- When is suggestion good enough?
- Synaesthesia



Haptics

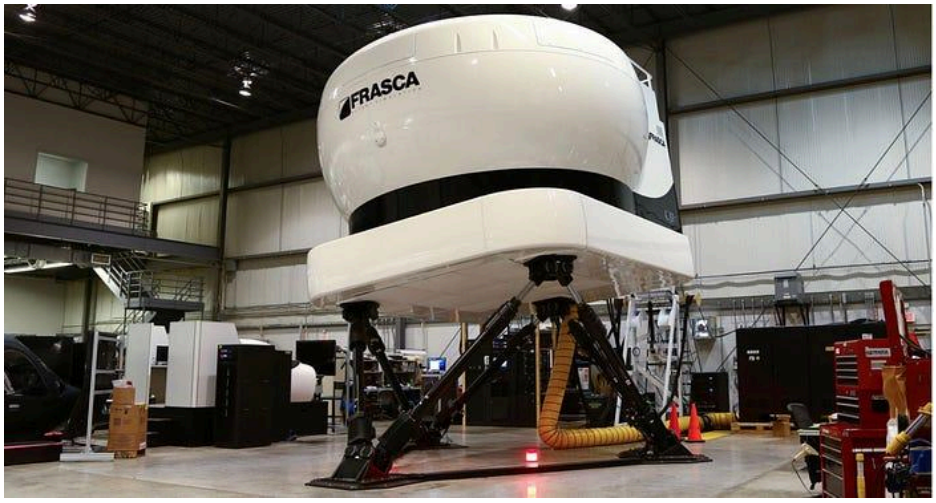
Haptics & Force-Feedback

Haptics is broadly defined as recreating the sense of touch through forces, vibrations, and motions, and force-feedback is defined as combining the sense of force to an input device such as a joystick or steering wheel. Sense of touch, meaning on the skin, is rich and complex with sensations ranging from featherlight touch to handshakes to massage to pain. And touch goes beyond skin deep.

Fremitus is a word rarely used outside of medicine but is a feeling we all know. It's the feeling of vibrations transmitted through the body, for example, the feeling of a powerful sub-woofer in the chest cavity. Body vibration devices today range from tiny vibrators on our smartphones to heftier add-ons for gamer controllers like Nintendo's Rumble Pak to VR chairs fitted with a monster tactile "bass shakers."

Seats & Motion Platforms

More effective than rumbles and shakers is when the seat or platform physically moves, such as with flight simulators or motion rides. In addition to touch-based haptics, our vestibular system inside our inner ear senses rotation and movement and provides powerful motion cues.



Frasca Helicopter Simulator — VR for one person

Flight simulators do a very good job adding haptics to an immersive audiovisual experience, but they're not particularly cheap. And still, they're not perfect. For example, what if the helicopter student pulls up and the simulator tilts up, then quickly pulls up again and the simulator tilts up more, then again? At some point, the powerful actuator legs reach their limit. The solution is call "simulator creep:" whenever the simulator is not centered but not in active motion, the system will "creep" it back to center at a speed below the threshold of detectability.


Douglas Trumbull's RideFilm simulator for the Back to the Future Ride, Universal Studios Florida, 1991

Slightly more cost-effective simulators have been built for groups, for the entertainment industry. One of the most novel simulators uses an "orthogonal motion base" invented by special effects and high frame rate wizard Douglas Trumbull. It solves the problem that when the front of a group platform goes down, the back of the group platform goes up, by only having the platform always flat and only moving orthogonally (up/down, left/right, front/back). So when the movie from a jet fighter nosedives, rather than tilting the platform down (which brings the rear of the platform up), the entire platform simply moves down while staying flat. It seems like it shouldn't work, but it does. Oh, and "slightly more cost-effective" still isn't cheap: the Back to the Future Ride cost $40 million.

There's another way to make VR experiences with the thrill and intensity of high G forces: take over a roller coaster. It's a simple idea. First, select a pre-existing roller coaster. Next, measure all of the movements and accelerations during the ride. This can practically be done with the vestibular-like sensors in everyday smart phones. Then, create a computer graphic VR experience in sync with the movements and accelerations of the ride. And if you're asking the roller coaster rider to wear VR headsets, why not also give them custom controllers, like a space gun, and add a level of interactivity to the experience?

Here it is.

Dare Devil Dive Virtual Reality Roller Coaster, Six Flags Over Georgia

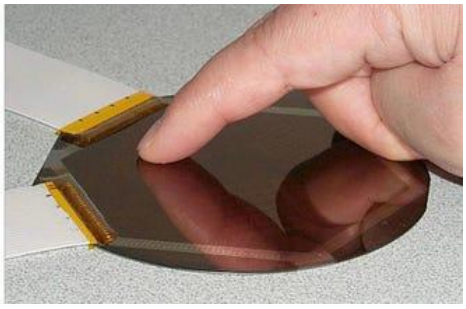
You may think this is a little crazy, and of course it's another not-very-cheap solution. In the early VR days, the VR-on-rollercoaster idea occasionally came up almost as a stoner joke. But check out the video. So far it's been the biggest hit in my class. Six Flags intends to repurpose nine of its rollercoasters for VR.
Seats and motion platforms for VR are a very ripe area for creative and inexpensive alternatives. I'd put my money on the health and fitness industry and on the arts community.

4D

"4D Film" is bantered around as something like the Holodeck — an ultimate, multi-sensory immersive experience. Experiences that advertise as 4D often add wind, rain, heat, smells, smoke, air bubbles, and back ticklers to stereoscopic image, multi-channel sound, and haptic seats.
4D, unlike holography, has no scientific or technical definition. And nobody owns it. It's basically a marketing term.

Skin as Input

On the other side, there has been solid research around "seeing" and "reading" through the skin.

Haptic Display (https://lmts.epfl.ch/haptics) and Electrostatic Display (https://tcnl.bme.wisc.edu/projects/)

“Haptic displays” physically move matrices of elements, sometimes called taxels, that can be easily seen and felt, while “electrostatic displays” have no moving parts and typically provide a sensation of touch rather than something physical. Such displays can be used as an “alternative eye” for the vision impaired.

I polled my class, if you wore a high-resolution dynamic display that covered the skin on your belly or your back with something that can be felt, would you “recognize” a landscape, a walk in the park, or a talking moving face. The consensus was a strong “maybe.”

Last year, Facebook demo’d an equally provocative system for “skin hearing.” We know it uses a system of actuators tuned to 16 frequency bands worn on the arm, and the demo video suggests it’s possible to discern three-by-three word sequences. The implications (as we understand it) is that users don’t learn in the sense of intellectual study like braille, but intuits over time: learning simply happens.

On the full body front, we’re beginning to see complete VR haptic suits, most using body-part specific vibrators which operate in sync with a VR game.

Then there’s haptics and VR sex. Now, I’m teaching an undergraduate class, in China (and mostly women), but I did show, without commentary, two published stories: Oculus VR Founder Wants To Make VR Porn With An “Industrial Robotic Arm” and Man has ‘sex’ with inflatable torso as he demonstrates bizarre adult virtual reality game in Japan (from the UK Daily Mirror no less, with an “explicit” video).

Hands & Controllers

Most of our everyday experience with the haptic sense is with our hands and controllers — game controllers, smart phone, key fobs, etc. — where the physical design of their shapes, sizes, knobs and buttons, could be considered haptic in nature.

Though I’m jumping ahead a bit to both Input & Effectors (next session) and Live & Social (final session), here’s possibly the most simple and elegant haptic hand demo ever.

inTouch, MIT Media Lab, 1998

In 1998, MIT Media Lab Professor Hiroshi Ishii and students Scott Brave and Andrew Dahley presented “inTouch,” a system consisting of two handsomely made identical devices each with three parallel wooden dowels. The two devices were connected live, so when one or more dowel moves on one device, it moves the corresponding dowel in sync on the other.

A “party trick” was to place both devices side by side with the electronics sections facing each other and covered with a napkin. The dowels behaved exactly as if they were three long dowels. Then the towel was removed and the units were
separated and still worked.

InTouch demonstrates the power and nuances of hands, touch, and movement. It’s been said that well-acquainted couples can “recognize” each other using inTouch remotely.

Touching Real Things / “Mixed Reality”

One of the first demos to come out of Scott Fisher’s VR lab at NASA in the late 1980s was a “surprise haptic demo,” made with Stanford intern Mark Bolas. They had made a 3D computer model of the VR lab space, and after visitors experience the standard demos, they’d switch from aircraft and elevators to the actual room, and say “see the table in front of you? Touch it.” The visitor’s VR hand (via VPL’s Data Glove) would reach out in a minimal wireframe world, viewed through then state-of-the-art VR headgear which Bolas calculated were equivalent to 20:200 vision, and alas!, touch the actual physical table.

Today this phenomena is sometimes called “mixed reality” (MR), now clouded by Microsoft’s different use of the same term. The phenomenon involves building a location-based space with physical props whose shapes approximate the virtual world the viewers will see with their VR headsets. The first major public appearance of this MR was a Ghostbusters VR experience, in 2016, in New York’s Times Square, built by The Void. Visitors wore standalone VR backpacks. Check out the video. A more recent startup, Nomadic, calls this “tactile and walkable VR adventures.”

A ground-breaking and emotionally resonant MR art installation was presented last year at the Tribeca Film Festival called Draw Me Close, an autobiographical story about the filmmaker as a child and his relationship with his terminally ill mother. The installation involved a live actress performing as the mother, captured live and appearing in the MR world, who would touch and hug the VR headset-clad visitor. See this video.

Non-Contact Haptics

Is it possible to feel something without any contact at all, beyond “very low resolution” wind? Can I feel a virtual ping pong ball hit a particular place on my shirt, or can I touch and control a virtual rotary knob? It would be nice, and there’s a lot of speculation (and hype) around non-contact haptics. So far, we’ve found two methods.

The first is the use of air vortex rings, a way to blow air out of a hole with impressively good aim and distance. Usually associated with smoke rings and “air bazookas,” air vortex rings are now a serious enough candidate for VR applications that they’re being studied by Microsoft Research.

The other non-contact haptic method uses a matrix of ultrasonic transducers. Ultrahaptics, a British startup, has developed a small array of 64 transducers that allow people to “touch virtual objects in mid air.” It’s been making the rounds at VR events and is impressive. I’ve tried it and the feeling is hard to describe. When you hold your hand above the matrix, you can definitely feel something, though more akin to a tingle, but can also definitely discern a sphere from a pyramid from a cylinder. As the video shows, there’s a good future for virtual knobs and other controls where not much force is needed.

ultrahaptics.com

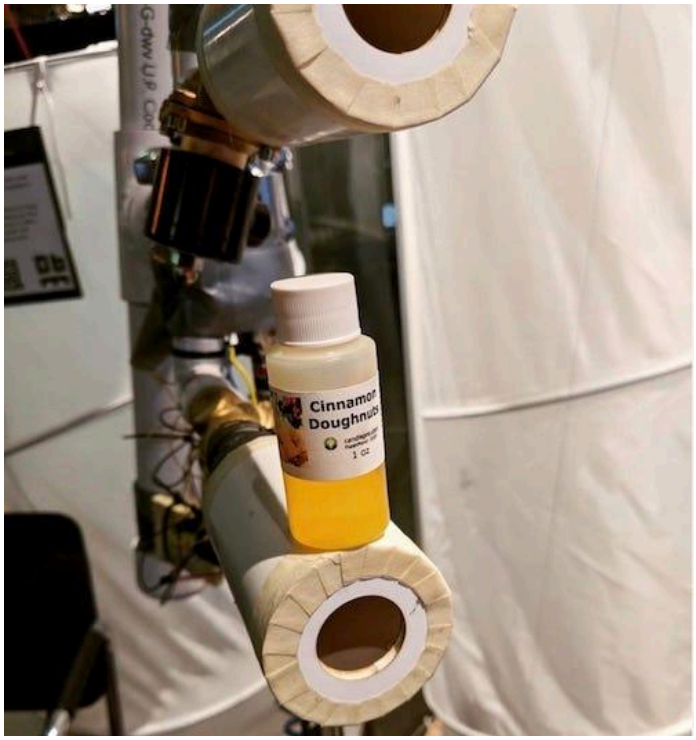
Smell & Taste

I'm combining these two senses into a single section partly because they're so similar, relying mostly on chemistry, and partly because there's not much that's truly new and revolutionary.

Smell-O-Vision & the Food Simulator

"Smell-O-Vision," specially equipt movie theaters with aroma emitting machines, really did exist (1960), as did AromaRama, Odorama, & Aroma-Scope, all with custom produced movies for the experience. The biggest problem was evacuating the aromas as fast as they were emitted, and allegedly this was the single biggest reason home "aroma players" never caught on. I once heard a radio interview with the maker of such a product, a CD player like device, which flopped and when asked why, he replied "people think they'd like to have the smell of 'baked bread' but then after a few minutes, they could no longer stand it."

One solution is to wear small "scent release devices" around one's neck. Los Angeles based start-up RemniScent makes small wireless modules loaded with chemical based scent filters.



Targeted Scents, Dan Novy, MIT Media Lab, 2018

Another solution, recently demonstrated by MIT Media Lab PhD student Dan Novy, is to “target” scents across the room using a vortex generator.

On the one hand, all of these methods work, in the sense of engaging smell as a sensory input. On the other hand, the technology remains entirely chemical, not electronic or digital, so each scent requires its own dedicated vial.

The same is essential true for the sense of taste, at least for the forseeable future.

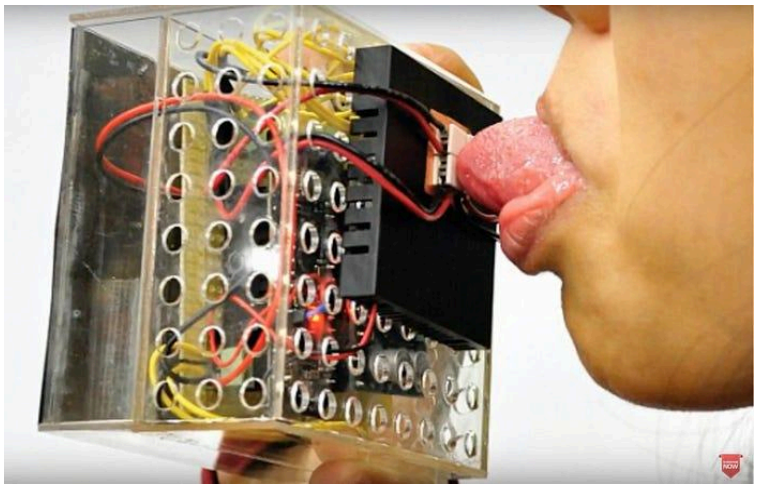

The Food Simulator, Hiroo Iwata,, University of Tsukuba, 2003

In 2003, the Food Simulator premiered at the Siggraph Tomorrow's Reality Gallery in the LA Convention Center. Participants were asked to put in their mouth a gauze-covered electro-mechanical device with a thin plastic hose attached. Biting down triggered the device to quickly contract while squirting a food flavored chemical into the participant's mouth. While many found it "novel" (or worse) virtually no one could make the leap between this device and virtual food. To its credit, the lead inventor, University of Tsukuba professor Hiroo Iwata, is perhaps the most prolific exhibitor of edgy haptic devices.

Meta Cookie, Takuji Narumi, University of Tokyo, 2010

In 2010, Meta Cookie combined headset-based VR with a "scent helmet" with visually coded "plain cookies" to make "augmented gustation," whereby the user sees an augmented reality cookie, like chocolate, while breathing chocolate scent. A seemingly more serious, well designed endeavor, Project Nourished, purports to use similar tech for weight loss, allergy and diabetic management, eating therapy, and remote dining.

Like smell, taste experiments are primarily still based on chemicals. Whether a usable connection exists between smell affecting taste is worthy of further study. And there's a trickle of research about electronic stimulation of the tongue to produce the sensation of sweet and salty and of the jaw to produce the sensation of chewing.



Virtual sweetness, Nimesha Ranasinghe and Ellen Yi-Luen Do, National University of Singapore, 2016

It's often hard to tell what's legit, what's irony, and what are design exercises. In 2013, artists Miriam Simun and Miriam Songster exhibited Ghost Food, a stark post-global-warming food truck. My San Francisco Art Institute students exhibited EAT, virtual dining via projection mapping as a commentary about consumption, and Virtuality, Inc. as a total VR hoax, which even included the dry-cracker-to-strawberry-cream-pie trick.

Mind

I'm using "Mind" as any sensory input not coming in through the known five senses. This may be related, but as I understand, different from Ayatana, the Buddhist belief in Mind as the sixth sense.

ESP, Brainstorm (the movie), & Science

ESP, Extrasensory perception, was coined by Duke University Professor J.B. Rhine "to denote psychic abilities such as intuition, telepathy, psychometry, clairaudience, and clairvoyance, and their trans-temporal operation as precognition or retrocognition." While many (actually most) people polled believe that some form of ESP or psychic phenomena exists, so far it's been impossible to reliably replicate these phenomena. And it's not like people haven't been trying, including the military. We even had a "psi research program" at Paul Allen's Interval Research Corporation in Palo Alto in the 1990s.

For this session, we're only focussing on "mind as sensor:" can the mind "read" other minds or "see" something far away without any other sensory input? Next week we'll address "mind as effector," which, it turns out, is a very different thing.
Even — especially — the best ESP or psi researchers will be the first to say that if these phenomena exist, they are very weak, inconsistent, unpredictable forces.

The 1983 movie Brainstorm, directed by the (thrice) aforementioned Douglas Trumbull, has perhaps the most technically believable premise, that a “brain helmet” can serve as a total input/output device, recording and playing back full sensory human experiences via something like video tape. The teaser gives an idea of the tech (and please forgive the early 1980s styles).

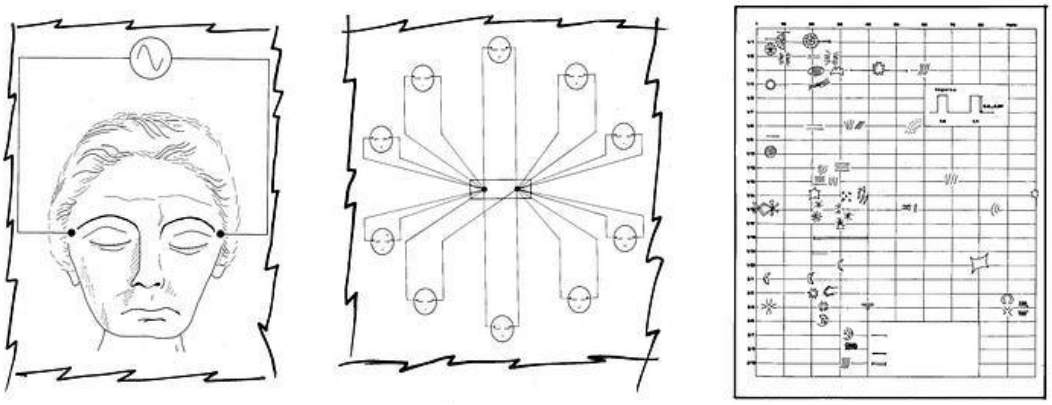
Using a brain helmet as input, to inject signals into the brain containing previously recorded human experiences is simply not on the horizon.

Using a brain helmet as output, to extract signals from the brain containing previously recorded human experiences, or as an input device — maybe. Next week . . .

Hacks

So far I’ve only been able to find two solid, repeatable, ESP-like phenomena. They’re not affecting the brain itself, but they do both use electrodes rather than eyes, ears, nose, or tongue to “get in.”

The first was the “Phosphotron” by Oakland, California video artist Steve Beck in the 1980s. Phosphenes are the dots, blurs, and scintillations of light we see when we gently rub or put pressure on our closed eyes. “Seeing stars” after a sneeze or standing up quickly are also phosphenes. Phosphenes are real, probably having something to do with stimulation of the retinal ganglion cells, but it’s not exactly clear how. In addition to pressure, phosphenes can be generated by mild electrical stimulation to the scalp, like around the temples.



Steve Beck’s Phosphotron, from www.vasulka.org

Beck’s Phosphotron was such a device. Participants were fitted with electrodes on their temples, usually as a group sitting in a circle, and Beck would “play” the Phosphotron, sending electrical signals of different shapes, sizes, and frequencies. Almost everyone saw something. Someone might say “white dots” and another “yeah” and another “I see blue lines.” The Phosphotron was far from a controllable image-making device, but it worked, in that people saw something with their eyes closed.

The other electrode-based sensory phenomena was "Shaking The World" by Taro Maeda and his team at Japan's NTT Communication Science Laboratories. It used electrodes behind each ear to produce "galvanic vestibular stimulation" which results in "lateral virtual acceleration," a fancy way of saying it can make you sway left and right as you walk. Shaking the World was exhibited in the juried Siggraph 2005 Emerging Technologies show, where I experienced it first hand. After signing a liability waiver, two participants were wired with electrodes and asked to walk side by side along an open space in the exhibition hall while the "operator," in plain sight, was sending control signals. No matter how hard everyone tried to resist, everyone would uncontrollably sway left and sway right as they walked, shown even more dramatically as two people at a time. The video is a must-see. Proposed applications for galvanic vestibular stimulation ranged from VR to automatic collision avoidance to pedestrian flow control.

Issues

When is Suggestion Good Enough?

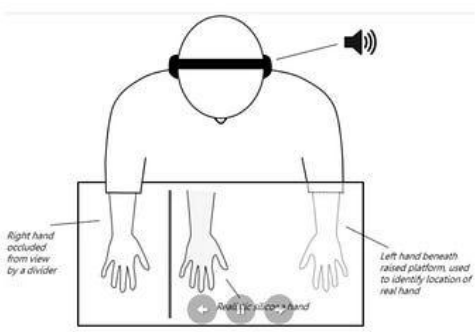
When is a suggestion of a knob via ultrasonic transducers, or the suggestion of getting hit by an arrow via a vibrator on your chest, or the suggestion of eating chocolate cookie via chocolate aroma with a tofu cookie, good enough?
Personally, I haven't a clue. We certainly know that low picture resolution in VR is bad (though not necessarily bad in painting), and if virtual ultrasonic knobs work, as can be empirically measured, we have some data points. But this is an entirely open and exciting area of exploration, largely because it's so unpredictable and counterintuitive.
My personal favorite example took place in Jon Barne's Ultimate Taxi in Aspen Colorado. His taxi is pretty ultimate, with live music, laser light shows, and magic, all while Jon Barnes drives around slowly through the picturesque streets of Aspen. Once, during the winter in the middle of an empty street, he simultaneously veered left, hit the breaks, exclaimed "Whoa!," and pressed a hidden button under the dashboard which sent a loud tire screeching sound to his sound system. The screech added so impressively to "like being there," more than anything else I've experienced.

Synaesthesia

Synesthesia is defined as a "perceptual phenomenon in which stimulation of one sensory or cognitive pathway leads to automatic, involuntary experiences in a second sensory or cognitive pathway." It's most often associated with different senses rather than pathways, such as "seeing color" or "tasting sound" and I've had my own good experience using sound to enhance haptic force (read #6).

Perhaps the most provocative, and repeatable, synaesthesia experiment is called the rubber hand illusion. A subject is seated with one hand out of view and replaced by a rubber hand in view. Both the human hand and the rubber hand are stroked by an operator in sync. Very quickly, the subject perceives the rubber hand as being her own. The rubber hand illusion can

even be performed with full disclosure and transparency and it still works. And it's also been shown to be affected by emotional audio cues.



Rubber Hand Illusion from parsingscience.org

The bigger idea here is called the body transfer illusion, the illusion of "owning either a part of a body or an entire body other than one's own." Researchers have studied using VR to understand first-person perspective changes, for example, when "transferring" from a woman to a man's body.

It's noteworthy that the word "feeling" applies both to touch, in the haptic sense, and to emotion. Smell and taste are not far behind, as particularly deep, emotional, limbic triggers.

Understanding Synesthesia: What 'Sound Purple' Really Means

Have you ever wondered how it would be to hear colors or taste sounds? Have you ever been on the receiving end of confusing artistic direction, like someone telling you to "sound more purple?" Welcome to the world of synesthesia — a neurological phenomenon that intertwines our senses in unpredictable and captivating ways, making the everyday experience a vivid tapestry of sensory delights.

Defining Synesthesia

According to the Cleveland Clinic, synesthesia is when your brain routes sensory information through multiple unrelated senses, causing you to experience more than one sense simultaneously. For instance, you may have visions of vibrant red when hearing the letter 'A' or sense flavors like chocolate while saying the word "soft." It's an invigorating interplay of senses and people with this condition are known as synesthetes.

Despite what many think, research suggests that it isn't rare at all — at least 4 percent of the population has some form of synesthesia. Furthermore, each synesthetic experience varies from person to person making it unique, similar to our fingerprints. Although this unusual phenomenon adds flavor to their lives for better or worse, it doesn't constitute a mental illness or a medical ailment. It's merely a way that someone perceives life differently due to certain brain conditions.

