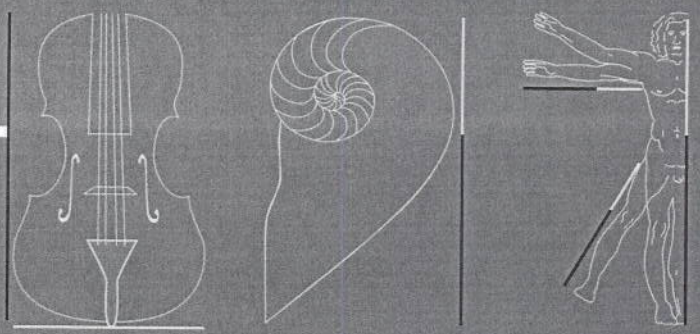
ACCESSIBILITY
ADVANCE ORGANIZER
AESTHETIC-USABILITY EFFECT
AFFORDANCE
ALIGNMENT
ARCHETYPES
ATTRACTIVENESS BIAS
BABY-FACE BIAS
CHUNKING
CLASSICAL CONDITIONING
CLOSURE
COGNITIVE DISSONANCE
COLOR
COMMON FATE
COMPARISON
CONFIRMATION
CONSISTENCY
CONSTANCY
CONSTRAINT
CONTROL
CONVERGENCE
COST-BENEFIT
DEFENSIBLE SPACE
DEPTH OF PROCESSING
DEVELOPMENT CYCLE
ENTRY POINT
ERRORS
EXPECTATION EFFECT
EXPOSURE EFFECT
FACE-ISM RATIO
FACTOR OF SAFETY
FEEDBACK LOOP
FIBONACCI SEQUENCE
FIGURE-GROUND RELATIONSHIP
FITTS' LAW
FIVE HAT RACKS
FLEXIBILITY USABILITY TRADEOFF
FORGIVENESS
FORM FOLLOWS FUNCTION
FRAMING
GARBAGE IN–GARBAGE OUT
GOLDEN RATIO
GOOD CONTINUATION
GUTENBERG DIAGRAM
HICK'S LAW
HIERARCHY
HIERARCHY OF NEEDS
HIGHLIGHTING
ICONIC REPRESENTATION
IMMERSION
INTERFERENCE EFFECTS
INVERTED PYRAMID
ITERATION
LAW OF PRÄGNANZ
LAYERING
LEGIBILITY
LIFE CYCLE
MAPPING
MENTAL MODEL
MIMICRY
MNEMONIC DEVICE
MODULARITY
MOST AVERAGE FACIAL APPEARANCE EFFECT
NORMAL DISTRIBUTION
OCKHAM'S RAZOR
OPERANT CONDITIONING

Universal Principles of Design

William Lidwell
Kritina Holden
Jill Butler



100 Ways to Enhance Usability, Influence Perception, Increase Appeal, Make Better Design Decisions, and Teach through Design

Alignment

The placement of elements such that edges line up along common rows or columns, or their bodies along a common center.

Elements in a design should be aligned with one or more other elements. This creates a sense of unity and cohesion, which contributes to the design's overall aesthetic and perceived stability. Alignment can also be a powerful means of leading a person through a design. For example, the rows and columns of a grid or table can be used to make explicit the relatedness of elements sharing those rows and columns, and to lead the eyes left-to-right and top-to-bottom accordingly. Edges of the design medium (e.g., edge of a page or screen) and the natural positions on the design medium (e.g., centerlines) should also be considered alignment elements.

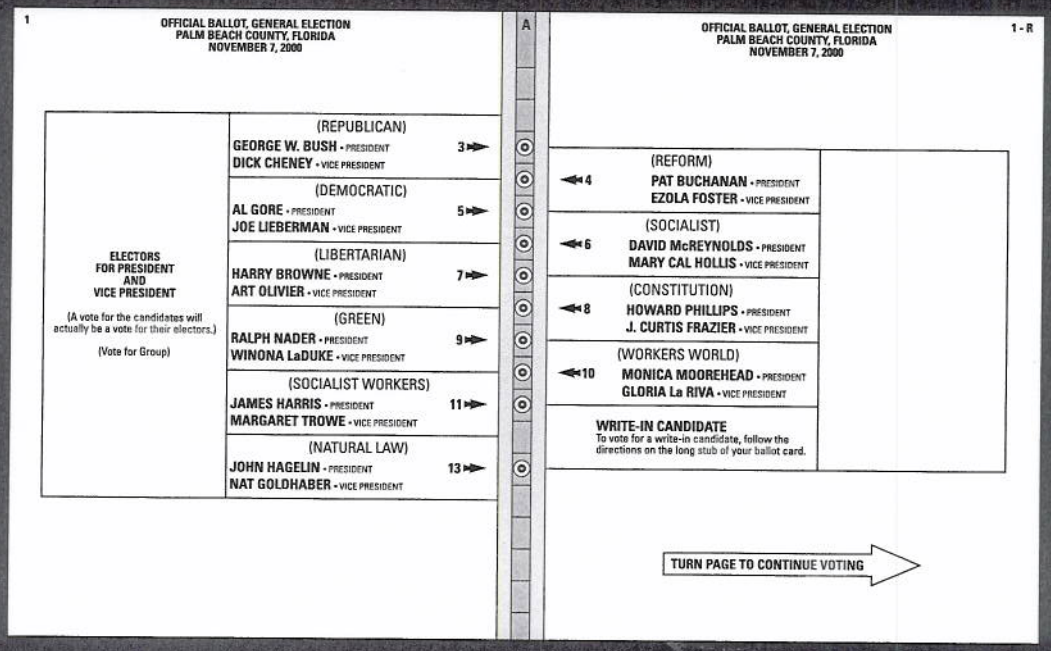
In paragraph text, left-aligned and right-aligned text blocks provide more powerful alignment cues than do center-aligned text blocks. The invisible column created by left-aligned and right-aligned text blocks presents a clear, visual cue against which other elements of the design can be aligned. Center-aligned text blocks, conversely, provide more visually ambiguous alignment cues, and can be difficult to connect with other elements. Justified text provides more alignment cues than unjustified text, and should be used in complex compositions with many elements.

