How Brain and Body Works

Daftar Isi

Class 1: The Human Brain & Cognitive Foundations of HCI

Objective: Explore how the brain processes information and its implications for interaction design.
Duration: 3 hours

1. Introduction to HCI & the Brain (30 mins)

- What is HCI? Why study the brain and body in HCI?
- Overview of cognitive processes: Perception, memory, attention, decision-making.
- Key Principle: Don Norman's Gulf of Execution & Evaluation (bridging user goals and system feedback).

Brain-computer interfaces (BCIs): The future of human-computer interaction

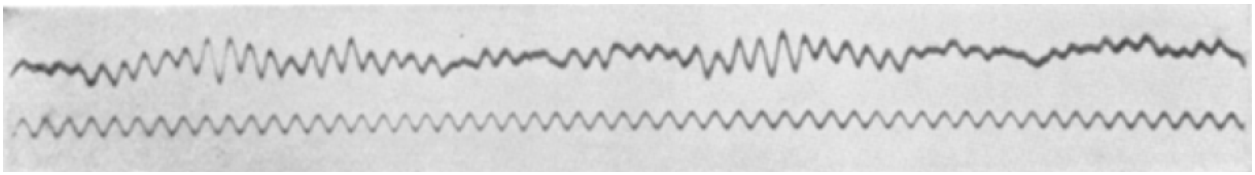
What is the brain-computer interface (BCI)?

Brain-computer interfaces (BCIs) or brain-machine interfaces (BMIs) are invasive, partially-invasive, and non-invasive devices that record the brain's electrical signals with EEG, EOG, and EMG methods. The signals are gathered by electrodes, analyzed on the interface of AI-powered software, converted to emotions or thoughts, and utilized for specific purposes. The determination of human beings to remedy people with diseases has made BCIs revolutionary. Today, BCIs can function as:

1. Brain-to-interface
2. Brain-to-prosthesis
3. Brain-to-text & image
4. Brain-to-brain

Development process

The history of BCIs goes way back than we expect. In 1924, Hans Berger discovered the brain's electrical activity and achieved to acquire them with the EEG method. In 1970, National Science Foundation granted the University of California, and research began by computer scientist Jacques Vidal; then, DARPA contracted the studies. This research appeared the term brain-computer interface in the scientific literature for the first time. In 2021, the global BCI market was $1.52 billion and is expected to reach $5.3 billion by 2030.



An early EEG recording done by Berger, 1929.

Types of BCIs

- Invasive BCIs are tiny chips that are planted inside the scalp. It can gather the most precise signals because it's located on the brain. It is mostly preferred for scientific research because of the cost, surgical process, and unknown long-term effects.
- Partially-invasive BCIs have two parts connected; the electrodes are planted under the scalp but not on the brain, lesser able to get brain signals for that reason, and the outer part is placed on the head and considered less risky than invasive BCIs.
- Non-invasive BCIs are devices worn on the head, like helmet or headphone, but cannot gather precise signals because the scalp absorbs them, but it is more marketable products for end-users to buy and use for personal use.

What do BCIs let humans do?

The purposes of BCIs' development are mostly medical-oriented. Scientists endeavor to remedy people with visual impairments, motor disabilities, and paralysis. These remedies provide us these cutting-edge technologies to improve and ease our daily life, like how accessibility standards enhance the usability quality of a digital product.

1. Brain-to-interface: Use digital products

- The research report published in 2004 demonstrates the achievement of moving a 2D cursor with BCIs on a digital interface, and recent studies are still progressing to improve that function today.

- Neuralink works on partially-invasive BCI and achieved to control a mouse cursor and keyboard using "The Neuralink App". Neuralink plans to develop an invasive BCI, allowing people to directly control computers and mobile devices with their thoughts in the future.

- Synchron developed an invasive BCI named "Stentrode", mesh-shaped electrodes placed into the brain vessel, allowing users to use their digital products entirely by thought. It is waiting for approval from the FDA.

2. Brain-to-prosthesis: Control physical products

- The first robot control with non-invasive BCI was achieved in 1988. In 2005, BrainGate's invasive BCI was achieved to control an artificial hand.

- The research report published in 2016 demonstrates and documents the achievement of controlling prostheses by thoughts via BCIs.

- UPMC (University of Pittsburgh Medical Center) achieved to let a person has quadriplegia move a prosthetic arm and relocate the objects by thought and let another patient with paralysis feel his fingers with the same prosthetic arm.

- Greg Gage, an adjunct professor from the University of Michigan, achieved to control arm of "another" person with thoughts.

- Meltin produces a consumer BCI "MELTz" that controls cybernetic prostheses for paralyzed people to let them relearn to use their hands.

3. Brain-to-text & image: Write and draw via thoughts

- The research report published by Standford University in 2021 demonstrates the achievement of letting the participants with paralysis write their thoughts with typing speeds of 90 characters per minute with 94.1% raw accuracy. The participants imagined moving their hands like writing the letters, and the software decoded them into digital.

- Synchron also achieved to provide their users to write their thoughts through their BCI, Stentrode.

- The University of Helsinki also achieved brain-to-image transmission in 2020. This concept is in the early development phase.

4. Brain-to-brain: Communicate telepathically

- The research run in 2014 achieved to let two people communicate with non-invasive BCIs. The subjects performed saying “hola” and “chaio” by imagining the letters of words they wanted to say, and the software encoded them in binary numbers and sent them to other people.

- The platform BrainNet that works with non-invasive BCIs that provides a way to communicate multiple people each other. According to the research report shared in 2019 demonstrates the achievement of letting three people communicate telepathically between their brains with their BCIs with an average accuracy of 81.25%.

How would BCIs impact human-computer interaction (HCI)?

Science and technology are correlated; as long as science advances and finds a way to produce the features easily, technology can cheaply bring those features as products to the end users for their daily life. The features above will certainly enter our lives in the future. The interrelations and combinations of recent technologies and BCIs are the futuristic extents of human-computer interaction which will be built for.

Combination with other devices and behavioral changes

Recent products have gone beyond desktop computers; they surround us. We wear them as watches and headphones, give control to our cars to autopilot, and make a robot clean our houses. Specific applications control all these products. We can assign tasks to them, and they run; we do that by tapping on the 2D screens. The screens will stay forever around us as sight is the most common sense of human-being, but our dependence on hardware like a keyboard or mouse will end up; using applications and achieving goals via screens will not remain forever.

Varjo has recently released their non-invasive BCI headset XR-3 combined with mixed reality (MR) glasses. These kinds of innovations will gradually increase in the future by combining wearables such as VR/AR/XR/MR devices. The size of these devices will reduce over time and extend the scope by spreading to the Internet of Things (IoT) and Bluetooth devices. Combining these devices with satellite internet services like Starlink will make the BCI and IoT combination accessible anywhere, anytime.

These companies below develops their BCIs make this probability real:

- Bitbrain: BCI research, non-invasive end-user BCIs, and software.
- Blackrock: Scientific and academic BCI research and development.
- Emotiv: End-user non-invasive BCIs and software.

- Neurable: Headphone-like non-invasive BCIs for end-users.
- OpenBCI: Open-source BCI software and end-user BCIs.

Image of Varjo's non-invasive BCI headset with MR glasses, XR-3.

Reverse interaction

The current devices we use have minimal interaction skills. The most capable one is the 2D screens we design primarily for. Sound and vibrations are the others and generally missing ones. The achievement of the University of Pittsburgh Medical Center that lets a person feel their hand with an artificial hand connected to a BCI shows us we could transmit signals to the user to feel artificial senses such as sight, sound, smell, touch, and taste in the future.

Pitt-UPMC Team Helps Paralyzed Man Feel Again with Robotic Arm

Withal, the existing accessibility standards would be expected to be updated and extended for the five senses. HCI people must learn and execute neuroscience and biology fundamentals besides user experience methodology to provide better interaction design for users.

Decentralization of UX with AI integration

The data of the user is always important to create a personalized experience. As mentioned, BCIs can collect users' thoughts, emotional states, and hormonal levels and provides us with an understanding of their instant state of them. All these data would occur infinite variable

parameters to create the required experience for the user that a UX team or person cannot handle. If we cultivate AI enough to understand and reason users' data efficiently, meaningfully, and reliably, it can create unique experiences for each user. That changes the existing situation:

- From: Static and pre-defined UX settings for all users by a UX team.
- To: Adaptive and variable UX settings for each user by AI.

Basically, that means decentralizing UX by assigning UX design to AI for future cognitive products that are controlled by thoughts. That structure could also provide adaptive accessibility settings for disabled users and variable environmental factors.

Unsurprisingly, AI has already become part of UX frameworks today; UX professionals have started to utilize AI for UX workflows; UX writing with ChatGPT is possible today. ChatGPT can understand contexts and create proper wordings to direct users. On the other hand, combining AI models such as ChatGPT to make Siri-like digital assistant, and communicating the digital assistant with reverse interaction, like hearing the assistant's speech in your head, and controlling it with your thoughts will bring the human-computer interaction to the next level and that doesn't seem far away.

For example, the growth rate of AI is increasing exponentially. OpenAI has released ChatGPT-4 has 100 trillion parameters, while ChatGPT-3 has 175 billion parameters, and the difference between these two release dates is just five months; that proves to achieve all concepts above very soon.

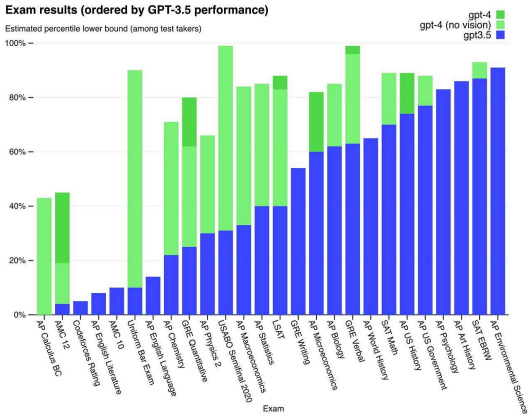


Image that shows the comparison chart of ChatGPT-3 and ChatGPT-4.

Blockchain and BCI association

When people have started to implant BCIs and do their daily needs with them, digital footprint tracking will be one of the most critical security requirements. Today, when you transfer your

money, only your bank knows it; if you change your official ID name, only the government knows it, and you have to share and present that information with relevant corporations in any need. There is already a technology that can meet that deficit.

Blockchain is the distributed ledger of encrypted codes containing specific information accessible by anybody. When information is recorded inside a blockchain, it is impossible to change and remove. Each blockchain includes data -transaction-, hash -a unique ID- and previous hash to keep the blockchain related to the previous one. If blockchain is combined with BCIs, all the users' data can be assigned to them to be responsible for, and companies and governments can utilize it.

As the closest example, thousands of people in Sweden have already implanted a subdermal implant, Bueno, developed by DSruptive Subdermals. Bueno allows users to store their ID information, state of health, electronic keys, business cards, public transport passes, and proof of vaccination.

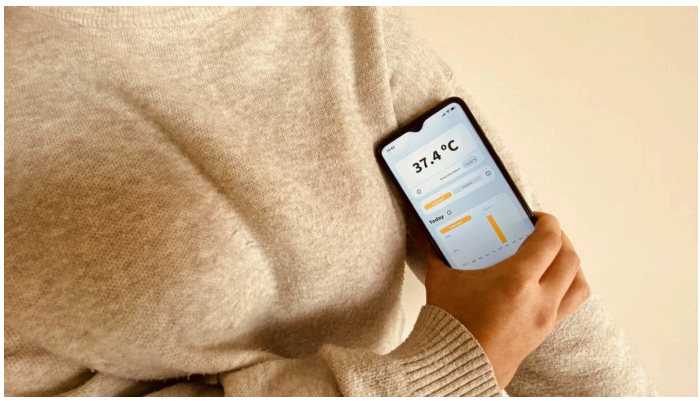


Image of Bueno, a subdermal implant, by DSruptive Subdermals.

If tech companies and governments will work collaboratively and ethically, BCIs' serial numbers could be citizens' ID numbers reliably and officially. That may provide users with accessible and responsible privacy and allow companies and governments to observe users'/citizens' omnichannel footprint to provide better services and maintain public order. However, that concept causes considerations and concerns from different points of view.

Considerations about brain-computer interfaces

Having a chip in our brain that makes us superhuman may seem stimulating; however, the limit of BCIs affects several fields more than the human body. When people have BCI in their brains, may it cause differentiation in public? Is it safe for a state to have BCIs for all of its citizens? Do we know the long-term effects of BCIs? These questions have answers:

Medical effects: Do we know enough?

Fundamentally, BCIs are developed to remedy people, but similar to other medical treatments, they have rare medical side effects. In addition, invasive and partially invasive BCIs need to be implanted with surgery; according to the research, BCIs may cause the following:

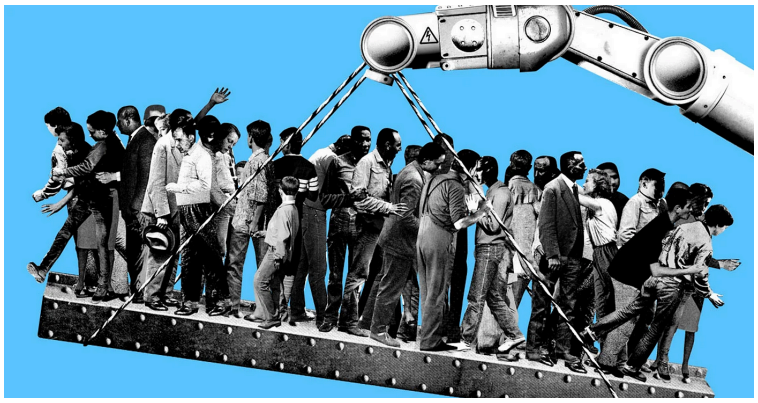
- Infection on tissue
- Acute trauma
- Glial scarring
- Reduce sleep quality
- Brain may deny BCI

These are some known short-term but severe side effects; we still do not know enough about them. Neuroscientists have intensely developed BCIs for approximately 50 years, less than a human lifetime. The same research also suggests observing the future effects of BCIs to make them safe for general use. FDA has a Guidance for invasive BCIs. As technological developments also support medicine, we could expect not to see too severe side effects of BCIs in the future.

Social and ethical reflections: Will we transform into cyborgs?

When a remarkable rate of the human population has been implanted BCIs worldwide, they will have some extra capabilities that separate them from the non-BCI-implanted fraction of the world population, which may cause discrimination.

Yuval Noah Harari, professor in the Department of History at the Hebrew University of Jerusalem, known as a techno-pessimist, puts forward bioengineering and AI would cause the creation of a global useless class and super-human class by 2100.



On the other hand, making the world population cyborg, mind tracking, and mind reading theories that violate personal privacy are the ethical considerations about BCIs, but conspiracy theories have always been around. However, the Privacy Act of the FDA and the General Data Protection Regulation (GDPR) of the European Commission covers and restrict these kinds of privacy deficits.

Official perspective: Who is the government now?

When the citizens of countries have implanted BCIs that record the citizens' emotions, thoughts, and hormone levels, that will rightly be a safety issue for the governments. The fundamental duty of governments is to protect their citizens, public order, and the country's safety. There are, fortunately, some regulations and guidance the governments can follow for BCI integration:

- The most comprehensive BCI regulation for governments is OECD Science, Technology and Industry Working Papers 2022/01. That regulation includes Ethical, Legal, and Social Implications (ELSI), consumer and data protection, and more.
- European Commission has proposal for Artificial Intelligence Regulation for the reliable use of AI.
- IEEE (The Institute of Electrical and Electronics Engineers) has released the AI Expertise and Safety Statement for governments and tech companies to develop AI properly and reliably.
- University of St. Thomas Journal of Law and Public Policy has released a paper named Neurolaw: Brain-Computer Interfaces that covers brain-hacking and other significant deficits of BCIs.

Suppose the governments act responsibly and avant-garde and collaborate with BCI companies, universities and global commissions. In that case, they can utilize that technology to build a better public order, country, and world for all without any issues. Nevertheless, there is still a need for a fully comprehensive regulation for the public and private use of BCIs that must be legislated by the FDA and European Commission that must be approved by all the countries worldwide.

How should HCI contribute BCIs?

Technology is advancing like evolution theory; the dedication of advancement needs to find a way to evolve and form the mainstream, then the side streams form as fractals. For example, the notion of HCI and UX did not exist when the first computer was invented. Today, besides UX design, we mention UX strategy, research, writing, accessibility, design systems, design-ops, etc. This structure must evolve and be associated with relevant fields of future technologies for human benefit.

Comprehend the associated disciplines

Human-computer interaction is regarding the interaction between humans and computers, as the name implies. Current digital products generally work on 2D digital screens that are seen by

the eyes and used with fingers, but BCIs will change all the structures with the multiple touch point that we need to understand the fundamentals of:

- Neuroscience: The biological basics of the human body are the primary restrictions of the design. The human brain will be the new framework of the HCI field with BCIs. Comprehending the basics of the human body would provide to analyze the users by the book and to suggest HCI-wise proposals for the study appropriately.
- Cybernetics and wearable products: Secondary design restriction is computers. As long as we learn the devices' varieties, capabilities, and limits, we can combine and utilize their unique skills to create functional design solutions for people's needs.
- Blockchain: Tracking users' digital footprint without missing any information securely will provide AI to generate decentralized experiences. Blockchain technology must be understood well to utilize efficiently, especially for companies and governments.
- Psychology: Current UX design structures depend on personas to create personalized experiences. We will be able to analyze users' emotional states and hormone levels with BCIs, and we must comprehend the psychological fundamentals to provide methodologically-approved personal experiences.
- Sociology: Each society worldwide has a different mentality according to its unique culture. We can project several types of individual psyches by observing thoughts with BCIs. We must understand the sociological fundamentals well to provide culture-compatible and culture-ethical experiences for different societies.
- Regulations: Having access to the brain data of a person does not mean we can freely utilize them. When the authorities have released a worldwide-confirmed regulation, and the countries regulated BCIs in their constitutions, all the laws and regulations must be digested to avoid official issues and provide high-level privacy to the users.
- Artificial Intelligence: Human nature is always endeavoring to convenience its life, and AI is the milestone of that process. The possibility of creating a human-friendly, bias-free, and nature-saver AI is in our hands; instead of concerning we should participate and contribute to the development of AI.

Besides these fields, HCI fundamentals must be comprehended in detail; the academic book Human-Computer Interaction by Alan Dix is one of the essential books of the HCI field to achieve it. As long as we understand these fields, we can investigate and provide HCI services for useful, functional, and reliable BCIs for users. Being professional in all these fields simultaneously is impossible. New professions would be born in the future with the intersection of these fields with HCI.

Keep the future safe with HCI

Human-computer interaction is a field where humans and computers meet. Scientists and engineers endeavor to develop their products -computers- most functionally; biologists try to keep humans healthy; the governments' duty is to keep the citizens and country safe, while AI is developing itself. HCI people are always the auditor of the products to keep them ethical, safe, and reliable. HCI people have more responsibility to audit each phase of the BCIs at this stage. We are the only community able to combine all these fields in harmony to create a better, safer, and more reliable future for all.

2. Perception & Sensory Processing (45 mins)

- Vision: How the brain processes visual information (e.g., color, motion, patterns).
    - Gestalt Principles: Proximity, similarity, continuity (applied to UI design).
- Auditory Processing: How sound influences interaction (e.g., feedback tones, voice interfaces).
- Multisensory Integration: Combining senses for richer experiences (e.g., VR/AR).

Visual Perception

Vision is the sense we most depend on in our daily lives, and it is complex - despite the huge strides recently made in artificial intelligence and image processing, the way our brains process images is vastly superior.

From the eye to the brain

The axons of ganglion cells exit the retina to form the optic nerve, which travels to two places: the thalamus (specifically, the lateral geniculate nucleus, or LGN) and the superior colliculus. The LGN is the main relay for visual information from the retina to reach the cortex. Despite this, the retina only makes up about 20% of all inputs to the LGN, with the rest coming from the brainstem and the cortex. So more than simply acting as a basic relay for visual input from retina to cortex, the LGN is actually the first part of our visual pathway that can be modified by mental states.

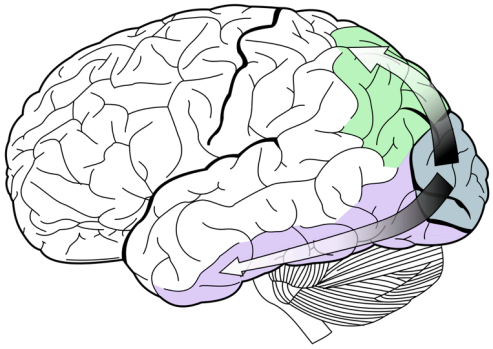
The superior colliculus helps us to control where our head and eyes move, and so determines where we direct our gaze. Saccades, the jumpy eye movements that you are using as you read this text, are also controlled by the superior colliculus. As with the LGN, the superior colliculus receives strong input from the cortex, which provides the dominant command as to where our gaze moves.

Cortical processing of visual input

From the thalamus, visual input travels to the visual cortex, located at the rear of our brains. The visual cortex is one of the most-studied parts of the mammalian brain, and it is here that the elementary building blocks of our vision – detection of contrast, colour and movement – are combined to produce our rich and complete visual perception.

Most researchers believe that visual processing in the cortex occurs through two distinct 'streams' of information. One stream, sometimes called the What Pathway (purple in the image below), is involved in recognising and identifying objects. The other stream, sometimes called

the Where Pathway (green), concerns object movement and location, and so is important for visually guided behaviour.

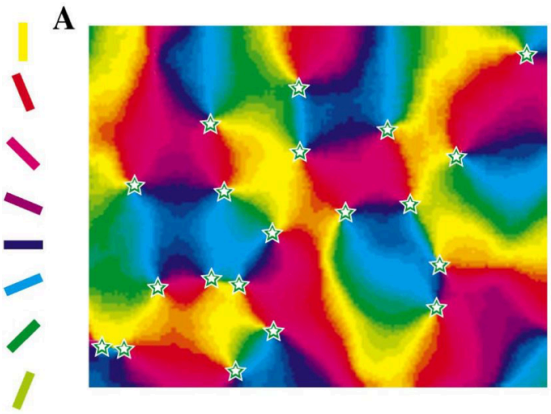


Building our visual world step by step

Our visual cortex is not uniform, and can be divided into a number of distinct subregions. These subregions are arranged hierarchically, with simple visual features represented in 'lower' areas and more complex features represented in 'higher' areas.