Types of Synesthesia

Synesthesia encompasses a vast array of sensory experiences, with more than 60 known variations, including grapheme color synesthesia, lexical gustatory synesthesia, spatial sequence synesthesia and auditory tactile synesthesia.

Grapheme color synesthesia is when letters or numbers are given colors as if they were part of your personal painting palette. In addition to being one of the most common types of synesthesia, grapheme color synesthesia is also one of the most studied. With sound to color synesthesia, certain sounds such as piano notes could be depicted by blue while car horns might register a red hue on someone's interior light show. Auditory tactile synesthesia exists where auditory sensations evoke physical feelings, like hearing chirping birds can feel like gentle caresses.

The Synesthetic Brain

Synesthesia is remarkable not only for its one-of-a-kind sensations but also because it helps us understand how our brains function. In these instances of sensory crossover, the primary visual cortex and limbic system collaborate to create an intense feeling that floods multiple brain areas at once.

The occipital lobe houses this same primary visual cortex which forms part of a unique symphony with other senses merging visuals into multi-sensory revelations. Meanwhile, the hippocampus works together in combination with the limbic system adding an extra emotionally charged impact to what most synesthetes experience and feel when they hear music — colors cascading across their mind's eye while stirring deep feelings from them all at once — as if attending a spectacular, tailor-made performance.

Primary Visual Cortex

The primary visual cortex has an extra job when it comes to synesthesia, playing a role in the creation of unique and interactive internal sensory experiences. This area of our brain combines sensory input from visuals with other senses — such as touch and taste — forming 'internal screens' for perception that go beyond what can be seen with just your eyes.

These enhanced cognitive abilities may not stop at providing extraordinary outcomes from ordinary tasks. The activity level displayed by lexical-gustatorial synesthetes presents evidence linking heightened response times to improved performance on various tasks related directly to this form of synesthetic perceptual experience. Although getting involved in colorful amalgamations might make life more vivid, synchronization could also equip individuals who practice such habits with greater mental dexterity overall.

Limbic System

The limbic system, which is linked with emotion and memory formation, can give an individual's sensory experiences a unique 'emotional flavor.' It could be why some people hear notes as flashes or hues or why they taste music. It's connected to enhanced fibers from their emotional center straight into their neocortex.

Synesthesia and Creativity

Synesthesia has been found to have profound impacts on creativity. Synesthetes' brains are much like bustling cities with many associations and connections between different regions, which can lead to the forming of new ideas, behaviors or experiences. This gift for combining seemingly unrelated things leads to creative possibilities unique from others, like creating artworks through colors inspired by songs or poems filled with flavors derived from food. When synesthetes join the creative ranks, it gives us all access to a more beautiful world full of re-defined abstract concepts.

Coloring Words

Synesthesia adds an extra layer to language. It gives synesthetes the ability to perceive words as unique colors on paper, allowing them to create stories through vivid hues and shades rather than just text alone. They often link particular letters of the alphabet with distinct tints. For example, they might describe 'A' as red or 'E' as yellow or white, creating a private code. Not only does this give written works more vibrancy, but it also helps unlock something called ordinal linguistic personification which enriches its meaning beyond conventional interpretations.

The sensory side of synesthesia means it transforms language into multisensory experiences like tastes, sights and sounds. This helps writers construct meaningful lines from what could otherwise be bland text. The use of such creative expression grants readers access to moments in time where description comes alive in exciting ways.

Voice artists are encouraged to color their words, creating a desired emotional response through tone, emphasis, timing and more. The meaning of a word and the context in which it's used, often dictates how it is approached and painted accordingly. Each voice actor comes at this from a different perspective depending on their life experience and worldview.

Coloring Music

Synesthetes have a special capability to combine their senses, blending visual colors with musical tones and notes. This creates an added dimension to the auditory experience, allowing them to visualize light shows dancing in time with music. Based on individual sensory experiences, higher-pitched sounds can be connected with pale hues like lavender and blue while deeper pitches may correlate with warmer tints such as gold or orange.

Having this unique ability offers creative inspiration for musicians when composing pieces of art that are multi-sensory encounters between color and sound. Through complex layers of audio stimulation accompanied by visuals coming from synesthetic color associations within each individual's orchestra, this transcends more traditional note structures. Synesthesia essentially fuses what you see alongside what you hear, which enriches composition brilliance.

Examples of Notable Synesthetes

Synesthesia has left a lasting imprint on the world of art and music thanks to notable synesthetes who incorporated their unique sensory experiences into masterpieces. Wassily Kandinsky used his synesthetic perception to produce vivid abstract paintings that almost mirror the sounds and melodies of synesthetic associations he experienced. Likewise, some propose that Vincent van Gogh's utilization of bold colors and dynamic brushstrokes could be reflective of synesthetic encounters.

One famous synesthete was Duke Ellington. He employed his synesthesia in crafting intricate jazz compositions whose moods were heavily influenced by being able to visually see sound as color. This ability is only possible through synchronized senses such as those acquired from having strong synesthesia properties within one's mindscape. Ellington could see music in colors.

Other notable synesthetes include Billy Joel, Itzhak Perlman and Nikola Tesla. These extraordinary individuals' visions serve up plenty for us to appreciate about our multifaceted existence through their colorful legacies.

Creative Direction and Synesthetes

In voice over, and voice production in general, there are myriad ways that we describe the vocal instrument. Synesthetes bring a special perspective to the creative process, enabling them to create sensory experiences that expand beyond our senses. This approach can provide stimulating and fresh insights into projects such as painting or designing buildings with music-inspired colors and shapes. Experiencing a project run by an artistic director who has synesthetic tendencies is extraordinary. They tap into all five senses when creating something far more than just what we see or hear.

For Synesthetes

Something you can do to make your direction clearer to those you are managing is to explain what you're seeing and how it relates to your expectations of them. Let's say you want something to sound "more purple" or "yellower." If you see an emotion or characteristic as a certain color, tell people so they have a reference point for what you're looking for. This may take practice but will help others follow your direction.

What does purple mean? How about yellow? If yellow means bright or loud, write that down and create a legend for how to decipher direction. Keeping this tool on hand and providing an artist with these definitions will help clarify your vision.

Final Thoughts on Synesthesia and Audio

Synesthesia is a powerful tool that opens the door to new and unique perspectives on sound, art, literature and more. Those who possess this ability can mix their senses to create stimulating auditory experiences like no other. Many synesthetes offer non synesthetes insights into how various senses interact with one another. They show us just how complex our perceptions are when it comes to creating meaningful moments out of everyday noises in life. In essence, through this phenomenon, we have been gifted an insight beyond what words alone can express.

2. Cognitive Load and Perception (45 mins)

- How the brain processes sensory input: Gestalt principles, mental models.
- Reducing cognitive friction: Simplicity, mapping, and consistency.
- Example: Poor mapping in stove controls vs. intuitive designs.

How Gestalt Principles Influence UX Design

Most online users expect user-friendly designs across all of their platforms when interacting with your brand. However, many businesses struggle to meet these expectations, which leads to poor user experiences. Disregarding users' expectations during your UX design process not only leads to frustrated users, but can also cause the loss of potential customers, result in users abandoning your Web site or app, and tarnish your brand reputation. The stakes are high, and these consequences are real.

"Gestalt principles of human perception ... can empower UX designers to create easy-to-use designs that meet your audience's psychological needs"

Given the high cost of alienating potential customers with confusing user interfaces, leveraging the use of Gestalt principles of human perception is crucial. These principles are not just theoretical concepts but practical tools that can empower UX designers to create easy-to-use designs that meet your audience's psychological needs. Gestalt principles can explain how people categorize similar elements, identify patterns, and comprehend sophisticated images when viewing user interfaces and other objects.

By understanding and applying Gestalt design principles, you can engage your audience and create better designs that users can easily understand.
By applying Gestalt principles to organize content and elements in your UX designs, you can ensure that they are both eye-catching and easy for users to comprehend. This article discusses Gestalt principles and demonstrates how they can be the key to creating engaging, effective user experiences. By understanding and applying Gestalt design principles, you can engage your audience and create better designs that users can easily understand.

Foundations of Gestalt Psychology

Understanding the foundations of Gestalt psychology is essential for you to implement Gestalt design principles effectively in your UX design solutions. Let's explore its historical context, core concepts, and relevance to modern UX design.

Historical Context

Gestalt psychology, which Wolfgang Köhler and Max Wertheimer developed in the 20th century, examines how humans interpret sensory information on the basis of recognizable patterns and structures. According to Köhler, our interpretation of the components of a design requires our analyzing components holistically rather than individually.

By developing a unified view of human perception and behavior, Gestalt psychology paved the way for Gestalt principles such as similarity and proximity to help humans achieve order in the world. (You'll learn about these principles later in this article.) According to Gestalt principles, people comprehend the objects around them by concentrating on them as a whole rather than focusing on their components.

Core Concepts

Perceptual grouping combines the existing relationships of an object's parts into a coherent whole.

The first core concept, perceptual organization, argues that we can understand people's perception of objects better through perceptual grouping. Perceptual grouping combines the existing relationships of an object's parts into a coherent whole. For the human brain to perceive complete wholes, perceptual grouping follows Gestalt laws in logically organizing visual information.

In the Phi phenomenon, a key concept of Gestalt, humans observe apparent motion when two nearby stationary images are presented at a relatively high frequency. This optical illusion tricks the human brain into believing that the fixed images are moving. Based on this observation, Wertheimer concluded that people perceive things by seeing the whole picture.

In UX design, you can apply the Phi phenomenon to create engaging user interfaces that guide users through a series of steps or actions, making the experience more dynamic and interactive.

Relevance to Modern UX Design

By applying Gestalt principles in design, you can create easy-to-use, engaging digital platforms that enhance user acquisition and retention….

Understanding Gestalt psychology is crucial to creating easy-to-use, aesthetically appealing user interfaces that meet users' perceptual needs. According to research by emplifi, 49% of consumers abandon brands because of a poor user experience. Ignoring the need to create designs that meet your audience's expectations can cost you customers.

By applying Gestalt principles in design, you can create easy-to-use, engaging digital platforms that enhance user acquisition and retention by doing the following:

- strengthening relationships between data points

- establishing a visual hierarchy
- grouping related elements
- improving navigation

Designers can use such Gestalt principles as figure-ground, similarity, and proximity to achieve easy-to-understand user interfaces, establish users' understanding of a platform, and deliver seamless user journeys.

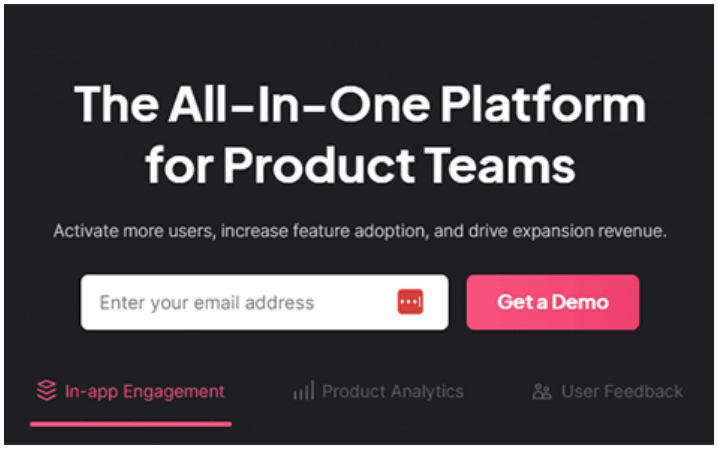
Key Gestalt Principles in UX Design

Gestalt theory comprises several design principles. Let's consider some of the key principles that you should prioritize using in your UX design solutions.

1. Proximity

The principle of proximity states that the strongest spatial relationships occur when design elements are close to each other. UX designers can use proximity to enhance understanding and navigation by grouping related functions. By applying proximity to form fields and buttons, you can enable users to easily comprehend the relationships between these different elements, making it easier for them to make decisions. For example, as shown in Figure 1, UserPilot replaces a field's label with placeholder text within the field so users can perceive these as a single design element.

Figure 1—Proximity of form elements



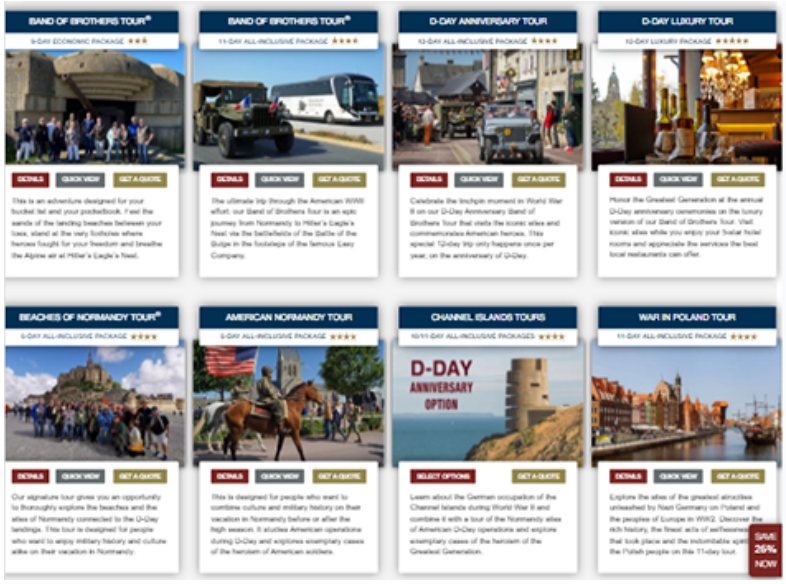
2. Similarity

According to the principle of similarity, the human brain perceives objects with similar elements as belonging to a single grouping or pattern. In Gestalt psychology, similarity is essential to the way humans perceive and organize visual information. In UX design, using similarity to categorize items based on their shared attributes creates visual consistency and hierarchy,

enabling you to achieve a cohesive visual experience. This lets users interpret patterns more efficiently, reducing their mental workload and improving their ability to perceive things correctly.

Use consistent icons, buttons, and tables in your designs to demonstrate grouping. For example, the Web site for a WWII tour agency in Normandy, which is shown in Figure 2, uses the principle of similarity effectively. Each tour-package card has a consistent layout with a photo, title, description, and buttons in the same style and position.

Figure 2—Consistent cards demonstrate similarity



This uniform design helps users quickly compare different tours and understand their options. The consistent fonts and colors tie the design together, reducing confusion and creating a smooth browsing experience. For example, when users see the Get a Quote button, they instantly know its function across all tour packages, making navigation straightforward and efficient.

3. Closure

The principle of closure empowers users to recognize familiar objects using pre-existing mental patterns.

The closure principle is in operation when the human mind automatically fills in missing parts of objects—even in cases where a designer has intentionally omitted some essential parts. The principle of closure empowers users to recognize familiar objects using pre-existing mental patterns.

By building user interfaces with elements that make users complete visual elements, you can trigger their inner curiosity and motivate them to engage with your designs. For instance, using interactive elements such as pop-up windows or animated transitions can create a sense of closure, encouraging users to explore further. When creating logos, adding some

mystery—which HP did in creating their logo, shown in Figure 3—can encourage the user to engage more deeply with the brand.

Figure 3—The HP logo uses the principle of closure

Image source: HP's Brand Central

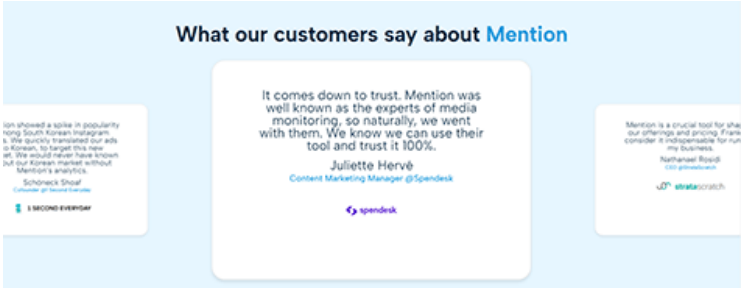
Other ways of achieving closure in design include simplifying icons and animating progress indicators that show a page is loading.

4. Continuity

The Gestalt principle of continuity lets people perceive the connected elements in a series as one continuous unit. In UX design, continuity can help you create a visual path using visual cues such as lines and shapes, creating a sense of flow that guides a visitor's eye in a specific direction. For example, using a consistent color scheme or visual style throughout a Web site can create a sense of continuity, helping users more easily navigate and understand the site's structure.

You can use slideshows, horizontal sliders, or carousels, and progress bars to create progressive layouts and reduce users' cognitive load. As shown in Figure 4, Mention executes this strategy well by using a carousel to enable users to scroll through their testimonial section.

Figure 4—A carousel on Mention demonstrates continuity

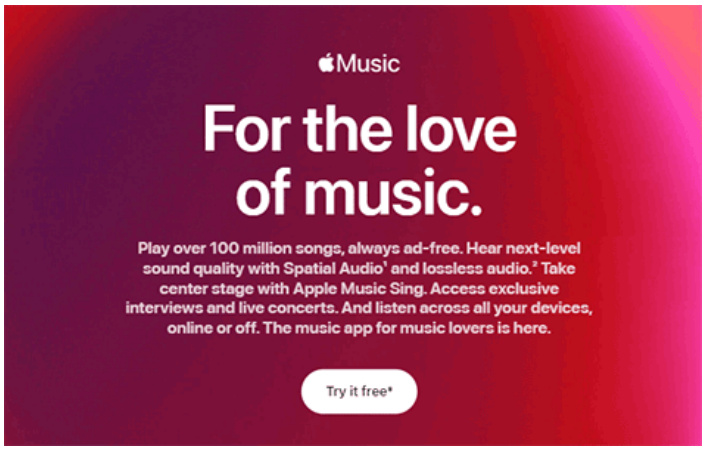


5. Figure-Ground

According to the figure-ground principle, humans categorize objects as either in the foreground or in the background. In UX design, you can use the figure-ground principle to dictate the content and elements that users perceive as being in the foreground or in the background.

By applying the figure-ground principle, you can emphasize modal windows, call-to-action buttons, and navigation bars, helping users concentrate on the essential aspects of your designs and potentially boosting conversion rates. For example, by using large, white text, Apple Music strengthens the foreground over the background in Figure 5.

Figure 5—Apple Music



Visual Perception and UX Design

Top-down processing … involves perceiving things based on our prior experiences and knowledge. Users rely on pre-existing concepts to internalize new information, recognize patterns, and make wise decisions.
Visual perception and UX design go hand in hand. Let's consider how the two interconnect to offer good user experiences.

Human Perception Mechanisms

Top-down processing, a critical human-perception mechanism, involves perceiving things based on our prior experiences and knowledge. Users rely on pre-existing concepts to internalize new information, recognize patterns, and make wise decisions.

In bottom-up processing, users' perceptual experience is based on the sensory stimuli they process. Using sensory data, people can make sense of the world, absorb energy from their environment, and convert it through sensation. Perception then results in the correct interpretation of these stimuli.

Visual Elements In Design

The use of whitespace is crucial in distinguishing and grouping the elements in a design, showing their relationship to improve visual perception. Using whitespace effectively in designs

helps create balance and visual hierarchy, enhancing a platform's usability and improving the user experience by

- drawing users' focus to critical elements on pages
- improving the readability of text
- organizing content effectively

However, managing negative space is also crucial for balance and emphasis. Optimize the use of whitespace when dividing or grouping elements so viewers can process the information they see more logically and more easily make decisions.

Perceptual Experiences in the User Experience

We can better explain perceptual experience through multistability, the ability to use certain technologies for a wide variety of purposes (the multi), but not all purposes (the stability). Multistability describes the human desire to seek certainty when we're presented with a stationary, ambiguous visual stimulus. When we're viewing ambiguous objects, our brain prioritizes one interpretation over another to reduce ambiguity. Thus, from a design perspective, you can make users focus on your desired perception by strengthening it and weakening the alternative perceptions.

Applying Gestalt Principles to UX Design

[A] user experience design should have a compelling visual hierarchy that informs, impresses, and persuades users. The use of Gestalt principles enables a clear visual hierarchy for easy navigation through a user interface.
Now let's consider some ways in which understanding Gestalt principles can help us achieve good UX design.

Creating Effective Visual Hierarchies

For digital platforms to succeed, their user experience design should have a compelling visual hierarchy that informs, impresses, and persuades users. The use of Gestalt principles enables a clear visual hierarchy for easy navigation through a user interface. For instance, by strategically structuring elements in line with Gestalt principles, you can ensure that users first notice the essential elements of your designs. Thus, you can direct users' attention to specific focal points, guiding them to take desired actions.

Enhancing Usability Through Perceptual Organization

Applying fundamental Gestalt principles is critical to creating well-organized, highly functional designs that foster smooth, seamless user interactions. Within the context of UX design, Gestalt principles enable you to place user-interface elements on pages strategically and craft easy-to-use, engaging user experiences that gain competitive advantage.

According to Forbes, research shows that 50% of consumers assess Web-site design to decide whether to engage with and recommend a business. Implementing Gestalt principles lets you

structure design elements in ways that naturally please the eye and meet your audiences' psychological needs.

Improving User-Interface Design

Integrating Gestalt principles into user-interface design helps you group information effectively, simplify visual elements, and organize user interfaces to enhance users' efficiency.
One application of Gestalt principles in data visualization is design color selection. Colors play an essential role in highlighting, categorizing, and differentiating visual elements. By thoughtfully selecting the colors for your designs, you can enhance their visual appeal and engage your audience. By applying other Gestalt principles—such as using closure in creating icons and symbols—you can achieve simplicity on a platform.

Conclusion

By using [Gestalt] principles in your designs, you can create effective visual hierarchies, improve navigation, and enhance a Web site's usability.

Comprehending and applying Gestalt principles in UX design is crucial in creating easy-to-use, visually appealing, user-friendly interfaces. By using these principles in your designs, you can create effective visual hierarchies, improve navigation, and enhance a Web site's usability.

As a UX designer, find ways of incorporating the Gestalt principles that I've discussed in this article into your design solutions. Doing so can ensure that you satisfy users' perceptual needs and create successful digital platforms.

Here's Why Simplicity Should Be Your North Star

Creating a Minimum Viable Product (MVP) is all about focusing on essential features to solve a core problem, save time, and reduce costs. Overloading your MVP with unnecessary features leads to delays, higher expenses, and poor user experience. Instead, simplicity helps you:

- Launch up to 3x faster and cut development costs by up to 50%.
- Gather user feedback quickly for future improvements.
- Deliver a straightforward, user-friendly experience.

How to Keep Your MVP Simple:

- Prioritize Features: Use the MoSCoW method to focus on "Must-Have" features and skip the rest.
- Streamline User Experience: Simplify navigation and workflows to boost adoption.
- Focus Development: Short, focused sprints minimize complexity and speed up iterations.
- Allocate Resources Wisely: Concentrate on features that provide the most value.

Real-world examples like Twitter and Snapchat show how simplicity leads to faster success and scalability. By focusing on solving one problem effectively, you can build a product that resonates with users and grows over time.

Identifying Core Features for Your MVP

Choosing the right features for your MVP means focusing on what solves user problems while aligning with your MVP's main objectives.

Using the MoSCoW Method for Feature Selection

The MoSCoW method is a straightforward way to prioritize features and avoid unnecessary additions. It organizes features into four categories:

Category	Description	Example Features
Must Have	Essential for basic functionality	User authentication, basic data input
Should Have	Important but not absolutely critical	Basic reporting, data export
Could Have	Optional features that are nice to include	Social sharing, advanced analytics
Won't Have	Features to leave out of the MVP	Advanced integrations

"A common best practice for determining the necessary features for a mobile app MVP is employing a MoSCoW matrix." – Clearbridge Mobile [2]
This method keeps the focus on what's truly necessary. If a feature isn't critical, leave it out.

Focusing on User Needs and Pain Points

Understanding user needs starts with research and validation. Ask yourself these two key questions:

1. What is the main problem users face?
2. How will your MVP's core features address that problem?

To gather insights:

- Talk to users through interviews and market research to uncover pain points.
- Develop user stories to map out scenarios and pinpoint essential features.

"Without an intelligent approach to MVP feature prioritization, product teams can waste time developing features that aren't essential to solving the problem while ignoring those that add the most value." [5]

Concentrate on one market segment for your MVP to avoid overwhelming your product with unnecessary features. This approach helps you build a more focused solution, which can later grow based on user feedback and market needs [6].
Once your core features are set, the next step is crafting a user-friendly experience to ensure maximum impact.

Creating a Simple and Effective User Experience

A well-thought-out user experience (UX) can make or break your MVP. Research shows that good UX design can boost conversion rates by up to 200%. Just like the MoSCoW method helps prioritize features, keeping your UX simple ensures those features are easy to use and understand.