At the bottom of the hierarchy is the primary visual cortex, or V1. This is the part of visual cortex that receives input the thalamus. Neurons in V1 are sensitive to very basic visual signals, like the orientation of a bar or the direction in which a stimulus is moving. In humans and cats (but not rodents), neurons sensitive to the same orientation are located in columns that span the entire thickness of the cortex.

That is, all neurons within a column would respond to a horizontal (but not vertical or oblique) bar. In a neighbouring column, all neurons would respond to oblique but not horizontal or vertical bars (see image below). As well as this selectivity for orientation, neurons throughout most of V1 respond only to input from one of our two eyes. These neurons are also arranged in columns, although they are distinct from the orientation columns. This orderly arrangement of visual properties in the primary visual cortex was discovered by David Hubel and Torsten Wiesel in the 1960s, for which they were later awarded the Nobel Prize.



Orientation columns in primary visual cortex, as viewed from above. All neurons within a column respond preferentially to bars of a specific orientation, denoted here by colour.

Moving up the visual hierarchy, neurons represent more complex visual features. For example, in V2, the next area up in the hierarchy, neurons respond to contours, textures, and the location of something in either the foreground or background.

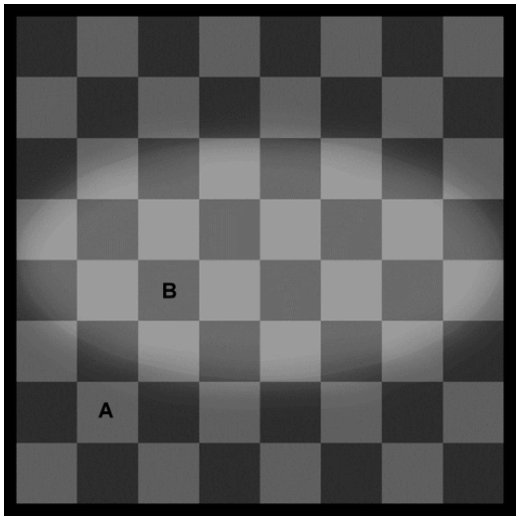
Beyond V1 and V2, the pathways carrying What and Where information split into distinct brain regions. At the top of the What hierarchy is inferior temporal (IT) cortex, which represents complete objects – there is even a part of IT, called the fusiform face area, which specifically responds to faces. The top regions in the Where stream are involved in tasks like guiding eye movements (saccades) using working memory, and integrating our vision with our body position (e.g. as you reach for an object).

In summary, the visual cortex shows a clear hierarchical arrangement. In lower areas (those closest to incoming light, like V1), neurons respond to simple visual features. As the visual input works its way up the hierarchy, these simple features are combined to create more complex features, until at the top of the hierarchy, neurons can represent complete visual objects such as a face.

Visual processing isn't all one way

This bottom-to-top processing of our visual world may seem the logical path, but it isn't the whole story. Such a 'bottom-up' approach would be far too slow and laborious, but more importantly, it would render our visual world full of ambiguity and we would struggle to survive. Instead, our perception relies to a very large extent on our previous experience and other 'top-down' mechanisms such as attention. QBI Professor Jason Mattingley uses cognitive approaches to study how attention can alter visual processing.

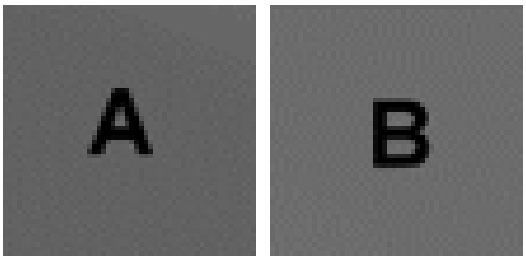
As an example of top-down processing, consider the image below:



Square A looks lighter, but is actually darker than square B. Clearly, our visual system is doing a terrible job at seeing reality. But that isn't its purpose. Instead, our brains are trying to make sense of what they are seeing, rather than seeking the truth.

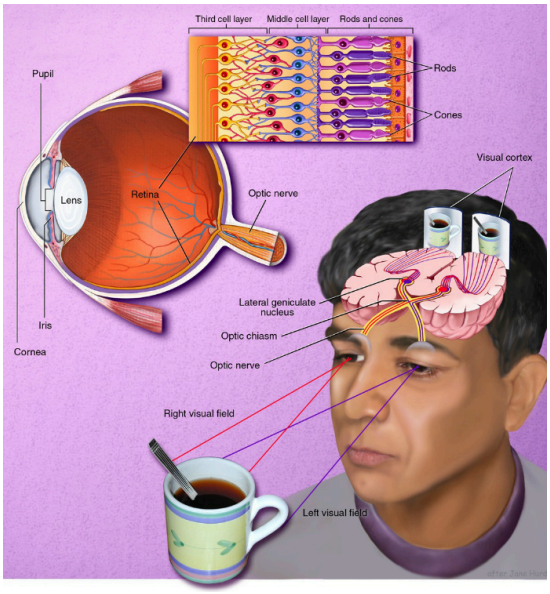
In the case of the above image, we automatically see – based on past experience – light and dark squares arranged in a checkerboard fashion, with a centrally lit portion and a shadow cast around the edges. With all of this information, we interpret A as a light square in shadow, and B as a brightly lit dark square. It isn't reality, but it is the most likely explanation given all of our previous experience and the data at hand. This is how our visual system works, ultimately to help us understand the world and so promote our survival.

Here are the squares side by side:



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.

How the human brain processes visual information

A team of researchers at the ARC Centre of Excellence for Integrative Brain Function, with lead researchers Dr Ali Almasi from the National Vision Research Institute of Australia and Associate Professor Hamish Meffin from The University of Melbourne, has studied brain cells in the primary visual cortex (V1) to determine how they respond to specific features that are important to a visual object's identity.

The human brain has a remarkable ability to recognise specific objects, even when those objects change in appearance. For example, we can tell that a hand is a hand regardless of its colour, size, location or orientation. When processing visual information, brain cells display 'feature selectivity', ignoring features that are not important, meaning that they are 'invariant' to feature manipulation.

To determine how these cells combine their qualities of selectivity and invariance, the researchers measured how the activity of cells in V1 changed when the cells received visual information about 'white noise', using random combinations of black and white pixels arranged in a square grid.

Because the white noise images are random, patterns can emerge in the pixels, which occasionally match the image characteristics to which the recorded neurons are tuned. The researchers used the brain activity data to map how the cells responded to different combinations of patterns and built a computer model to estimate the cells' selectivity and invariance to particular features of the different patterns, such as their orientation, spatial scale and position.

The model revealed that most cells had a high degree of selectivity and a low degree of invariance for both the orientation and spatial scale of the patterns. However, the cells varied in their response to the position of the pattern; some cells were highly selective, but others were completely invariant. Returning to the example of the hand, this means that some cells would only respond when the hand was in a certain position, while others were completely invariant to hand location as long as it was a hand. This shows that even at an early stage of visual processing, the brain forms an elaborate set of sensitivities to generic features, which form the basis of more sophisticated processing in other visual areas of the brain.

What are the Gestalt Principles?

Gestalt Principles are principles/laws of human perception that describe how humans group similar elements, recognize patterns and simplify complex images when we perceive objects. Designers use the principles to organize content on websites and other interfaces so it is aesthetically pleasing and easy to understand.

Gestalt Principles – a Background

"Gestalt" is German for "unified whole". German psychologists Max Wertheimer, Kurt Koffka, and Wolfgang Kohler created the Gestalt Principles in the 1920s.

They wanted to understand how people make sense of the confusing things they see and hear. They identified a set of laws that address the natural compulsion to find order in disorder. According to this, the mind "informs" what the eye sees by perceiving a series of individual elements as a whole.

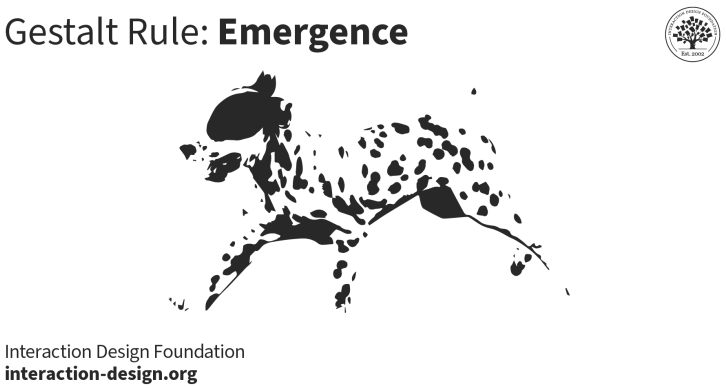
Graphic designers quickly embraced Gestalt Principles, using them to create eye-catching designs with well-placed elements.

Gestaltism's philosophy is not the same as Aristotle's saying, "the whole is greater than the sum of the parts." In Gestaltism, the whole is different and may even be completely unrelated to its parts.

Gestalt Principles

Gestalt Principles are an essential part of visual design. There are more than ten overlapping principles. Here's a look at some of the more common ones.

1. Emergence

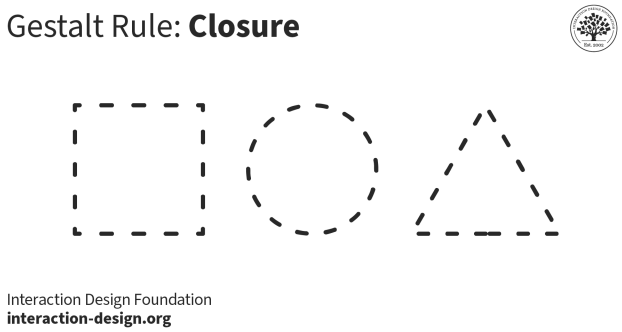


Instead of interpreting each blotch separately, we immediately identify a Dalmatian from a collection of oddly shaped black blotches. In other words, the Dalmatian emerges from the seemingly random scene.

The principle of emergence is central to Gestalt thinking. We perceive the world without thinking too much about understanding every small thing around us. This ability to quickly make sense of our environment is essential for survival. Imagine if we spent hours analyzing our world to understand what was going on; wild animals would have devoured our ancestors in no time!

Unilever's logo is composed of several smaller shapes. But the letter "U" emerges from the combination of those smaller elements. Looking further, we see many smaller icons emerge from these abstract shapes.

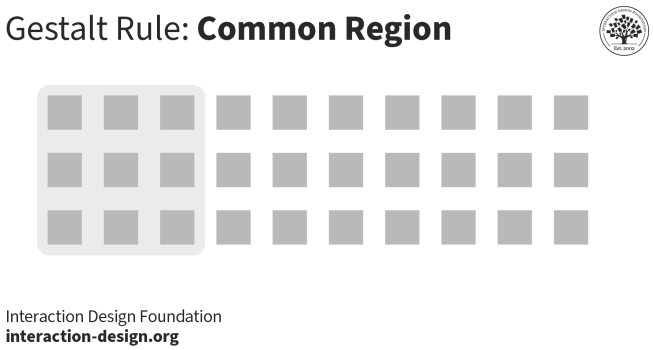
2. Closure (Reification)



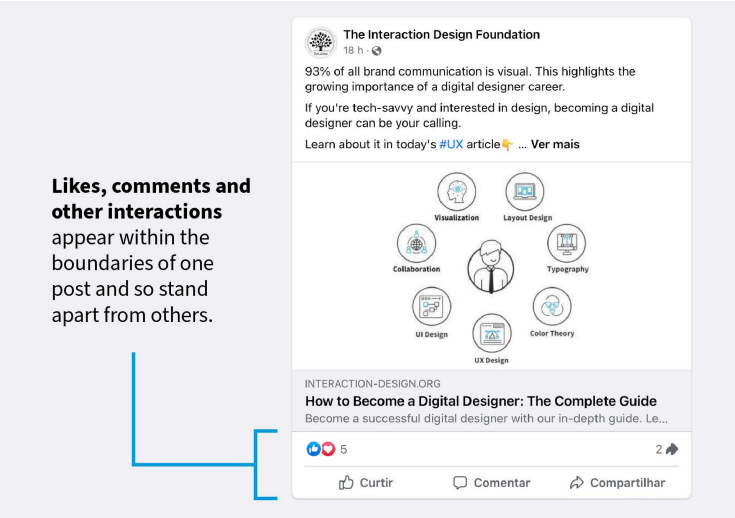
We prefer complete shapes, so we automatically fill the gaps between elements to perceive a complete image. That's how we can see the whole first. You can use closure creatively to gain users' trust and admiration. Users will appreciate it when they see pleasing "wholes" made from cleverly placed elements like lines, dots, or shapes.

Iconic logos like IBM's and the World Wildlife Fund's are great examples of closure. IBM's logo has blue lines in three stacks. WWF's logo has black shapes on a white background that we interpret as the shape of a panda.

3. Common Region

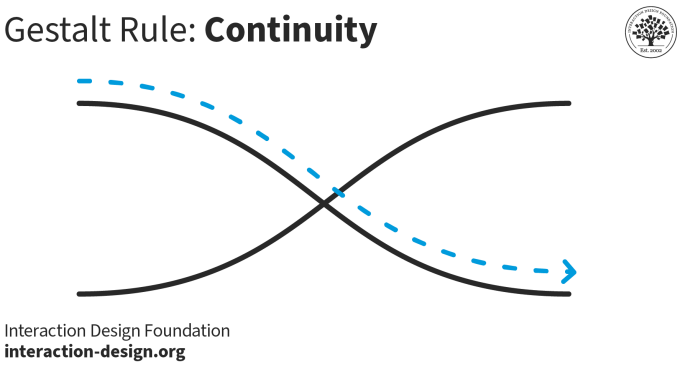


We perceive elements that are in the same closed region as one group. To apply this principle to your interfaces, group related objects together in a closed area to show they are separate from other groups.



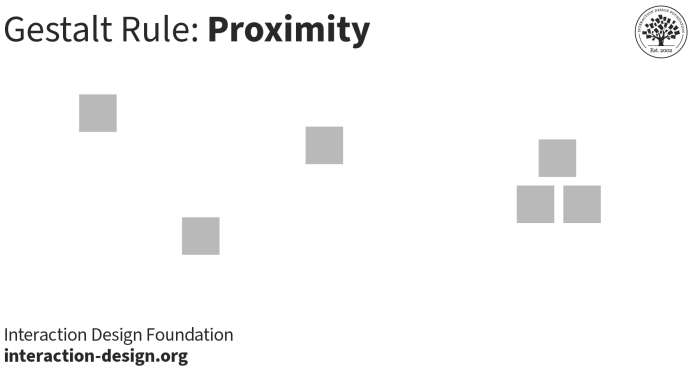
We can see the principle of common region applied in Facebook posts. Likes, comments and other interactions appear within the boundaries of one post and so stand apart from the other posts.

4. Continuity or Continuation



The continuity principle of Gestalt states that we group elements that seem to follow a continuous path in a particular direction. The human eye follows the paths, lines, and curves of a design and prefers to see a continuous flow of visual elements rather than separated objects. The human eye continues to follow the path even if an obstacle hides it or its flow is "broken" by interlinking or bisecting visual elements.

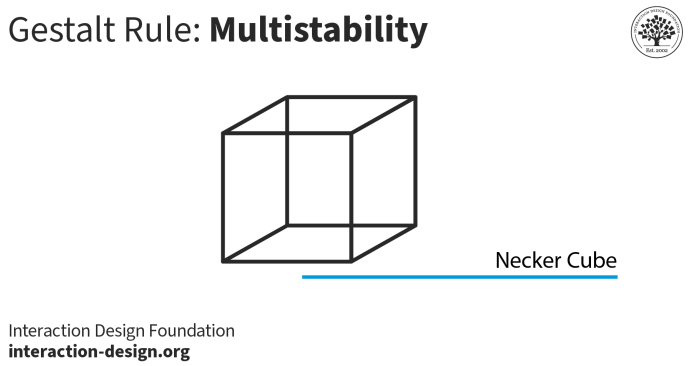
5. Proximity



We group closer-together elements, separating them from those farther apart. When you group elements in your design, users will see it as one distinct entity on the screen.

An example of proximity in design is the Girl Scouts logo, with its three faces clustered in profile (two green, one white).

6. Multistability

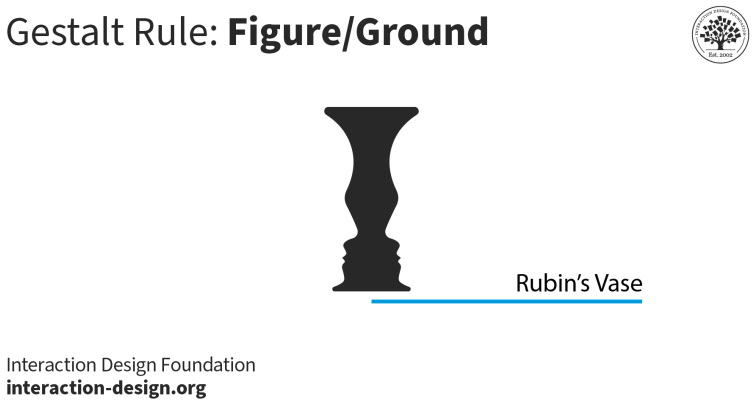


In the Necker cube optical illusion, you can interpret it as a three-dimensional cube with the "front" face either toward the lower left or the top right. A third interpretation is that intersecting lines create a diamond in the center. Often, when we interpret the image one way, we find it hard to see the other interpretations.

When images are ambiguous and present two or more meaningful interpretations, we experience the sensation of switching between them. We cannot see the multiple versions simultaneously. This switching sensation is called multistability.

"My wife and my mother-in-law" is a famous optical illusion that demonstrates multistability. Depending on where you focus, you might see either a young lady looking away or an elderly one looking sideways.

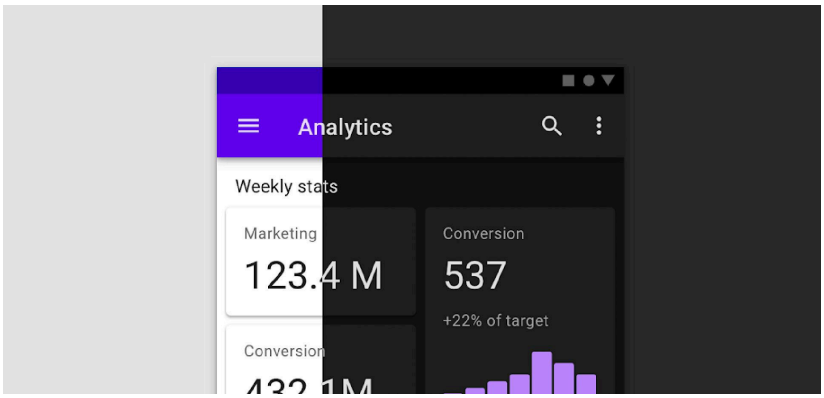
7. Figure/Ground



Rubin's Vase is a classic illustration that demonstrates the principles of figure/ground and multistability. If you consider a white background, you see a black vase in the foreground. And if you consider a black background color, you see two faces looking at each other.

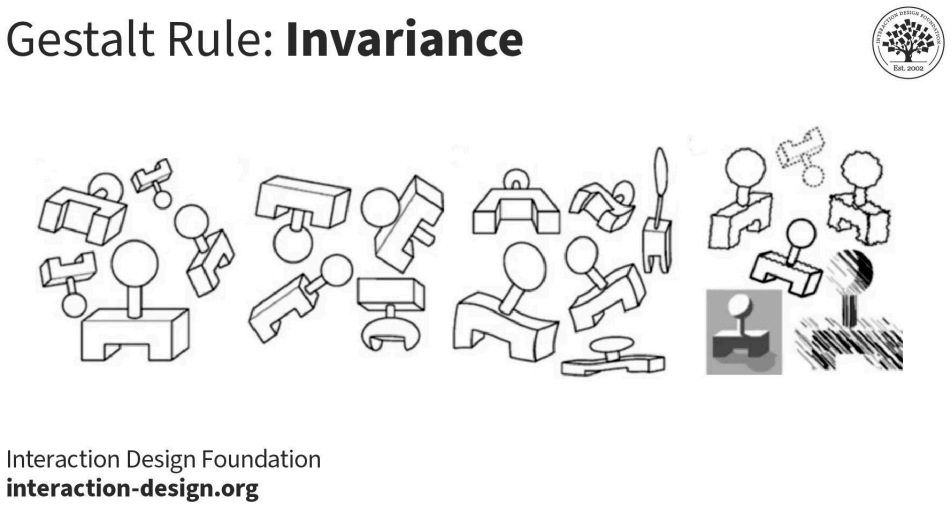
We dislike uncertainty, so we look for solid, stable items. Unless an image is ambiguous—like Rubin's Vase above—we see its foreground first. You can apply figure/ground in many ways, but chiefly to contrast elements: for example, light text (i.e., figure) from a dark background (i.e., ground). When you use figure/ground well, alongside other considerations such as color theory, you'll help guide users in their tasks and lessen their cognitive load.

Figure/ground and multistability are sometimes confused to be the same. However, there is a slight difference. In most cases, background and foreground are stable, but in some cases, such as the optical illusion of Rubin's vase, it can contribute to multistability.

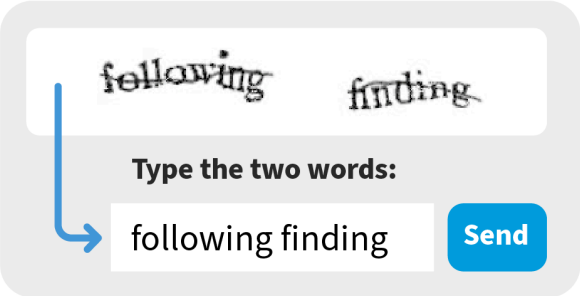


When an interface's color theme changes from light to dark, the previously black text becomes white, and the white background becomes black. Even though the colors have reversed, we have no trouble recognizing the interface. We automatically interpret the foreground and background colors.

8. Invariance

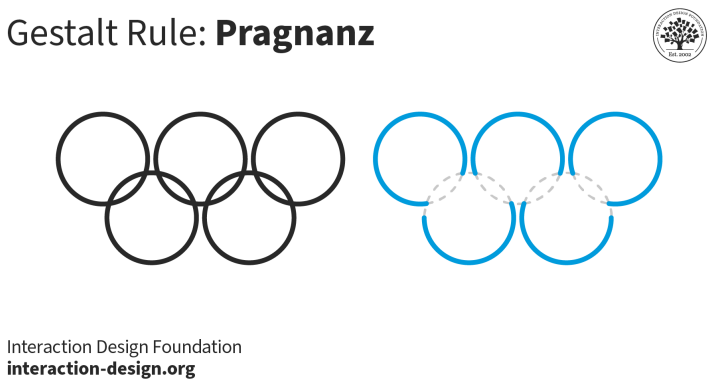


The Gestalt principle of invariance explains how we perceive basic shapes as idetical despite various transformations. These transformations include rotation, movement, size alteration, stretching, different lighting conditions, and variations in parts. This principle is crucial for recognizing faces, for example. Thanks to invariance, we can recognize our friends and family members from afar or different angles or even when they make funny faces.



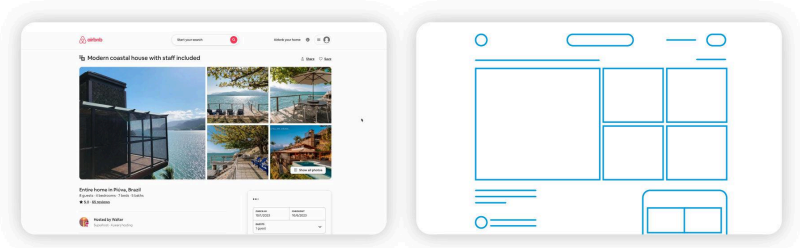
Captchas rely on the human ability to recognize shapes even if they are distorted.

9. Pragnanz



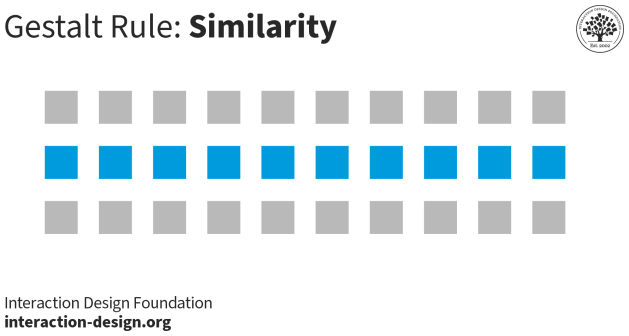
When we see the Olympic rings, we see five interlocked rings instead of "C" and lens shapes. The circles are simpler shapes to process than the C or lens shapes.

Pragnanz describes the human tendency to simplify complexity. Our environment constantly bombards our senses with stimuli, while we have limited attention and processing capacity to handle all the complexity. Pragnanz helps us see order and regularity in a world of visual competition.

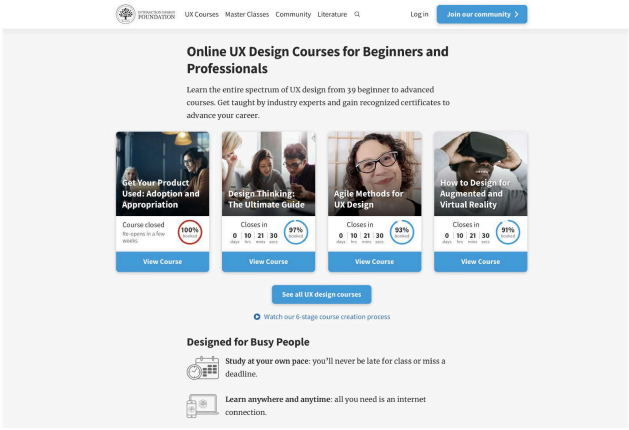


Pragnanz shows the importance of simplicity. It is no accident that interface elements across applications use simple shapes such as rectangles and circles instead of complex ones that are hard to recall or process.

10. Similarity

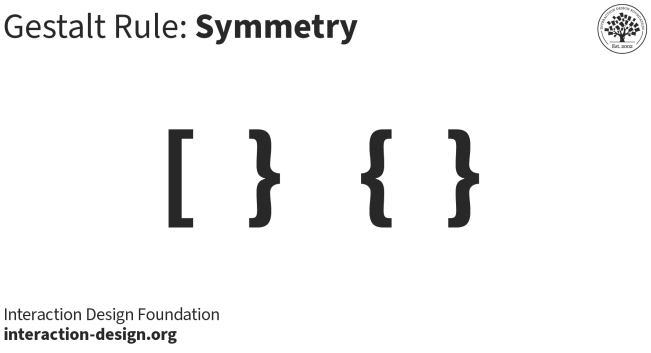


When items, objects or elements share superficial characteristics, we perceive them as grouped. We can see the similarity principle in branding and design system guidelines.



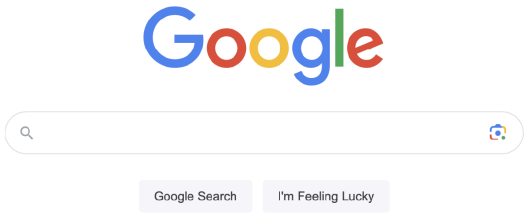
Brands implement design systems to guide users. For example, on the IxDF homepage, all buttons are styled similarly to let the users know that clicking the button will lead to an action. All text elements that share a specific style will also be interpreted as being part of a group (say, links, headings, captions, etc.).

11. Symmetry and Order



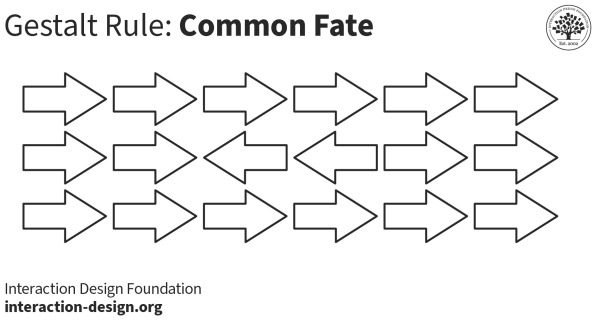
Which of these shapes would you group together? Chances are, you'll pick the matching square brackets instead of the mismatched curly and square bracket combination.

Humans tend to see visual elements as grouped when they are arranged symmetrically. The natural world is filled with symmetry (or near symmetry), and our brains tend to favor symmetrical forms. Grid systems that evenly divide the space help designers implement symmetry and order in user interfaces.



Google's home page is symmetrical, with almost all major elements center-aligned and the two buttons, "Google Search" and "I'm Feeling Lucky," nearly mirroring each other.

12. Common Fate

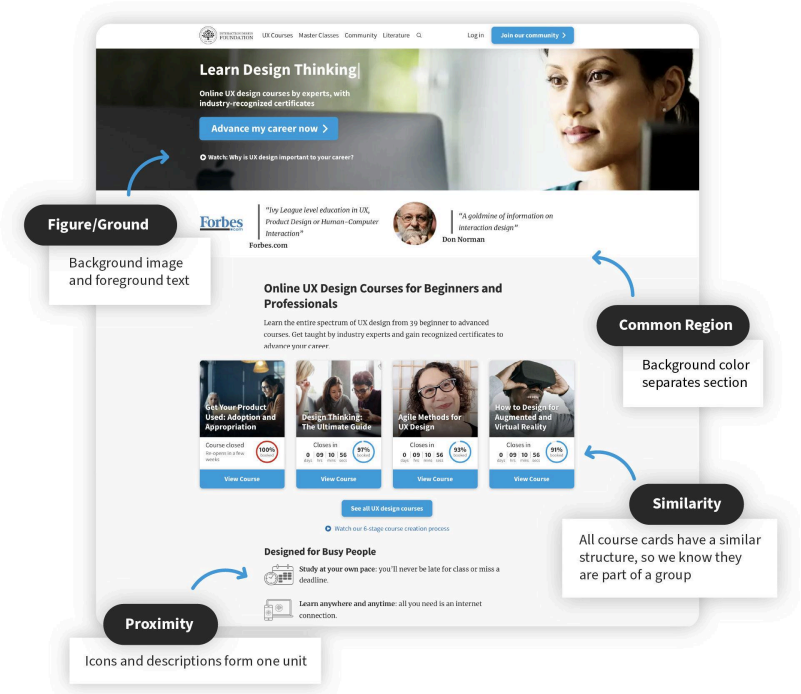


This principle refers to the human tendency to perceive visual elements moving in the same direction or in unison as grouped. Visuals need not be moving to convey motion. Cues such as arrows and the rotation angle can indicate the direction in which the elements are perceived to move.

The "Frequently Asked Questions" section on websites is often an accordion. We interpret all the questions as part of a group "moving" in the same direction. In this case, the downward arrows point to the direction each of them will open.

Gestalt Principles are in the Mind, Not the Eye

The Gestalt Principles are vital in user experience (UX) design. When you design interfaces, users must be able to understand what they see—and find what they want—at a glance. Below are examples of the Gestalt principles from the IxDF landing page.



The background image and the text overlaid on it demonstrate the principle of figure/ground. The course cards have a similar structure, so users know they are part of a group. The icons and descriptions are placed in close proximity to indicate that they belong together. And finally, colors and graphics divide the page into separate regions. Without this, users would struggle to make associations between unrelated clustered-together items and leave the site.

In your designs, you should never confuse or delay users. Instead, guide them to their options so they can identify with organizations/brands rapidly.

Gestalt principles in UI design

Have you ever looked at the sky noticing an unusually shaped cloud, resembling a familiar animal or an object? Have you ever wondered, why or how you make this association just by looking at a fluffy, blob of gas? It's all because of how your brain works!

Your brain is always trying to make sense of the world by comparing previous experiences or visual patterns and connecting the dots. It has its own “weird” way of perceiving shape and form, grouping information, fill in the gaps to draw the big picture.

Having an understanding how your brain works will help you become a wiser designer; master manipulator of Visual Communication. It can help you determine which visual elements are most effective in any given situation, so you can use them to influence perception, direct attention and cause behavioural change. Something particularly useful when it comes to goal-oriented, problem-solving, intuitive design; User Interface design.

> *“Great designers understand the powerful role that psychology plays in visual perception. What happens when someone’s eye meets your design creations? How does their mind react to the message your piece is sharing?” — Laura Busche, Brand Content Strategist at Autodesk*

It’s clear by now, visual design and psychology are linked and can influence one another. Gestalt principles can help us understand and control these links.

What is Gestalt?

Gestalt (form, shape in German) is a group of visual perception principles developed by German psychologists in 1920s. It is built on the theory that “an organized whole, is perceived as greater than the sum of its parts”.

> *“The whole is other than the sum of the parts.” — Kurt Koffka*

The Gestalt principles attempt to describe how people perceive visual elements when certain conditions apply. They are built on four key ideas:

Emergence

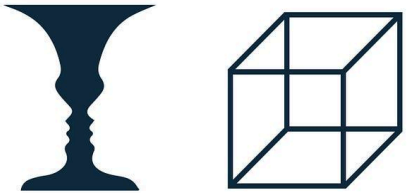
People tend to identify elements first in their general outlined form. Our brain recognises a simple, well-defined object quicker than a detailed one.

Reification

People can recognise objects even when there are parts of them missing. Our brain matches what we see with familiar patterns stored in our memory and fills in the gaps.

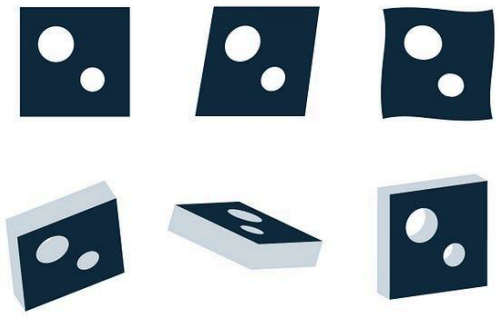
Multi-Stability

People will often interpret ambiguous objects in more than one ways. Our brains will bounce back and forth between the alternatives seeking certainty. As a result, one view will become more dominant while the other one will get harder to see.



Invariance

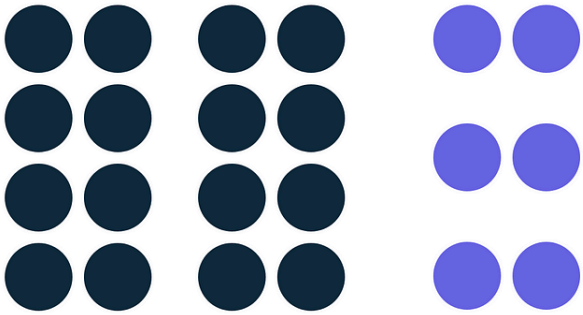
People can recognise simple objects independently of their rotation, scale and translation. Our brain can perceive objects from different perspectives, despite their different appearance.



Here’re the Gestalt principles which can inform today’s UI design.

Proximity

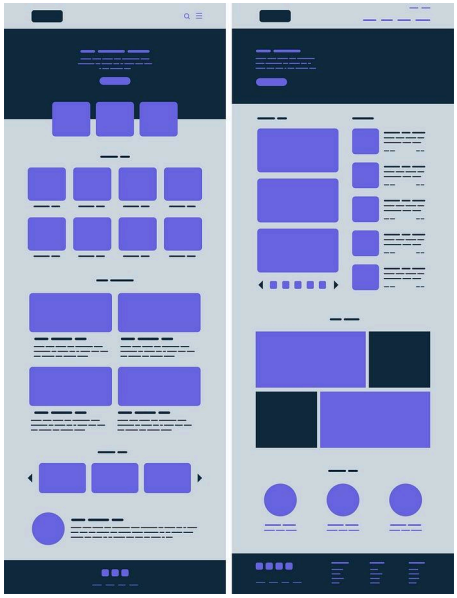
Elements arranged close to each other are perceived as more related than those placed further apart. This way different elements are viewed mainly as a group rather than as individual elements.



How does the Proximity principle apply to UI design?

We can use the Proximity principle in UI design for grouping similar information, organising content and decluttering layouts. Its correct use will have a positive impact on visual communication and user experience.

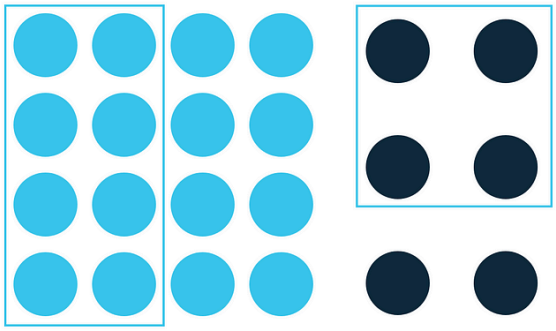
As the principle states, items that are related should stay close to each other, while the unrelated items should stay further apart. White space plays a vital role here as it creates contrast guiding the users’ eyes in the intended direction. White space can boost visual hierarchy and information flow, contributing in easy to read and scan layouts. It will help users achieve their goals faster and delve deeper into the content.



We can apply the Proximity principle pretty much everywhere from navigation, cards, galleries and banners to lists, body text and pagination.

Common Region

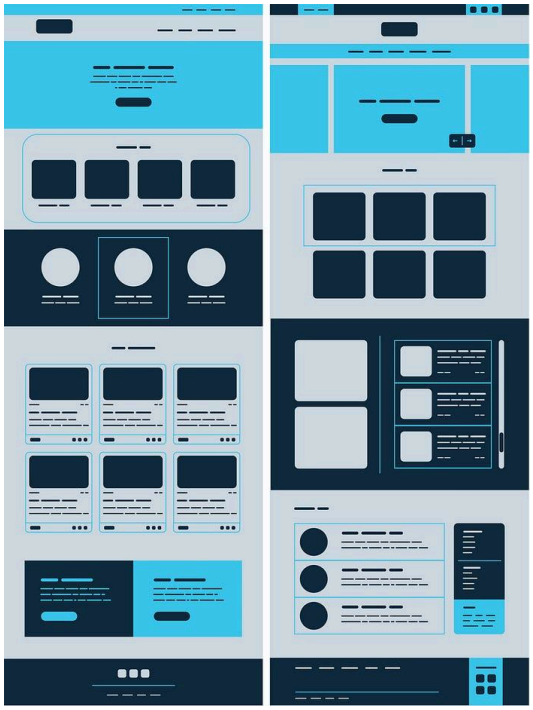
Similarly to the Proximity principle, elements placed within the same region are perceived as grouped.



How does the Common Region principle apply to UI design?

The Common Region principle is particularly useful. It can help with information grouping and content organisation, but it can also achieve content separation or act as a focal point. It boosts hierarchy, scanability and assists in promoting information.

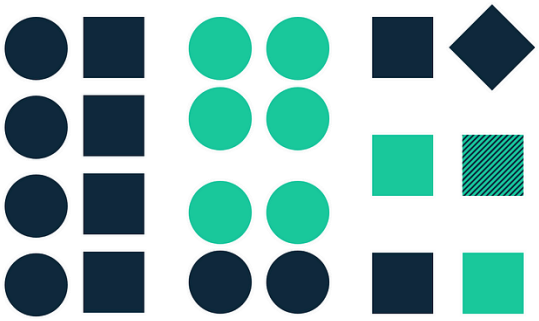
The Common Region principle can hold together many different elements keeping them unified within larger groups. We can achieve it with the use of line, colour, shape and shadow. It can often be used to bring elements into the foreground, indicating interaction or importance.



A good Common Region example would be the card UI pattern; a well defined rectangular space with different bits of information presented as one. Banners and tables are good examples as well.

Similarity

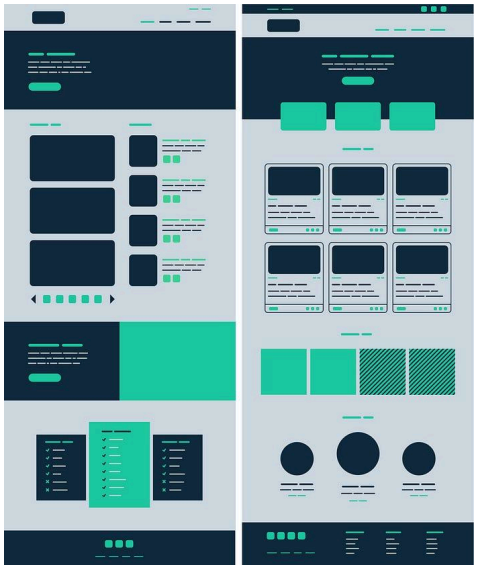
Elements sharing similar visual characteristics are perceived to be more related than those not sharing similar characteristics.



How does the Similarity principle apply to UI design?

We tend to perceive similar to each other elements as grouped or a pattern. We also might think that they serve the same purpose. Similarity can help us with organising and classifying objects within a group and linking them with a specific meaning or function.

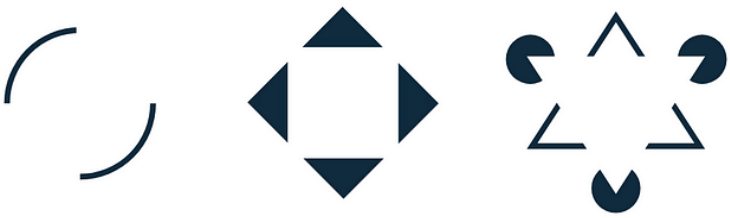
There are different ways of making elements perceived as being similar, and thus, related. These include similarity of colour, size, shape, texture, dimension, and orientation; with some of them being more strongly communicative than others (ex. colour > size > shape). When Similarity occurs, an object can get emphasised by being different from the rest; this is called 'Anomaly' and can be used to create contrast or visual weight. It can draw the user's attention to a specific piece of content (focal point) while assisting with scanability, discoverability and the overall flow.



We can use the principle of Similarity in navigation, links, buttons, headings, call to actions and more.

Closure

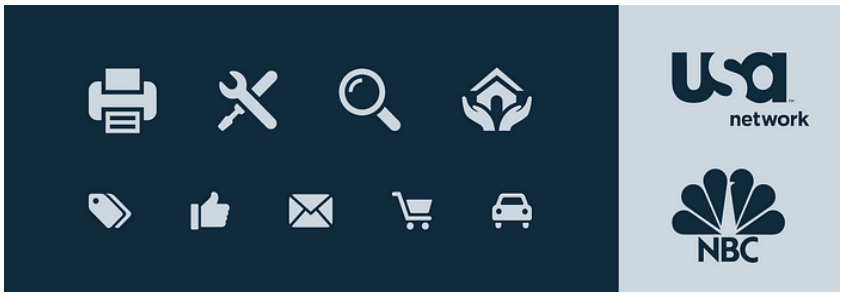
A group of elements are often perceived to be a single recognisable form or figure. The Closure also occurs when an object is incomplete, or parts of it are not enclosed.



How does the Closure principle apply to UI design?

As the Closure principle states, when presented with the right amount of information, our brain will jump to conclusions by filling in the gaps and creating a unified whole. This way we can decrease the number of elements needed to communicate information, reducing

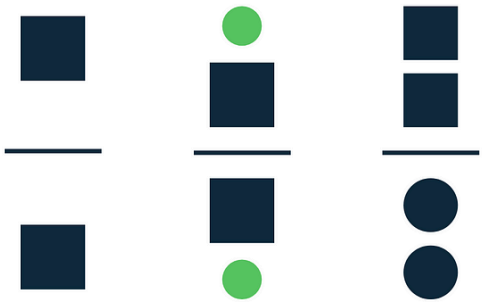
complexity and making designs more engaging. Closure can help us minimise visual noise and convey a message, reinforcing a concept within a pretty small space.



We can use the Closure principle in Iconography, where simplicity helps with communicating meaning, swiftly and clearly.

Symmetry

Symmetrical elements tend to perceived as belonging together regardless of their distance, giving us a feeling of solidity and order.



How does the symmetry principle apply in UI design?

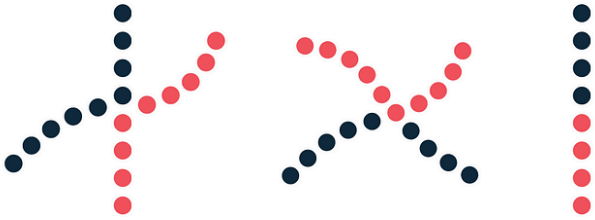
Symmetrical elements are simple, harmonious and visually pleasing. Our eyes seek those attributes along with order and stability, to make sense of the world. For this reason, Symmetry is a useful tool for communicating information quickly and efficiently. Symmetry feels comfortable helping us focus on what's important.