Simplifying User Flows and Navigation

The best MVPs guide users through key tasks by cutting out unnecessary steps and reducing friction. The goal is to avoid anything that might frustrate users or cause them to leave. Here are some ways successful apps keep navigation simple:

Navigation Element	Purpose	Example Implementation
Bottom Navigation	Quick access to core features	Slack's minimal bottom bar with only essential options
Clear CTAs	Direct user actions	Grammarly's bold, easy-to-spot action buttons
Visual Hierarchy	Focus user attention	Nike's clean design that highlights products
Progressive Disclosure	Avoid overwhelming users	Instagram's gradual introduction of features

Principles of Simple UI/UX Design

Research from Nielsen Norman Group highlights that straightforward, intuitive designs can improve user satisfaction by up to 20%.[1]. To achieve this, keep these principles in mind:

Reduce Cognitive Load

- Focus on essential information and break tasks into smaller, easier steps.
- Stick to familiar design patterns so users know what to expect.

Maintain Visual Consistency

- Use a consistent visual style with a limited color palette for clarity.
- Leverage whitespace to make your layout clean and readable.

Optimize for First-Time Users

A poor first impression can drive away 88% of users. Avoid this by:

- Designing clear, logical pathways for navigation.
- Using recognizable icons and visual cues.
- Delivering value immediately without requiring lengthy onboarding.

Spotify's first MVP is a great example of this. Its simple navigation and clear design made it easy for users to start streaming music right away. This focus on usability helped Spotify grow quickly, proving how important a straightforward experience can be. Research shows that 76% of users expect apps to meet their needs, so keeping your design user-focused is key.

Once you've nailed a simple and effective user experience, you can use that foundation to speed up development and refine your product further.

Speeding Up Development with Simplicity

Simplicity doesn't just improve the user experience – it also makes the development process smoother, saving both time and resources.

Cutting Costs by Reducing Complexity

Keeping things simple during MVP development lowers costs, speeds up delivery, and reduces resource demands. On the flip side, complexity drives up expenses and slows progress

Cost Factor	Impact of Simplification	Benefit
Development Hours	30-50% reduction	Quicker deployment
Testing & Resources	40% fewer iterations, 25% smaller teams	More efficient testing and staffing
Maintenance Costs	35% reduction	Lower long-term expenses

The trick is to stay laser-focused on the core features that offer the most immediate value. By simplifying, teams not only save time but also open the door for quicker feedback and iterative improvements.

Faster Iterations and Better Feedback

A streamlined MVP makes it easier to collect and act on user feedback. This method prioritizes ongoing improvement through real-world input and quick adjustments.

Here's how to make simplicity work for you:

Prioritize Rapid Prototyping

- Focus on building essential features first.
- Test those features with actual users early on.
- Adapt quickly based on their feedback.

Simplify Decision Processes

- Base priorities on data.
- Skip unnecessary features.
- Keep development sprints sharply focused.

This approach delivers results. For example, Sidekick Interactive used simplicity to cut their development cycles by 60%, all while maintaining strong user satisfaction [2][3].

By simplifying development, teams can:

- Test assumptions faster.

- Respond to user needs promptly.
- Adjust to market demands with ease.
- Use resources more effectively.

Beyond just speeding up development, a focus on simplicity helps create MVPs that can adapt and thrive in changing markets.

MVP Success Stories Built on Simplicity

Several well-known platforms illustrate how starting with a focused core offering can lead to significant achievements:

- Twitter's Start: Twitter initially launched as a basic SMS-based communication tool for Odeo employees. Its simplicity became the foundation for its global reach [4].
- Snapchat's Niche: Snapchat gained traction by centering its MVP on one standout feature – disappearing photos and videos. This focused approach helped it carve out a unique space in the crowded messaging market and attract millions of users [4].

"By embracing the simple MVP approach, teams can quickly get the core of their product to users at a relatively low cost." – Sparck and BJSS [1]

These examples underscore how simplicity not only speeds up development but also lays a solid groundwork for future growth. By focusing on delivering a clear and concise solution, these companies maintained user engagement while preparing for long-term success.

Evaluating the Success of a Simple MVP

Key Metrics for Simple MVPs

To gauge the effectiveness of a simple MVP, focus on metrics like retention rates, engagement levels, and customer satisfaction. These indicators help confirm whether your product meets user needs while staying straightforward. Tools like Firebase and Mixpanel make tracking these metrics easier. Metrics such as Net Promoter Score (NPS) and Average Revenue Per User (ARPU) shed light on your product's market fit and financial potential.

Metric Category	Key Indicators	What It Reveals
User Retention	30-day retention rate	How well users stick with your product
Engagement	Daily/monthly active users, session duration	How users interact with your product
Revenue	ARPU, conversion rate	Whether your business model is working
Customer Satisfaction	NPS, CSAT scores	How well your product fits user needs

Simple MVPs often perform better in retention because users can quickly grasp their value. This is crucial, as engagement during the first month often dictates long-term success.
Collecting and Using User Feedback
User feedback is essential for refining a simple MVP. In-app surveys, user interviews, and A/B testing are great ways to gather insights and understand feature usage.

"At the very beginning, you should establish your goals and ways to measure them." – Bright Inventions

When reviewing feedback, give priority to suggestions that affect core functionality and align with your goal of keeping the product simple. Establish a feedback loop that:

- Gathers input from various channels
- Identifies patterns and recurring themes
- Makes updates while preserving simplicity
- Tracks the impact of changes using your chosen metrics

Metrics like Customer Effort Score (CES) and feature flow analysis can help ensure your MVP stays streamlined while meeting user expectations.

Conclusion: Simplicity in MVP Development

Examples like Sidekick Interactive and Snapchat show how keeping things simple can lead to faster development and scalable success. Many startups stumble because they overcomplicate their product, losing sight of the core value they aim to deliver.
Focusing on simplicity in MVP development brings several advantages:

- Faster Development and Cost Efficiency: A streamlined approach speeds up the process, cuts unnecessary costs, and ensures resources are used wisely by concentrating on essential features.
- Better User Engagement: A straightforward MVP addresses users' main needs without overwhelming them, increasing engagement and encouraging useful feedback.
- Clear Business Focus: Prioritizing key features avoids waste and aligns product goals with business objectives, ensuring every step serves a purpose [1][2].

To maintain simplicity, prioritize features systematically using methods like MoSCoW, and consistently gather user feedback while tracking metrics. This keeps your MVP focused and relevant.

Bad UX Exposed: A Comprehensive Guide to Avoiding Pitfalls

In today's vibrant digital design landscape, creating meaningful connections with users goes beyond offering innovative products or services. It leads us into the world of user experience design (or UX design). This critical factor shapes our interaction with the users and plays a big role in making our designs digitally inclusive and successful.

Think of UX design as the behind-the-scenes director of digital performance. It sets the stage for how users feel and interact with your website, app, or online service. A well-directed, intuitive design can captivate users, make them feel part of the story, and invite them to play on.
Beautiful visuals or trendy interfaces don't themselves make good UX design. Good design is about creating seamless, user-friendly experiences that meet users' needs and expectations. It's about making it easy for users to find what they're looking for and accomplish their goals. A well-crafted UX not only promotes user satisfaction but also bolsters business success. It can increase engagement, boost conversions, and foster customer loyalty.

But what happens:

- When UX design goes awry?
- When the user journey is more of a maze than a straight path?
- When interfaces are cluttered, information is hard to find, or pages take forever to load?

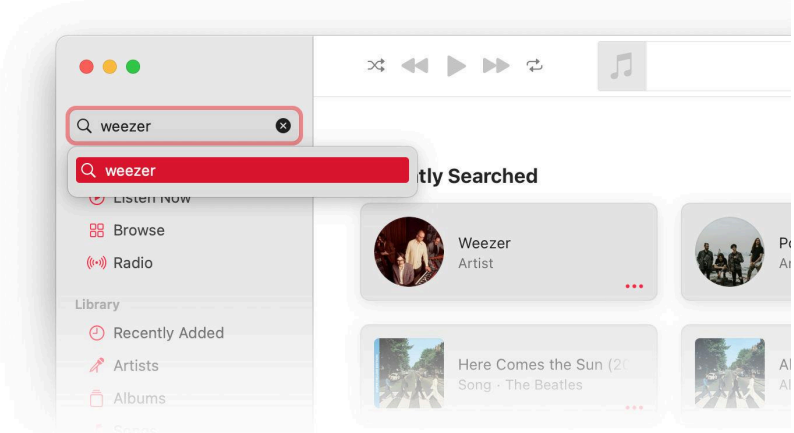
That's when we venture into the world of bad UX.
Bad UX design often results from a lack of understanding or consideration of the user's needs and expectations. It can be due to oversight, a misguided focus on aesthetics over functionality, or a need to invest more time and resources into UX design. But whatever the reason, the consequences can be severe.

Bad UX can frustrate users, driving them away from your website or app. It can ruin trust, tarnish your brand image, decrease conversions, and negatively impact your business. In a world where users are presented with abundant digital options, bad UX can be the deciding factor that leads users to your competitors.

Here, we'll go into the good, bad, and ugly UX design world. We'll explore bad UX design and UI examples, the impact of UX design problems on the business, and tips for transforming a bad UX into a great one.
As we navigate these topics, we aim to provide the insights and strategies needed to elevate your UX design and enhance user satisfaction and business success.

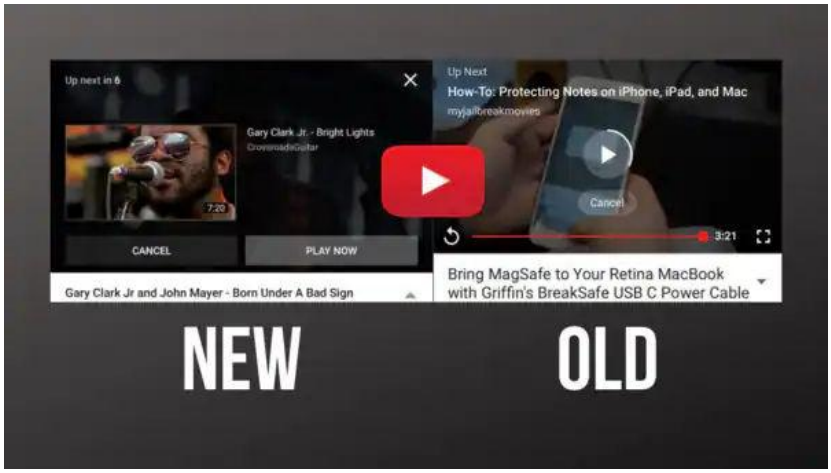
Real-World Examples of Bad UX

1. Apple Music



Apple Music is a comprehensive music and video streaming service by Apple Inc. It offers on-demand, ad-free access to a vast media library, live radio, and curated playlists.
© Apple Inc, Fair Use
UX Problem
Apple Music suffers from confusing navigation and unresponsive elements, which create a disorienting user experience. This includes poor autocomplete suggestions, a lack of a universal back button, non-interactive elements, slow page transitions, and the inability to remember the user's last session.
Impact
These UX hurdles put unnecessary strain on the user, turning a simple music search into a complex puzzle. This can lead to frustration and even force users to abandon the app. For Apple, this translates into potential drops in subscriptions and user engagement, ultimately affecting the profitability of Apple Music.

2. YouTube



YouTube, the behemoth of video-sharing platforms, needs no introduction. It boasts billions of users and offers an array of video content. An integral feature of the platform is the "Autoplay" feature. This function automatically queues up and plays the next video once you finish the current one.

© Youtube, Fair Use (sourced from Mint)

UX Problems

With autoplay, YouTube takes the reins of your viewing experience, often leading you down unexpected paths. The feature can disrupt your intention and push unsolicited content that might not align with your mood or interests.

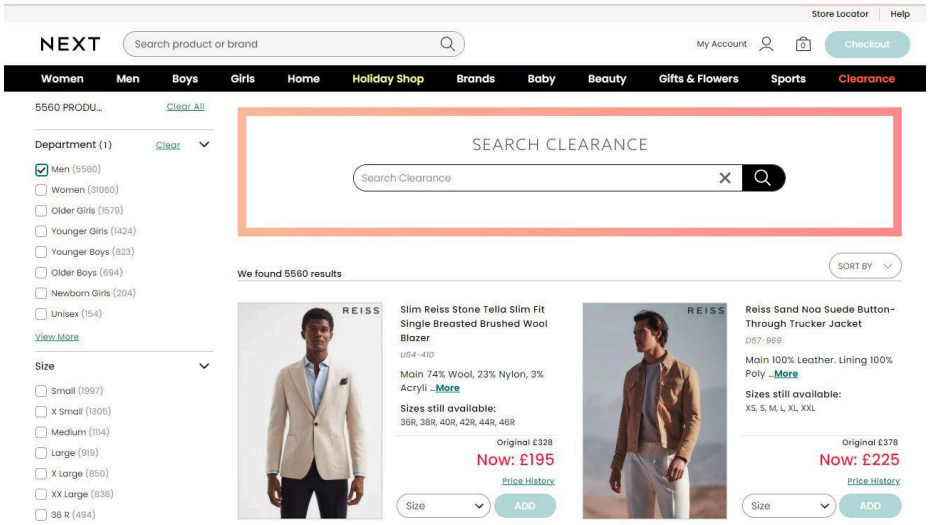
Autoplay can quickly drain these resources on a device with limited battery life or internet data by playing unwanted videos. It can overwhelm viewers with constant content, leaving no breathing space between videos.

YouTube also makes it difficult for users to pick up where they left off. In the app, viewing history is hidden under the less-than-obvious Library tab.

Impact

These UX issues can lead to a less-than-satisfactory user experience, potentially causing irritation, frustration, or user attrition. Users may feel they need more control over their viewing experience. Over time, this could erode user satisfaction and trust, affecting YouTube's engagement and retention rates. It's a delicate balance between ensuring seamless content delivery and respecting user preferences.

3. Next



Next is a major online clothing retailer in the US and UK. But unlike many sites, they provide scant information on their products.

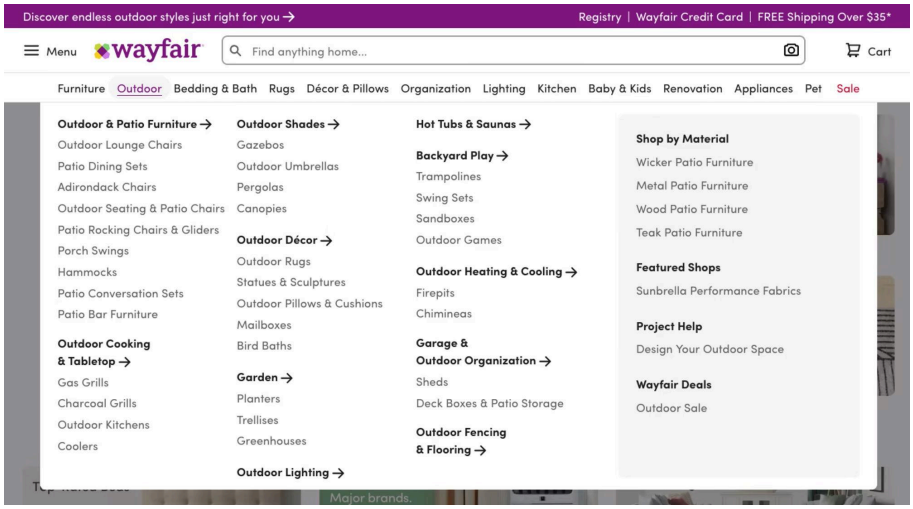
UX Problem

When shopping online, users need information to decide whether a product is suitable and how it compares with others. The site is improving, but this page of clearance items demonstrates the dearth of detail. The single photo (enlarged when clicked) is the only view provided, and the details shown in the adjacent are all that's available.

Impact

Customers are always taking risks when ordering clothes online. Will they fit? What weight is the fabric? Can I wear it on a summer evening? Does the jacket have side vents? While the minimalist approach can be appropriate in UI design, it usually doesn't help to hold back on product details. Next could take clues from retailers like Zappos and Lands' End, who provide copious descriptions and even videos of some of their products.

4. Wayfair.com



Wayfair.com is a major online platform for home goods. It thrives on its wide-ranging selection of furniture, decor, and more. It navigates this vast array through a long dropdown menu on its website. However, the execution falls short.

UX Problem

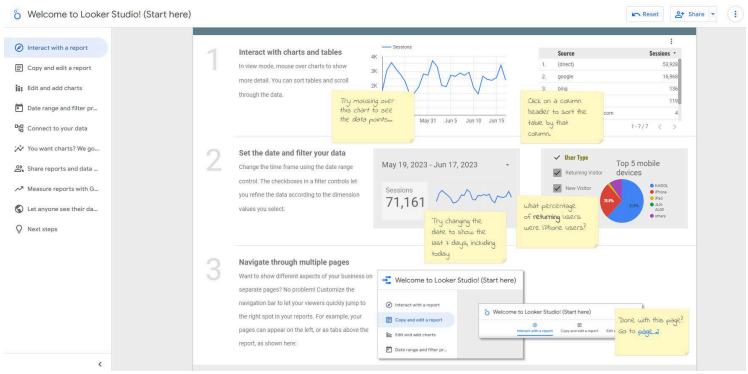
Wayfair's long dropdowns are designed to simplify the shopping experience by making every category accessible. But instead, it leads to navigation fatigue. Users may accidentally open the menu or other items on the homepage due to the website's hover-based interface.

The mega menu is also overwhelming due to its size and content density. Its layered sub-menus requires users to navigate the same path repeatedly to explore similar items.

Impact

These design shortcomings potentially hinder the customer's shopping experience. Users may feel overwhelmed, confused, or frustrated. It can lead to decreased site interaction, reduced purchases, and decreased customer satisfaction. A simpler, less overwhelming design would greatly improve the user experience.

5. Looker Studio



Formerly known as Google Data Studio, Looker Studio is a powerful visualization tool, but its onboarding tutorial leaves much to be desired. The tutorial is designed to guide new users. However, it is far from the concise and clear instructions we've come to expect from Google's product tours.

© Google, Fair Use

UX Problem

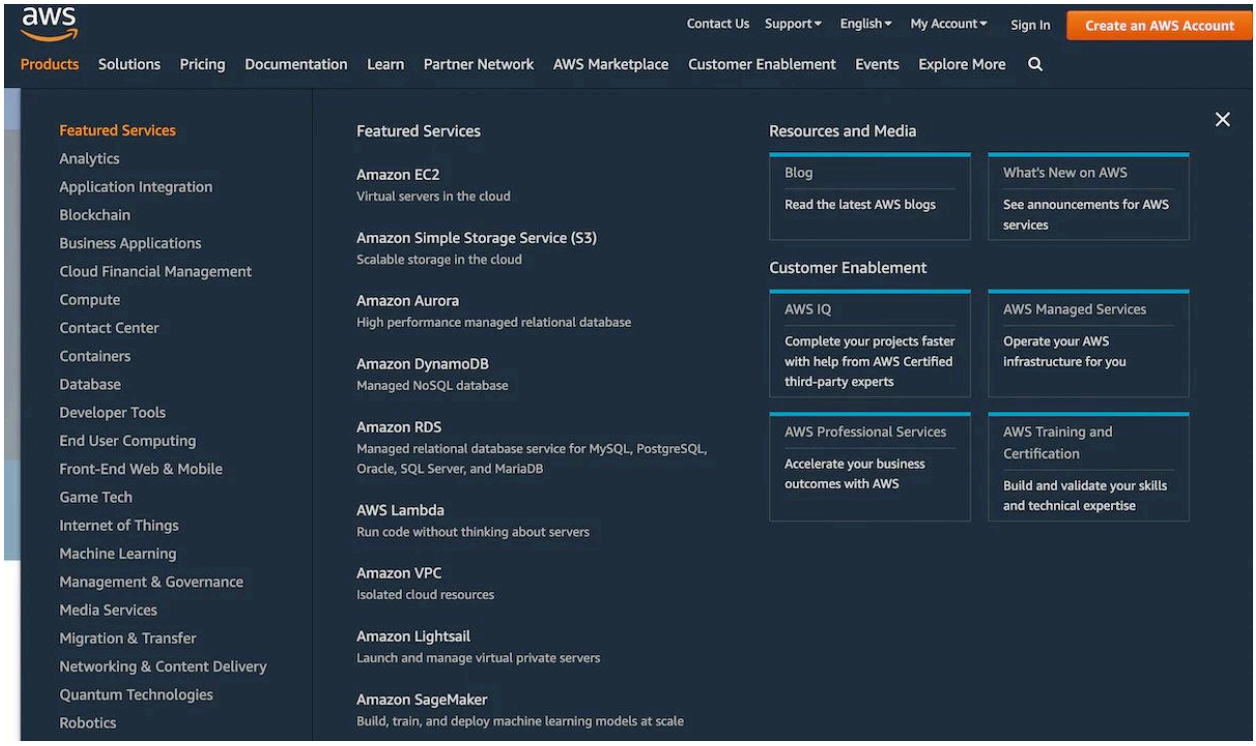
The main issue lies in the overwhelming amount of information. Numerous directions, annotations, and a 6-step tour all fight for the user's attention.

The already easy-to-use design, with a clear navigation bar and side panel, makes the extensive tutorial redundant. This confuses the user. They might be unsure where to start, proceed, or focus their attention.

Impact

Excessive guidance can lead to information overload for the users, causing them to abandon the tutorial before completion. This potentially hinders their understanding of the tool and affects their overall experience and usage. Simplifying the tutorial to three steps and utilizing principles like the Gestalt figure-ground principle can significantly improve user engagement and tutorial completion rates.

6. Amazon Web Services



Amazon Web Services (AWS) is a comprehensive and widely-used platform boasting many unique features and services. However, the platform's website presents specific navigational challenges that can hinder the user experience.

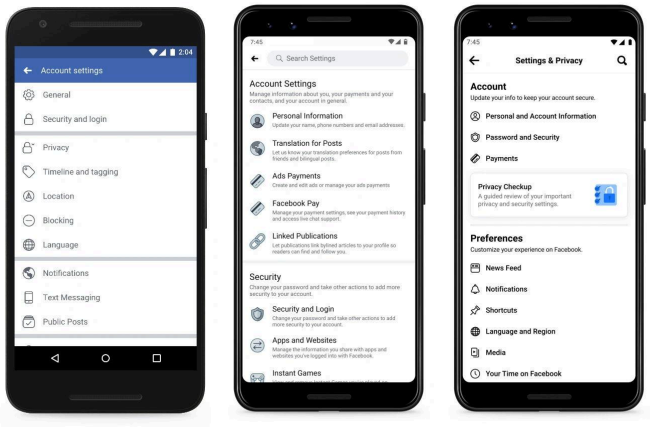
UX Problem

AWS's main navigation has too many options. This makes it hard to navigate, especially on smaller screens. Scrolling becomes a necessity. Although the design is visually nice and well-organized, there are too many choices.

Impact

The complex navigation can confuse users, who might struggle to locate the information they need promptly. Despite the aesthetic appeal and structured data, the dense navigation can overwhelm users. This, in turn, could lead to a poor user interface experience, with users feeling lost amidst a sea of options. So, it’d be better to simplify the main menu.

7. Facebook



Before Before Before After

Facebook is a popular social networking platform with numerous settings and options for user customization. One area of concern is that Facebook has a maze of settings. All three of these screenshots refer to account settings of different types.

© Facebook, Fair Use (sourced from 9to5Mac)

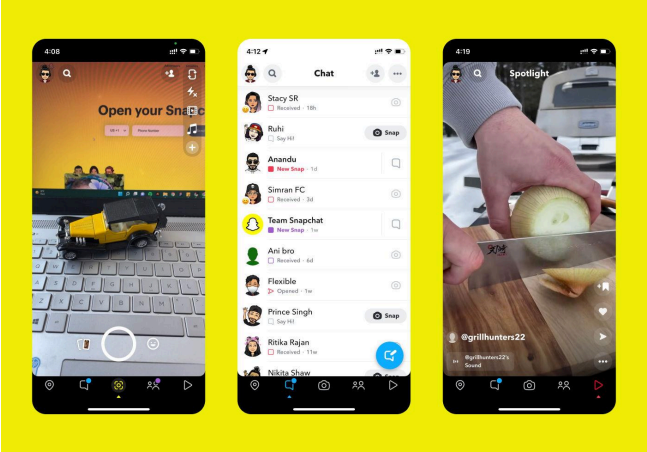
UX Problem

Facebook's privacy settings are incredibly complex. The settings are presented as macro-categories, each housing a range of additional sub-menus, external links, and multiple choices. The settings configuration is such that it becomes overwhelming and confusing, even for regular users. It becomes a maze of choices and decisions that need to be better placed or easy to find.