Symmetrical compositions are satisfying, but they can also get a bit dull and static. Visual symmetry tends to be more dynamic, and interesting. Adding an asymmetrical element to an otherwise symmetrical design can help with drawing attention while making an impression; something useful for any point of interest or a Call To Action, for example. Symmetry, along with a healthy amount of asymmetry is important in any design.

It’s good to use Symmetry for portfolios, galleries, product displays, listings, navigation, banners, and any content-heavy page.

Continuation

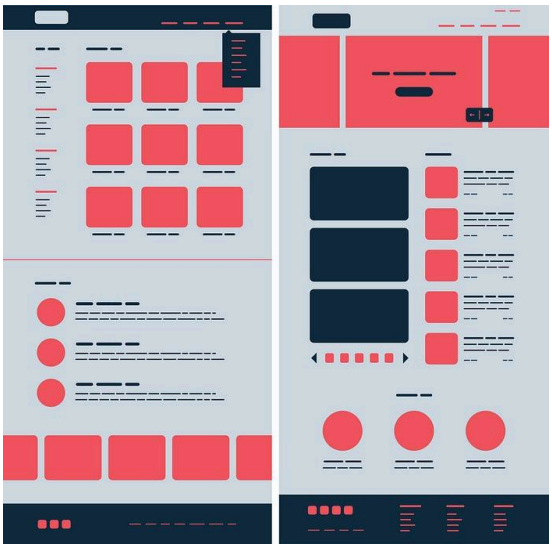
Elements arranged in a line or a soft curve are perceived to be more related than those arranged randomly or in a harsh line.



How does the Continuity principle apply in UI design?

Elements following a continuous line are perceived as grouped. The smoother the line segments, the more we see them as a unified shape; our mind prefers the path of least resistance.

Continuity helps us interpret direction and movement through a composition. It takes place when aligning elements and it can help our eyes move smoothly through the page, assisting with legibility. The Continuity principle strengthens the perception of grouped information, creating order and guiding users through different content segments. Disruption of continuity can signal the end of a section drawing attention to a new piece of content.



The linear arrangement of rows and columns are good examples of Continuity. We can use them in menus and sub-menus, lists, product arrangements, carousels, services or process/progress displays.

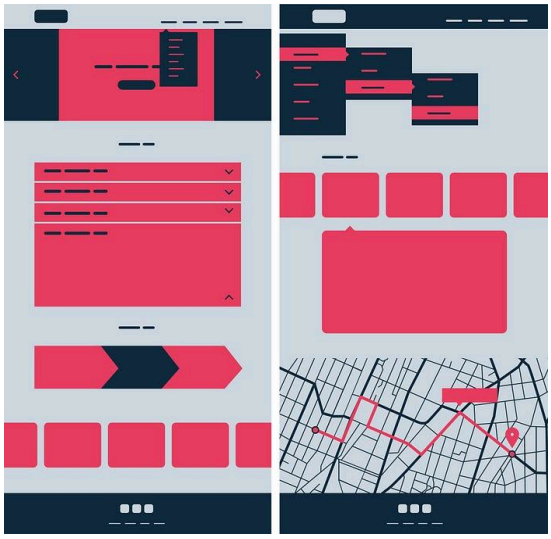
Common Fate

Elements moving towards the same direction are perceived as more related than those moving in different directions, or not moving at all.

How does the Common Fate principle apply in UI design?

Regardless of how far apart are the elements or how dissimilar they might appear, if they are moving or changing together, they are perceived as related. This effect can take place even when movement is implied, by other visual elements.

The Common Fate principle is more potent when elements move synchronised; in the same direction and at the same time and speed. It can help with grouping relevant information and linking actions with results. The disruption of a synchronised movement can grab users' attention and direct it to a specific element or feature. It can also, establish relationships between different groups or states.



We can use the Common Fate principle in expandable menus, accordions, tool-tips, product sliders, parallax scrolls and swiping indicators.

Exploring the Gestalt Principles of Design

Negative space has long been a staple of good design. Leaving white space around elements of a design is the first thing that usually comes to mind. But then there are designs that use that white space to infer an element that isn't actually there (the arrow hidden between the E and X in the FedEx logo immediately comes to mind as an example).

The human brain is exceptionally good at filling in the blanks in an image and creating a whole that is greater than the sum of its parts. It's why we see faces in things like tree leaves or sidewalk cracks.

This principle is one of the most important underlying ideas behind the gestalt principles of perception. The most influential early proposal written about the theory was published by Max Wertheimer in his 1923 Gestalt laws of perceptual organization, though Wolfgang Köhler's 1920 discussion of Physical Gestalten also contains many influential ideas on the subject.

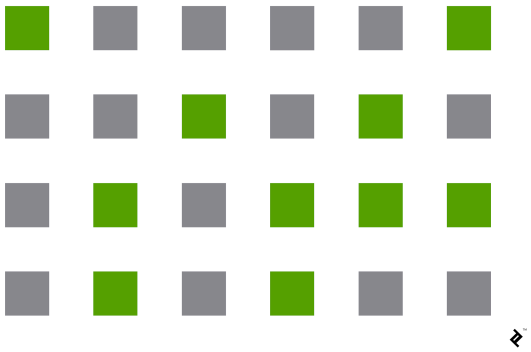
Regardless of who first proposed the ideas (there have been essays dating back as far as 1890), gestalt theory principles are an important set of ideas for any designer to learn, and their implementation can greatly improve not just the aesthetics of a design, but also its functionality and user-friendliness.

In the simplest terms, gestalt theory is based on the idea that the human brain will attempt to simplify and organize complex images or designs that consist of many elements, by subconsciously arranging the parts into an organized system that creates a whole, rather than just a series of disparate elements. Our brains are built to see structure and patterns in order for us to better understand the environment that we're living in.

There are six individual principles commonly associated with gestalt theory: similarity, continuation, closure, proximity, figure/ground, and symmetry & order (also called prägnanz). There are also some additional, newer principles sometimes associated with gestalt, such as common fate.

Similarity

It's human nature to group like things together. In gestalt, similar elements are visually grouped, regardless of their proximity to each other. They can be grouped by color, shape, or size. Similarity can be used to tie together elements that might not be right next to each other in a design.



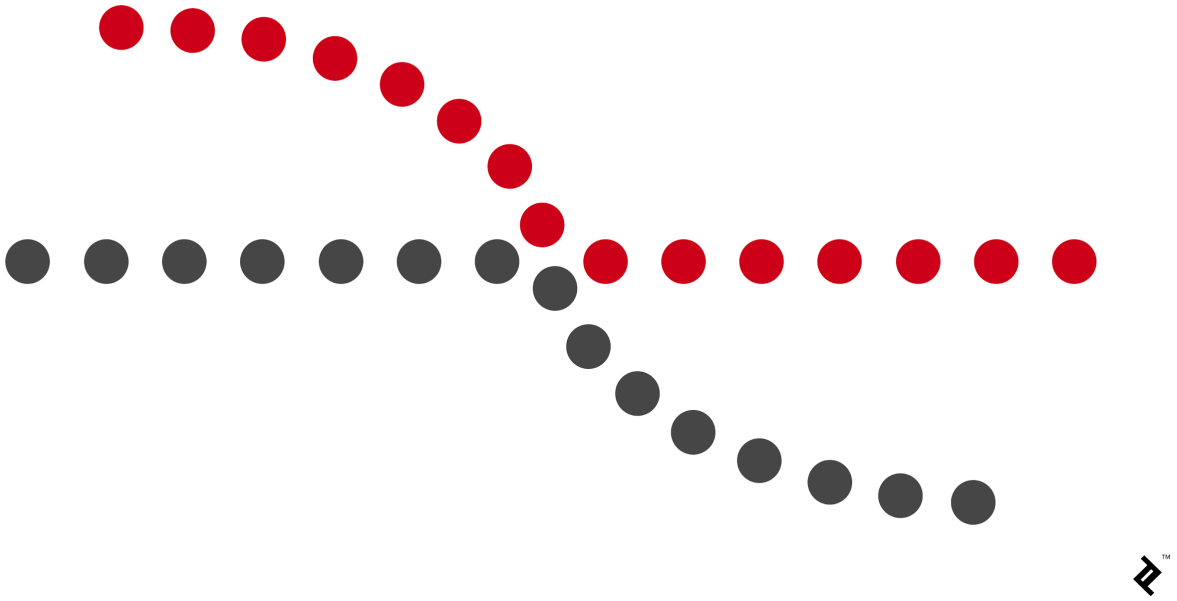
Of course, you can make things dissimilar if you want to make them stand out from the crowd. It's why buttons for calls to action are often designed in a different color than the rest of a page—so they stand out and draw the visitor's attention to the desired action.

In UX design, using similarity makes it clear to your visitors which items are alike. For example, in a features list using repetitive design elements (such as an icon accompanied by 3-4 lines of text), the similarity principle would make it easy to scan through them. In contrast, changing the design elements for features you want to highlight makes them stand out and gives them more importance in the visitor's perception.

Even things as simple as making sure that links throughout a design are formatted in the same way relies on the principle of similarity in the way your visitors will perceive the organization and structure of your site.

Continuation

The law of continuity posits that the human eye will follow the smoothest path when viewing lines, regardless of how the lines were actually drawn.



This continuation can be a valuable tool when the goal is to guide a visitor's eye in a certain direction. They will follow the simplest path on the page, so make sure the most vital parts they should see fall within that path.

Since the eye naturally follows a line, placing items in a series in a line will naturally draw the eye from one item to the next. Horizontal sliders are one such example, as are related product listings on sites like Amazon.

Closure

Closure is one of the coolest gestalt design principles and one I already touched on at the beginning of this piece. It's the idea that your brain will fill in the missing parts of a design or image to create a whole.

In its simplest form, the principle of closure allows your eye to follow something like a dotted line to its end. But more complex applications are often seen in logos, like that for the World Wildlife Fund. Large chunks of the outline for the panda are missing, but your brain has no problem filling in the missing sections to see the whole animal.

Closure is quite often used in logo design, with other examples including those for the USA Network, NBC, Sun Microsystems, and even Adobe.

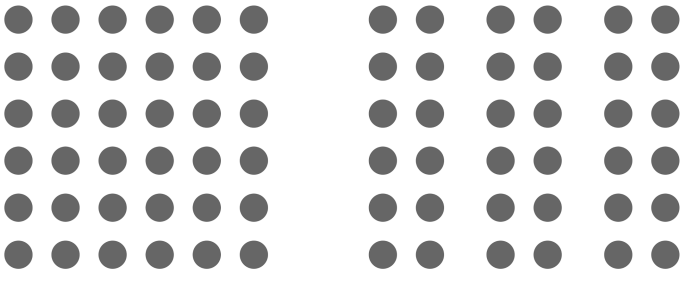
Another very important example of closure at work in UX and UI design is when you show a partial image fading off the user's screen in order to show them that there is more to be found if they swipe left or right. Without a partial image, i.e., if only full images are shown, the brain doesn't immediately interpret that there might be more to be seen, and therefore your user is less likely to scroll (since closure is already apparent).

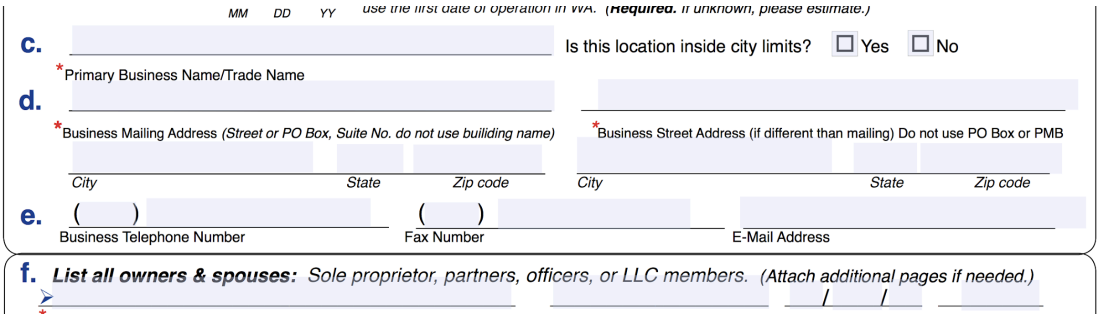
Proximity

Proximity refers to how close elements are to one another. The strongest proximity relationships are those between overlapping subjects, but just grouping objects into a single area can also have a strong proximity effect.

The opposite is also true, of course. By putting space between elements, you can add separation even when their other characteristics are the same.

Take this group of circles, for example:



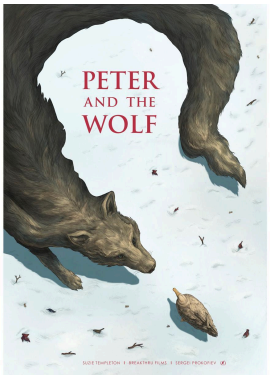


In UX design, proximity is most often used in order to get users to group certain things together without the use of things like hard borders. By utilizing gestalt grouping principles and putting like things closer together, with space in between each group, the viewer will immediately pick up on the organization and structure you want them to perceive.

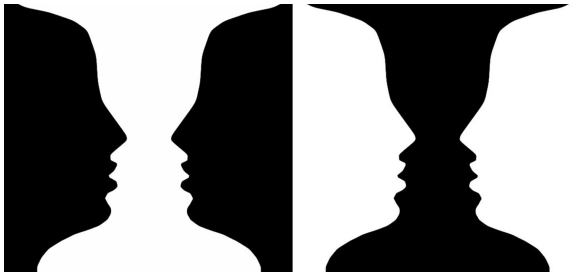
Figure/Ground

The figure/ground principle is similar to the closure principle in that it takes advantage of the way the brain processes negative space. You've probably seen examples of this principle floating around in memes on social media, or as part of logos (like the FedEx logo already mentioned).

Your brain will distinguish between the objects it considers to be in the foreground of an image (the figure, or focal point) and the background (the area on which the figures rest). Where things get interesting is when the foreground and background actually contain two distinct images, like this:



A simpler example can be seen with this image, of two faces creating a candlestick or vase between them:

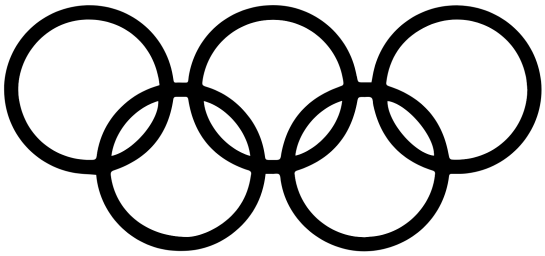


In general terms, your brain will interpret the larger area of an image as the ground and the smaller as the figure. As shown in the image above, though, you can see that lighter and darker colors can influence what is viewed as the figure and what is viewed as the ground.

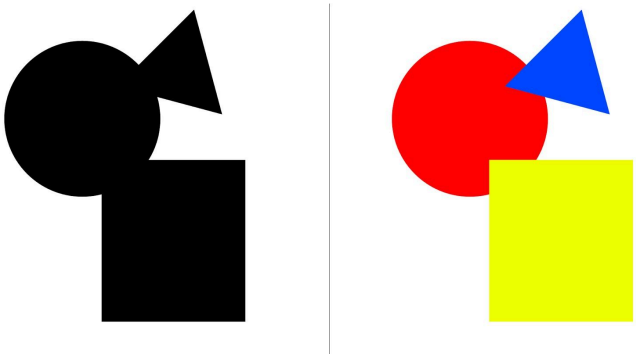
The figure/ground principle can be very handy when product designers want to highlight a focal point, particularly when it is active or in use—for example, when a modal window pops up and the rest of the site fades into the background, or when a search bar is clicked on and the contrast is increased between it and the rest of the site.

Symmetry and Order

The law of symmetry and order is also known as prägnanz, the German word for "good figure." What this principle says is that your brain will perceive ambiguous shapes in as simple a manner as possible. For example, a monochrome version of the Olympic logo is seen as a series of overlapping circles rather than a collection of curved lines.



Here's another good example of the gestalt design principle "prägnanz":



Your brain will interpret the image on the left as a rectangle, circle, and triangle, even when the outlines of each are incomplete because those are simpler shapes than the overall image.

Common Fate

While common fate was not originally included in gestalt theory, it has since been added. In UX design, its usefulness can't be overlooked. This principle states that people will group together things that point to or are moving in the same direction.

In nature, we see this in things like flocks of birds or schools of fish. They are made up of a bunch of individual elements, but because they move seemingly as one, our brains group them together and consider them a single stimulus.

This is very useful in UX as animated effects become more prevalent in modern design. Note that elements don't actually have to be moving in order to benefit from this principle, but they do have to give the impression of motion.

Gestalt Principles in UX Design

As with any psychological principle, learning to incorporate the visual perception principles of gestalt into your design work can greatly improve the user experience. Understanding how the human brain works and then exploiting a person's natural tendencies creates a more seamless interaction that makes a user feel comfortable on a website, even if it's their first visit.

Gestalt laws are relatively easy to incorporate into just about any design and can quickly elevate a design that seems haphazard or like it's fighting for a user's attention to one that offers a seamless, natural interaction that guides users toward the action you want them to take.

The influence of sound design in UX

The use of sound in everyday design is crucial and without it, we are missing out on a major component of human interaction. Humans have been using sound for thousands of years to communicate. And these sounds have helped us survive and share stories for centuries. Today there are many different types of sounds and ways to create them. All of them have the ability to add to our experience of the world. As we continue to create and design products, we have the opportunity to add these sounds in more unique ways that enhance both the experience and your brand.

After checking out different experiences on mobile and web products and reading a couple of blogs on related topics, I found that sound has an amazing experience when included in the products.

The sound helps us to recognize the brand as well. Every brand has a unique tone and on listing to the tune we can say the brand. I think it's very important to understand the user situation and design the sound accordingly.

The sound itself has an amazing experience and when included in the sites & apps, it's will be amazing when it's linked with the user interaction. All the sounds that we relate to are in the very nature of the event, so we remember the sound easily and relate to it.

Sound is the greatest communication to bank on and also think of solving some purpose to the product on how we can integrate for the blind people who can use the sound and enjoy the experience.

Recently I heard a whole episode on Netflix using audio description and it's a pretty amazing feature and it's solved the core purpose to reach greater audiences, in case you haven't checked it, do check the procedure to try it.

Every sound has a feeling to it and we connect to it super easy, it helps to instigate an emotion and move the right chords with your customer.

Especially in a digital world where we are increasingly visually driven. It is the most natural way to bridge people, technology and cultures. It adds a layer of emotion, sensuality and personality to the user's experience that cannot be communicated through visual design and interaction alone.

How does sound enhance UX?

Sound sells:

It conveys brand personality, gives credibility, authenticity and “humanizes” a product or service. As you heard with Netflix, here’s another example that helps you connect with the brand easily.

Sound creates presence and engages users:

It invites them into an experience that feels more real than virtual. Sound can help build trust between you and your users. It helps them know that you are taking care of their needs and that you are responding to their actions appropriately.

Sound provides feedback:

It shows users they’re doing something right, gives them clues to what they’re doing wrong or allows them to know when an action has been completed successfully.

Sound creates user interface:

It provides feedback on function and action, allows users to navigate without visual cues, creates hierarchy or information structure, and communicates with users using tone of voice or messaging.

Sound helps users understand content:

It helps establish time sense (when things will happen), establishes location (where the user is) and creates a context for content.

It’s important to remember that we are not consciously aware of sound’s effect on our perception and behaviour, but we certainly feel it subconsciously. What’s more, sound has been proven to generate empathy between people. For example, if you hear someone crying while watching a video online, chances are you’ll feel sad too.

Sound improves usability:

It guides users through the experience with confidence and reassures them if something unexpected happens.

It is also useful to consider the use of haptic interfaces that is something tangible. With voice assistants like Siri, Google Home, Cortana on our side, hearing what it feels like to touch something becomes more realistic swiping through virtual images with your hands or seeing a virtual object turning upside down with your eyes.

There's no denying the fact that every design is an interface. But it can be defined differently; Some people think that interface is a way to make things happen, others think that interface is communication between user and computer. In other words, the ultimate goal of designing is to make everything goes smoothly and easily, just like what I said in the title "Design is a UX Design" plus, above everything else, the most important part of achieving this ultimate goal is sound. I think designers should pay attention to this part because sound can move people.

The sound of an Apple product. The beep from a microwave. The chime from the elevator. These are the sounds that are recognizable globally and evoke certain emotions in us.

Sound User Interactions: The Sonic User Experience in UI Design

While visual design is often the focus, an often-overlooked aspect is sound UX. This article explores the concept of sound UX, its role in audio feedback, and how it enhances UI design.

Sound UX, or sonic user experience, refers to the use of audio cues and elements to improve a user's interaction with digital products. It involves designing, creating, and incorporating audio feedback to enrich the user experience, making it more engaging, informative, and intuitive. Sound UX enhances UI design by providing additional context, delivering timely feedback, and stimulating emotional responses that connect users to a product.

The Role of Audio Feedback in UI Design

1. Confirmation and reinforcement:

Audio feedback can help confirm user actions, such as clicks or swipes, and reinforce that an action has been successfully performed. This can be particularly useful in situations where visual cues are limited or when users need to focus on other aspects of the interface. For example, a user might be multitasking and rely on sound cues to acknowledge that their action has been registered, allowing them to continue without having to constantly check the screen.

2. Error prevention and correction:

Audio cues can alert users to mistakes or potential issues before they escalate. For example, a subtle sound might indicate that a user has entered an incorrect password, prompting them to

re-enter it before being locked out of an account. This proactive approach helps users avoid frustration and makes the interface more user-friendly.

3. Accessibility:

Sound UX plays a crucial role in improving interface accessibility for visually impaired users by providing auditory cues and feedback, enabling them to navigate and interact with digital products more easily. This is particularly important when considering the needs of users with diverse abilities. Audio feedback can supplement or even replace visual information, making digital products more inclusive and accessible to a wider audience.

For instance, screen reader software relies on audio feedback to convey information to visually impaired users. By incorporating descriptive audio cues, designers can enhance the screen reader's output, making it more efficient and enjoyable for users to navigate the interface. Additionally, audio cues can help users with cognitive or learning disabilities by offering another layer of feedback, supporting their understanding and interaction with the interface.

4. Emotional engagement:

Audio elements can evoke specific emotions, enhancing the overall user experience. For example, a pleasant melody or sound effect can create a positive atmosphere, while a suspenseful tone might heighten anticipation for an upcoming reveal. Music and sound effects can also help establish a brand identity and create a more immersive experience for users, fostering a sense of connection and loyalty to the product.

Audio feedback serves multiple purposes in UI design, ranging from confirming actions and preventing errors to improving accessibility and fostering emotional engagement. By recognizing and leveraging the power of sound UX, designers can create more inclusive, intuitive, and enjoyable user experiences for all.

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.

Best Practices for Implementing Sound UX in UI Design

Keep it simple: Audio feedback should be concise and unobtrusive to avoid overwhelming users or distracting them from their primary tasks. Use short, simple sounds that convey clear messages.

Prioritize consistency: Maintain a consistent sound palette across your product to establish familiarity and coherence. This will help users more quickly associate specific sounds with their corresponding actions or events.

Consider cultural differences: Be aware that sounds and music can have different meanings across cultures. Research your target audience to ensure your audio elements resonate positively and don't inadvertently offend or confuse users.

Test and iterate: As with any UX design element, testing is crucial. Gather user feedback and iterate on your sound design to refine the experience and ensure it meets user needs and expectations.

Provide control: Give users the option to adjust volume levels or mute audio elements entirely. This allows them to personalize the experience and ensures that sound UX doesn't become an annoyance or hindrance.

Sound UX and audio feedback play a vital role in enhancing UI design by providing additional context, improving accessibility, and fostering emotional connections. By incorporating these

elements thoughtfully and following best practices, designers can create more engaging, intuitive, and enjoyable user experiences that cater to diverse audiences.

How Multi-Sensory Web Design Can Improve the User Experience

Use the Science of Sensory Memory to Better Connect with Website Audiences

Close your eyes, and imagine your favorite pie coming out of a hot oven. You can almost smell it in the air and taste it on your lips. Maybe it brings up memories of the holiday season, with the crisp fall weather and sound of rustling leaves under your feet. But what does this have to do with design and the user experience?

We all want our websites to be memorable. Our five senses—sight, sound, touch, taste, and smell—are an integral part of experiencing the world around us and creating memories of it. At Astriata, our multidisciplinary approach to design integrates concepts from human psychology, such as multisensory design, leading to a more engaging and memorable user experience. Continue reading to learn how it all works.

How Multi-Sensory Stimulation Impacts Memory

When we experience something for the first time, our senses are stimulated, and a brief memory called “sensory memory” may become part of our short-term or long-term memory. Research shows that learning and the absorption of new information is more effective when more than one sense is engaged. Beyond engaging solely through visual elements, we can also stimulate the auditory, olfactory, gustatory, and tactile senses to evoke emotion and improve the user experience. Let’s take a look at each of the five senses and how they work their way into our design thinking.

1. Appeal to sight and iconic memory to make a strong first impression

For most website visitors, the visual impact of design is the first aspect that will engage them. This is no surprise to neuroscientists, as ninety percent of information processed by the brain is visual. Research shows that the ability to recall information is much higher when there is a visual involved, when compared to an auditory-only experience.

Whether it’s a dynamic photo, a video, or an eye-catching typography, the way the page looks elicits a reaction from the viewer, be it small or large. This visual stimuli may be remembered briefly and is a type of short-term memory referred to as “iconic memory.” Iconic memory helps the brain to quickly respond to and make decisions about visual stimuli–which is why the visual design of a website has a big influence on whether a new user continues scrolling or clicks away.

When choosing images for your website and brand, the visual itself has to be meaningful and support your message, but the color choice can also be intentional:

- Warm colors such as reds, oranges, and yellows evoke a very different emotional reaction than cooler colors like blues and greens.
- Color can be symbolic and take on different meanings, with our experiences guiding our associations with imagery and color.

Color comparison on two logos

If your message is that your organization is approachable, friendly, and welcoming, then you may want to incorporate warm colors. Does a warmer blue with small amounts of orange in the design strike the right balance of welcoming and professional? These are the sorts of questions we consider as we work with clients to determine the colors that best suit their brand. But the sensory experience doesn't have to end with sight. The "Proustian Effect" explains how minor details such as color can become associated with memories that are more relevant and, therefore, more memorable.

You can enhance your site, and leave a lasting impression, by appealing to more senses. This doesn't mean that your website needs to appeal to all five senses at once, which could cause users to experience sensory overload and tune out–the opposite desired impact. What it does mean, is that additional senses can be engaged strategically to enhance the overall user experience.

2. Use sound to engage echoic memory

When sound enters the ears, the brain stores it for a very short period of time as echoic memory. After classifying the sound as important, your brain will then move it into short-term memory for longer periods than iconic memories are stored. This means that adding sound can bring a whole new dimension to the online experience.

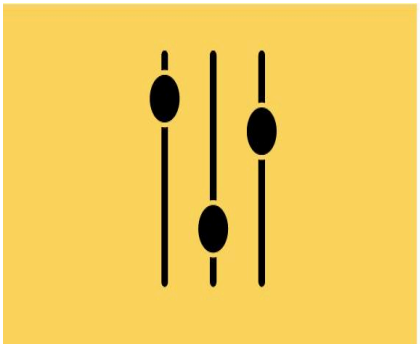
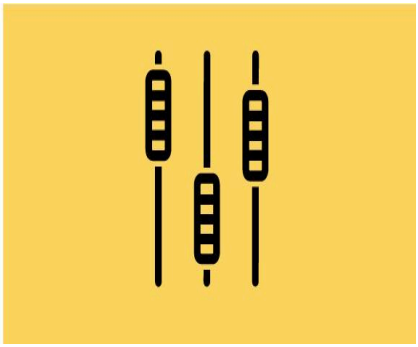
Compare, for example, one of our social media posts without music to one with music. Which is likely to be more memorable for you? Does one evoke more emotions and associations for you? Does the music sound uplifting? Music actually activates the left and right side of our brains and can trigger the release of the chemical dopamine, which is related to mood. A change in your

users' mood can influence their perception and experience, making the effort worthwhile to shape the right tone through music and sound on your website.

3. The role of touch, or haptic memory

Haptic memory is the sensory memory that helps people identify, remember, and interact with objects through touch. How does touch play a role in design? While we touch our screens on smartphones, tablets, and laptops, these surfaces are all flat and smooth. However, an image or graphic with texture can elicit a different response through your association with the image.


Does one of these graphics feel more tangible and look like something you could grab onto?

Design can evoke feelings of how something might feel through touch, while conjuring up memories associated with that feeling—adding to the depth of the user experience.

4. Taste (gustatory memory) and smell (olfactory memory)

Both taste and smell are similar to touch when it comes to designing the user experience. While we can't directly experience those senses online, certain imagery can evoke powerful memories of taste and smell. Remember that pie you envisioned earlier? There's a reason why cookbooks and recipe websites invest in professional photography. Those photos can really make your mouth water! Depending on your website's purpose and message, you may want to leverage associations with taste or smell.

Taking a multi-sensory design approach brings the potential to resonate and connect more with our audiences. When thinking about how to design a website or interface, think beyond just the visuals to consider how you can create a more immersive experience for your users.

Improve User Experience with Multi-Sensory Design

Multi-sensory web design isn't just about visuals—it's about creating a deeper, more memorable experience by engaging multiple senses. Using elements like images, sound, and textures can help your website connect with users on a whole new level. By thinking beyond just what people see, you can make your site more engaging and unforgettable.

How multi-sensory design can help you create memorable experiences

Multi-Sensory Design is becoming so much relevant in this age of digital interactions. But the most memorable experiences we have are always multi-sensorial. In this article, I will talk about the importance of multi-sensory design giving some great examples, talking about the design process and some activities that you can do to be more aware of your senses.

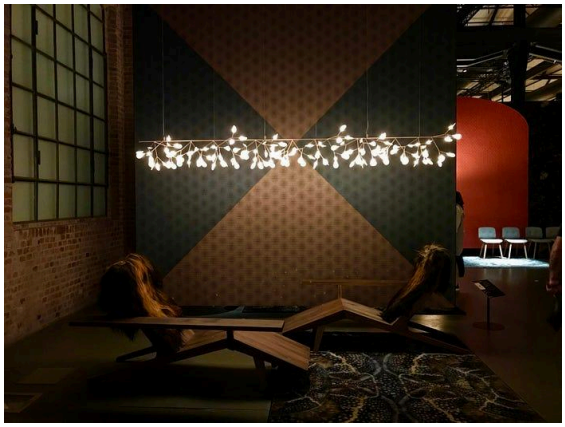
Food is a complete multi-sensory experience.

We often have great memories related to food, be it our grandma's cooking or that delicious treats we tasted while traveling or the lovely smell of a freshly baked pizza that takes us down the memory lane. This is all because of the fact that food is a complete multi-sensory experience which involves all your five senses: vision, touch, sound, smell and taste.

Try to remember your last such experience with a product, service or environment. It can be difficult to think of one. In this age of digital interactions, designers are forgetting to use senses to their advantage in creating memorable interactions with products and services. Designing for all the senses is important to enrich design experiences and avoiding design incongruities[1].

Some examples of multi-sensorial experiences from daily life

Back in 2018, I was visiting the Milan Design Week and I remember visiting the Moooi (a luxury lighting and furniture brand) exhibition and I noticed it was very calm inside. As soon I went out of the space, I noticed a sudden change. I instantly knew it was the smell that was dispersed inside (probably with high quality perfumes) that made it a wonderful sensorial experience. So just by adding the sense of smell, they changed how people experienced their space.



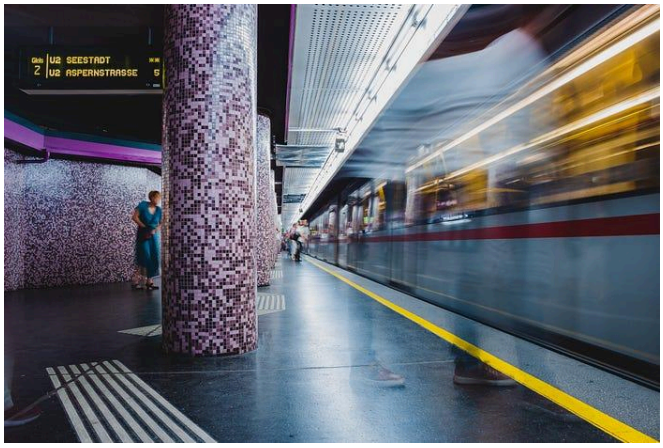
Moooi Exhibition, Milan Design Week 2018.

Another amazing example of multi-sensorial design exploration was done by Sony called Hidden Senses at the Milan Design Week, 2018. They had some wonderful prototypes created which the people could interact with and explore their senses to find hidden meanings of how things functioned.

A social campaign done by Volkswagen in 2009 in Sweden converted normal stairs at an underground station into a piano stairs installation. They wanted to encourage people to take stairs rather than an escalator. And it again made use of the sense of sound to create such a great engagement. All the people started using stairs as they were so happy interacting with piano sounds.

Fun Theory: A campaign done by Volkswagen in Sweden. (Copyright: Volkswagen, 2009)

Recently, the Vienna Lines (city public transport system) started trialling perfumed carriages as many commuters complained about unpleasant smells. Now as they enter the crowded carriage, they are met not with a musty mix of human odors, but with the subtle aroma of citrus fruit[2]. The day-to-day commute is always stressful but with adding the sense of a good smell, they tried to remove the problem of smelly trains and the perfume relaxes people making the commute less stressful. Another great use of multi-sensory design!



Wiener Linien or Vienna Lines. (Photo by Samuel-Elias on Unsplash)

In the spring of 2018 during my design masters at Politecnico di Milano, I participated in a course: Design for Multi-sensory Experiences. The goal of the course was to become aware of the role of the senses, to become sensitive to sensorial experiences and to develop skills to design for the senses.

The Multi-sensory Design Process

I would like to briefly describe the process which are basically some steps we should do when designing anything:

1. Why: what is the desired effect of your design?
2. How: what is the desired experience?
3. Sampling: what objects/materials elicit that experience?
4. Analysis: what are the sensory properties of the samples?
5. Integration: what is the sensory experience going to be?
6. Design: translating the findings in a coherent design!

By using these steps as a guide, designers can have a deeper understanding of the sensorial experience their designs could have.

Activities for understanding the meaning of the senses

I would like to share some activities that anyone can do to get more aware of their senses:

Activity 1:
Find a sensory congruent and a sensory incongruent object. Try to experience their texture, color, shape, weight and material. What did you observe? For example: A beach hat has a natural texture, with light colors, round shape and lightweight material.

Photo by Jens Kreuter on Unsplash

Activity 2:

Try to explore the world of care (could be any type of care) and look for interesting multi-sensory objects. Analyze the objects on: intended effect, intended experience and their designed sensory properties. For example: a pillow is an object of care which allows you to be comfortable while supporting you.

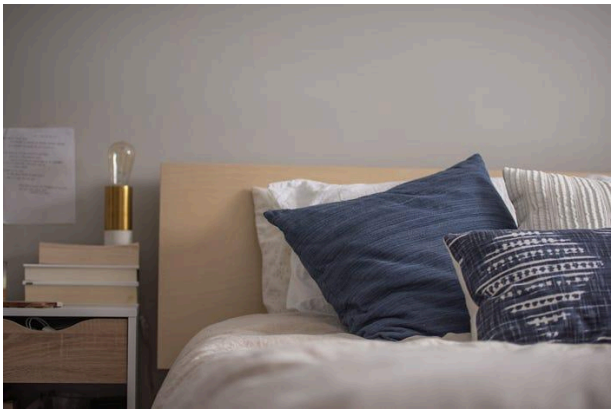


Photo by Christopher Jolly on Unsplash

Activity 3:

This activity is about tactual perception. The touch can be: Active or Passive. When we hold an object it is called Active Touch (we experience tactual properties of the object) and when the object touches you it is called Passive touch (skin and bodily sensations that you feel). I suggest to find an object which you like or some object you like to fidget with. Try to understand the meaning of Active and Passive touch with that object.

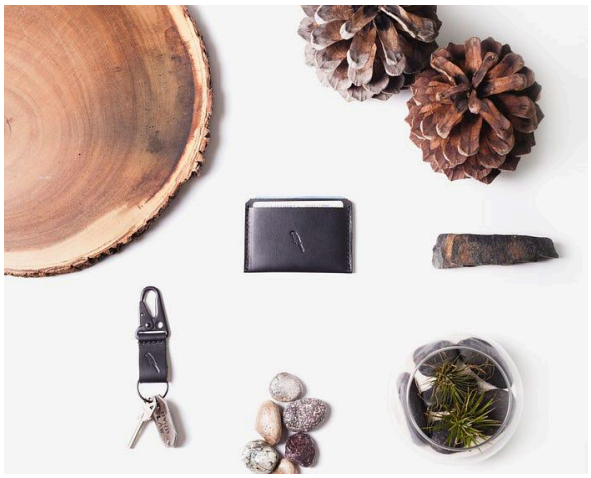


Photo by Dane Deaner on Unsplash

Activity 4:

Now you will need to find your Soul Mate! (just kidding). What personality traits characterize you and how are they expressed in your behavior? Find objects with that same behavior and same personality traits. What are the tactual properties of the object that are related to your personality? For example: I chose my bluetooth speaker!

Activity 4: Find your Soul Mate

This was a brief introduction to the process of multi-sensory design and some activities that you can do to be more aware of your senses while designing or experiencing things.

Another very interesting example of multi-sensory design is this idea by a Dutch artist and creative Jasper Udink ten Cate. Creative Chef Records is ought to be a collection of ceramic plates in a record-sleeve on which you can find an artists name, a song you can play with a scan code and a favorite recipe of the artist[5]. This is a clever way of involving the different senses by combining the idea of art, music, food and objects.

3. Memory & Cognitive Load (45 mins)

- Types of Memory: Sensory, short-term, long-term.
- Cognitive Load Theory (Sweller): Designing to reduce mental effort (e.g., chunking information, progressive disclosure).
- Miller's Law: The "magic number 7±2" and its impact on menu design.

The Properties of Human Memory and Their Importance for Information Visualization

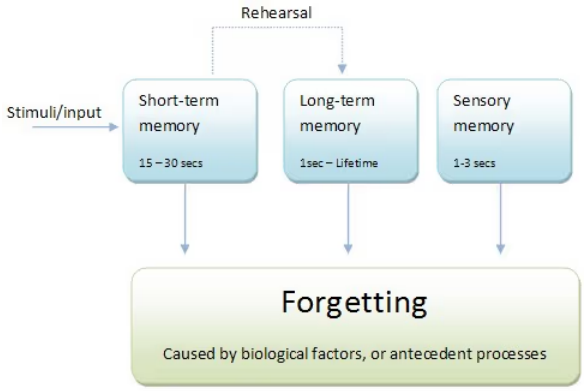
It is important to know that while neuroscience has progressed dramatically over the last decades; there is no complete understanding of how human memory works. We know, for example, that data in the brain is stored in clusters of neurons but we don't know how, precisely, it is stored or even how it is encoded. Thus when it comes to understanding memory from a design perspective we will examine certain properties of human memory that are commonly understood to be correct.

Human memory doesn't exist in isolation; the brain isn't just responsible for memorizing things but also for processing the data and acting on that data. Much of our memory and much of the information we receive is visual and it is with visual memories that the designer is mainly concerned.

Three Types of Memory

There are three main types of memory that are processed in the brain:

- Sensory Memories
- Short-term Memories
- Long-term Memories

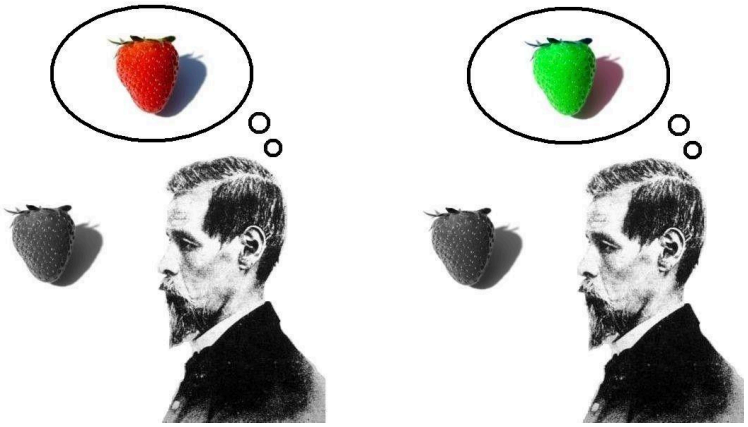


Sensory Memories

Sensory memories are the memories which are stored for tiny time periods and which originate from our sensory organs (such as our eyes or our nose). They are typically retained for less than 500 milliseconds.

Visual sensory memory is often known as iconic memory. Sensory visual memories are the raw information that the brain receives (via the optic nerve) from the eye. We store and process sensory memories automatically – that is without any conscious effort to do so.

The processing of this information is called preattentive processing (e.g. it happens prior to our paying attention to the information). It is a limited form of processing which does not attempt to make sense of the whole image received but rather to a small set of features of the image – such as colors, shapes, tilt, curvature, contrast, etc.



It is sensory memory which draws your attention to the strawberries in this graphic.

Short-Term Memories

Short-term memory is used to process sensory memories which are of interest to us – for whatever reason. The sensory memory is transferred to the short-term memory where it may be processed for up to a minute (though if the memory is rehearsed – e.g. repeated – it may remain in short-term memory for a longer period up to a few hours in length).

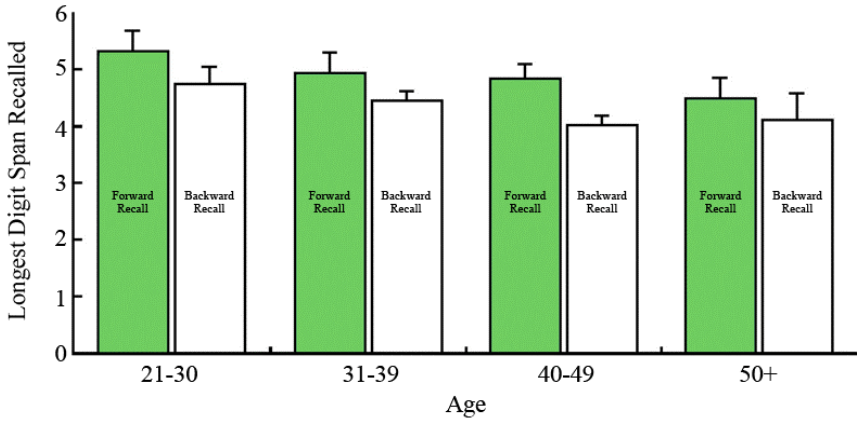
Short-term memory is of limited capacity. Experiments conducted by, among others, George A Miller the psychologist, and reported in his paper “The Magical Number Seven, plus or minus two” suggest that we can store between 5 and 9 similar items in short-term memory at the most.

This capacity can be increased by a process known as “chunking”. This is where we group items to form larger items. So, for example, you can memorize a 12 digit phone number in

short-term memory by taking digits in pairs (35) rather than singly (3 and 5) which gives you 6 chunks to remember (which falls between 5 and 9) rather than 12 digits (which exceeds the capacity of short-term memory).

Chunking can occur visually as well as through combination of numeric or alpha-numeric attributes. A common example of this would be in a bar chart where a single bar may represent a chunk of information.

This is useful to the visual designer because it allows a visual representation of information to be easily processed in short-term memory and for that representation to offer more complex insights than an initial examination of the capacity of short-term memory might allow.

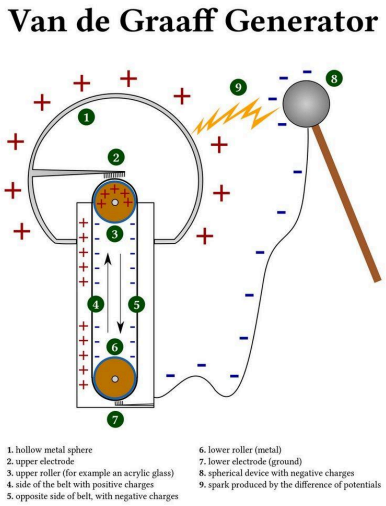


This graph, above, shows how information recall is limited from the short term memory and recall becomes worse when asked to recall a sequence backwards.

Long-Term Memories

In most instances the memories transferred to our short-term memories are quickly forgotten. This is, probably, a good thing. If we didn't forget the huge volumes of information that we perceive on a daily basis we could well become overloaded with information and find processing it in a meaningful way soon became impossible.