Impact

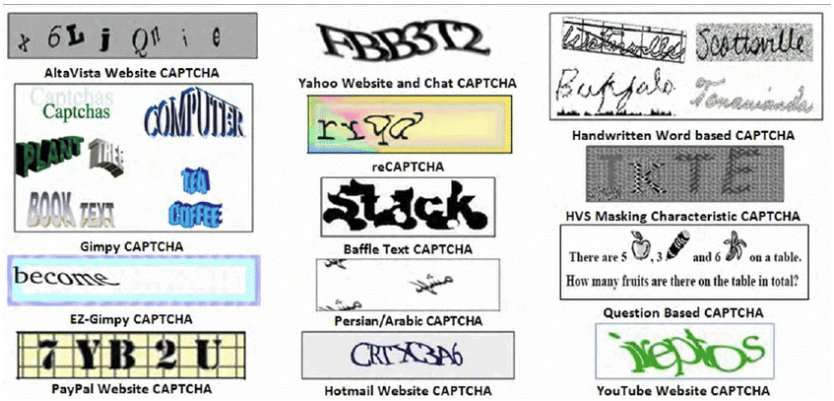
The complexity creates a significant barrier for users attempting to control their privacy settings. It becomes so daunting that many users may give up or be unaware of such options. This opacity is particularly challenging for non-tech natives or less tech-savvy individuals. It is an unfair user experience.

8. Snapchat



Snapchat is a social media platform best known for its self-deleting messages and creative image filters. It provides an engaging, dynamic way to share daily moments through snaps and stories. Snapchat's target audience is Gen Z, and the platform has been designed accordingly.
© Snap Inc., Fair Use
UX Problem
Snapchat's user interface can be confusing, especially for new or non-tech-savvy users. The platform relies heavily on icon-based navigation and gesture controls, which lack clear labeling. It is challenging to discover and remember various features and settings.
Impact
The cryptic interface design creates a learning barrier, potentially deterring new users or frustrating existing ones. Clearer signposting and instructions could significantly improve Snapchat's accessibility and user-friendliness. It can promote a more inclusive user experience.

9. Annoying CAPTCHA



CAPTCHA is a widely employed security feature that distinguishes human users from bots. It essentially helps prevent automated abuse on websites. While it is helpful for businesses, it's a different case for users.

© Google, Fair Use (sourced from Image Flip Captcha Research Paper)

UX Problem

The issue arises when Captcha is poorly configured, treating each new visitor as a potential bot. This leads to users being forced to solve complex and often hard-to-decipher puzzles before accessing the site's content. Captcha's excessively lengthy or malfunctioning codes intensify the problem, causing undue user frustration.

Captchas also become very challenging for older users and those with (even minor) vision issues.

Impact

Captcha annoyances can lead to a significant deterioration of the user experience. It may cause a site to lose its target audience and witness reduced conversion rates. You can conduct a usability analysis of your site and optimize the Captcha to fix the problem. Consider looking at visitor statistics to discover how many potential users are giving up at a Captcha and consider experimenting with alternatives.

10. Spotify

Spotify is a popular music streaming service with millions of users worldwide. It offers an expansive library of songs, playlists, and podcasts. They made a reasonable effort to create an error-free experience for the users but fell short when it came to delivering the message of error.

© Spotify, Fair Use (sourced from Spotify Community)

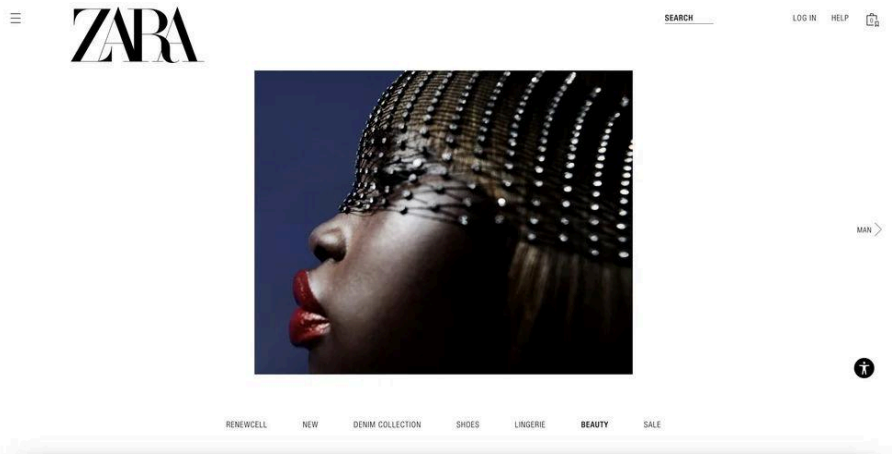
UX Problem

An issue arises when there's a critical failure, such as a login error. The app fails to provide clear, instructive feedback to the user in situations like these. A generic error message shows up informing the recipient, and that's it.

Impact

Overlooking such edge cases can lead to frustration and confusion. It's essential to remember that maintaining users is a privilege, and they should feel reassured and well-guided, even when encountering problems. In such situations, instead of displaying an abstract error message, Spotify could provide a more guided response, like this: "Uh oh, something went wrong. We're going to restart Spotify for you."

11. ZARA



ZARA's website has a visually striking aesthetic, like browsing a fashion magazine. However, due to its unconventional design, the site's primary purpose, shopping, becomes more challenging for users.

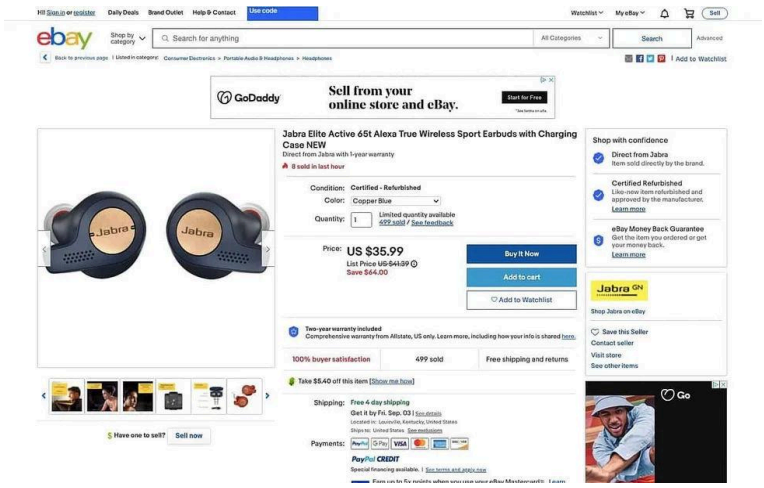
UX Problem

The site's homepage features small text and a navigation menu hidden behind a hamburger button, lacking a clear call-to-action. This ambiguity can lead to confusion and frustration. The site offers a non-standard navigation menu on mobile with no direct "Clothing" option. It leaves users to sift through an extensive list to find their desired items. The site lacks breadcrumbs and sorting options, making browsing laborious.

Impact

Due to the complexities, users may abandon the site in favor of more traditionally structured e-commerce sites. It can negatively impact Zara's potential sales and user satisfaction.

12. eBay



eBay is a global online marketplace that facilitates consumer-to-consumer and business-to-consumer sales. It's a platform where users can purchase various products from different sellers. However, the product pages on eBay are considerably more complex. It leads to a sense of information overload for users.

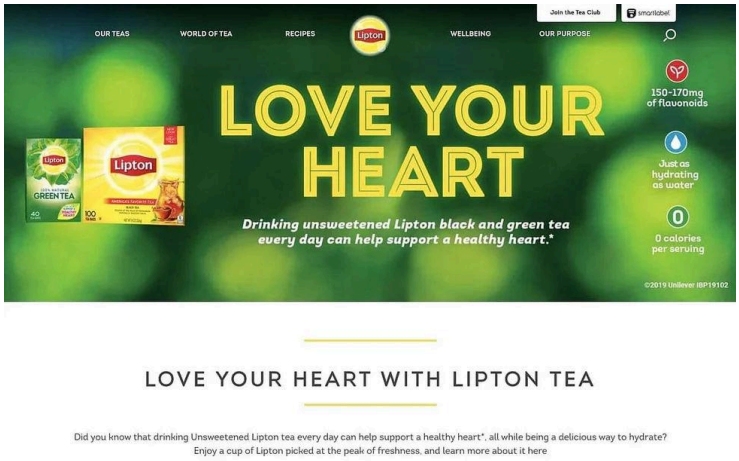
UX Problem

eBay's product pages contain excess information, all presented above the fold. Additionally, there's another section that reveals even more information when toggled. This approach overwhelms the user with an overload of details, making the decision-making process harder.

Impact

Over-complexity can paralyze visitors, causing confusion and making it difficult for them to proceed with a purchase. This could lead to increased bounce rates and a potential loss of sales for eBay. eBay should simplify its product pages with less clutter and a proper visual hierarchy.

13. Lipton



Lipton is a widely recognized tea brand that uses its website to showcase its products and engage with customers. However, the quality of the images on their site leaves room for improvement.

© Unilever, Fair Use

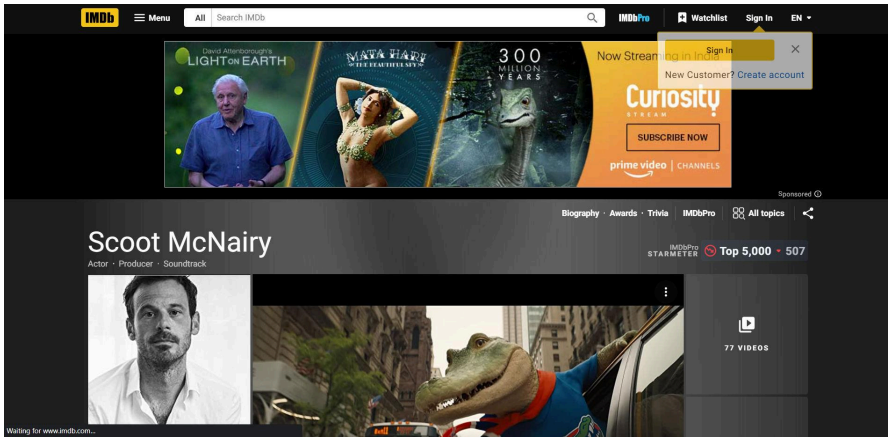
UX Problem

Lipton's website uses noticeably low-resolution images, resulting in a fuzzy appearance. Moreover, the images are primarily stock photos or packaging pictures. They need to adequately capture the unique appeal of Lipton tea or its community of consumers.

Impact

Poor image quality undermines the perceived professionalism of the site and fails to foster trust in the brand's messaging. This visual misstep may create a negative impression, potentially leading visitors to question the quality of Lipton's products. Lipton should replace the existing images with high-resolution ones that load quickly and accurately depict their uniqueness.

14. IMDb



IMDb is a renowned film and TV database that has made strides in modernizing its website. Yet, some pages retain an older design that can be less user-friendly.

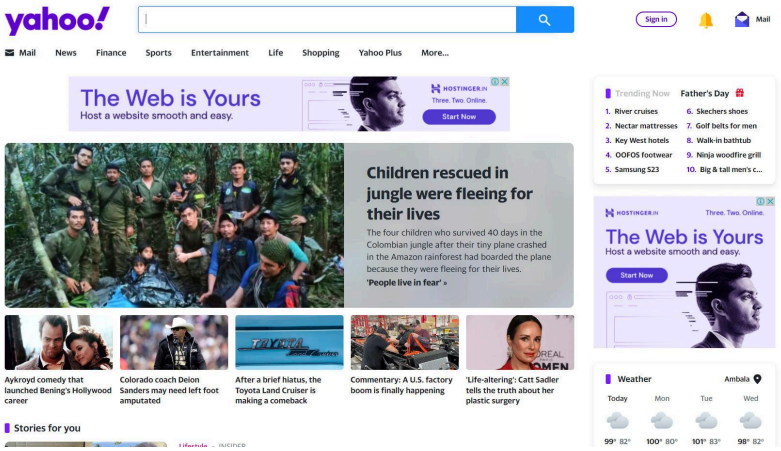
UX Problem

The design of the older pages, such as actor biographies, is marked by a lack of white space and color, a small font size, and a high volume of ads and other content. This contributes to a cluttered appearance that can make it challenging for users to locate desired information (in this case, details about actor Scoot McNairy). Without clear navigation options, users must scroll through extensive content to reach their target information.

Impact

The complexity and clutter of the pages may discourage new users and frustrate regular visitors. It undermines the ease of use essential for a practical user experience. IMDb should improve the organization of its website layout to enhance the website's usability and cater to both new and existing users.

15. Yahoo!



Yahoo! is a recognized digital media hub, hosting an impressive collection of articles spanning numerous categories. However, their attempt to display this array of content results in an overloaded homepage that can bewilder users.

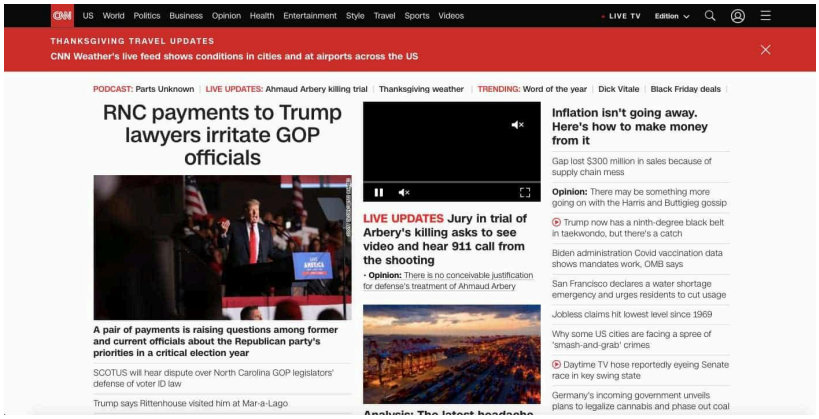
UX Problem

The Yahoo! site suffers from imbalances in white space utilization, with excess negative space above the fold on the desktop version and insufficient white space during scrolling. Coupled with small fonts and ad clutter, this leads to an exhausting reading experience that can feel cramped and disorienting.

Impact

The complicated layout can deter users from exploring the variety of content. They might feel overwhelmed by the crowded display and leave for a less chaotic news platform. Yahoo! can better manage its white space and reduce ad interference to enhance its user experience. It'll make the browsing experience more pleasant and less overwhelming.

16. CNN



CNN is one of the world's leading news organizations. It hosts a broad array of content, including articles, images, and videos. Yet its extensive content library has a downside, as it contributes to a painfully slow load time.

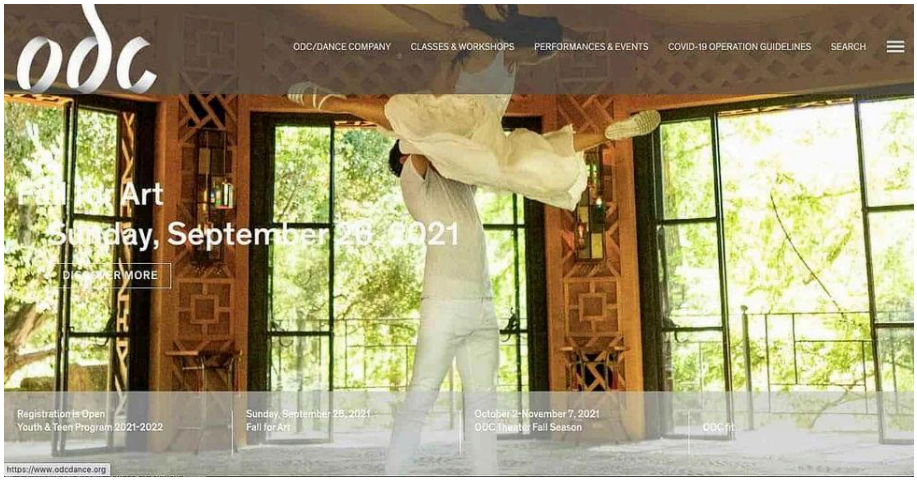
UX Problem

The load time for CNN's site is excruciatingly slow. It is identified as one of the slowest sites on the internet by SpeedMonitor.io. Sluggish load times can significantly impair the user experience, causing impatience and frustration.

Impact

The slow load time is a critical hindrance for CNN. More than half of mobile website visitors will abandon a site if it takes over three seconds to load. Consequently, CNN is likely losing many visitors due to its slow load time. Improving the load speed by streamlining the amount of text, images, and videos could potentially enhance the user experience and boost their SERP rankings.

17. ODC/Dance



ODC is a vibrant website dedicated to dance and art. However, the site has significant accessibility issues including problematic video control and color choices, which may restrict its ability to reach a wider audience.

UX Problem

The website's homepage features an auto-playing video that lacks the necessary controls for users to pause or stop it, violating WCAG guidelines. The site also struggles with color accessibility issues. Text headings and CTAs are difficult to see against image backgrounds, and white text on semi-transparent navigation bars and banners is challenging to read.

Impact

Accessibility problems can deter users. It may lead to fewer clicks on CTAs or navigation links and potentially higher bounce rates. Addressing the issues would help ODC adhere to WCAG guidelines and improve the user experience, engagement, and overall site reach.

18. Hacker News

Hacker News is a premier destination for the latest tech and cybersecurity updates. However, it has substantial readability issues that make it one of our bad usability examples.

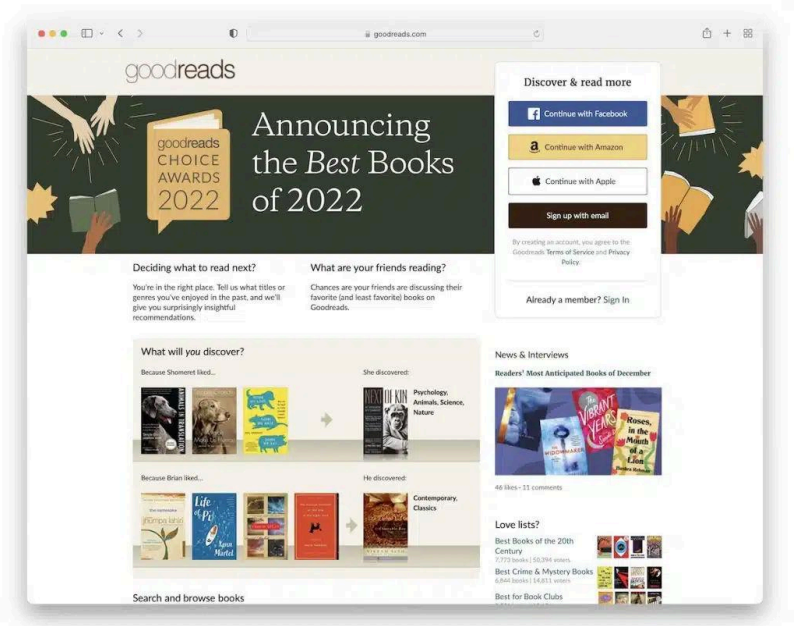
UX Problem

The site's presentation of various actions like upvoting, sorting, commenting, and visiting stories is complex due to the small font size and muted colors. Additionally, the lack of whitespace, icons, and hover effects makes it challenging for users to distinguish between these actions.

Impact

These readability issues could impede user interaction, reduce user engagement, and reduce site visit duration. Enhancements in typography, color, placement, and white space could significantly augment the site's readability, usability, and user engagement.

19. Goodreads



Goodreads is a massive platform for book enthusiasts to explore and review books. However, a rudimentary and user-unfriendly desktop design plagues the platform.

© Goodreads, Fair Use

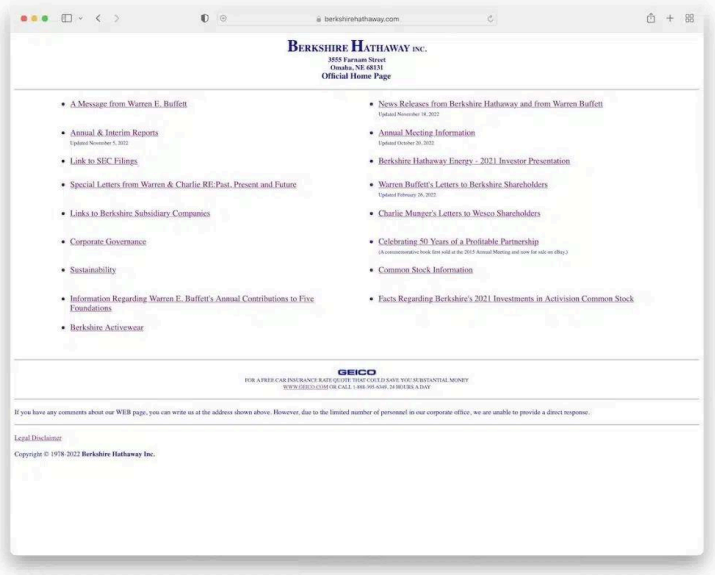
UX Problem

Despite being a large-scale business, Goodreads suffers from a poorly executed desktop interface marked by basic design and terrible navigation. Users may find locating and accessing desired sections difficult due to unclear navigational cues.

Impact

The lackluster user experience could deter users from fully engaging with the platform, potentially leading to lower user retention and reduced activity. While the mobile layout and the app offer some relief, the desktop version's inadequacy could still tarnish the overall perception of Goodreads, impacting its brand reputation.

20. Berkshire Hathaway



Berkshire Hathaway is a global holding company. Its website, however, feels like a basic directory. It has no visuals, only hyperlinks.

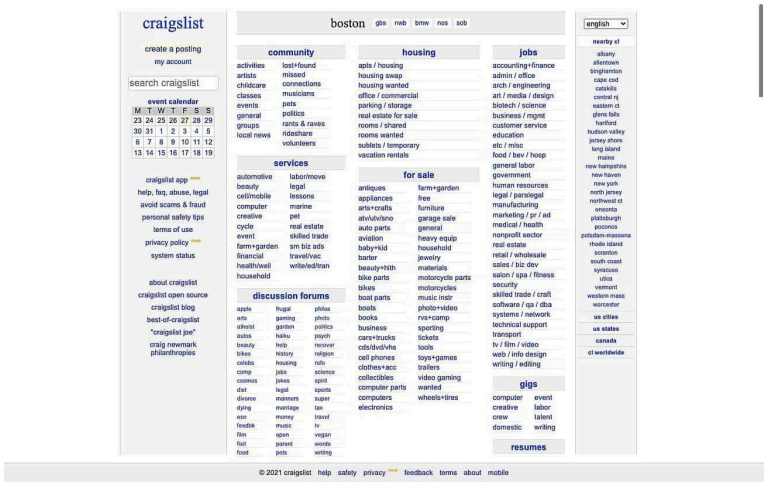
UX Problem

The Berkshire Hathaway website offers a subpar user experience due to its outdated design. It lacks images and relies solely on hyperlinks, making it challenging for users to find what they want. You need to know the company well to find anything.

Impact

The design is off-putting. Users might not find what they need. Despite decent mobile performance, the poor layout can reduce user satisfaction and the overall experience.

21. Craigslist



Craigslist is an immensely popular platform to buy, sell, and connect. Yet, it suffers from a major design issue: it lacks responsive design.

© craigslist, Fair Use

UX Problem

The site's non-responsiveness means that when users try to resize the Craigslist window on a desktop or laptop, a significant amount of content gets hidden. This issue directly violates today's standard, where users anticipate a seamless browsing experience across all devices and screen sizes.

Impact

A lack of responsive design might result in reduced traffic and higher bounce rates, as visitors may feel frustrated by the impaired user experience. Craigslist could substantially improve user satisfaction by investing in a more responsive design. It can potentially lead to increased traffic and decreased bounce rates.

22. Paper Source

Paper Source, a stationery retailer established in 1983, faces challenges with an outdated website design. Its layout, cluttered with images, text boxes, and CTAs, feels old-fashioned.

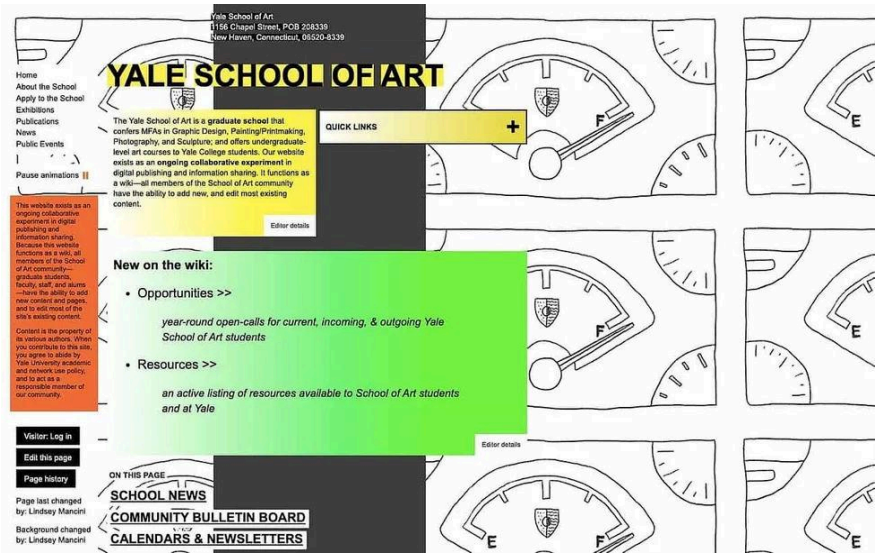
UX Problem

This antiquated design can confuse users, especially with the double CTAs positioned above the logo. It can cause a feeling of information overload, leading to user paralysis.

Impact

The outdated look and complex layout may cause users to perceive the brand as old-fashioned. It could lead them to choose trendier alternatives with more user-friendly designs. Consequently, due to design issues, Paper Source may lose potential customers and sales.

23. Yale School of Art



The Yale School of Art's website stands out for its bold design. It includes elements like an animated background and various color schemes, font styles, and effects. However, these elements come at the cost of the user experience.

© Yale School of Art, Fair Use

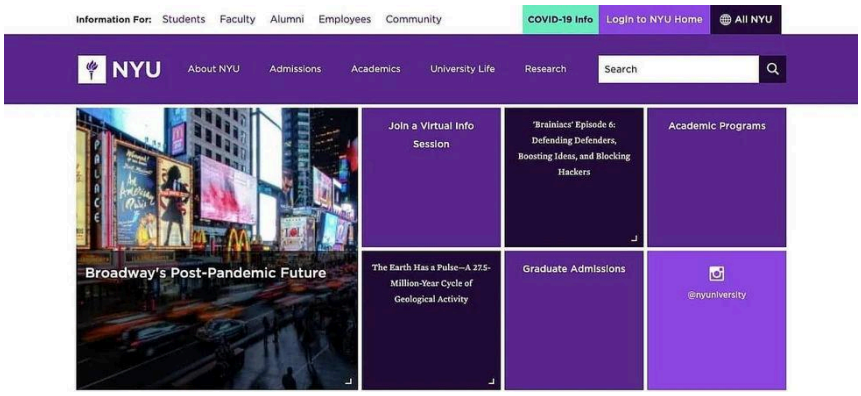
UX Problem

The animation speed and glitch effect detract from the core content. The inconsistent application of color schemes, font styles, and effects creates distractions.

Impact

The confusing design elements disrupt user engagement, likely leading to frustration. This could affect the site's ability to attract and retain users. The Yale School of Art must improve its layout and style to enhance readability and user experience.

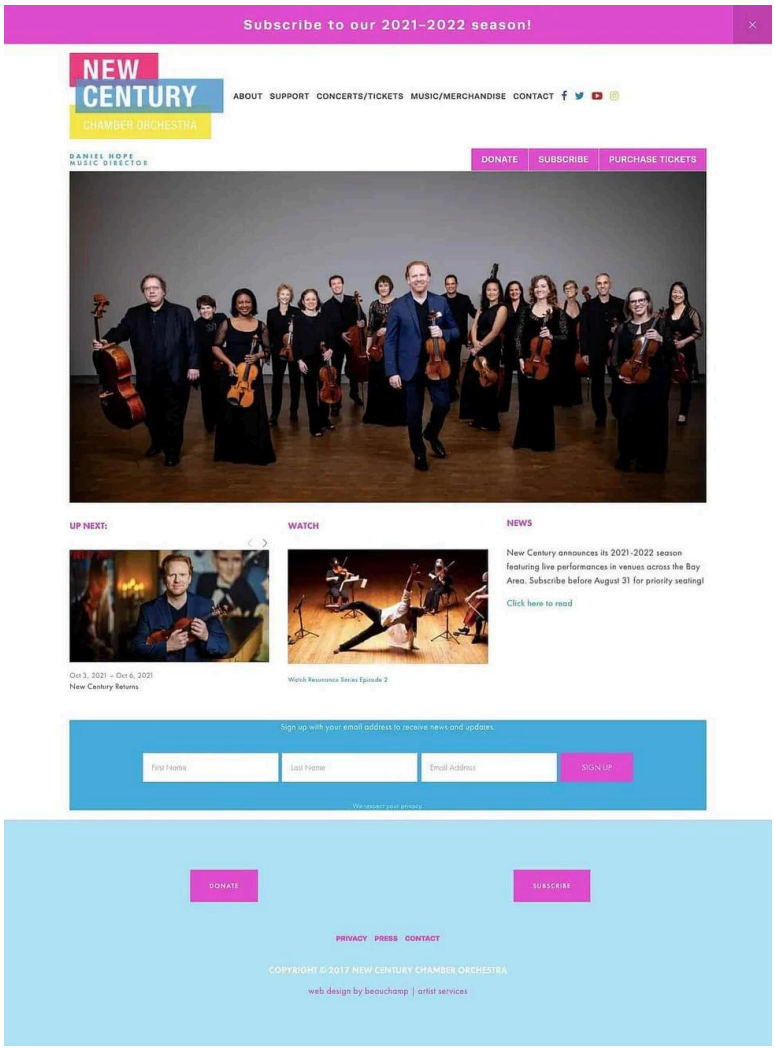
24. NYU



NYU's website features a unique grid layout. However, it overuses the color purple in its three primary components – the navbar, body, and footer.

© New York University, Fair Use
UX Problem
The similar shades of purple cause a lack of contrast. This makes it hard to distinguish one section from another, resulting in a confusing navigation experience. Limited images and solid color blocks with text on the grid layout give the impression of an incomplete web page load.
Impact
The confusing design could cause frustration for users and make it harder to find the information they need. NYU should enhance contrast, use color more wisely, and consider a visual hierarchy instead of a grid for a better user experience.

25. New Century Chamber Orchestra



The New Century Chamber Orchestra's website features a vibrant pink, blue, and yellow logo. Yet, throughout the site, these colors appear in varying shades.
© New Century Chamber Orchestra, Fair Use
UX Problem

The headings, opt-in email forms, and footer use different shades of blue. On the other hand, the site has CTA buttons in neon pink, yellow, and blue. This results in a lack of visual harmony. For accessibility, most of the colors have inadequate color contrast when used with white text. According to WCAG guidelines, the only exception is the pink, which would be acceptable for text that is 18 pt or larger.

Impact

The inconsistent color choices might confuse users and dilute the brand's identity. Adhering to a cohesive color palette could significantly enhance the user experience and reinforce the brand's identity. To comply with accessibility guidelines, the pink, blue, and yellow colors should not be used with white text to convey meaningful information. They should be used for decorative purposes only.

Common UX Mistakes and How to Avoid Them

When creating a good user experience for users, it's easy to fall into traps. A bad UX design can cost a company valuable users and lower its conversion rate. Here, we'll walk you through common UX blunders from the top UX design fails and how to sidestep them.

1. Slow Load Times

One crucial aspect often overlooked in UX is load times. Users won't wait for a slow-loading page; it's a cardinal sin of UX design. Consider this: a one-second delay in page response can reduce conversions by 7%. A study by Google found that 53% of mobile users will abandon a site if it takes more than three seconds to load. Imagine the damage that a slow load does to the overall user experience.

How to avoid slow load times?

Optimize website code and content to avoid slow loading times. Implement techniques like compression, caching, lazy loading, and image optimization. Regularly test your website's speed and work with developers to ensure efficient performance.

2. Complicated User Flows

A good user flow allows users to achieve their goals efficiently and quickly. This adds up to usability issues if things are complicated. Users won't stick around if the path to the desired action is long and intricate. An example of poor usability is a checkout process that requires numerous steps.

How to avoid complicated user flows?

Simplify. Start by sketching a simple roadmap. Each box you draw represents a user action step. It is helpful to divide your roadmap into three main parts: the beginning, the middle steps, and the end. The end is when the user completes a task, or the final interaction happens.
Test. Conduct usability evaluations or use A/B testing to optimize flow with real users.

3. Graphics Mismanagement

Small and low-resolution graphics can negatively impact the customer experience. Clear, high-quality visuals are a cornerstone of user-friendly interfaces, as they help with navigation and understanding. Low-quality graphics, however, can confuse users and make a website seem unprofessional.

How to avoid graphics mismanagement?

To avoid a bad user experience due to graphics, ensure images and graphics are optimized for the platform they're displayed on and allow users to see suitable details. You need to maintain high resolution without sacrificing load times.

4. Poor Information Architecture

Information architecture refers to making the information findable and understandable on a site. Often, designers need to do more than arrange information logically. This leads to a messy content setup. Users can find this confusing and need help locating the information they need.

5. Poor Landing Page Design

A landing page is the first interaction point between a user and your website. If it's hard to navigate, users will leave. A good landing page should be user-friendly and easy to understand. It also needs to confirm that users are in the right place.

How to avoid creating a poor landing page design?

Prioritize clarity. Keep design and copy simple, relevant, and clear. Make sure that page titles and headings correctly reflect the content and that links to a landing page are consistent with users' expectations. Also, consider relevant video content. Statistics show that landing pages featuring appropriate embedded videos can boost conversions by 86%.

6. Lack of Negative Space

Negative space, or the white space surrounding objects or text in a design, is often underutilized in UX. Ignoring negative space can lead to cluttered, overwhelming interfaces that hinder user comprehension and navigation.

How to avoid having a lack of negative space?

Plan your design layout carefully. You need to ensure that there's breathing space for all the design elements you use and that designs work well regardless of screen size. Prioritize simplicity over excessive details and make good use of margins and padding. This promotes a clean and balanced look.

7. Poor Accessibility

Many bad UX examples stem from overlooking accessibility. Regardless of their abilities, all users should be able to interact with your product easily.

How to avoid accessibility issues?

Follow accessibility guidelines, such as those provided by the Web Content Accessibility Guidelines (WCAG).

Prevention Is Better than Cure

The best way to avoid bad UX is to focus on user-centered design from the start. Invest time in understanding your users' needs, behaviors, and frustrations. This knowledge helps shape an experience that's tailored to their needs.

Usability testing is another powerful tool in your arsenal. Regular testing uncovers issues before they become problems. And remember, it's not a one-time thing. Regular tests help keep your UX current as user behaviors and technologies evolve.

User research, usability testing, and a keen focus on the users' needs are the pillars of good UX design. They help avoid bad UX design, enhance the overall user experience, and ultimately increase your conversion rate in the battle for good UX design.

UX Design Is an Ongoing Process

UX Design isn't a one-and-done endeavor. It's an ongoing process that requires constant evaluation and improvement. Minor issues, like slow load times or a poorly placed 'delete message' feature, can significantly impact the overall user experience and conversion rate.

UX mistakes can be costly, but they're also an opportunity for learning and improvement. You can avoid these common pitfalls if you keep user needs at the heart of your design process and follow standard UX practices.

Ultimately, it's all about ensuring your users feel understood, respected, and valued when interacting with a product. And that's a surefire way to turn a bad UX design into a good one. Remember, users win when the design is right. You want to create an experience that's not only easy to navigate but also enjoyable and rewarding.

Ensuring good UX isn't all about avoiding mistakes. It's about creating an environment where users can flourish. Keep testing, refining, and keeping your users at the forefront of every decision. After all, good UX isn't just good business. It's good practice.

How Bad UX Can Impact Your Business

Bad UX design doesn't frustrate users. It has real-world repercussions for your business. From tarnishing your reputation to causing dwindling sales, poor UX can wreak havoc on your bottom line. Let's explore these impacts in more detail to help you understand how to identify bad UX design.

1. Lower Customer Satisfaction

Customer satisfaction is deeply intertwined with UX. A Microsoft report found that 56% of consumers have stopped doing business with a brand due to poor customer service, which includes digital interactions.

Whether it's a cluttered layout, difficult navigation, or a lack of accessibility, a bad UX design can leave users feeling frustrated and undervalued. For instance, some common mistakes that a web designer may make can lead to these issues. This dissatisfaction can lead to lower

customer retention rates, especially on mobile devices. Dissatisfied users may seek better experiences from competitors.

2. Decreased Sales

At its core, a product's UX directly impacts its conversion rate. A user-friendly experience can push customers toward purchasing or signing up for a service. However, bad UX design can have the opposite effect.
For instance, a Baymard Institute study found that 69.8% of shopping carts are abandoned. Much of this can be attributed to poor UX, like the complicated checkout process, a lack of payment options, or slow load times. These factors can frustrate users, causing them to abandon their carts and diminishing potential sales.

3. Reduced Business Credibility

In the digital world, your website is often the first point of contact between you and potential customers. A poorly designed, hard-to-navigate website creates a wrong first impression, reducing your business's credibility. According to a Stanford study, 75% of users admit to judging a company's credibility based on their website's design.

4. Higher Customer Acquisition Costs

Bad UX design can inflate customer acquisition costs. If users leave your site due to poor UX, you'll need to invest more in marketing to attract new ones. A Forrester report shows that a well-designed user interface could increase your website's conversion rate by up to 200%. Enhancing your site's entry point can organically attract and retain more customers. It reduces the need for costly marketing campaigns.

5. Increased Customer Support Costs

A bad UX design can confuse users, leading to an influx of customer support requests. Each query adds to your business costs and pulls resources from other areas. For instance, according to Gartner, reducing customer effort can reduce costs by up to 37%.

6. Lost Competitive Advantage

Bad UX isn't just a customer problem; it can also affect employees. A study by Robert Half Technology found that workers lose an average of 22 minutes per day due to IT-related issues. For example, complex flow charts or flow diagrams in these tools can lead to confusion. Multiply this by the number of employees and the days in a year, and how bad UX can lead to significant productivity loss becomes evident.

Transforming Bad UX into Great UX

Turning a bad UX into a great one isn't an insurmountable task. It takes insight, creativity, and commitment. Here, we offer some practical tips and best practices to aid your UX design journey.

Tips and Best Practices for Improving UX Design

1. Know Your Users

Understand your users' needs, behaviors, and pain points through user research. This includes methods like user interviews, surveys, and usability testing.

2. Utilize White Space

White space or negative space is a crucial element of UX design. It enhances readability, guides users' attention, and makes your interface look clean and uncluttered.

3. Use Consistent Design Elements

Consistency in design elements like colors, fonts, and buttons can significantly improve the UX by making your product easier to use.

4. Simplify Navigation

A simplified navigation structure helps users find what they're looking for more easily. Use breadcrumb navigation, dropdown menus, and a search bar to aid navigation.

5. Use Responsive Design

Ensure your product works seamlessly across all device types, whether desktop, tablet, or mobile. A responsive design enhances the user's experience no matter how they access your product.

6. Incorporate User Feedback

Create a feedback loop to regularly gather user feedback and make iterative improvements. This helps you stay aligned with your users' needs and expectations.

7. Prioritize Accessibility

Make your product accessible to everyone, including users with disabilities. Use colors, fonts, and layouts that are easy to understand and interact with.

Real-Life Examples Illustrating Successful UX Problem Resolutions

Airbnb

Airbnb addressed a significant issue in their group booking process to enhance user experience. Users often found it challenging to share potential accommodations with group members. Airbnb introduced an efficient feature allowing users to annotate and share multiple property links directly from the platform. This organized, fuss-free solution significantly streamlined the group booking experience.

Google Maps

Earlier, Google Maps had a cluttered interface with too much information that confused users. Google introduced a cleaner interface and adaptive maps showing only relevant information based on the user's activity. This resulted in an improved user experience and increased usage of the app.

Slack

Slack faced a UX challenge with its notification system. Users found it difficult to keep up with the large volume of notifications. Slack introduced a smart notification system that prioritizes notifications based on the user's activity, interactions, and settings. The result was a significant decrease in notification overload and an improved user experience.

Apply Resolution Strategies in Your Own UX Design Efforts

Transforming bad UX into great UX is not a one-time task. It's a continuous process that requires ongoing user research and iterative improvements. It's also crucial to identify and resolve failed onboarding experiences, which can act as a deterrent for new users.

Here's how you can apply these strategies to your UX design efforts:

- Continuous User Research: Regularly conduct user interviews, surveys, and usability tests to understand your users' needs and expectations.
- Iterative Design Process: Implement a continuous and iterative design process where you make small changes based on user feedback and test them for effectiveness.
- Collaboration: Collaborate with all stakeholders, including designers, developers, and users, throughout the UX design process. This ensures that all perspectives are considered, and the final product meets everyone's needs.
- Human-Centered Design: Always keep the user at the center of your design process. Make decisions based on what would be best for the user, not what would be easiest for you to design or develop.
- Accessibility: Remember that accessibility is a part of UX. Ensure that your product is accessible to everyone, including users with disabilities.

Duolingo, a language-learning app, continuously improves its UX based on user feedback. They regularly conduct user research and make small changes to the app based on the feedback. They test these changes for effectiveness before implementing them in the app. This continuous and iterative design process has led to an improved user experience. As a result, Duolingo experienced a massive 62% year-on-year growth in Q1 2023.

Conclusion

We took you through the fascinating world of user experience (UX) design, a field that's becoming increasingly crucial in today's digital era.

A good UX design isn't merely a one-time effort; it's a continuous process of learning, adapting, and innovating. It's about:

- Staying attuned to users' needs and wants.
- Keeping up with technological trends.
- Delivering seamless experiences that make people want to return to your website or app.

However, the path to perfecting UX design is often laden with mistakes. Yet, these mistakes are valuable learning opportunities. With instances of bad UX like the examples we've discussed, you can gain insights into what not to do and, more importantly, how to correct flaws.
We've also outlined key strategies to improve UX design. These include keeping the design and copy simple, straightforward, and relevant while incorporating elements like videos that can significantly boost conversions.

A bad UX can lead to lost traffic, decreased customer satisfaction, and even a drop in revenue. But with a committed focus on enhancing the user experience, you can avoid potential UX design pitfalls.

We encourage you to share your own experiences and examples of bad UX. Engaging with others in the field can broaden your perspective and enrich your knowledge.
If you want to delve deeper into the world of UX/UI, we have a range of courses that can help. Whether you're looking for a beginner course to explore this field or an intermediate course for upskilling, our carefully curated courses can guide you on your journey.

3. Perception Limitations and Design (30 mins)

- Sensory thresholds (e.g., just-noticeable differences).
- Designing for aging populations or sensory impairments

Sensory Threshold in Psychology

As you may already know, we have five primary senses: smell, taste, sight, hearing, and touch. While these are the most observable senses, they are not the only senses we have. We have others, such as pain and body position and movement.

Our world is full of stimulus energy information (i.e. frequency, hertz, etc.), and our senses can detect much of it. Some animals have senses that can detect types of stimuli that we cannot. For example, dolphins hunt their prey by using sonar, a signal that judges distance based on how it bounces off surpasses. While we can detect a lot of energy information, we still require a certain amount of that energy to detect it consciously.

Sensory threshol is the weakest energy output required for us to detect it. The sensory threshold can vary for everyone and often relies heavily on our past experiences, beliefs, expectations, and values.

Or, consider you are expecting an important call but are at a loud party. What affects your ability to detect the faint sound of your phone amid background noise? In psychology, signal detection theory is often used to describe this phenomenon.

Again, several factors can affect our ability to detect stimuli in these circumstances. Signal detection theory is often used to explain why a mother may be able to sleep through a loud alarm but quickly awakens to the faintest cry of her baby.

High Sensory Threshold

Once again, everyone's sensory threshold is different. Some of us will have a high sensory threshold, while others may have a low one. Sensory processing disorder is when an individual is on either extreme.

The effects of a high sensory threshold can easily be seen among children. Children with a high sensory threshold have a higher absolute threshold and therefore need more stimuli to react. These children might not respond to whispering and need to be spoken to at a louder volume to react.

Children with a high sensory threshold will often engage in sensation seeking. In other words, they actively look for sensory experiences because they need more stimulation to react. These children may be seen chewing on their shirts, fiddling and touching everything around them, or constantly moving.

In contrast, children with a low sensory threshold are extremely sensitive to stimuli. Their absolute threshold is much lower and does not require as much stimuli energy to react to it. These children might engage in behaviors that block stimuli, such as closing their eyes or plugging their ears. They also try to avoid sensory experiences that may overwhelm them and might be unwilling to try new things.

Sensory Threshold Examples

Now that we have a handle on what the sensory threshold is, let's discuss a few sensory threshold examples through our five primary senses.

1. Taste: Johnny is baking a Mexican chocolate cake and wants to make sure he adds enough spices so it can be tasted through the chocolate. His sensory threshold is the point at which he begins to taste the cinnamon in the chocolate.
2. Hearing: Yolanda lives about ten blocks from the parade, while Randy is only two blocks from the parade. Randy can hear the crowd and the bands quite easily, while Yolanda can't hear anything. While on her way to Randy's house, Yolanda noticed she could start hearing the parade when she was about two blocks from Randy's house or four blocks from the parade. The amplitude around this point surpasses Yolanda's sensory threshold, allowing her to begin hearing the event.
3. Touch: Camilla tried to startle Annie by rubbing a feather on the back of her neck. Her prank, however, didn't work because Annie did not feel the feather, suggesting the touch did not reach Annie's sensory threshold.
4. Sight: From far away, Zach can't see the little spider on his bedroom ceiling. However, as the spider crawls down the wall next to his bed, he can see it clear as day.
5. Smell: Lily's neighbor smokes cigarettes all day but can never smell them in her apartment. However, her neighbor often has several friends who also smoke, which is when the smell usually floods her apartment, crossing the sensory threshold.

Sensory Threshold vs Absolute Threshold

Let's compare similar terms: sensory threshold vs absolute threshold. The sensory threshold is not an exact measurement. One way psychologists measure our sensory threshold is by determining the absolute threshold. Absolute threshol is: the lowest value of sensory energy required for us to detect it 50% of the time.

Anything above the absolute threshold can be perceived on a conscious level while anything below the absolute threshold is considered subliminal and cannot be consciously perceived. Some messages may get through, but it is not enough for our brains to be consciously aware of them.

Another way sensory threshold is measured is by the difference threshold or just a noticeable difference (jnd). Difference threshold or just noticeable difference (jnd) is the minimum difference between two stimuli required for it to be detected 50% of the time.

Take the following image, for example. At which point do you notice a color difference?

But is the difference threshold the same for every one of our senses? In the late 1800s, German physician Ernst Weber discovered the answer is no. Weber found that each of our senses has a specific difference percentage (not value) that is required in order for it to be possible for us to detect a difference. This finding is now called Weber's Law.

Sensing through impairments – design for all

Good design for public spaces and buildings should not discriminate by age, gender, class or bodily ability. The fifth event of the series focused on how to design public spaces that empower people with sensory impairments, covering some of the less well-known sensory functions that aid our bodily perception of space.

The British Standards Institute (BSI) (2005) defines inclusive design as:

The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible … without the need for special adaptation or specialised design.

Whether this or other definitions are used, it suggests that inclusive design is embodied as standard in the design process. However, the mainstream approach is to design additional tactics for what is considered to be a minority.

We are all likely to experience an impairment of some sort during our lives; as we age, we may develop either a visual or hearing impairment, as well as issues with physical mobility and balance. As the proportion of people over 75 years has increased by 89% since 1974, what was once a minority section of the UK population could well be the majority in the future, suggesting that designing for inclusivity is a vital part of future-proofing our public spaces. Although there is a wealth of guidance and policy that addresses accessible design, evidence from the series prompts the question: is policy comprehensive enough to ensure suitable life-course spaces for all, in the context of an aging population and a changing climate?

Ensuring a space is truly inclusive, in the BSI sense of the word, requires designers to look closely at people's needs and expectations of a space. From a practitioners point of view,

co-design – putting people at the heart of the design process – while acknowledged as a useful technique, in practice is far from straightforward. During the event discussions, practitioners expressed frustration with the tricky task of amassing representation from a whole community, and on the difficulties of engaging with people who are living with impairments, not all of whom will be known to housing, health or social services. For example, people with mental health issues are unlikely to get involved, or may need one-to-one engagement. Ascertaining the specific views of people with sensory impairments can be perceived to be catering for a minority, and the associated costs considered an additional expense.

The event discussions highlighted the contradictions between guidance on what is considered 'good design' and the seemingly negative impact this can have on people with sensory impairments:

- Street guidance that promotes shared space, designed to tackle traffic speed and the creation of a 'sense of place' can often make it difficult for people to process and understand how to use that environment. The use of mixed materials and patterns can create visual confusion, especially for people with visual impairments.

- The move to de-clutter streets by removing signage and street furniture, while on the one hand helping to remove obstacles, also creates problems for people who rely on the signage to navigate, or use the furniture to lean against and use as support.

- Secure-by-design guidance tends to remove opportunities for quiet spaces, seeing elements such as alleyways and door recesses as places that encourage crime. These spaces, if designed well, can offer quiet points for those suffering from auditory conditions to escape traffic noise.

- While there is general consensus on how the 'car must no longer be king' in cities, we must not forget that excluding cars also excludes people with impairments who rely on the car for mobility.

We should think critically about the impact of such contradictions, and find alternative design solutions that don't have negative impacts; this means working across sectors to find solutions that work for all.