In order for most memories to transfer from short-term to long-term memory – conscious effort must be made to effect the transfer. This is why students review for examinations; the repeated application of information or rehearsing of information enables the transfer of the material they are studying to long-term memory.



It is also possible for a long-term memory to evolve through a meaningful association in the brain. For example, we know that a static shock is painful even if we are only shocked once. It doesn't take repeated shocks to memorize that. The meaningful connection between the pain and the shock allow us to process the memory long-term. In fact strong emotional or physical connections are often the easiest way for something to enter long-term memory.

The image above is of a Van de Graaf Generator which can be used to generate static electricity – you can then touch the generator and another person to give them a static shock. It's worth remembering that they won't come back for a 2nd attempt…

It is worth noting that majority of designs and in particular, information visualizations, will not be committed to long-term memory. It may be that the conclusions or understanding they bring will be transferred to long-term memory (usually through revision or application) but the design itself will not.

The vast majority of interaction between the user and an information visualization will occur in sensory and short-term memory.

What is Cognitive Load Theory?

Cognitive Load Theory (CLT) is an instructional design framework that focuses on how the human brain processes, stores, and retrieves information. Rooted in the psychology of learning, CLT provides valuable insights for educators, enabling them to optimize teaching practices by considering the brain's cognitive capacity. Although initially introduced by John Sweller in the late 1980s, CLT has gained significant recognition in recent years for its profound implications on learning outcomes and instructional design.

At the heart of CLT is the understanding that the human brain has limited memory resources, specifically within working memory. This working memory is easily overwhelmed when processing large amounts of new or complex information, leading to reduced comprehension and retention. By designing lessons that respect these limitations, educators can enhance learning experiences and prevent cognitive overload. For instance, distinguishing between primary and secondary knowledge can help teachers focus on essential content while scaffolding complex subject matter.

CLT identifies three types of cognitive load: intrinsic, extraneous, and germane. Intrinsic load relates to the inherent complexity of the subject matter, while extraneous load stems from poorly designed instructional methods. Germane load, however, is the desirable mental effort learners expend to form meaningful connections and develop schemas in long-term memory. Effective instructional strategies minimize extraneous load and maximize germane load, ensuring learners can focus on processing and integrating new information.

The theory also highlights concepts like the expertise reversal effect, which occurs when instructional strategies beneficial for novices become redundant or even detrimental for more advanced learners. From a cognitive load perspective, this emphasizes the need to tailor teaching methods to the learner's level of expertise to maximize the efficiency of memory resources.

John Sweller's work continues to shape modern pedagogy by bridging cognitive science and classroom practice. His research underscores that effective learning environments align with cognitive capacity, prioritize schema development, and reduce unnecessary cognitive strain. Educators who adopt CLT-informed strategies, such as chunking information or integrating visuals with verbal explanations, can create more engaging and effective learning experiences.

What do we mean by Cognitive Load?

Cognitive load is referred to as the amount of information that our working memory capacity can hold at one time. Sweller J argues that human memory has a limited capacity; therefore, instructional procedures need to avoid overloading it with those activities that don't directly enhance learning.

When information is entered into human brains, it carries a cognitive load that exerts a processing burden on the brain to provide meaningful learning outcomes to the information. According to Educational Psychology experts, students use their working memory to hold bits of information into their working memory. This limited working memory is used by the students while paying attention to explicit instruction in the classroom.

Although working memory & cognition has a limited cognitive processing capacity it plays an important role in a person's process of learning. It may lose its effectiveness, especially in the case of a complex instructional design, where the learner needs to put more effort to process the information. The cognitive load of learners indicates the amount of mental activity carried out by the working memory to perform a specific learning task.

Certain factors may affect the Cognitive load in the working memory & cognition. For example, the greater the amount of information taught at once, the greater are the chances that the private and public schools students will not retain it. Due to this, it is crucial to manage the mental workload of learners efficiently.

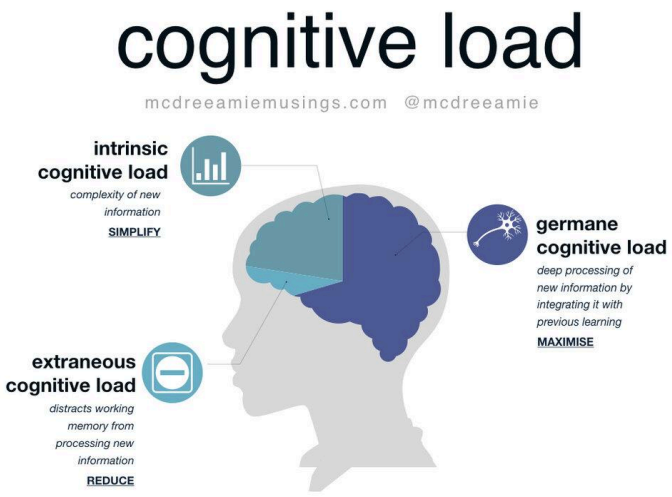
As it has been mentioned, Cognitive Load Theory was developed by John Sweller, who published his findings in the book Cognitive Load Theory: Toward a Practical Science of How People Process Information. He found that the brain could only focus on three items simultaneously, and that the amount of cognitive load increased exponentially as the number of tasks increased.Sweller argued that the human mind had evolved over millions of years to cope with limited attention spans, and that modern technology was causing us to overload our brains. He believed that the solution was to simplify the design of products so that they would require less mental effort to navigate.

This theory is still very much debated today, and there is no consensus among researchers as to whether it holds true. Some studies have shown that the effect is real, while others have failed to replicate the finding.

Regardless of whether or not the theory holds true, it does provide insight into the psychology behind how humans interact with digital educational platforms. There are two main points to consider when applying this theory to educational technology:

- •Simplicity increases usability. As the number of choices decreases, the likelihood that users will choose the correct option increases. Students tend to prefer simpler designs, and they are more likely to remember the interface if it is easier to understand. If the platform is too complicated then the students attention might focus more so on the functionality as opposed to the content.
- Complexity increases efficiency. When the user needs to perform multiple actions to complete a task, they become frustrated and give up faster. Teachers should strive to create interfaces that minimize the number of steps required to accomplish a given goal.

In addition to simplifying the design of an educational activity, teachers must also try to avoid making it unnecessarily complex. Avoiding unnecessary complexity allows children to focus on the task at hand rather than trying to figure out how to navigate through menus and other features.



What are the different forms of cognitive load?

The Cognitive Theory has identified the following three different forms of cognitive load:

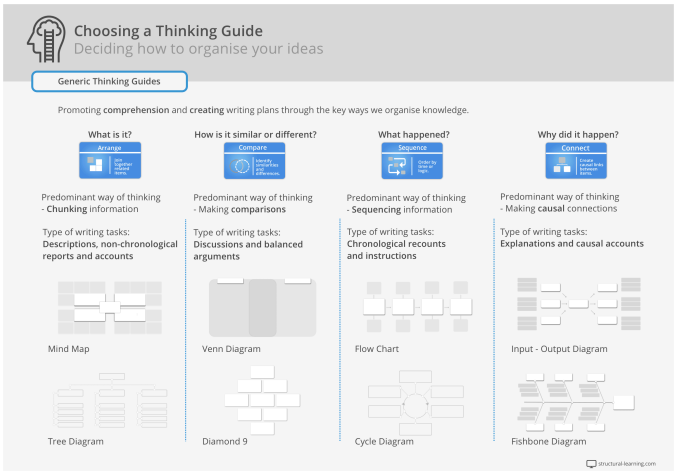
- Intrinsic Load: Intrinsic load indicates the inherent difficulty of the learning task, which mostly occur due to the prior knowledge of the topic. It is a complex concept to understand in the real world. Sweller Et Al believed that the intrinsic cognitive load can only be reduced by altering the nature of learning material or by changing the cognitive tasks or the act of learning itself. For example, a reader's mental workload can be reduced by using more plain and legible handwriting, rather than using a cursive, scribbly font.

- Extraneous Load: Extraneous load is a kind of load created due to the way the instructional materials are presented, which does not help in the learning process. The extraneous load can be increased or reduced based on several factors – the type of task, whether or not the student has difficulties with attention, attentional demands for a task, etc. An example of Extraneous Memory Load is a situation where someone is trying to study but is disturbed by loud music or nearby traffic. These noises are considered extraneous load as they act as obstacles to the completion of cognitive tasks.

- Germane Load: Germane Load includes the components that help the processing of information and contribute to the long-lasting construction of schemas. A typical example of Germane load is creating diagrams and flowcharts to perform complex tasks. The systematic organization of Germane materials makes complex learning easier and helps to remember.

Depending on its nature, cognitive load can either be helpful or detrimental in learning. Hence, for an effective learning process, one must:

- Optimize extraneous cognitive load;
- Manage intrinsic cognitive load; and
- Promote germane cognitive load.



Applying the cognitive load theory to improve learning outcomes

It is possible to apply the concept of cognitive load to improve the private and public schools students learning and training processes to achieve meaningful learning outcome. The cognitive load theory states that when we're trying to learn something, our brain must work harder than usual. We need to process information faster and remember it longer.

This means that we can only handle so many things at once. When we try to learn too much at once, we experience overload. Overload happens when we're overloaded with information and overwhelmed by the task at hand. Overload leads to stress. Stress makes us tired, irritable, and unable to concentrate. This is bad news for students because overload causes them to forget important details and fail tests.

But there's hope! There are ways to reduce the amount of information we take in at once. One of these methods is called chunking. Chunking is breaking down large amounts of information into small chunks. Chunks help us understand concepts better and retain information longer. They also allow us to focus on just one concept at a time instead of having to juggle multiple ideas. By reducing the number of items we try to learn at once, we can avoid overload and improve our ability to absorb and recall information.

That's why teachers should pay attention to cognitive load theory and here are some practical ideas for your classroom for reducing your children's mental load.

1. Reducing the Problem Space

The gap between a present situation and the ultimate goal of the instruction is called problem space. In case of a large problem space, students' working memory may become overloaded. It mostly happens at the time of learning complex concepts, where the learner needs to hold a lot of details in the working memory at once. A better way is to reduce the problem space by breaking the information down into parts or providing worked examples with some solutions for the learners. This will make learning more effective while reducing the problem space and taking the cognitive load off from the learner activities.

2. Measuring Expertise to adapt Presentation

According to the cognitive load theorists, it is a good idea to adapt the design of instruction according to the level of expertise of the students. It can be done by asking the students to describe how familiar they are with the learning task. Also, instructional designers may use Bloom's Taxonomy of Educational Objectives to present the right information to the students with the right level of primary knowledge about the concept and to achieve meaningful learning outcome.

3. Reducing Split-Attention Effect

Using more than a single piece of visual information, such as graphs, diagrams and explanatory text, may divide a students' attention between them. This increase in the memory load may make it more difficult to establish new schemas.

According to Cognitive Psychology experts in the educational psychology review, this effect can be reduced by altering the instructional conditions, such as incorporating labels into diagrams or by focusing on any single item in the visual stimuli or visual instructional design in a sequential manner. For teachers, it's important to remember that students have limited mental storage capacity and we should design complex tasks so as not to cause too much 'attention flipping'.

With all the digital distractions that our students encounter, taking personal responsibility for our own mental load might soon be regarded as an essential problem-solving skill. This type of knowledge of instructional control can certainly improve outcomes by lessening the load during learning.

4. Using Visual and Auditory Channels in the Working Memory

The split-attention effect can be reduced by replacing some of the visual instructional design with auditory details. This will reduce the cognitive load on students' visual working memory while also utilizing the auditory instructional materials, which owns their individual memory space. Some of the instructional designers and teachers replicate this by directing their students' attention to parts of a visual representation while talking about it.

This has the effect of reducing the mental storage capacity needed as the working memory is no longer struggling to decode lots of text. Reducing the mental load using this type of approach during cognitive tasks is sometimes referred to as dual coding. There are particular implications for using this strategy in reducing the load in multimedia learning. Minimising the amount of text and incorporating symbols can significantly improve the learner's experience.

How does cognitive load affect learning?

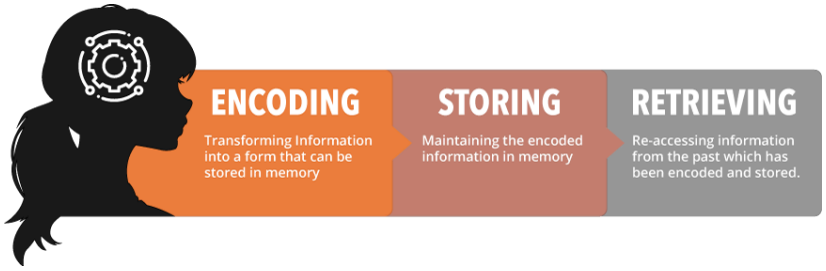
To understand cognitive load theory, it helps to first understand how our memory works. Researchers have identified three parts to our memory:

- Sensory Memory
- Short-Term Memory
- Long-Term Memory

Our sensory memory processes everything in our environment, taking in information from all our senses. It holds on to each piece of information for less than half a second while it filters it for anything of importance that we need to pay attention to.

When that happens, we become focused on specific pieces of information, giving it entry into our short-term memory. Information can stay in our short-term memory for up to 30 seconds, and we can slightly extend that time by repeating information using our inner voice.

If we want to remember the information to use in the future, it must be moved into our long-term memory. This is where information is filed, ready for us to retrieve when we need it. New information is linked with previous learning from related topics to help us retrieve it more effectively in the future. There seems to be no limit to the capacity of our long-term memory; the challenge lies in transferring the information to there from our short-term memory and then storing it in a way that makes it possible for us to retrieve it later.



How is learning affected by exceeding our cognitive load?

Learning is the acquisition of new knowledge or a new skill that can be used at a future date. It is therefore characterised by a permanent change in our long-term memory. This occurs when information is successfully transferred (or encoded) and stored in our long-term memory.

Cognitive Load Theory explains how information is transferred to long-term memory; understanding this process enables us to identify small changes that will improve how quickly and effectively we can learn new information. Students, teachers, and families can use cognitive load theory to create environments where teaching, learning, and revision can occur more effectively.

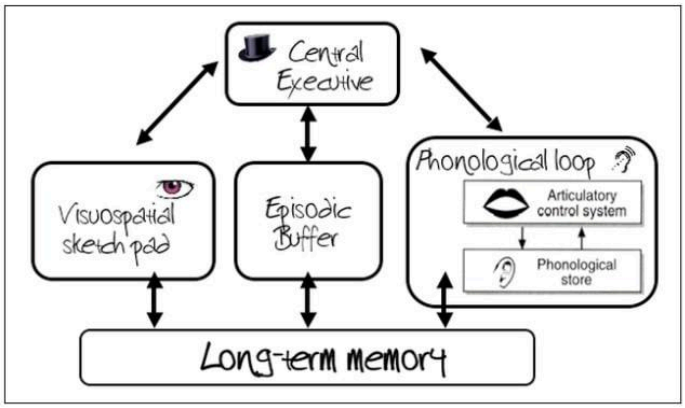
For information to move into our long-term memory, it must be actively attended to and processed by our short-term memory in a way that requires effort.

Our short-term memory consists of different stores:

- The Visuo-Spatial Sketchpad encodes visual information, such as location, colour, or shape
- The Phonological Loop encodes speech and 'hears' your inner voice when you read text
- The Episodic Buffer creates and retrieves memories of experiences
- The Central Executive monitors and coordinates the different memory stores

Each store is limited in how much information it can process at a given time. If a store becomes overloaded with information, it will become very difficult to focus on anything well enough to move it into the long-term memory.

One way to increase the capacity of our short-term memory is by using two stores at the same time: dual processing. This technique often involves presenting learners with a picture, which is processed by their visuo-spatial sketchpad, and talking about the picture, which will be processed by their phonological loop. This provides the new information with two routes into the long-term memory and two potential cues (visual and auditory) that can make retrieving the information easier.



Embracing Cognitive Load Theory in your classroom

John Sweller's cognitive load theory suggests that cognitive resources are limited, which implies that teachers must find ways to manage student cognitive load in the classroom effectively. Teachers can embrace this theory by designing learning activities that are aligned with the cognitive architecture of learners. In particular, novice learners require explicit instruction and a reduced extraneous load to process new information effectively. Teachers can help novice learners by providing clear, step-by-step instruction, breaking down complex concepts into smaller parts, and using visual aids such as diagrams or charts.

To build schema, or a mental framework of understanding, teachers can help students manage their cognitive capacity by minimizing extraneous load. This involves eliminating unessential information that may distract students from the task at hand. Teachers can also prioritize germane load, which refers to the essential information that students need to acquire new knowledge effectively. Teachers can do this by providing opportunities for practice and application, such as through hands-on activities or engaging discussion.

Reducing intrinsic cognitive load with visuals

Teachers need to understand that learners have limited memory resources. Hence, it is vital to help learners direct their attention towards relevant information. Teachers can do this by structuring learning tasks and using explicit instruction to help students understand the critical connections between concepts. By embracing John Sweller's cognitive load theory, teachers can create learning environments that are conducive to schema acquisition, which helps students understand more of the curriculum content.

Cognitive Theory is more related to understanding how people can process and store information. It is a concept that all private and public school teachers need to embrace, as it helps to understand how learners process information. To improve the intellectual performance

of the students, one must think about how to use a format of instruction to help reduce cognitive load to achieve the meaningful learning outcomes that we all strive for.

Cognitive load theory states that we should take away any unnecessary pressure from the short-term memory, leaving it more able to focus on the information that needs to move into the long-term memory.

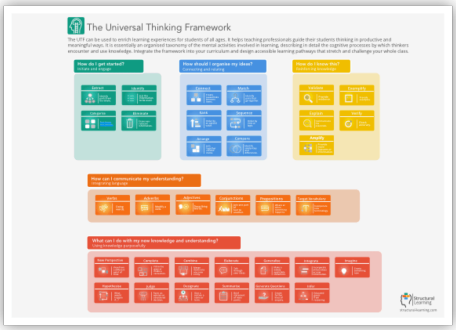
…when teaching

- Avoid overloading one store with information
- Don't speak when you need students to be reading
- Stop talking when there is text on the board
- Use two separate stores to present new information
- Talk when you are displaying images
- Use coloured font to show links or differences
- Make explicit links with prior learning to help students integrate the new information into their long-term memories
- Reduce unnecessary visual distractions from the front of the classroom

…as a learner

- Don't divide your attention when you learning
- Put your phone out of sight and turn off the TV
- Listen to music without lyrics to relieve your phonological loop
- Working in silence is even better
- Read out loud to focus all of your attention on what you are reading
- Use colour and put notes in different positions on the paper to help you remember them
- Recall information rather than copying it – this will force you to pay more attention to the information

Consider how you can use cognitive load theory to create an environment that will support learning. Small changes that free up space in your short-term are likely to make learning faster and more effective.



Cognitive load measures students can take

At Structural Learning, we embrace cognitive science to help us design classroom tools. The following list will help you think about how you can utilise CLT to achieve your classroom goals.

1. Writer's Block: this toolkit enables children to increase their cognitive capacity. Very much inspired by the work of Sweller, the building blocks are used to offload some of the mental work. The pedagogy enables schema acquisition at a very practical level. A simple task such as building a sentence can be turned into something increasingly more complex without being a burden on the mental load of the learner.

2. The Universal Thinking Framework: This instructional taxonomy helps teachers design for meaningful learning outcomes. The guidance materials help children to build domain knowledge systematically. This cognitive load approach enables teachers to design subject specific activities that incremental increase with complexity. Children can engage in creative critical thinking exercises whilst broadening their cognitive skill acquisition.

3. Graphic Organisers: These visual tools help students understand knowledge in greater depth. Again, these simple PDFs were influenced by John Swellers work on reducing the extraneous load for the learner.

Further Reading on Cognitive Load Theory

These papers offer insights into the development and application of Cognitive Load Theory, emphasizing its role in optimizing learning by managing cognitive load in both simple tasks and complex educational settings.

1. Cognitive Architecture and Instructional Design by J. Sweller, J. V. van Merrienboer, F. Paas (1998)

This paper discusses Cognitive Load Theory's application in instructional design, highlighting that reducing working memory load and encouraging schema construction optimizes

intellectual performance. It focuses on balancing intrinsic load and cognitive resources to enhance primary knowledge acquisition.

2. Cognitive load theory, educational research, and instructional design: some food for thought by T. Jong (2010)

Jong addresses conceptual, methodological, and application-related issues in Cognitive Load Theory. The study emphasizes the importance of understanding cognitive processes and cognitive load ratings in designing effective learning environments.

3. Cognitive load theory in health professional education: design principles and strategies by J. V. van Merriënboer, J. Sweller (2010)

Van Merriënboer and Sweller explore Cognitive Load Theory's implications in health professional education, focusing on intrinsic, extraneous, and germane load. The paper highlights the need for efficient strategies to manage mental load and facilitate complex learning.

4. Cognitive Architecture and Instructional Design: 20 Years Later by J. Sweller, J. V. van Merriënboer, F. Paas (2019)

Sweller et al. reflect on the impact of Cognitive Load Theory over two decades, discussing its significance in understanding the human mind's cognitive architecture. The study emphasizes the role of short-term memory and long-term memory in effective learning.

5. Evidence for Cognitive Load Theory by J. Sweller, P. Chandler (1991)

Sweller and Chandler provide evidence supporting Cognitive Load Theory, arguing for its validity as a scientific method in studying cognition and instruction. They discuss the types of load and how cognitive load approach can optimize learning in various contexts.

What is Miller's Law?

Miller's Law was conceived in 1956 by the American psychologist George Miller, one of the fathers of cognitive psychology, and, more broadly, cognitive science.

He was concerned with our "working memory": the brain's capacity for actively holding multiple bits of information, and our ability to make judgment calls using those items.

Miller's Law asserts that the immediate memory span of people is limited to approximately seven items, plus or minus two.

So, now that we know what it is, how does it work in reality?

How does Miller's Law work?

Through controlled experiments, Miller found that pushing the number of "bits" of information above this threshold caused confusion, leading to incorrect judgment calls being made. He called this point the "channel capacity".

The magical number seven

In other words, the number of bits that can be reliably transmitted through a channel (your short term memory), within certain time constraints, is roughly seven. A simple way to remember this is the magical number seven.

So far, so simple. Miller had observed the rule of seven in test conditions, and his theory was holding up. But there was one concern.