To create effective, inclusive design solutions, we need a truly holistic understanding of how humans function at a physiological and psychological level; how the senses interact and influence each other, and how they adapt to differing conditions and climates. The disconnect between evidence, practitioner knowledge, and policy needs to be rapidly closed before we can really claim to be designing healthy, inclusive, sustainable places.

The importance of designing thoughtful spaces for older adults with sensory disabilities

Designing inclusive and accessible healthcare spaces can be a challenging experience, especially when architects and planners must heed guidelines that don't always comprehensively address the needs of residents, patients and staff. This challenge is especially prevalent when designing living spaces for older adults in long-term care.

Many seniors experience some form of sensory impairment as they age, from loss of sight to arthritis. In the long-term care community, the Americans with Disabilities Act (ADA) sets the standard for accessibility design, but these guidelines do not always thoroughly address the needs of older citizens. The ADA guidelines for accessibility were adopted in 2021 and written to address all disabilities, but we often find that many vulnerable adults are left out of the conversation and lack the daily support and assistance they need.

To create environments that enhance residents' quality of life, long-term care spaces must go above and beyond accessibility guidelines so seniors can thrive and staff can assist with daily activities when needed. As long-term care planners, we believe the best designs must create environments that not only meet code, but push boundaries, thus promoting the success of both residents and staff. We make it a priority to understand the limitations of guidelines and address each of the five senses in nursing home environment designs.

Understanding ADA requirements

Each state has different guidelines regarding ADA compliance for older adult spaces. In some states, like Minnesota, facilities do not have to abide by ADA standards if owners can prove there are safety and protection elements in place for residents. In Wisconsin, however, 10% of all rooms must be compliant with ADA guidelines, but owners and architects are free to incorporate other designs that support seniors' abilities and safety in the other 90% of rooms.

Additionally, some veterans' homes are exempt from ADA requirements because they must follow more in-depth guidelines, like the Barrier Free Design Standard. This is because the percentage of disabled people at Veterans Affairs (VA) hospitals and housing is much higher than the percentage of disabled people in the general population. The guidelines ensure all VA buildings are designed and constructed to be accessible to everyone, and many of the requirements mirror the recommendations our team makes for nursing home environments.

Designing with empathy for the senses

According to Mordor Intelligence, the United States is seeing an increase in long-term care needs due to a longer-living population and a growing aging population, especially among baby boomers. To better advocate for and support residents' needs, long-term care spaces must be

designed with empathy and consideration for the disabilities and sensory challenges many older adults experience.

Our team always aims to work closely with residents, staff and owners to create a comprehensive strategy that exceeds ADA requirements and focuses design elements around the five senses.

Sound

Hearing loss is a common sensory challenge for older adults, but there are many ways to help design spaces that support acoustics. A recent study from the JAMA Network reported that 80% of all people over age 85 will experience noticeable hearing loss.

Soothing music and nature sounds can promote relaxation and improve residents' moods. Reducing unnecessary background noise and enhancing resident privacy also helps minimize distractions and disruptive noise. This may include adding acoustic "masking" to certain areas or making changes to housekeeping schedules to reduce noise.

Touch

As older adults age, use of their hands can decrease due to arthritis, thus dulling their sense of touch. Swapping doorknobs for more accessible handles is a small but powerful change that can make rooms easier to enter and exit. Grab bars at the bedside aid in helping an older adult climb into and out of bed. The grab bar should be installed for use by the resident's stronger or more dominant hand.

Lastly, residents with diabetes or Parkinson's may have a dulled sense of touch and require extra care and consideration. For example, furniture should be comfortable and easy to grasp, and rough fabrics, sharp edges and hard metals should be avoided.

Sight

Although vision may diminish as we age, there are many opportunities to use color and design features to create safe and supportive environments. Earth tones can help an environment feel calm and therapeutic and even promote healing. Artwork and photography of nature or historic photos can create a calming space and encourage memory recall for older adults.

Well-lit spaces can also increase independence for older adults. Light helps reduce falls, increases socialization and stimulates positive physical and mental health. Lighting should provide even illumination, avoid black spots on floors or walls and eliminate glare to help reduce headaches and agitation. Facilities should consider including slider dimmers or push buttons to provide residents with more manageable lighting options.

Taste

Most people know that our sense of taste changes over time, but when it comes to designing long-term care facilities, considerations for older adults with a loss of taste are often left off the planning plate. A dulled sense of taste can lead to a lack of appetite and energy. When designing facilities, it's important to provide spaces that can accommodate a variety of menu options. This may include everything from pub and restaurant-type meals to cafe and bakery options, so residents have the freedom to choose. With loss of taste, offering more options can stimulate a better appetite.

Smell

One in two people over 60 deal with a loss of smell, but many are unaware of the loss until it's tested. Further, some seniors suffer from diseases like Parkinson's, which often results in a dulled sense of smell that can impact taste. Introducing strong, pleasant smells can help increase patients' appetites. A person's sense of smell also commonly triggers memories that can evoke behaviors. For example, lavender, fresh linen, and baked bread are known to induce feelings of relaxation, and the smell of coffee brings feelings of comfort.

Although older adults may have a diminished sense of smell, designing with scents in mind can create a more positive, upbeat environment. Consider where laundry, storage and waste areas are placed within facilities to eliminate unwanted smells adjacent to rooms or common areas and design opportunities to introduce good smells.

As the baby boomer generation enters retirement age, thoughtful long-term care spaces are more important than ever. By conducting virtual simulations and creating physical mock-ups, we routinely put ourselves in the shoes of residents to fully understand their experiences and the ways our team can use our expertise to create comforting and functional living spaces. Well-designed environments meet operational needs and create better living conditions and quality of life for all.

4. Case Studies and Ethics (45 mins)

- Good design: Apple's haptic feedback, Google's Material Design.
- Bad design: Confusing airport kiosks, cluttered interfaces.
- Ethical considerations: Accessibility (WCAG standards), inclusivity.

Apple's Human Interface Guidelines vs Google's Material Design Guidelines

In the realm of user interface design, guidelines play a crucial role in shaping the way applications are built and experienced. Two of the most prominent frameworks are Apple's Human Interface Guidelines (HIG) and Google's Material Design. Each of these guidelines has been developed with distinct philosophies and principles that reflect their respective brand identities and user experiences. This article delves deep into the differences between these two design systems, exploring their foundational philosophies, visual languages, interaction designs, layout systems, accessibility considerations, and more.

Philosophy and Core Principles

Apple's HIG is built on three fundamental principles:

1. Clarity: The design should be easy to understand and navigate, with text that's legible at every size, icons that are precise and lucid, and a focused approach that eliminates ambiguity.
2. Deference: The UI should help users understand and interact with content, but never compete with it. Apple emphasizes that the design should be in service of the content.
3. Depth: Visual layers and realistic motion convey hierarchy, impart vitality, and facilitate understanding. Users should be able to visualize the relationships between elements.

Google Material Design

Google's Material Design is based on the concept of a unified system that allows for a single underlying design system across platforms and device sizes. Its core principles include:

1. Material as a metaphor: Inspired by the study of paper and ink, the material surfaces and edges provide visual cues grounded in reality.
2. Bold, graphic, intentional: Elements are deliberately placed on the screen, with a focus on color, imagery, large-scale typography, and intentional white space to create immersive designs.
3. Motion provides meaning: Motion is used to focus attention and maintain continuity, helping users visualize the impact of their actions.

Visual Design

Apple HIG Visual Design

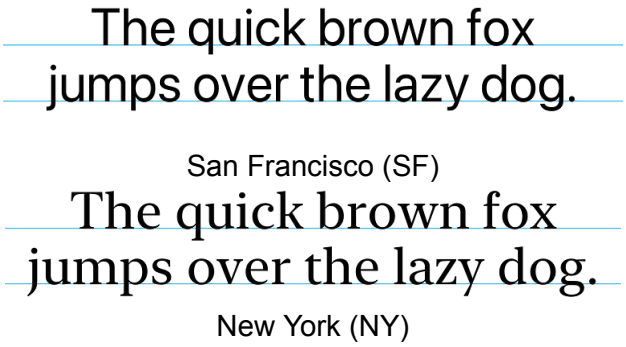
Color:

Apple advocates for the judicious use of color to communicate, impart vitality, and provide visual continuity. The guidelines suggest using color as a supplementary way to impart information, not as the only way. Key aspects include:

- Color Palette: Apple encourages the use of a limited color palette to create a clean and cohesive look. Colors should be chosen carefully to enhance the overall design and user experience.
- Semantic Colors: Colors are used semantically to convey meaning (e.g., red for errors, green for success), which aids in user comprehension and interaction.
- Contrast and Legibility: Emphasis is placed on sufficient contrast between text and background colors to ensure legibility and accessibility for all users, including those with visual impairments.
- Adaptive Colors: Apple's guidelines promote adaptive color schemes that respond to different environments (like light and dark modes), ensuring that interfaces remain usable in various lighting conditions.
- Color in Context: The guidelines suggest considering how colors interact with other design elements and the overall context to maintain a harmonious and functional design.

Typography:

Apple uses its custom-designed San Francisco and New York fonts, which are designed for legibility across various device sizes.



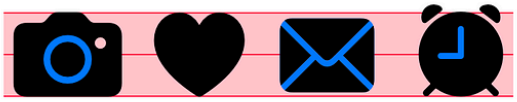
Apple's system fonts offer a variety of weights and widths to help you create clear and legible designs across different sizes and contexts. SF Symbols match these weights perfectly, ensuring consistent visual hierarchies.

	Ultralight	Thin	Light	Regular	Medium	Semibold	Bold	Heavy	Black
Upright	Text	Text	Text	Text	Text	Text	Text	Text	Text
Italics	*Text*	*Text*	*Text*	*Text*	*Text*	*Text*	*Text*	*Text*	*Text*

Icons:

Apple's icons are designed to be simple, recognizable, and consistent across the system. They often use a filled style with subtle gradients.

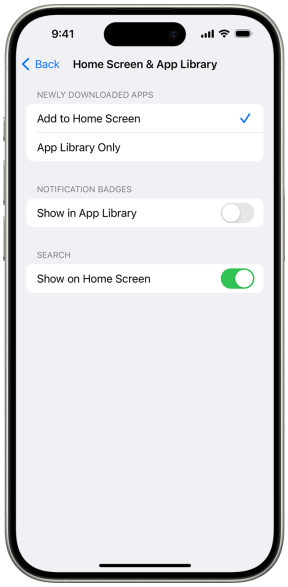
To help achieve visual consistency, adjust individual icon sizes as necessary...



...and use the same stroke weight in every icon.

Negative Space:

Apple designs often feature ample white space, creating a clean and uncluttered look.



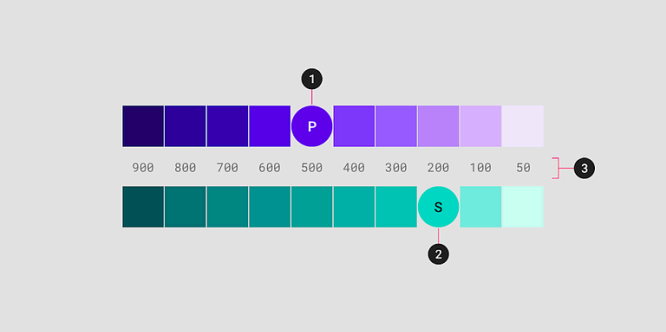
The ample white space around different sections (like "NEWLY DOWNLOADED APPS," "NOTIFICATION BADGES," and "SEARCH") helps create a clear visual hierarchy. This makes it easier for users to differentiate between various settings and understand their organisation and white space draws attention to the text and options available, minimizing distractions

Google Material Design Visual Design

Color:

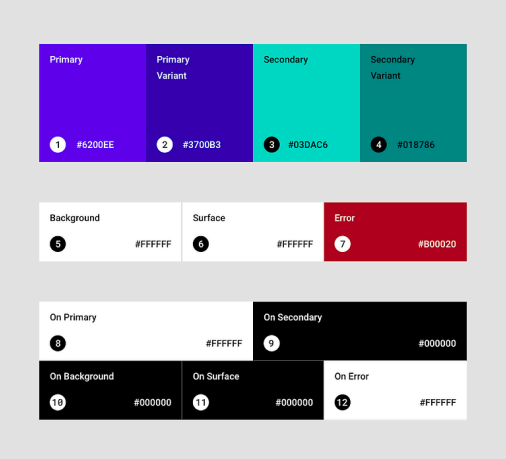
Material Design uses a more vibrant and diverse color palette. It provides a color system that can be used to create a color theme that reflects your brand or style. Key aspects include:

- Color Themes: Material Design emphasizes cohesive color themes that enhance usability and aesthetic appeal. Designers are encouraged to establish primary and secondary color palettes for consistency across applications.



Primary and Secondary Color Theme

- Color Roles: Colors are categorized by roles (e.g., primary, secondary, background, surface) to maintain clarity and functionality, helping to create a clear visual hierarchy.



Material color theme

- Dynamic Color: Support for dynamic color systems allows for adaptation to user preferences and environmental factors, enhancing personalization and accessibility.
- Contrast and Accessibility: The guidelines stress the importance of contrast for readability, ensuring that text and important elements stand out against backgrounds.
- Color Usage: Recommendations for using color in various contexts (icons, buttons, backgrounds) are provided to create an engaging user experience.

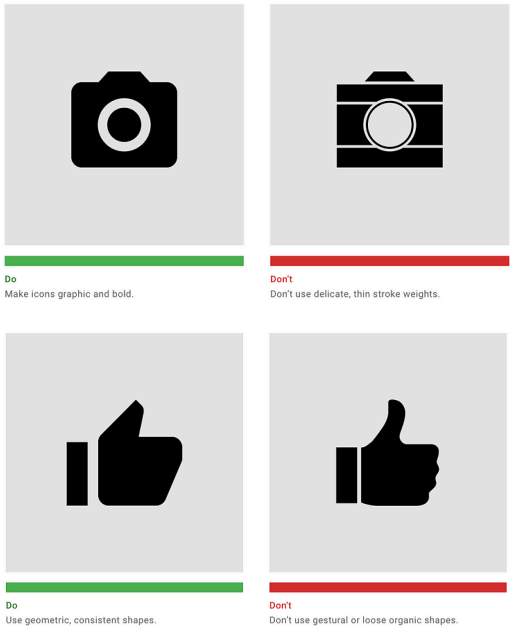
Typography:

Material Design recommends Roboto for Android and web interfaces, and Noto for multi-language support. It also provides detailed guidelines for typographic scale and style which is as follows:

Scale Category	Typeface	Weight	Size	Case	Letter spacing
H1	Roboto	Light	96	Sentence	-1.5
H2	Roboto	Light	60	Sentence	-0.5
H3	Roboto	Regular	48	Sentence	0
H4	Roboto	Regular	34	Sentence	0.25
H5	Roboto	Regular	24	Sentence	0
H6	Roboto	Medium	20	Sentence	0.15
Subtitle 1	Roboto	Regular	16	Sentence	0.15
Subtitle 2	Roboto	Medium	14	Sentence	0.1
Body 1	Roboto	Regular	16	Sentence	0.5
Body 2	Roboto	Regular	14	Sentence	0.25
BUTTON	Roboto	Medium	14	All caps	1.25
Caption	Roboto	Regular	12	Sentence	0.4
OVERLINE	Roboto	Regular	10	All caps	1.5

Icons:

Material icons are geometric, bold, and often use simple outlines or filled shapes with flat colors.



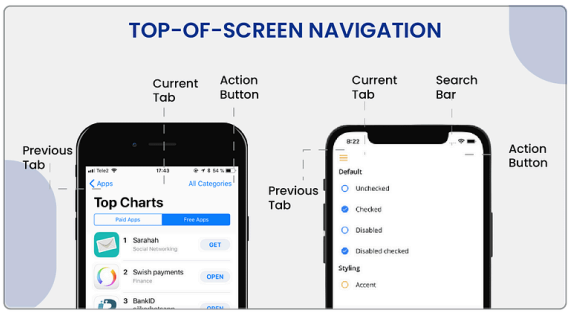
Layout and Structure

Apple HIG Layout and Structure

Navigation:

Apple prefers a flat navigation structure, often using tab bars for primary navigation in iOS apps.

A navigation bar provides a natural place to display a title that can help people orient themselves in your app or game, and it can also include controls that affect the content below it.



iOS on left side follows a tab-based navigation pattern and Android follows a hierarchical navigation pattern

Gestures:

Apple incorporates a variety of gestures into its interfaces, such as swipe, pinch, and long-press, but emphasizes that these should be discoverable and consistent.

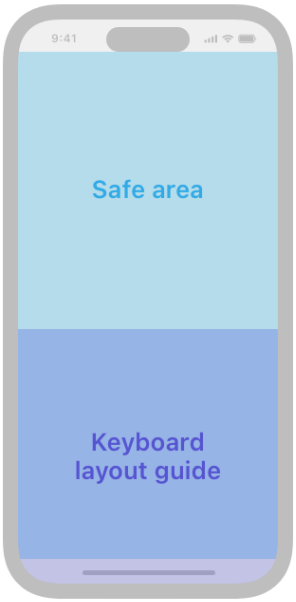
Gesture	Common action
Three-finger swipe	Initiate undo (left swipe); initiate redo (right swipe).
Three-finger pinch	Copy selected text (pinch in); paste copied text (pinch out).
Four-finger swipe (iPadOS only)	Switch between apps.
Shake	Initiate undo; initiate redo.

Adaptivity:

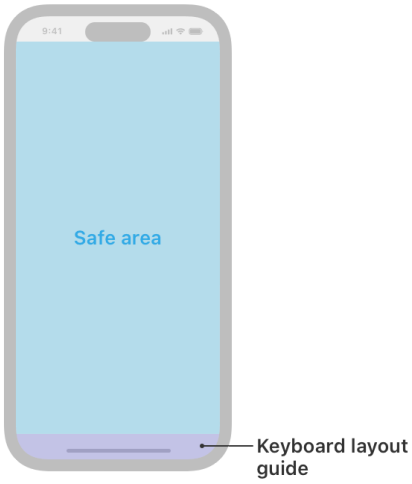
Apple stresses the importance of designing adaptive layouts that work across different device sizes and orientations. Here are some of the most common device and system variations you need to handle:

- Different device screen sizes, resolutions, and color spaces

- Different device orientations (portrait/landscape)
- System features like Dynamic Island and camera controls
- External display support, Display Zoom, and multitasking modes on iPad
- Dynamic Type text-size changes
- Locale-based internationalization features like left-to-right/right-to-left layout direction, date/time/number formatting, font variation, and text length



When the keyboard is visible, the layout guide represents its area and position.



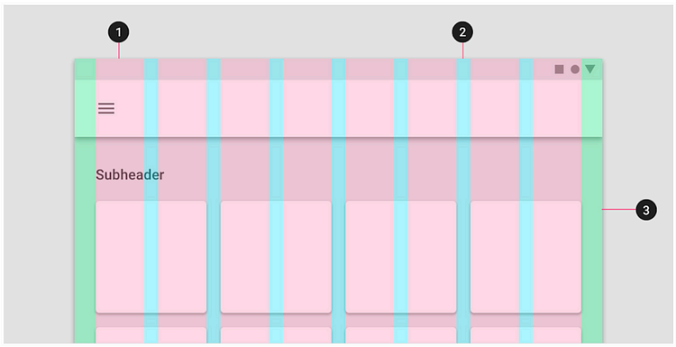
When the keyboard dismisses, the top of the layout guide matches the bottom of the safe area layout guide.

Google Material Design Layout and Structure

Grid-based Layout:

Material Design uses a responsive grid-based layout system that scales and adapts to various screen sizes.

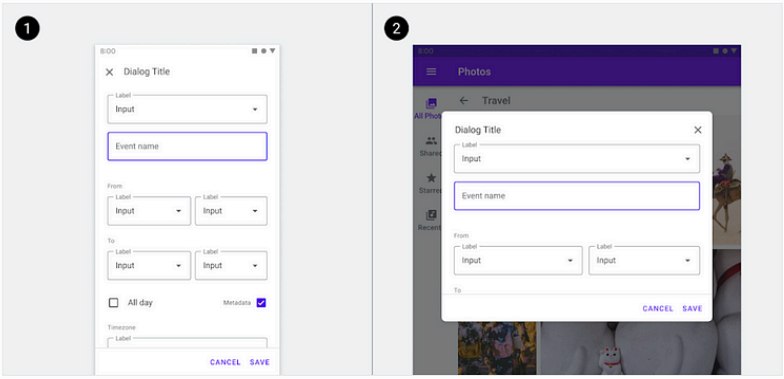
The responsive layout grid is made up of three elements: columns, gutters, and margins.



1. Columns
2. Gutters
3. Margins

Components:

Google provides a comprehensive set of pre-built components like cards, sheets, and navigation drawers that developers can use consistently across applications.



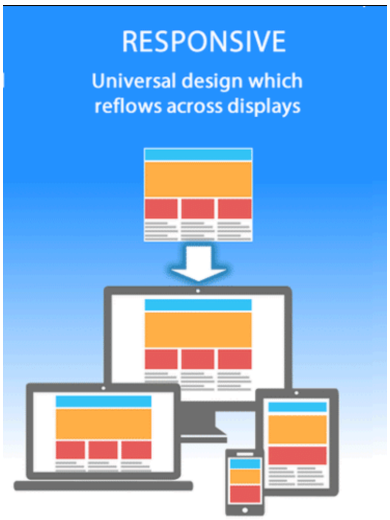
A full screen dialog can adapt to a simple dialog on larger screens.

Some functionally-equivalent component groups are defined below.

Component type	Mobile option	Tablet option	Laptop option
Navigation	Bottom navigation	Navigation rail	Navigation drawer
Navigation	Modal navigation drawer	Modal navigation drawer	Permanent navigation drawer
Communication	Full-screen dialog	Simple dialog	Simple dialog
Action	Bottom sheet	Menu	Menu

Responsive Design:

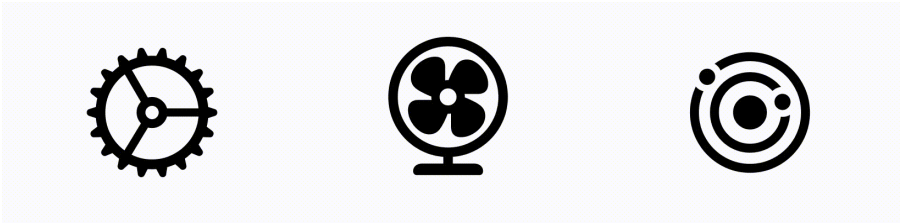
Material Design places a strong emphasis on creating designs that work seamlessly across different devices and screen sizes.



Animation and Motion

Apple HIG Motion Best Practices:

- Incorporate motion intentionally to enhance the experience without overwhelming it. Avoid adding motion just for the sake of it; unnecessary or excessive animations can distract users and may lead to feelings of disconnection or discomfort.
- Make motion optional. Recognize that not all users may want to experience motion in your app or game. It's crucial to ensure that important information isn't conveyed solely through motion. To create an inclusive experience, complement visual feedback with alternatives like haptics and audio cues.

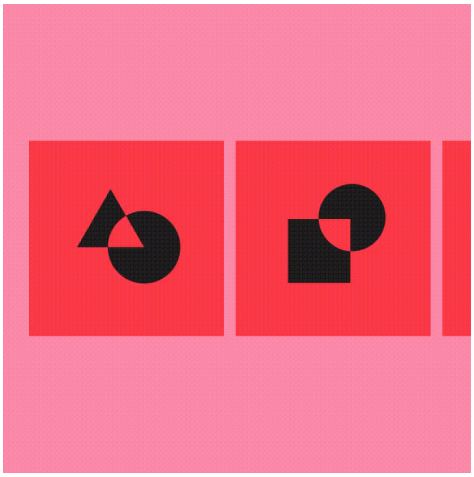


The rotate animation causes some symbols to rotate fully, while in others, only specific parts of the symbol rotate. This rotation serves as a visual indicator or mimics the behavior of a real-world object. For instance, when a task is in progress, the rotation reassures the user that it's functioning as intended.

Google Material Design Motion Principles:

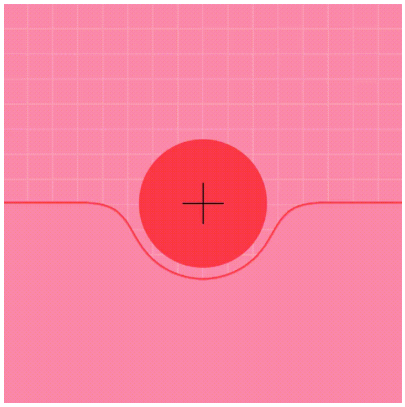
Motion is a core principle in Material Design, used to convey hierarchy, functionality, and user flow. Motion in Material Design adheres to three essential principles:

- Informative: Motion design guides users by clarifying relationships between elements, indicating available actions, and illustrating the results of those actions.



- Focused: Motion directs attention to key elements, ensuring that important information stands out without introducing unnecessary distractions.