Miller found that the memory span of seven was consistent across vastly different types of information. For instance, seven words (each containing multiple letters) exerted the same cognitive load as seven single digit numbers.

His explanation for this phenomenon was a new theory called "chunks".

What are chunks?

Miller's conclusion was that the memory span is limited to chunks, not bits, of information. He defined a chunk as the largest meaningful or recognisable unit of information in a larger array of material. So, what counts as a chunk is subjective; their content depends on the knowledge of the person being tested.

For example: a word could be a single chunk for a native speaker. However, to someone totally unfamiliar with the language, this same word would most likely present as a series of phonetic segments—a collection of chunks.

Can I have your number?

This holds true for memorizing long strings of numbers, such as your phone digits. Here's a quick experiment—have a read and try to memorize this sequence of numbers:

087182349

Close your eyes and try to recall the sequence. Struggling? Now, try again with this format:

(087) 182-349

You should find that this clustering or chunking really aids your brain's immediate recall.

But what does this all mean for UX design?

How to use Miller's Law in UX design

Your brain initiates a learning process every time you visit a website, or fire up an app on your phone.

Dynamic menus, image carousels, and virtual carts all call on the brain's ability to learn, navigate, and stay on task to achieve an end goal.

Each needless click, clunky moment of navigation or confusing command adds to the cognitive load. The working memory, where our seven (plus or minus two) items are stored and processed, becomes increasingly crowded.

As the brain receives more information than it can handle, its function begins to slow, decision-making is compromised, and at worst tasks may be abandoned.

Some level of cognitive load is inevitable for the brain when tackling such tasks. The designer's job is to predict and accommodate the mind's working limitations in order to serve the user. Working memory overload can be avoided by steering clear of these main pitfalls:

- Too many options
- Lack of clarity
- Too much thought required

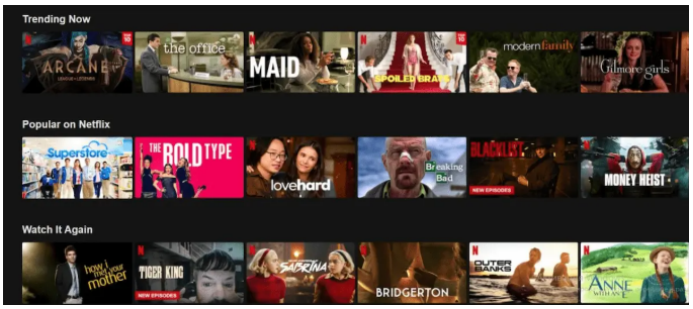
Common errors include adding huge menus, long lists of items, too many design elements, and large chunks of written content to your site, all of which cause information overload and may increase your bounce rate.

Instead, remove unnecessary elements and tasks, prioritize readability, minimize choices, and avoid confusing icons. This will relieve the cognitive load on users.

Now let's take a look at some examples of Miller's Law in action.

Five examples of Miller's Law in UX design

Netflix

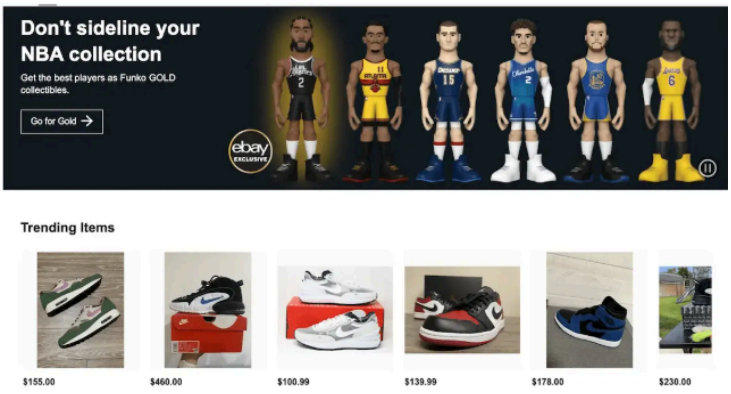


The daddy of streaming sites seems to have settled on six as its magic number. Each menu and carousel is presented on the homepage as a separate chunk, offering six options.

From the navigation menu in the site's header, to the horizontally chunked rows of icons displaying "Trending Now", or "Popular on Netflix", the site studiously avoids treading outside of Miller's recommended limitations.

Even the overtly numbered list of "Top 10 Shows in the U.S. Today" displays with the last four shows obscured.

eBay



Similarly, care has been taken at eBay to minimize cognitive load and decision paralysis. Despite the huge number of items up for auction, the homepage item gallery stubbornly refuses to expand beyond six images.

Clicking "See all" doesn't present the user with an endless list. Instead, the auctions are displayed in a scrolling grid, where again around six items are visible at any given time.

Individual auction pages are chunked into sections divided by gray lines:

- A vertical image gallery chunk on the left
- A similar item carousel chunk at the bottom
- A product description chunks in the center
- A seller information chunk on the right

This chunking is crucial for scanning and navigation of the page.

Phone numbers

Number chunks are easier to process, and reduce the cognitive load on those reading them. Strings of digits have been broken up in this way for decades.

In telephone numbers, perhaps the earliest example of Miller's Law being implemented in UX design, brackets and hyphens create chunks that aid both memorization and vocalization.

Credit card details

With credit card numbers, it's commonplace to divide the long 16-digit number into four chunks.

The security information on the rear is also often chunked into different sections—using bold, italics, dividing lines, and various fonts to delineate the chunks, and reduce strain on the user.

Blog posts

A key tenet of blog writing is to divide long passages of text into smaller paragraphs (chunks), surrounded by white space, and divided by subheadings.

This increases readability.

Formatting or chunking a blog post (just like this one!) breaks up what would otherwise be a relentless stream of information, making it much easier to digest.

Subheadings also enable readers to easily navigate within the blog, jumping from section to section, depending on what they're interested in.

Using aesthetically pleasing, content-appropriate typography will reduce distraction for the reader. This will in turn lower their cognitive load, resulting in a better understanding of the content.

Shake, Rattle & Roll to my Magic Number: 7 +/- 2

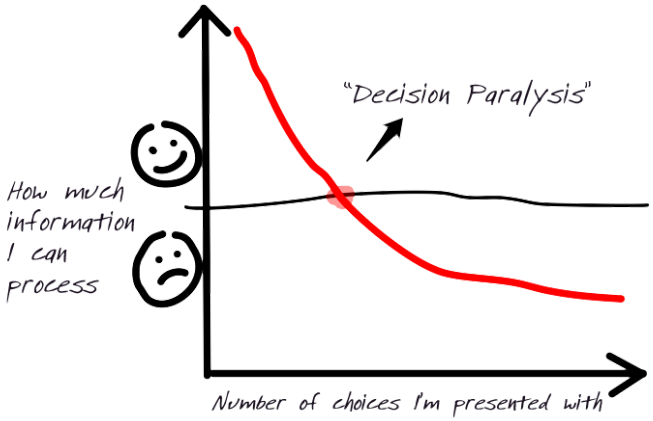
De La Soul says 3 is the magic number.

In the design world, however, the magic number is 7 plus or minus 2 (so more of a magic range, I suppose). The reason is simple: apparently people can only remember or process 7 +/- 2 pieces of information at a time (George A.Miller, 1956). So, we IAs set about ensuring our designs had only 5 to 9 options in a navigation system or 5 to 9 tabs on a screen.

Well, that magic number has been consigned to the scientific rubbish bin by all sorts of psychologists since then, from Cowan in 2001 (who now names 4 as the magic number for working memory capacity) to Miller himself (who tries to distance himself from the misreadings of his original paper).

Applied to information architecture, we talk about breadth vs. depth in navigation and menu system design for websites. Which is better? A site that is broad and shallow so that everything is within just a few clicks? Or a narrow and deep site that reduces the number of options at each step, but results in much longer journeys to the content?

Rather than relying on the changing nature of mystical numbers, I focus on the underlying rule of thumb or design heuristic instead:



Decision paralysis is also known as the paradox of choice, feature fatigue, or Hick's Law. But as the incredibly smart book Nudge says, "As choices become more numerous… good choice architecture will provide structure, and structure will affect outcomes."

Good choice architecture applied to facet and navigational design balances the following competing issues:

- How familiar your lawyers are with the terms or content being explored
- How often your lawyers will use the UI
- Whether the menus appear on already cluttered pages (although balance that with successful link-rich studies)
- Whether you can chunk your tabs or options into fewer intuitive link clusters (without creating many sub-sub-menu layers in your navigation)

So, unless you are part of the brilliant De La Soul posse and can get away with singing about magic numbers, I recommend you apply the underlying heuristic instead. Focus on looking for the unique decision paralysis point on your UI with your users.

4. Attention & Decision-Making (30 mins)

- Selective Attention: How users focus (or don't) on UI elements (e.g., pop-ups, notifications).
- Hick-Hyman Law: Decision time increases with choices (e.g., simplifying menus).
- Dual-Process Theory (Kahneman): Fast vs. slow thinking (e.g., autocomplete vs. complex forms).

Selective Attention and User Experience

If you've been involved in usability tests, you've witnessed this scenario: a test subject is looking for a specific interface element, and even though he is looking directly at it, he can't seem to see it. This idea of looking but not seeing is a well-known concept in psychology called inattentional blindness, or selective attention. The below video documents a study by Daniel Simons and Christopher Chabris that's a great demonstration of this phenomenon.

In their research, Simons and Chabris found that only 50% of viewers saw the gorilla, even though this unexpected, strange figure was plainly visible for several seconds. Participants missed it because they focused their attention on the white shirts and the ball being passed. Selective attention made the test subjects unable to see the gorilla, and it's the same phenomenon that contributes to usability test subjects' inability to see certain interface elements.

Psychological research abounds in this area (I reference a couple great books at the end of this article), but there are several points related to selective attention that are particularly relevant to UX design:

1. Human visual perception is much more incomplete and inaccurate than most people realize. Our eyes are not able to process everything that comes into their field of view. Our minds simply do not have enough cognitive resources.
2. More focus in one area means less attention elsewhere. Attention is a zero-sum game. If we pay more attention to one object, we consequently pay less attention to others. Difficult or important tasks require a great deal of attention, which leaves less cognitive processes left for gorilla-noticing, or observing whatever else happens to be in one's field of view.
3. Expectations manipulate our perceptions. Because we have limited visual intake, we use our biases, expectations, and memories to fill in the gaps. As a result, what we process are highly subjective interpretations of what's actually there—interpretations that vary drastically from person to person.
4. Motivations manipulate our perceptions. When we take an action, we do so with intent. We have some task or goal in mind and we want to take steps that bring us closer to

achieving that goal or accomplishing that task. Balcetis and Dunning use the term "wishful seeing," which means that we interpret things in a way that fits with our goals—in other words, we see what we wish to see. Again, these interpretations are highly subjective and vary drastically from person to person.

These quirks and limitations of human visual perception have some specific ramifications for UX:

- Don't be surprised when different users perceive your product in radically different ways, or overlook and misinterpret elements of your interface. This is simply the way that our visual perception works. Expect users to be unpredictable and inconsistent. Assume they'll make errors and misinterpretations. Assume that different users will interact with and react to your product in very different ways. Consequently, don't overlook the importance of effective and helpful error handling, and design your product to be clear and straight-forward, reducing the likelihood of misinterpretation or error.
- Know users' motivations and goals, and reinforce them using information scents. Users are goal-oriented, and will ignore anything that does not help them achieve their goals. Giving off a strong information scent means presenting words and actions that reassure users that they're on the right track. This requires understanding your users and their motivations, and using the specific words and interactive elements that reinforce them.
- Make your interface predictable. Your users have limited perceptive capabilities, and will fill in the cracks with their memories and expectations. So, align your product's interface with those expectations by following accepted design conventions and mental models. Again, understanding your user base is crucial, and by meeting their expectations, they will more easily accomplish their goals.
- Practice "right place, right time" design. Your users focus their attention on the task at hand and see little else, particularly if their task is difficult or important (such as an e-commerce flow, where you're spending real money and it's difficult to undo). Avoid cluttering your product's interface with all possible options, just in case a slim minority of users might want them. Instead, only give users access to tasks at the right place and right time. One easy way to determine the right place and right time to include an interface element is by using analytics. It's an invaluable tool to determine what is and isn't being used in your interface. Be aggressive about removing elements that are infrequently used.

Most people are unaware of how limited, imperfect, and subjective human visual perception really is. Understanding these limitations is very helpful in predicting how your users will

interact with your product. You can counteract these limitations with good, basic design principles:

- Have a solid understanding of your users
- Design interfaces that have focus and clarity
- Meet your users' expectations
- Use information scent to reassure to users that they are progressing toward their goals
- Practice "right place, right time" design

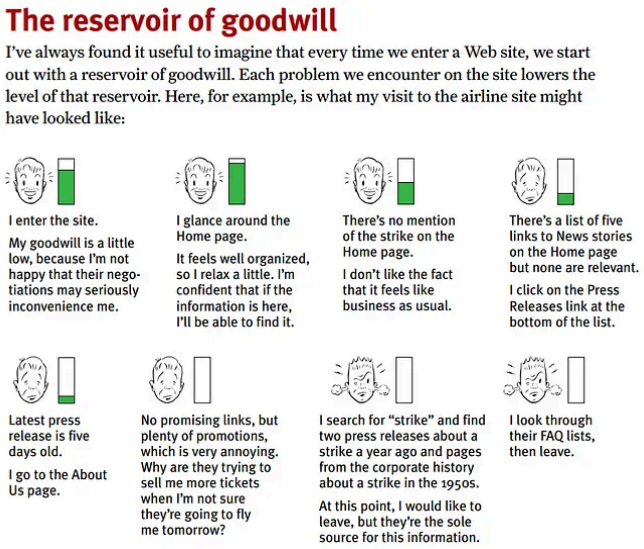
Selective attention & content blindness in UX design

How our attention works

Limited capacity

Attention is a limited resource. There is a similar concept: Steve Krug's reservoir of goodwill. "I've always found it useful to imagine that every time we enter a Web site, we start out with a reservoir of goodwill. Each problem we encounter on the site lowers the level of that reservoir."

Similarly, when I think about human attention, I imagine a jar that contains a certain amount of attention to work with.



Selective attention

We focus on the — seemingly — relevant pieces of information and filter out what appears to be irrelevant. A related concept is working memory.

Cocktail party effect

An example for selective auditory attention: it is about paying attention to one conversation (filtering out the background noise), then switching to another conversation when you hear your name mentioned. [Colin Cherry, 1953 — “how do we recognize what one person is saying when others are speaking at the same time (the “cocktail party problem”)”].

It is like scanning websites: you filter out the noise, and focus on the elements that might be relevant.

Content blindness

Users (unconsciously) not paying attention to elements that:

- look too similar
- appear to be less important (e.g. ads)

Spot the difference

Do you know the game “Spot the difference”? Well, your users don’t want to play this game — they have other tasks at hand (goals, motivation).

Some examples of elements on your UI that might cause content blindness:

- too similar form labels or steps (e.g. inside an onboarding flow)
- a very long survey with many almost identical questions (probably combined with the so-called survey fatigue)

What are the chances of getting valid data from such forms or surveys?

So you should avoid using elements that look (almost) identical but serve a different purpose.

Visual Hierarchy

The way you arrange and present the elements on your UI should reflect their importance:

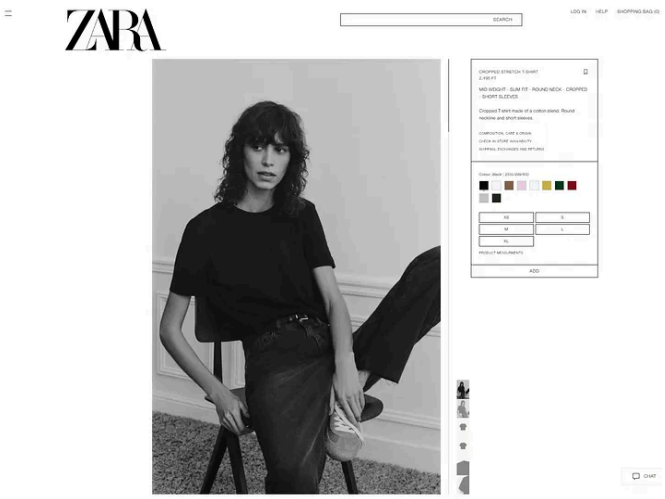
- it supports scannability
- it guides your users’ attention

It’s equally problematic if

- nothing is calling for attention
- everything is calling for attention

on a website or inside a digital product, since these require a big amount of mental effort to find content and complete tasks (cognitive load).

Nothing is calling for attention: an example



Zara — an example I discovered thanks to Built for Mars (Peter Ramsey): “The problem with Zara, is that because everything looks the same, nothing matters more than anything else.”

Everything is calling for attention: an example

LingsCars.com — a famous example :) (Not the best example, since they are doing this intentionally, but you get the idea.)

Banner blindness

Users might overlook banners or other content that resemble ads (even if those elements’d help users accomplish their goals) ~ Jakob’s law

Banner blindness is a type of content blindness. There are certain cues that signal an ad:

- placement on the UI
- visual cues, styling

- close proximity to ads (my sketch about the Gestalt Principle called proximity — the objects that are closer to each other are perceived as more related than the ones that are not positioned near them)

Jakob's Law

"Users spend most of their time on other sites." — states Jakob Nielsen. He also adds that "users prefer your site to work the same way as all the other sites they already know."

Consequently, users' past experiences influence how they perceive an element (~ Gestalt Principle: past experiences — see my sketch). Since our attention is a limited resource, users might ignore elements they perceive as less useful — they want to complete tasks or consume content.

How to deal with banner blindness

One possible tactic to deal with banner blindness is making your ads look like an other type of content (e.g. a post) — users'll more likely to pay attention to it.

Keep in mind that you shouldn't use annoying design patterns (e.g. flashy moving parts) in order to make an ad "visible" — while there might be short-term benefits, this practice is damaging in the long run (just like deceptive or dark patterns).

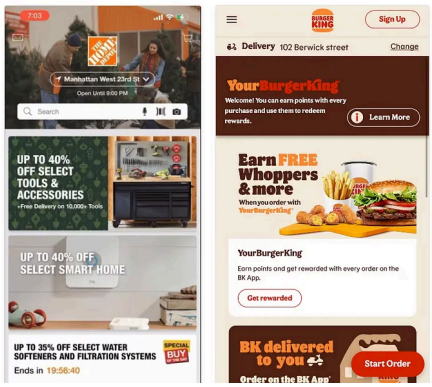
The "reversed effect" is also problematic: if important messages, notifications or other "core" content look like an ad, your users might miss those.

In each cases, you should conduct usability tests to discover how your users perceive certain elements.

When ads are too prominent

It's also interesting to look at banner blindness from another angle: what if users actually see the ads, but they are too prominent? Here is what the Baymard Institute has found in its recent study (Mobile App UX Trends: The Current State of Mobile App UX):

2) 72% of Mobile Apps Create Issues by Displaying Overly Prominent Ads on the Homepage



Source: Mobile App UX Trends: The Current State of Mobile App UX) by the Baymard Institute

“During testing across all platforms, overly flashy ads in a prime content location on the homepage (particularly in the upper part of the page) were often met with negative reactions from users, and pop-up banners and overlays were met with even greater disdain. Therefore, especially for mobile apps, it’s critical to be particularly mindful of the size, placement, aesthetics, and integration of ads within the overall homepage design.”

Change blindness

The tendency to fail to notice significant changes in an interface, especially when changes occur

- gradually (e.g. too subtle changes)
- during an interruption or distraction (e.g. page reload)

How to deal with change blindness

- use animations to emphasize the change (but keep in mind that animations might cause VIMS — visually induced motion sickness)
- apply prominent visual cues to signal the change (e.g. color, different background)
- microinteractions might also help
- you can add elements that underline the change, e.g. an arrow
- next to visuals, you might consider adding feedback that utilizes a wider range of human senses, e.g. audio and haptic feedback
- avoid using multiple simultaneous animations that compete for attention

Inattentional blindness

"Change blindness and inattentional blindness are both failures of visual awareness. Change blindness is the failure to notice an obvious change. Inattentional blindness is the failure to notice the existence of an unexpected item. In each case, we fail to notice something that is clearly visible once we know to look for it." (Jensen et al., 2011)

Daniel Simons and Christopher Chabris designed a famous experiment to test how a certain "everyday illusion" (they use this terminology in their book) affects our behavior.

The experiment is not about finding out the correct answer to the initial question (how many times the players wearing white pass the basketball), it's just a way to set your focus. And while you are focusing on one thing, it is likely that you won't notice an unexpected change or element.

"Amazingly, roughly half of the subjects in our study did not notice the gorilla! How could people not see a gorilla walk directly in front of them, turn to face them, beat its chest, and walk away? What made the gorilla invisible? This error of perception results from a lack of attention to an unexpected object, so it goes by the scientific name "inattentional blindness." […] When people devote their attention to a particular area or aspect of their visual world, they tend not to notice unexpected objects, even when those unexpected objects are salient, potentially important, and appear right where they are looking. In other words, the subjects were concentrating so hard on counting the passes that they were "blind" to the gorilla right in front of their eyes."

And what is the difference between selective attention and inattentional blindness?

"Selective attention is the process of focusing on a particular object in the environment for a certain period of time. Attention is a limited resource, so selective attention allows us to tune out unimportant details and focus on what matters. This differs from inattentional blindness, which is when you focus hard on one thing and fail to notice unexpected things entering your visual field."