- Expressive: Motion enhances user experiences by celebrating key moments in their journeys, adding personality to interactions, and reflecting a brand's unique style.



Common Challenges in UX Design of Self-Service Kiosks

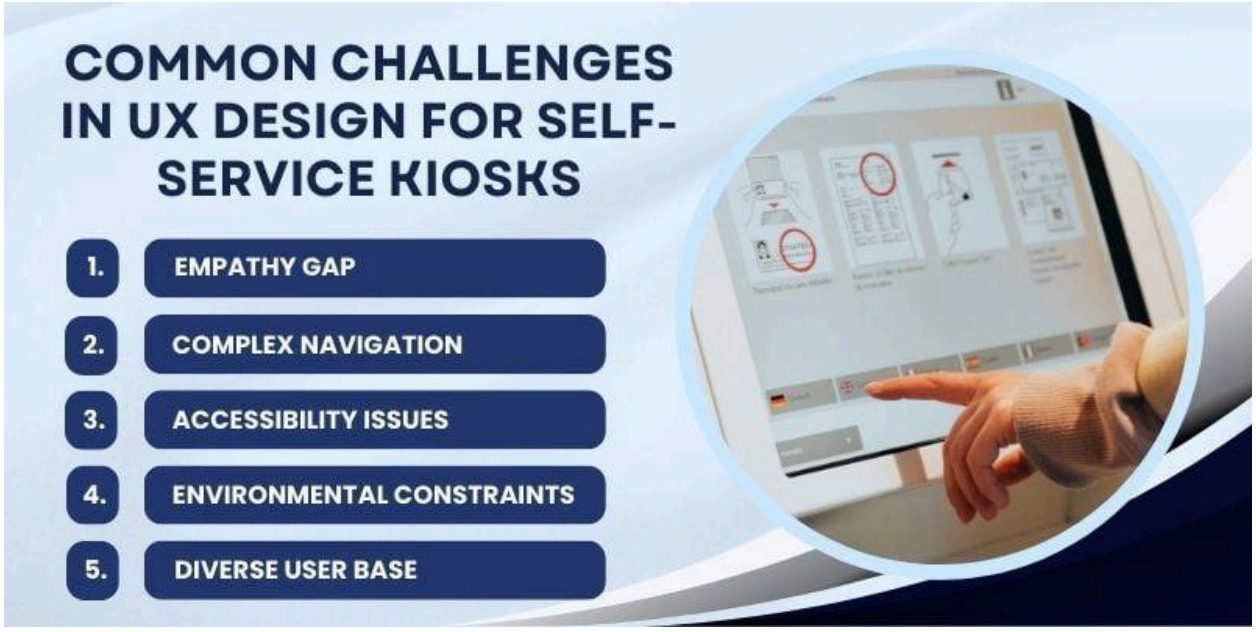
Self-service kiosks are popping up everywhere, from airports to fast-food restaurants, offering a modern way for customers to check in, order food, or make purchases without waiting in long lines. These kiosks have become essential for businesses seeking to improve efficiency and streamline operations.

However, as convenient as they are, self-service kiosks only work if the user experience (UX) is spot on. If customers find them confusing or difficult to use, the benefits can quickly become frustrating.

Designing an easy-to-use kiosk might sound easy, but the challenges in their UX design are very real. From complicated menus to poor accessibility features, minor design flaws can make a simple task a headache.

In this blog, we'll explore common challenges in the UX design of self-service kiosks and offer practical solutions. By tackling these issues, businesses can create user-friendly kiosks and leave customers satisfied and eager to use them again.

Common Challenges in UX Design for Self-Service Kiosks



Self-service kiosks are becoming common in airports, restaurants, and retail stores. They provide customers with a quick and efficient way to check in, order food, or purchase. While these kiosks offer great convenience, ensuring users have a smooth and effortless experience is key to their success.

If the kiosk's interface is confusing or difficult to navigate, users may quickly become frustrated and abandon the kiosk. Therefore, it's important to address the common user experience challenges in kiosks to avoid these issues.

Below, we explore five major design problems in self-service kiosks and offer solutions to make them more intuitive and user-friendly:

1. Empathy Gap

The empathy gap occurs when designers overlook users' needs and focus too much on functionality or business goals. For example, a kiosk might have a complicated multi-step process that confuses users, especially those less familiar with technology.

This is a significant UX design difficulty, as it can make users feel frustrated and overwhelmed. For example, older adults or less tech-savvy individuals may struggle with unclear navigation or small icons, resulting in them abandoning the process.

To close the empathy gap, designers must deeply understand the users' perspectives through regular testing and feedback. This will help ensure the kiosk is designed to meet their specific needs.

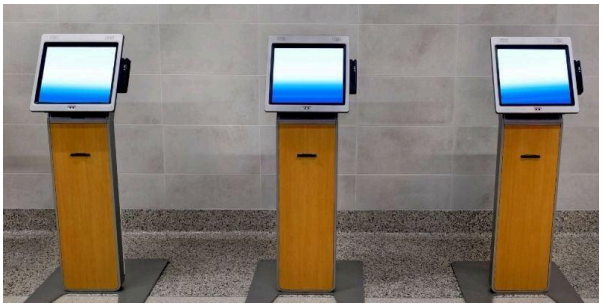
2. Complex Navigation

A kiosk that's hard to navigate will create significant frustration for users. Long or complicated menus with too many options can overwhelm users and lead them to walk away.

For example, airport kiosks where passengers must go through multiple screens to confirm flight details are a classic example of design problems in self-service kiosks.

Therefore, navigation must be simple. Streamlined menus, logical categorization of options, and more precise instructions can make all the difference. Making the process easy to follow and reducing the number of steps ensures customers can complete their tasks without stress or confusion.

3. Accessibility Issues



Another major issue with kiosk UX design is accessibility. Everyone should be able to use kiosks regardless of physical abilities or digital literacy. Features like small text or touch interfaces that require fine motor skills can create barriers for users with disabilities.

To address these issues, designers should focus on making kiosks accessible to many users. Options like larger text, high-contrast colors, and audio assistance can make kiosks more inclusive.

To create a more welcoming experience for users with different needs, the kiosk should be responsive to different touch pressures, provide screen readers, and offer alternative interaction methods.

4. Environmental Constraints

The physical environment significantly affects how easy it is to use a kiosk. For example, kiosks placed in direct sunlight may suffer from screen glare, making them hard to read. Similarly, cramped spaces can make it difficult for users to approach or interact with the kiosk.

Environmental constraints are often overlooked in self-service kiosk UX designs but can have a major impact. To mitigate these issues, kiosks should have adjustable screen brightness, glare-resistant displays, and ergonomic designs.

Placing kiosks in well-lit, easily accessible areas and ensuring they are at a comfortable height for all users can improve the self-customer service experience.

5. Diverse User Base

One of the most significant difficulties in the UX design of self-service kiosks is accommodating diverse users. From tech-savvy millennials to older individuals who may be unfamiliar with digital interfaces, kiosks need to meet the various needs of all users.

To overcome this, designers should conduct thorough user research, including surveys and usability tests, to better understand the expectations and challenges faced by different user groups.

Offering customizable options, such as language settings or simple instructions, can ensure that everyone, regardless of their background or technical skills, can use the kiosk effectively.

Addressing these user experience challenges in kiosks can ensure that businesses' self-service systems are easy to use, accessible, and effective. Considering design difficulties when creating kiosks will improve the user experience, boosting customer satisfaction and engagement.

Essential Features of a Well-Designed Kiosk

When designing different types of self-service kiosks, it's essential to make the experience easy for users. The goal is to ensure users can easily interact with the kiosk and complete their tasks efficiently.

Every feature is vital in making the kiosk easier to use and ensuring a better overall user experience, from simplifying navigation to ensuring brand consistency across platforms.

In this section, we'll explore the important features that make a kiosk well-designed and enhance the overall user experience.

1. Simplicity and Clarity

Any effective kiosk design must be simple. An interface that is easy to understand and navigate minimizes the risk of user frustration. For example, airport kiosks often feature clear icons for tasks such as checking in, printing boarding passes, or viewing flight status, making it easy for passengers to find what they need.

Intuitive designs also help users know what to do next, reducing mental effort and making the experience smoother. Streamlined options and clear labeling are essential, especially in busy environments where users need quick, no-fuss interactions.

When kiosks are straightforward, they become efficient tools that help users without confusion.

2. Touch-Friendly Elements

Touchscreens are the primary way users interact with kiosks, so it's vital to design interactive elements that are easy to use. Buttons, icons, and sliders should be large enough to tap accurately, with adequate spacing to avoid accidental presses.

Touch-friendly design is about more than size; it also involves responsiveness. Buttons should react instantly when tapped, and the interface should swiftly respond to touch gestures.

Best practices suggest a minimum size of 44×44 pixels for interactive elements, ensuring users can comfortably engage without frustration.

Moreover, incorporating accessibility features, such as voice feedback and haptic responses, improves the touch experience and makes kiosks more usable for people with different abilities. These features can reduce common design challenges and ensure that kiosks are easy for everyone to interact with.

3. Visual Hierarchy

Visual hierarchy helps users quickly focus on the most important actions by organizing elements in a way that guides attention. By adjusting elements' size, color, and position, designers can prioritize tasks like confirming an order or selecting payment options.

For example, a large, bold "Confirm" button placed at the end of a transaction process directs users to the next step, while secondary options such as "Cancel" or "Edit" are kept smaller or in less prominent areas.

Poor visual hierarchy, such as cluttered screens with no clear distinctions between options, can overwhelm users and cause them to abandon the kiosk.

A well-designed visual hierarchy is essential for improving the UX in self-service kiosks and making the user journey as straightforward as possible.

4. Feedback Mechanisms

Feedback mechanisms are significant for ensuring users know their actions have been recognized. These visual, auditory, or tactile cues confirm each step of the interaction.

For example, when a user selects an option, the button could change color to indicate the action has been registered, or an audible sound might play to confirm the selection.

Feedback is vital for users unfamiliar with the technology, reassuring them and reducing uncertainty. Effective feedback mechanisms, such as progress bars, status indicators, and auditory cues, boost user confidence and make the interaction smoother and less prone to errors.

This is essential in resolving UX challenges in interactive kiosks, where users may need constant reassurance as they navigate the process.

5. Consistency Across Platforms

Consistency ensures a smooth user experience, especially when interacting with different platforms. Whether users engage with a mobile app, website, or self-service kiosk, using familiar design elements makes transitioning between platforms seamless and intuitive.

For example, consistent use of colors, fonts, and icons across mobile and kiosk interfaces makes it easier for users to recognize and engage with the system.

Brand consistency builds trust with users and ensures that the kiosk aligns with the overall digital experience. This makes the user journey smoother and more predictable, enhancing the overall experience.

Real-World Success Stories

Learn how businesses from different sectors have used self-service kiosks to improve customer experiences, optimize processes, and boost sales. These examples highlight kiosk's real-world advantages and results in various industries:

1. Delta Airlines Self-Service Kiosks

Delta Airlines implemented Wavetec's self-service kiosk solutions to enhance passenger experience at its Sky Club lounges. Deploying a ticket-dispensing kiosk and a notification system streamlined passenger management, offering paperless tickets and SMS alerts for queue status.

This reduced wait times and improved operational efficiency. The seamless integration enhanced convenience, resource allocation, and customer satisfaction.

2. McDonald's Self-Service Kiosks

McDonald's self-service kiosks are designed to streamline the ordering process with a simple, intuitive interface. Customers can customize their meals through easy-to-navigate touch screens, enabling a quicker, more efficient ordering experience.

In fact, McDonald's has seen a 30% increase in average order value through these kiosks, which incorporate upsell options and clear visual cues. Automating the ordering process also reduces human errors, leading to a smoother experience for customers and staff.

3. Liberty Regional Medical Center Check-In Kiosks

Liberty Regional Medical Center implemented Wavetec's self-service kiosks to streamline patient check-ins and registration. The kiosks allowed patients to update personal information, check in for appointments, and make payments without waiting in line, reducing administrative workload and improving patient flow.

The user-friendly interfaces enhanced the patient experience by speeding up the process, ensuring efficiency in the facility.

What is Visual Clutter in UX Design?

If your user interface is inefficient, it's probably down to visual clutter. Examples of visual clutter include:

- Overused interface components
- Information without a clear structure
- Over-embellished typography
- Visual elements and colour palettes fighting for attention

All of these factors can have a negative impact on the user experience. And that's because visual clutter increases the cognitive load.

Cognitive load describes the amount of working memory required to process the interface. As a result, visual clutter slows down the user, distracts them from the task at hand and leaves them feeling frustrated and overwhelmed.

We see this often. We know it's not intentional – after all, websites scale up over time with multiple contributors, products and services, product teams and marketing managers – and they're all pushing to update content, improve functionality and re-brand.

But when this happens, the purpose of the page can be lost.

5 Ways to Reduce Visual Clutter in Your UX Design

Good news – you can do a few things to reduce visual clutter. And by removing unnecessary visual clutter, you can improve the overall user experience. Read on to learn more.

Question the Purpose

Whether you're working on a live site or some wireframes you're planning to test, take a step back. Question why each element is there in the first place. What purpose does it serve?

If you can't answer confidently, it probably doesn't need to be there. You can use this approach to review everything from the level of information and functionality to the use of design embellishments.

Identify the Priorities

Think about your users – what is their main priority? What do they want to achieve? Your job is to help them reach these goals – so having a good understanding is crucial to the success of the page and, ultimately, conversion.

Make sure the messaging and page structure is tailored to these priorities. Sure, you can have secondary elements that convey trust or offer alternative avenues, but the primary focus should always be addressing the user's needs.

Organisation and a clear visual hierarchy are key. This can help you to distinguish between must-have features and good-to-have extras.

Make use of Progressive Disclosure

A common mistake you want to avoid is overwhelming users. This can happen in a few different ways. It could be the volume of the information presented or feature-rich web pages that require a steep learning curve to engage with. This can lead to unnecessary stress on the user.

Remember, 'clicks' aren't the enemy. Putting less popular features or information behind a 'click' should never be frowned upon.

Progressive disclosure offers a number of benefits, including:

- Improved first impressions
- Empowers users by giving them control
- Easier to use – the learning curve is reduced
- Helps the user to stay focused on the most critical actions and content
- Cleaner, simpler and more productive interface

Minimise Overcomplicated Aesthetics

The embellishments we choose to add to a design can be the difference between a beautiful, intuitive interface and an overcomplicated design. Embellishments should be used sparingly – ask yourself what they bring to the design? How do they help the user to interpret the interface?

For example, a user interface can start to look messy when you introduce nested components. Each one contains a stroke, and these strokes actually make it harder for the user to decipher the information. If you want to add structure, try using white space instead.

Small details like this can hinder comprehension. It takes longer for the user to process the individual elements. Try stripping the design back until it looks clean and still makes sense. If your interface starts to lose structure, try adding things back in. This method offers you a good baseline from which to test and iterate from.

WCAG 101: Understanding the Web Content Accessibility Guidelines

The Web Content Accessibility Guidelines (WCAG), developed by the World Wide Web Consortium, are technical standards that help make the digital world accessible to people with disabilities. Numerous stakeholders, including disability advocacy groups, government agencies, and accessibility research organizations, collaborated to create these guidelines, which are considered the universal standard for digital accessibility.

Importantly, WCAG isn't a law—but organizations that want to comply with the Americans with Disabilities Act (ADA) should follow WCAG standards. WCAG includes many success criteria that developers and designers can apply to remove barriers to access for people with disabilities in digital environments.

Below are several examples of web accessibility best practices recommended by WCAG:

- Ensure form-entry functions have either no time limit or an extended time limit for those who need more time.
- Provide consistent elements, including navigation features, headers, footers, and sidebars, across all web pages. This consistent approach helps ensure end users can easily find these elements on any webpage.
- Make your website navigable without using a mouse—the keyboard "tab" button, alone, should enable end users to navigate any page on your website.
- Provide a proper, clearly identifiable content level structure for screen reader users.
- Use proper contrast ratios between foreground text and background colors for those with vision-related disabilities.

- Avoid design elements that may induce seizures. For example, no website element should flash more than three times in a one-second interval.
- Help users prevent and fix their mistakes. For example, provide text descriptions of all automatically detected errors.

What is POUR and why is it critical to WCAG standards?

WCAG standards are rooted in four main principles: perceivable, operable, understandable, and robust, often called POUR.

- Perceivable: Information must be perceivable to people using only one of their senses, so they understand all related content.
- Operable: End users must be able to interact with all webpage elements. For instance, your website should be easily navigable with just a keyboard or voice controls for non-mouse users.
- Understandable: The principle is just what it seems—end users must be able to understand web page content and functionality information.
- Robust: Your website must effectively communicate information to all users, including users of assistive technologies, and remain compatible with evolving technologies and user needs.

WCAG Versions 1.0, 2.0, 2.1 and 2.2

The W3C regularly updates WCAG guidelines, as digital accessibility continually evolves with improved technology and more sophisticated design practices.

- WCAG 1.0 was released in May 1999, comprising 14 guidelines and the A, AA, and AAA conformance level hierarchy.
- Published in 2008, WCAG 2.0 introduced POUR and redefined the A, AA, and AAA conformance levels.
- WCAG 2.1 was published in 2018 to provide interim updated standards reflecting advancements in digital content after WCAG 2.0. WCAG 2.1 covers considerations for the accessibility of mobile devices and tablets not addressed in WCAG 2.0. Overall, WCAG 2.1 introduced 17 additional success criteria.
- WCAG 2.2 added nine new success criteria, many of which relate to barriers for users with visual, mobility, hearing, and cognitive disabilities.

WCAG Conformance Levels and Related Compliance Requirements

WCAG guidelines offer specific information on making websites and other digital experiences more accessible. But understanding and conforming to the WCAG standards is also critical for any organization that wants to mitigate legal risks. Let's unpack the different conformance levels with WCAG and explore some of the laws and regulations referencing these guidelines.

The Three Levels of WCAG Conformance: A, AA, and AAA

There are three levels of conformance with WCAG guidelines:

- A = the minimum level requirements any website should be able to meet.

  Requirements include:

  - Keyboard-only content access
  - Clearly labeled forms with instructions so users know what the forms require
  - Content compatibility with assistive technologies
  - Providing clear information or instructions in additional ways to using just shape, size, or color

- AA = the mid-range conformance level that represents strong accessibility. It satisfies all Level A and Level AA criteria.

  Requirements include:

  - Text and background must have the proper color contrast (a minimum of 4.5 to 1)
  - Content organization must have a clear heading structure and follow a logical order (e.g., H1, H2, H3)
  - Navigation elements must be consistent throughout every webpage

- AAA = the highest level of conformance, providing exceptional accessibility, but unachievable for certain content. It satisfies A, AA, and 28 additional criteria.

  Requirements include:

  - A minimum of 7 to 1 contrast ratio for text and backgrounds
  - Sign language translation for pre-recorded video content
  - Expanded audio descriptions for pre-recorded video content

WCAG Conformance and Legal Compliance

Even though WCAG itself isn't a law, it's widely recognized as the web accessibility benchmark for legislation and court decisions. For example, Section 508 of the Rehabilitation Act of 1973 requires that federal agencies make their electronic and information technology conform with WCAG 2.0 AA standards. Similarly, the Accessibility for Ontarians with Disabilities Act (AODA) mandates that public websites and web content published after January 2, 2012, conform to WCAG 2.0 AA.

Additionally, the Unruh Civil Rights Act and California Assembly Bill 434 (AB424) require the websites of California state entities to align with WCAG 2.1 Level AA Standards and Section 508 requirements. WCAG is also part of EN 301 549, the harmonized European information and communication technology standard and benchmark for European Accessibility Act (EAA) compliance.

While Title III of the Americans with Disabilities Act (ADA) doesn't explicitly mention website accessibility, the U.S. Department of Justice (DOJ) has referenced WCAG in its private enforcement of the law. Additionally, Title II of the ADA now requires that the websites of state and local governments conform with WCAG 2.1 level AA standards.

Evaluating Accessibility Based on WCAG Success Criteria

Many free web accessibility tools can help determine if your web content conforms to WCAG standards. One example is the WAVE tool. Simply type in your URL, and you're given a summary of errors on that page. Another is the IBM Equal Access Accessibility Checker, which enables you to complete page-level testing on Chrome and Firefox browsers.

However, it's essential to understand that these tools rely solely on automation, which cannot detect every error. Human testing is necessary to assess your digital assets' usability and accessibility comprehensively.man testing is necessary for a truly comprehensive assessment of your digital assets' usability and accessibility.

What is Inclusive Design?

Inclusive design is an approach to create accessible products and experiences that are usable and understandable by as many people as possible. It goes beyond accessibility to consider users' diverse needs, backgrounds and experiences.

Why Do We Need Inclusive Design?

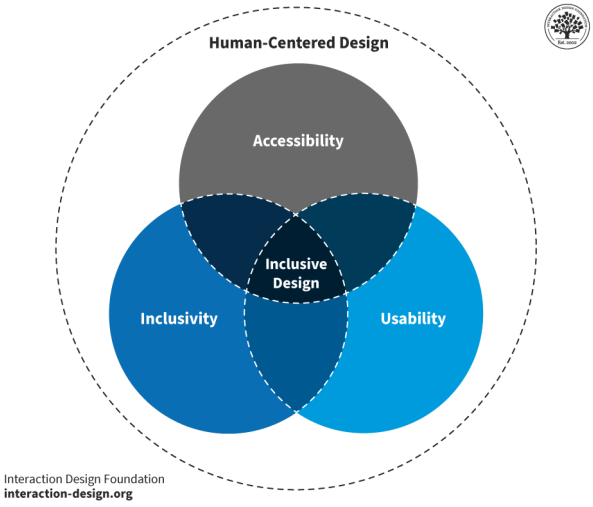
Inclusive design ensures that every person—regardless of their gender, location, native language and physical abilities—can enjoy and use products or services.

To understand inclusive design, we as user experience (UX) designers must understand the sections of our users who have historically been excluded from product designs:

- Women
- People of color
- People with non-binary identities (LGBTQ+)
- People who do not speak English natively
- People with restricted mobility
- People with different cognitive abilities.

These exclusions are sometimes obvious. In most cases, they're subconscious. For example, you may find websites that use gender stereotypical images such as suit-clad Caucasian men in a boardroom or young female service professionals.

Conversely, inclusive experiences are those that reach beyond assumptions about demographics to embrace the full range of human diversity. They bring out the best in human-centered design to grant equal access across the board. Making your design work accessible to people from all backgrounds, ability levels, and other imaginable categories ensures a strong brand identity as well. When design focuses on inclusivity, it proves it hasn't let the biases of a bygone era make it visually impaired.

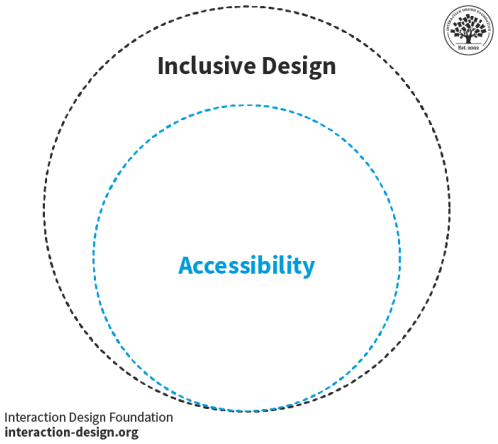


Inclusive design is the meeting place of several key design factors.

Inclusive design has its roots in the disability rights movement, which began in the 1950s. The goal of this movement was for people with disabilities to have access to the same rights, opportunities, and resources as non-disabled people. One example of a powerful design benefit that came from this is the curb cut. Curb cuts help wheelchair users, but they also act as ramps for cyclists and many others.

Sidewalk granite curb cut for wheelchair users, or anyone with tired or aching knees.

Inclusive design practices take this spirit of accessible design a step further in user interfaces. For example, it's not just about images that have high contrast and alt text for screen readers. It's also about how you design these images. For example, you practice inclusive design through clear and unambiguous messages that depict a diverse group of people. You also do it through thoughtful use of pronouns in the caption. You make your target users feel welcome because you include them from your designer's research right through to user testing. In the process, you learn to recognize exclusion in web design and far beyond.

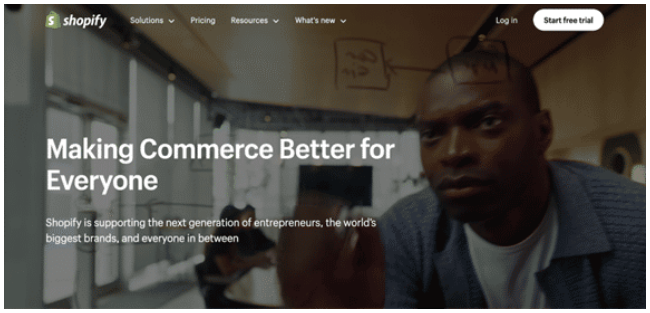


To practice inclusive design, don't design for an "ideal user" or make assumptions about user behavior or their needs for functionality. Instead, ask critical questions during the early stages of your design process. In your UX research, you can uncover potential barriers that may affect your users. You should consider the accessibility of content for individuals who may have disabilities, limited vision, or use assistive technologies. Many aspects of disability are in the

realm of neurodiversity. For instance, think about how users on the autism spectrum might not recognize features in your design because of how you set out the elements.

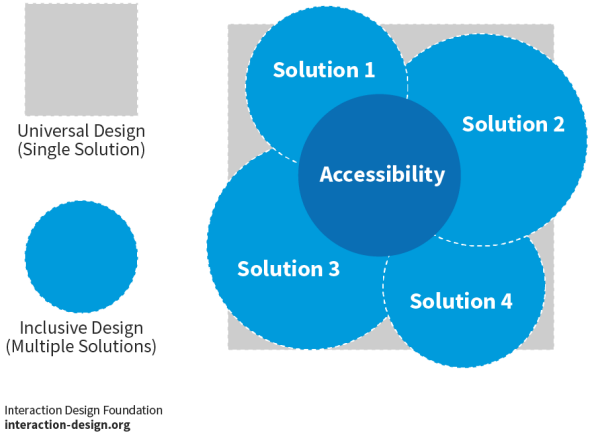
It's also important to challenge assumptions about users and understand how their experiences may differ. For example, is design practice geared solely toward users in the United States? In the early phases of design and development, it's vital to get to grips with questions like this.

Such questions could involve age, gender identity, ethnicity, language, culture, location, religion, and socio-economic status. For example, "What is the impact of language on users' understanding and use of the product?" When you have the answer, you as a UX designer can create products that you tailor to the needs of a diverse range of users. Consequently, all users will benefit because you will have designed to address a vast range of pain points. When you build inclusive products, you infuse them with a sense of belonging to a huge span of user groups .



Something as "small" as images can be a huge step towards inclusive design. Shopify's homepage has a rotating cast of diverse users. Its prominent headline "Making Commerce Better for Everyone" and the subtitle, "...supporting the next generation of entrepreneurs, the world's biggest bands, and everyone in between." reinforce this ideology.

Inclusive Design vs Universal Design vs Design For All vs Accessibility: Related but Distinct Concepts



Accessibility is the lowest common denominator and is an integral part of inclusive and universal design. While inclusive design and universal design both cater to the widest range of users, universal design strives for a single solution to cater to everyone, while inclusive design tries to achieve the goal through multiple adaptations.

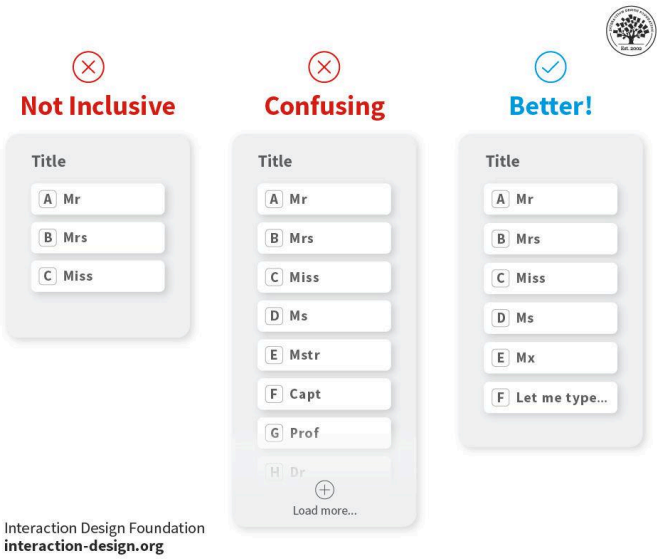
Inclusive design is related to three other concepts in the spirit of removing barriers: Accessibility, Universal Design and Design for All. Accessibility is narrower in scope and involves designing products so that people with disabilities can use and enjoy the products just as well as people without disabilities. Accessibility is the bare minimum with respect to Inclusive Design and Universal Design.

Both inclusive design and universal design aim to ensure that a design is usable and understandable for the maximum number of people. The difference lies in how designers implement the design. Universal design opts for a one-size-fits-all answer to design. All users use the same product, without any specialization. For example, in a digital design, subtitles cover accessibility in the sense that hard-of-hearing viewers have them. Also, they satisfy this universal design principle of equitable use. Viewers who aren't hard-of-hearing but who aren't native speakers of the language either can understand the content better with the closed captioning. The feature also benefits people who are in loud environments.

Inclusive design doesn't require designers to stick to a single design. Designers can implement multiple variations of the design to cater to different user segments.

Design for all is most closely related to inclusive design. It focuses on including accessible features in digital interfaces from early on in design—as opposed to retrofitting a "mainstream" design with options for users with disabilities later. However, its scope is not quite as explicit regarding how it involves users in the design process who have been traditionally underrepresented.

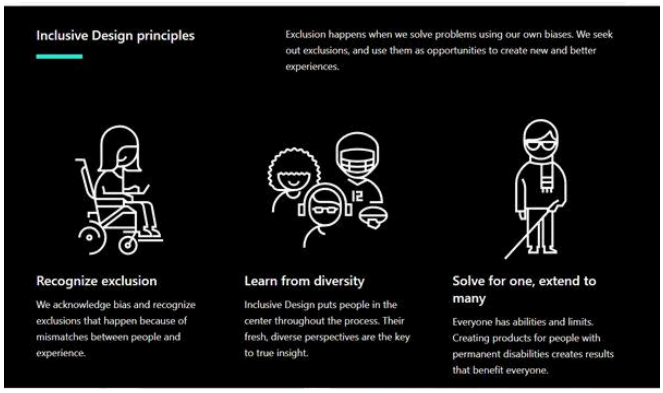
In general, universal design is used for physical products, where customization or multiple variations become expensive to develop. Inclusive design works well with digital products as they are relatively inexpensive to mass-customize. Dark mode options, text-size selectors, options to select age, and ways of identifying the user's full name (i.e., some cultures term and place "first" and "last name" in different ways) are some examples of inclusive design.



Always research current best practices to make the most inclusive and optimal decision for your products.

The Principles of Inclusive Design

Microsoft defines 3 main guiding principles of inclusive design:



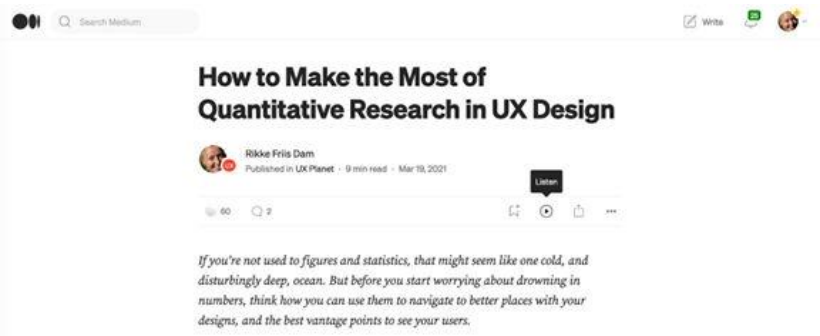
Microsoft's three fundamental principles of Inclusive Design: Recognize exclusion; Learn from diversity; Solve for one, extend to many.

1. Recognize Exclusion: We may not realize it, but all of us have biases—it is human nature. If we design solutions for user problems without recognizing these biases, we will end up excluding certain groups of people. Note that this is not limited to physical disabilities. It can apply to other forms of exclusion, such as social participation or temporary impairments. For example, if your app won't work well on older phones (e.g., for users who can only afford those), it will exclude them. It is only after we recognize and acknowledge exclusion, that we can begin to design inclusive experiences. User research can provide powerful insights for you to design more inclusively. User testing can also reveal points of exclusion.

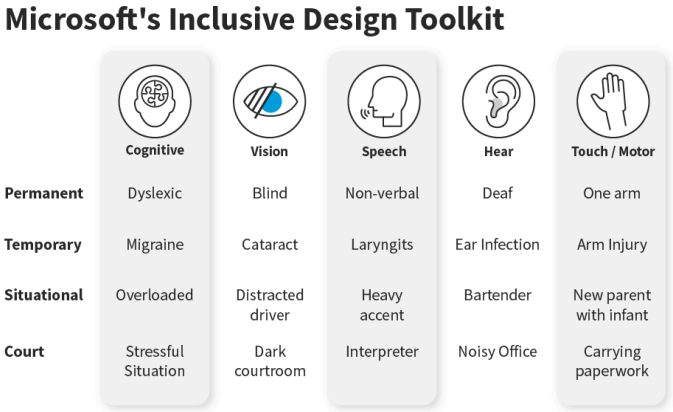
Nonprofit Girls Who Code's mission steps from historical exclusion. Despite the name, their target audience includes non-binary people.

2. Learn from Diversity: Inclusive Design puts people in the center throughout the process. Involving people from different communities throughout the design process will help you gain fresh, diverse perspectives. So, include people from different age groups, cultures, ability levels, socioeconomic backgrounds, education levels and more in your design team.

3. Solve for One, Extend to Many: When you design a feature with one group in mind, you can expand the scope to help others who can benefit. For example, if you offer users an option to listen to content rather than read it, you'll help users who have limited sight as well as those who may just want to rest their eyes.



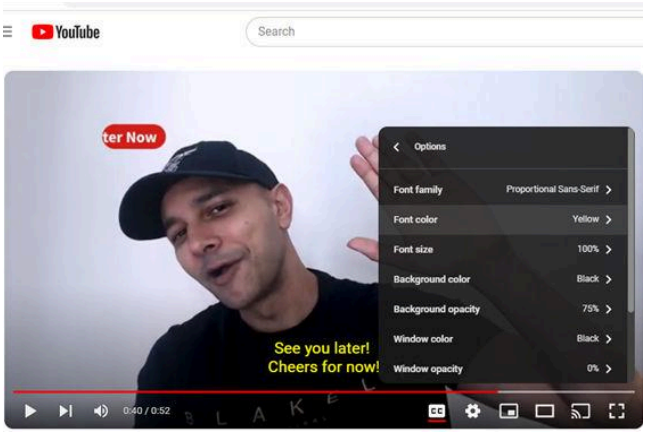
Medium offers the feature to listen to a story on its platform that is helpful for people who might find it hard to read long passages either due to vision difficulties or simply to rest their eyes after a long day staring at the screen!



Additional Inclusive Design Principles

In 2017, accessibility experts Henny Swan, Ian Pouncey, Heydon Pickering, Léonie Watson developed a set of seven principles for inclusive design:

1. Provide a Comparable Experience: Build your UI so everyone can perform tasks and achieve goals in a way that suits them without compromising on your content. Different users will have different ways of using your interface, and tools to do so. For instance, you help users of all types with content for alternative means such as screen readers and transcripts. Or you might give users options to change the font size, color, etc. of their subtitles to suit them.



YouTube offers the feature to adapt how your subtitles appear, including the color.
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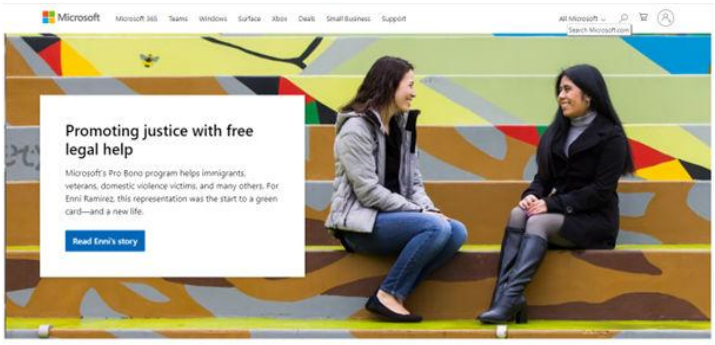
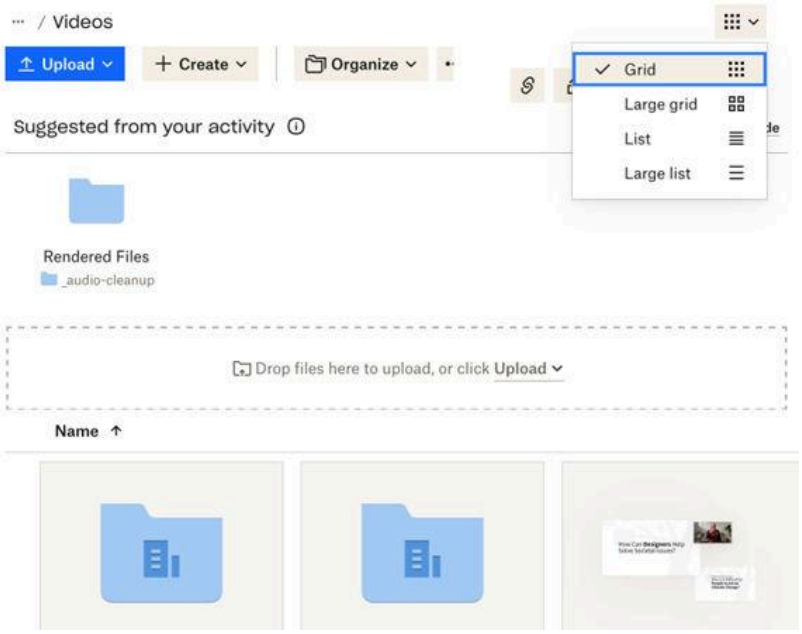
2. Consider situation: Consider the situation, or rather the context of your user and design accordingly. For example, Google Maps automatically switches to dark mode when you enter a tunnel or at sundown.
3. Be Consistent: Use well-established patterns to make an interface that users will find familiar. So, use design patterns to achieve that consistency in information architecture and more, and maximize users' understanding. Another example of consistency is to write the same things in the same way (e.g., micro copy, instructions) and in plain language to make text easy to understand.

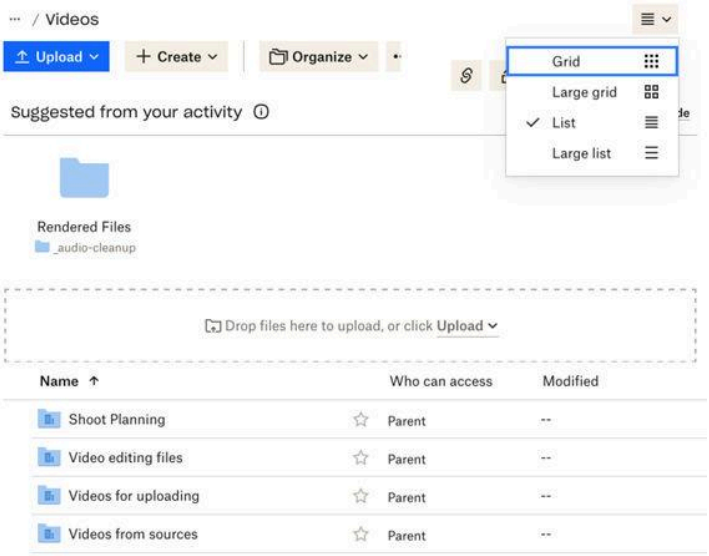


Microsoft's homepage shows a highly familiar layout. The logo is in the top left and the search is the magnifying functionality in the top right.

4. Give Users Control: Provide several ways for users to appreciate content and complete tasks. For example, if you have a long list of content for users, consider letting them choose to have a grid or a list. Another form of control might be to let users delete items by swiping left and also have the option to select them from another screen so they can delete more at once.

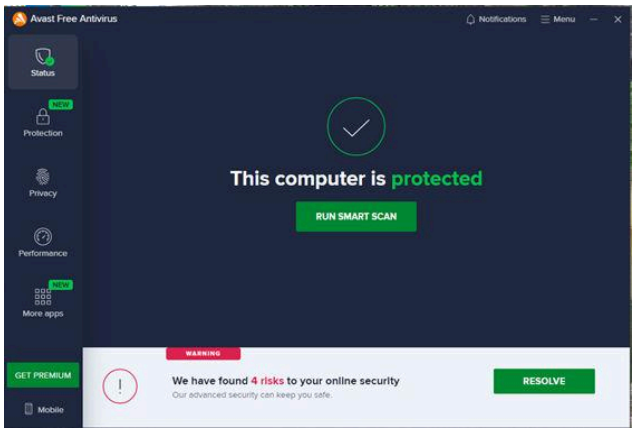


Dropbox offers a variety of views.



Dropbox offers a variety of views.

5. Offer Choice: Give your users several ways to achieve the same goal. For example, three ways to delete an email on an email client: Swipe, hit the delete key on the keyboard, or right-click and select delete.
6. Prioritize Content: Help users focus on one thing at a time. For example, for each page of a website, present users with the core task, feature or information they need and expect to find. So, be clear what the purpose of each page is and highlight that to them. Use progressive disclosure to reveal the prioritized content to them. If it's a button, for example, what is the most frequent action users will take on a virus-scanning app? It will be "Scan Device" rather than secondary actions such as "See Scan History."

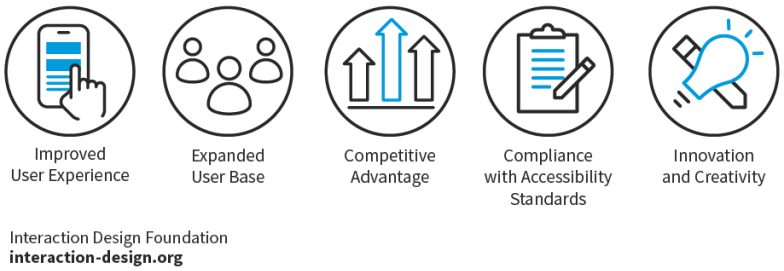


Avast prioritizes the function of running a smart scan here.

7. Add Value: Focus on adding value to your interface with features that are not only efficient but also versatile in how they let users interact with content in diverse ways. You can do this in several ways—for example, integrating with connected devices, such as voice commands to control a TV. Or you might add some bonus functionality, such as a "show password" feature.

The Benefits of Inclusive Design

Inclusive design offers numerous benefits, both for users and businesses. Here are some key advantages:



- Improved User Experience

Inclusive design enhances the overall user experience. It ensures that everyone—irrespective of physical or cognitive abilities, age, culture, educational background, gender, and language can access and navigate digital products effectively. This results in a more inclusive and satisfying experience for all users.

- Expanded User Base

Inclusive design enables products to reach a broader audience. As they accommodate diverse needs and preferences, inclusive designs attract users who may have been excluded in the past. This expands the potential user base and increases the market reach of the product.

- Competitive Advantage

Inclusive design has become a standard practice for many businesses. By embracing inclusive design principles, brands can differentiate themselves from competitors and position themselves as leaders in accessibility and inclusivity. This can enhance brand reputation and attract loyal customers.

- Compliance with Accessibility Standards

Inclusive design ensures compliance with accessibility standards and legal requirements. Many countries have laws mandating digital accessibility, and failure to comply can result in legal consequences. By prioritizing inclusive design, businesses can avoid legal issues and demonstrate their commitment to accessibility.

- Innovation and Creativity

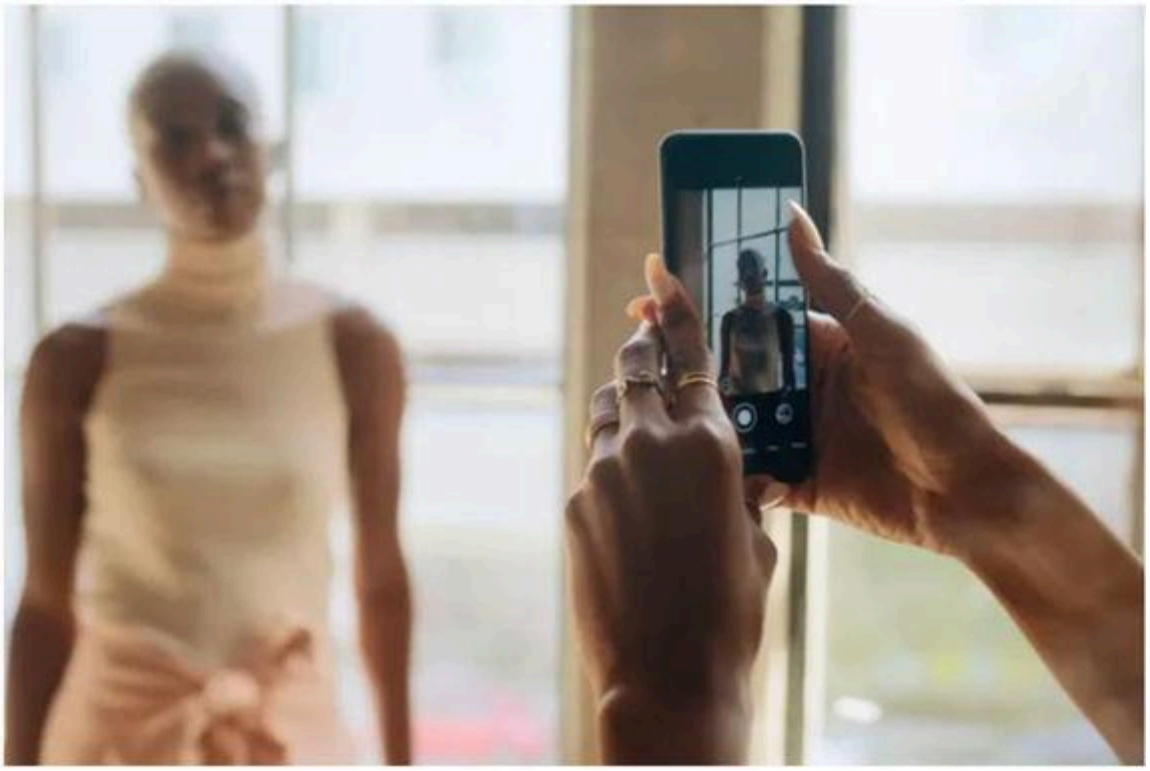
Inclusive design promotes innovation and creativity by encouraging designers to think outside the box. From there, they can develop solutions that cater to diverse user needs. When you consider a wide range of perspectives, you can uncover new ideas and create unique user experiences in products or services that take the extra step beyond user-centered design and universal design.

Inclusive Design in Practice: Examples and Case Studies

Many well-known brands have embraced inclusive design principles and have created products that cater to a diverse range of users. Here are some examples:

Google

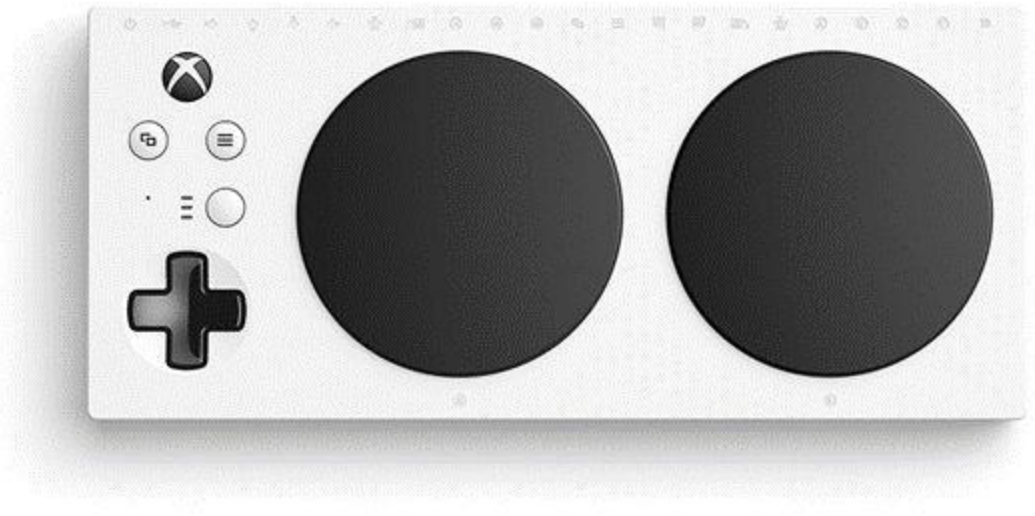
Google has prioritized inclusive design in its products. The Google Camera features the technology to capture accurate and fine-tuned tones of people's skin color. Previously, cameras had overlooked this tendency for the imaging of people with darker skin colors to come out inaccurately, Google embraced inclusive testing to accommodate everyone.



Google’s camera fine-tunes how it captures some skin tones to ensure accuracy.

Microsoft

Microsoft has made significant efforts to promote inclusive design. Their inclusive design toolkit provides resources and guidelines for designers to create products that are accessible to a wide range of users. Microsoft's Xbox Adaptive Controller is a notable example of inclusive design. It was specifically designed to meet the needs of gamers with limited mobility.



The Microsoft Xbox Adaptive Controller offers exceptional control.

These examples demonstrate how inclusive design can be integrated into various digital products to improve accessibility and enhance user experiences.