Key takeaways

How to design for our limited attention:

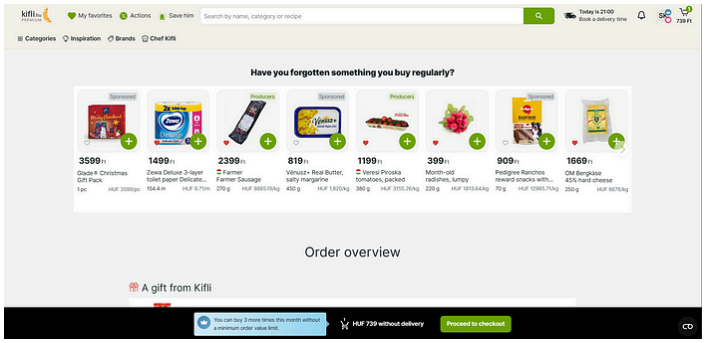
- Users don't see (pay attention to) everything that is visible on your UI (selective attention)
- The way you place & style elements should support completing user goals and business goals (the latter: in case of e.g. ads)
- If you want users to notice your ads, try out new placements / formats
- To deal with change blindness: state changes should be prominent (~ giving useful feedback to the users)

Some examples

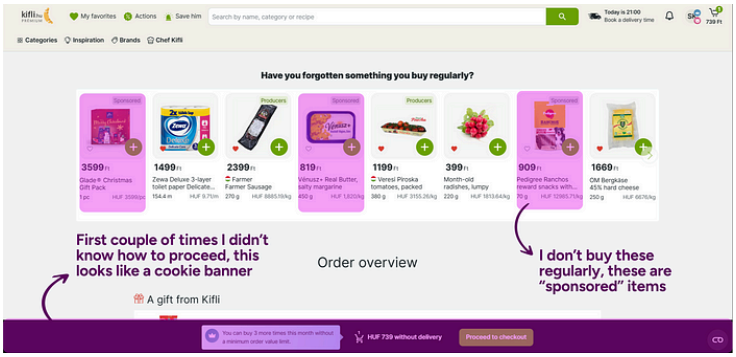
Kifli (online grocery shop)

The checkout flow on the Kifli.hu website contains a screen that provides two great examples for what I have been discussing in this article:

- The site asks if I have forgotten something I regularly add to my basket. While it is a great tactic to make me add some more “last minute” items before the checkout, there are items I have never bought before: these are disguised ads (“sponsored” items). It might be annoying for users since these items create unnecessary noise (it is not a recommendation based on my past behavior, it is random)
- The next step of the user flow is not that easy to reach due to the button being part of an element that is too similar to a cookie banner (thanks to its styling and placement) — the first few times I was really confused (naturally, “you are not your user”, so as always, conducting some usability tests’d be really useful)



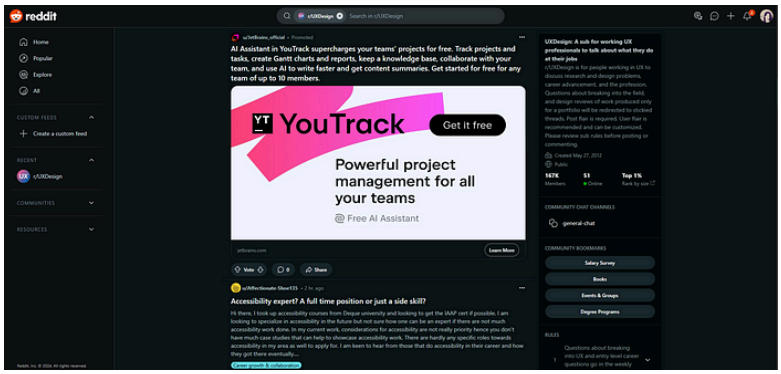
The step before the checkout on kifli.hu (online grocery provider)



1. Sponsored items among my regularly chosen items (disguised ads); 2. The next step of the user flow is not that easy to reach due to the button being part of an element that is too similar to a cookie banner

Reddit

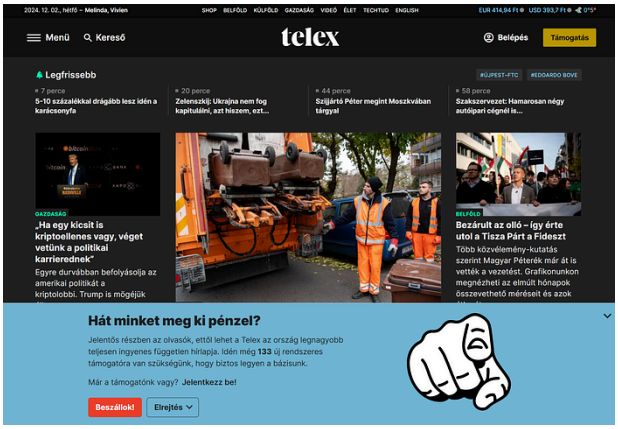
As I mentioned, one possible tactic to make your ad more visible is to make it look like an other type of content, like a post:



JetBrains ad that looks like a post on Reddit

Telex

An example for how Telex, an online newspaper tries to deal with banner blindness by using an additional illustration:



Telex, an online newspaper's attempt to make the banner at the bottom more visible

What is Hick's Law?

Hick's Law (or the Hick-Hyman Law) states that the more choices a person is presented with, the longer the person will take to reach a decision. Named after psychologists William Edmund Hick and Ray Hyman, Hick's Law finds frequent application in user experience (UX) design—namely, to avoid overwhelming users with too many choices, thereby keeping them engaged.

Specifically, Hick's Law states that the time required to reach a decision increases logarithmically with the number of choices—this means that the increase in time taken becomes less significant as the number of choices continues to increase. Thus, Hick's Law becomes less important when designing long lists (for instance, a contact list, or a list of UX design topics), but it is crucial when designing short lists (such as a navigation menu, or action buttons in a website or app). In other words, the risk of information saturation/overload rises when website visitors encounter too many options. This will almost certainly have a bearing on how quickly they abandon their user experience by leaving (i.e., the bounce rate).

There are exceptions to Hick's Law. For one, it applies only to equally probable choices, where the user is equally likely to select any of the choices. This means that if users already know what they want to do before seeing the list of choices, the time it takes them to act is likely to be less than what Hick's Law describes. However, the general rule of thumb of Hick's Law is still valuable, and it informs a wide range of design decisions—from the number of controls in a microwave oven, to the number of links in a website's header. As such, this law tends to be a vital determinant in user engagement and conversion rates.

The Implementation of Hick's Law

You can find applications of Hick's Law everywhere, not just in web and app design. Hick's Law determined the number of controls on your microwave or your washing machine. A design principle known as "K.I.S.S." ("Keep It Short and Simple") became recognized in the 1960s for its effectiveness in this regard. Echoing Hick's Law, K.I.S.S. states that simplicity is the key for a system to work in the best way. First embraced by the U.S. Navy, the principle of "K.I.S.S." was in general use in many industries by the 1970s. In some environments, K.I.S.S. gets translated as "Keep It Simple Stupid".

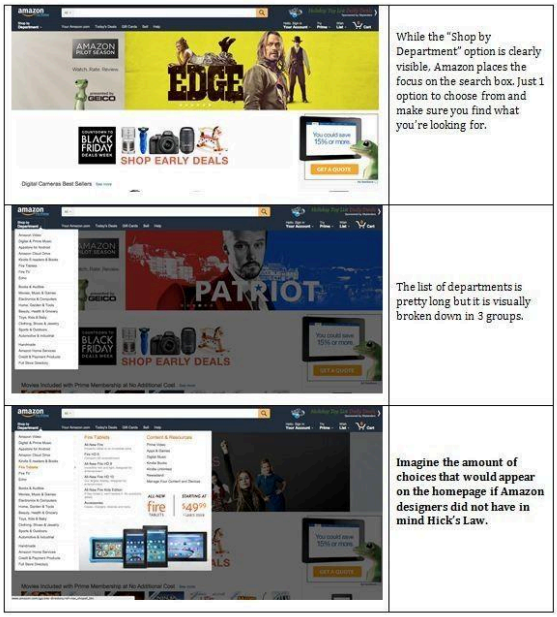
Hick's Law surrounds us. When you go to a high-end restaurant, often whoever has written the menu has used Hick's Law to give you the "right" number of choices. By not getting bogged down in a decision-making process, you're more likely to savor you meal out with the important company joining you. Look at the menu above: what a daunting job to choose a pizza!

Of course, designers don't use Hick's Law in isolation in design. We always combine it with other design principles to make it work effectively. We often have to make compromises with Hick's Law, too – sometimes there is no avoiding complexity. This is why a DSLR camera has many more controls and options than a camera on a smartphone. The objective of Hick's Law is to try and simplify the decision-making process, not eliminate that process entirely.

In web and app design, as with other types of product design, we often have several functions and choices to present to the user. Here, we have to take the time to think about how we'll introduce those.

The landing page is the first glimpse your user will have of your site. That's a make-it-or-break-it chance to create an impression using Hick's Law. So, it's particularly important to minimize choices here. Are you promoting a product or a service? If you're selling aquariums, what's your best-selling model? Introduce your company and highlight the model on the landing page, organizing text carefully. Most importantly, draw the user's eye with a well-placed image (remember those sweet spots). They'll see that before they start reading. Make the option you most want them to select stand out.

Separating the essential material from the secondary, less-likely-to-be-selected options is vital. On one hand, we may know which, say, aquarium will jump out at most users, and which are the more specialized ones that only expert fish-keepers might want. However, because we have more familiarity with such functions and choices, we run the risk of forgetting that our users won't have this. They're arriving at the website or examining the product with a fresh perspective. So, understanding this difference, we must stand back and see what we will offer the users to get them to decide their next move. Good designers try to employ Hick's Law to respect their users' time and to ensure a high-quality user experience.



To employ Hick's Law effectively in the design of interactive products, you can consider the following:

Categorizing Choice - You can see Hick's Law in action in the navigation of almost any website. If your menus offered direct access to every link within your site, you could quickly overwhelm the visitor. If Amazon's menus did that, it could take several hours to scroll through a menu! Suddenly, searching for a last-minute birthday present or replacing a printer cartridge becomes a "stressfest"!

Happily, designers group menu items into high-level categories instead. These slowly expand as the users select options; the new categories then take users where they want to go. Do you recall Amazon screenshots just above? There's a compromise between offering all functionality and Hick's Law, which pressures the designer to keep things as simple as possible.

With highly complex sites, the use of Hick's Law requires further implementations of choice. As designers, we notice how we can scatter navigation items throughout the design in small, discrete clusters. These help narrow down huge volumes of information without overloading the user.

The card-sorting method is great to find out about the categories that make more sense to your users. You can use card-sorting to define the groupings of the functionalities and also the labels for these categories. You should do this early on in your project, before starting any sketching or wireframe.

As you move on in the design process, you can use eye-tracking to have a heat map of your site. This can help you work out where future design changes might benefit from further applying Hick's Law. Heat maps display areas of a site that users look at most, showing problem areas quickly, too.

Obscuring Complexity - If you have a complex process, you can use Hick's Law to rationalize only presenting specific parts of that process at any one time on the screen. Instead of throwing the entirety of your payment process up in a long, complex form, you can break it down into prompting users to register their e-mail and create a password. Then, you can give them another screen with shopping cart details, then another which collects delivery information and so on.

By reducing the number of options on screen, the payment process becomes more user friendly, and it's more likely that the user will reach the end of the process than abandon the cart.

Hints from analytics

Once your app or website is launched, it is also important to keep an eye on how Hick's law might be affecting your users' experience. Here are some variables that you can use to analyse it:

Time on Site - There is a sweet spot for most websites when it comes to time spent on site. Too little time and the user has likely left without purchasing or registering. Too much time and they may get caught up in information consumption and again fail to make a purchase or register. Just enough time and the majority of users who will make a purchase and register will do so.

Once a site is live, you can start to gauge where that sweet spot is and utilize Hick's Law either to increase or decrease the average amount of time spent on site.

While simplifying decision making can extend the time spent on site, it might also reduce it. If the decision making is so simple that users make little progress towards their objectives each time they make a decision, they'll be as likely to leave as users who find a decision-making process impossibly confusing because they've seen too many options at once.

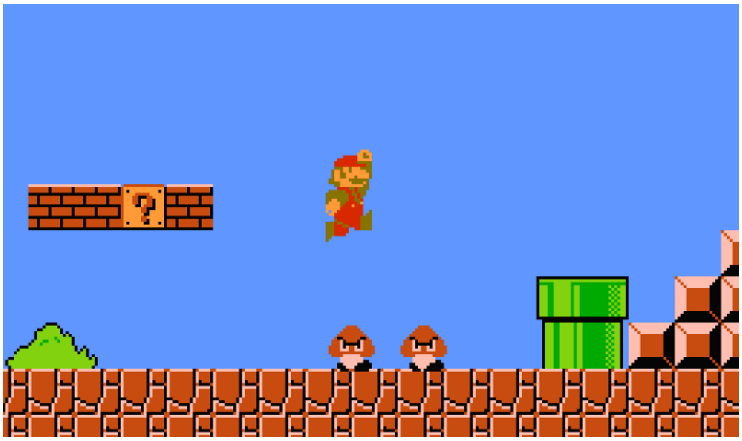
Page Views - Hick's Law can also affect the number of page views that each user carries out. If the navigation menu is too complex, the number of page views is likely to be lower than if users were offered a navigation menu that better met their needs.

Of course, page views are only important if the users are achieving their objectives while on site. It would be easy to construct a very deep menu system of binary choices that required 10 or more clicks to get to the desired information. Unfortunately, were you to design that, you'd

almost certainly find that users would abandon the site long before getting to the information they needed. This approach might deliver more page views at first, but it is unlikely to deliver the results required from your design, either.

Design Principles: Hick's Law — Quick Decision Making

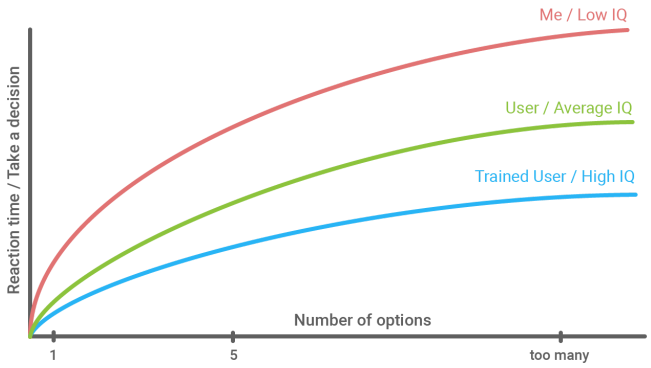
Do you remember the old video games from before 20 years and how much fun it was to play them. The controls were so simple you could learn to play in seconds. For example, Super Mario with just left, right and jump controls.



In comparison, today's input controls of modern gaming consoles and PC games are offering so many choices and combinations. All these controls, multiply the options user can choose in any certain situation.

Having so many options makes learning the game and enjoying it much harder and time consuming. One of the reasons is explained by Hick's Law.

Hick's Law predicts that the time and the effort it takes to make a decision, increases with the number of options.



"Hick's law, or the Hick–Hyman Law, named after British and American psychologists William Edmund Hick and Ray Hyman, describes the time it takes for a person to make a decision as a result of the possible choices he or she has: increasing the number of choices will increase the decision time logarithmically."

So, the time it takes a user to finish their task increases with the number of available options. We can shorten this to: Less is Faster (easier to remember)

When to use Hick's law?

Use Hick's Law when response times are critical. It applies to any simple decision making with multiple options. This is especially important in control system environments.

If the nuclear reactor is overheating you wouldn't want the user to search for the manual.

When things go wrong and alarms are triggered users need to be able to make quick decisions. When users enter the stress zone they get tunnel vision. If you combine that with the input from all the body senses, you can get a pretty nasty situation.

Having one choice acts as light in the tunnel when users are stressed or confused.

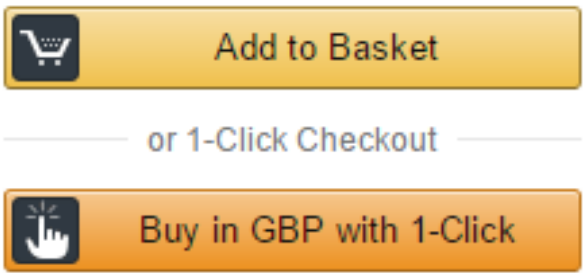
When response time is critical keep the choices to a minimum. It will speed up the decision making.

What about normal everyday situations and products?

Hick's law can be used to narrow down big volumes of information without overloading the user.

When you need to simplify complex process, use Hick's law. Present specific parts of that process at any one time on the screen.

An example can be a payment process. Instead of showing everything at once, you can break it down. Show the screen with shopping cart details then another with delivery information, then optional account creation and so on.



Amazon's 1-click buy is a great example of Hick's law and KISS application.

Reducing the number of perceived options on screen makes the interface more user friendly. It is also more likely that the user will accomplish the goal and not give up or get confused.

It is important to point out not to oversimplify! Breaking down choices to a series of too many small chunks can also cause the user to drop off before reaching the goal.

A way to get started with Hick's law

Card-sorting is a great method to find out about the categories of information that make more sense to your users. It will help you define the groupings of functionalities and terms. You can use old-fashioned paper cards and human interaction or digital tools for distant card sorting. Tools like Optimal Workshop or similar, can be very efficient and quick to get actionable results.

When not to use Hick's law?

It's equally important to know when not to use it. Hick's Law does not apply to complex decision making. If decisions are requiring extensive reading, researching, or extended deliberation. Hick's Law won't be able to predict the time to make a decision.

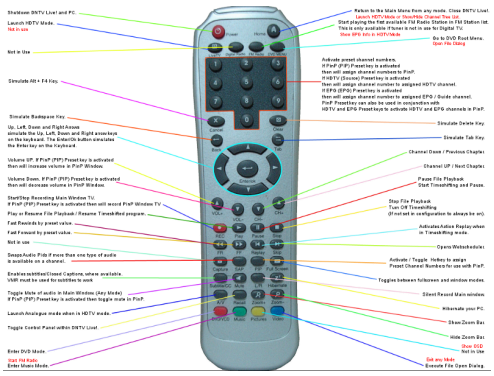
For example, choosing a dinner at a fancy restaurant or picking an AirBnB place to stay for your vacation next week.

These type of choices are complex. Users need to consider and weight many options before making the final decision. In these cases, Hick's Law prediction will fail. It only applies to simple quick decisions in appropriate context.

Practical use of Hick's Law

When response time is critical, keep the number of options small. One to five is a good rule of thumb.

Humans are strange. We like to say we want as much options as possible. When we get them…we get confused and can't take a decision.



Don't you want to use all these buttons?

Having too many options with equally perceived hierarchy can cause analysis paralysis. Yeah, that leads to feeling frustration. Not the best user experience.

In contrast, system with less and clearer options frequently are rated from users as having better user experience.

Complexity is hidden for when it is needed

Highlighting is another way to use Hick's Law. Make a few important options to stand out among cluttered user interface to speed up the response times.

In decision-making context aim at reducing distractions. Having distractions can act like having more choices. This leads to slow response time.

Is Hick's Law affecting my design?

Here are a couple of ways to see if applying this design principle has effect on your design. We always have to look at metrics to confirm that our design decisions have effect.

Look at time spent on site

You have to hit the sweet spot. On one hand, if the user spends too little time, they probably left without making a decision. On the other hand, if the user spends too much time, they probably got distracted from the goal.

Focus on optimizing the design to provide the user with the right amount of options to keep the engagement. Help the user to make the choices and convert.

Look at page views

The number of page views can also be indicator for how effectively you've used Hick's Law. If the navigation is too complex, the number of page views is likely to be lower than if it was simple.

That said, avoid creating deep navigation that requires 2–3 choices for each level and continues for 10 levels. This will increase the time for completing a task, which will increase the likelihood of users leaving the site prematurely.

Dual Process Theory

Dual process theory is a framework used to explain how people think. It traces its roots back to William James (an early American philosopher and psychologist). At its core is the idea that humans have two different streams or means of thinking. These dual means of thinking give rise to the name dual process theory.

These dual processes are sometimes referred to as “systems” and known as “system 1” and ”system 2”. System 1 is evolutionarily older, more automatic, instinctive, implicit and unconscious. System 2 is evolutionarily newer, intentional, effortful, explicit and conscious.

Dual process theory continues to evolve. It remains a popular framework in the field of cognitive psychology. It also has some applications in learning theory and in relation to how humans process and store information. More recently it has sprung up in behavioral economics as well. Danny Kahneman’s interpretations in his excellent book “Thinking, Fast and Slow”, helped bring these concepts to the mainstream.

Dual process theory also has a key role to play in understanding how we make decisions.

System 1: Our Automatic Processor

Humans constantly function. The majority of time we do so without really thinking about it. We know what our senses are telling us and we know what they mean we should do.

If we’re hungry, we should eat. And, if we’re a bit tired, we should sleep. If we see some information we dislike, we should ignore it… or perhaps not. We don’t think about walking. And we don’t calculate the trajectory of our steps. We don’t use our knowledge of physics to help us throw a ball. All of these things come naturally.

We’ve developed rules, internal processes and shortcuts in our thinking and decision making that help us survive without conscious effort. And it’s this system of automatic processing that’s known as System 1. We use it to get along in our daily lives without really needing to try too hard or think too much. We also find that the more tired we are, the more we use System 1.

This is economic in many ways. It’s fast too, allowing us to respond almost instantly in many situations. It’s also often reasonably accurate and effective. It also reserves our mental energy

for draining thoughtful effort when it's really required. It does though, rely on generalities and is prone to some sloppy errors.

System 2: Our Controlled Thinking

Sometimes we, as humans, find ourselves in situations where we either don't have mental shortcuts that we can use, or where we need to be more than just reasonably accurate.

In these circumstances we need to focus on our thoughts. We need to consciously think our way through key factors and reach logical, calculated, informed decisions. To do this we need to slow our thinking down. We ignore our mental shortcuts, we start from the building blocks of information that we have and use logic to reach decisions and conclusions.

This way of thinking is known as System 2 thinking. It often produces better (or at least more reasoned) answers for us, but it's effortful and it's slow. This process is excellent in some environments and situations, but dreadful in others. If you rely on system 2 to calculate the moment when a leaping tiger will reach you and plot your escape, then you'll never finish your calculations.

System 2: Characteristics

System 2 has lots of different characteristics. Some of the most important ones are as follow:

- It's conscious,
- Mostly voluntary,
- Mostly detached from emotions,
- Explicit,
- Controlled,
- High effort,
- Small capacity,
- Slow,
- More objective (and fact / rule based),
- Evolutionarily recent,
- Logical and rational.

Dual Process Theory in the World of Work

Many of the challenges that individuals and leaders face in the world of work stem from the very natural tendency for individuals to predominantly use System 1 thinking as opposed to System 2 thinking.

In fact, most cases of sloppy thinking by otherwise capable individuals probably result from their use of System 1 thinking. And this is entirely natural. System 2 thinking requires a lot more effort, and a lot more focus. And this means that to use System 2, individuals normally need to be more motivated.

From a leadership perspective it's helpful to be aware of these two different types of thinking. The more you can use system 2 thinking yourself, the better the decisions that you make will probably be. And similarly, the more you can help your team use system 2 thinking, the better their decisions will probably be.