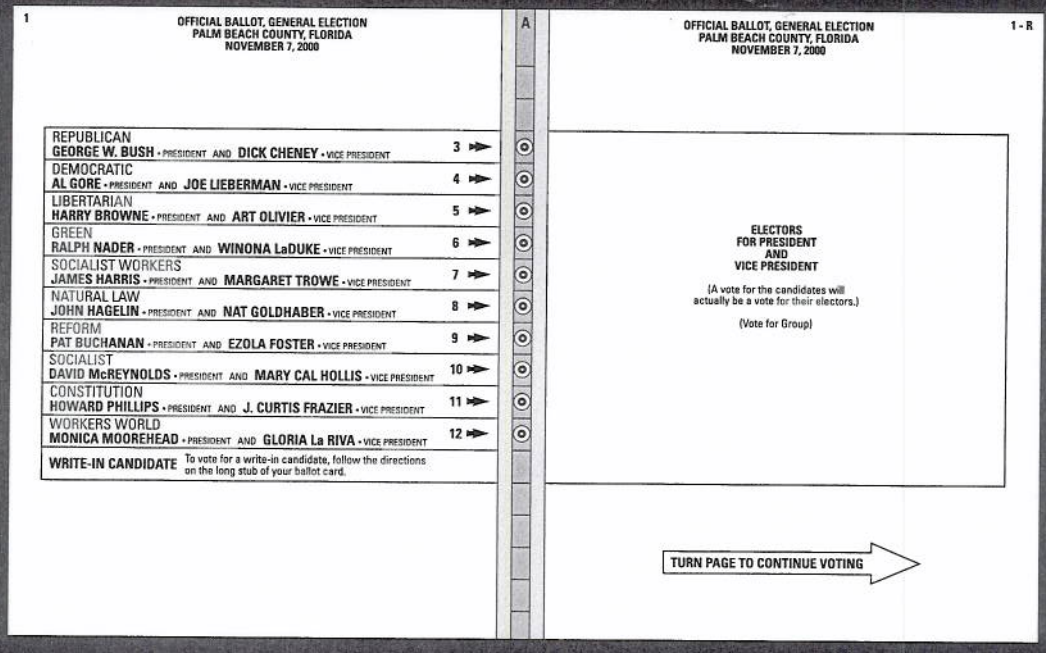
Although alignment is generally defined in terms of rows and columns, more complex forms of alignment exist. In aligning elements along diagonals, for example, the relative angles between the invisible alignment paths should be 30 degrees or greater because separation of less than 30 degrees is too subtle and difficult to detect.[1] In spiral or circular alignments, it may be necessary to augment or highlight the alignment paths so that the alignment is perceptible; otherwise the elements may not seem to be placed according to any particular pattern. As with all such principles of this type, there are exceptions (e.g., the misalignment of elements to attract attention or create tension). However, these exceptions are rare, and alignment should be considered the general rule.

For most designs, align elements into rows and columns or along a centerline. When elements are not arranged in a row/column format, consider highlighting the alignment paths. Use left- or right-justified text to create the best alignment cues, and consider justified text for complex compositions.

See also Aesthetic-Usability Effect and Good Continuation.

[1] See, for example, *Elements of Graph Design* by Stephen M. Kosslyn, W. H. Freeman and Company, 1994, p. 172.





The design of the "butterfly ballot" of Palm Beach County, Florida, may have decided the presidential election of 2000. Although there are several problems with the design of the butterfly ballot, most confusion likely resulted from the misalignment of the row and punch-hole lines. This conclusion is supported by the improbable number of votes for Patrick Buchanan in Palm Beach County, as well as the number of double votes that occurred for candidates that were adjacent on the ballot. A simple adjustment to the ballot design would have dramatically reduced the error rate.

Closure

A tendency to perceive a set of individual elements as a single, recognizable pattern, rather than multiple, individual elements.

The principle of closure is one of a number of principles referred to as *Gestalt principles of perception.* It states that whenever possible, people tend to perceive a set of individual elements as a single, recognizable pattern, rather than multiple, individual elements. The tendency to perceive a single pattern is so strong that people will close gaps and fill in missing information to complete the pattern if necessary. For example, when individual line segments are positioned along a circular path, they are first perceived holistically as a circle, and then as comprising multiple, independent elements. The tendency to perceive information in this way is automatic and subconscious; it is likely a function of an innate preference for simplicity over complexity, and pattern over randomness.[1]

Closure is strongest when elements approximate simple, recognizable patterns, such as geometric forms, and are located near one another. When simple, recognizable patterns are not easily perceived, designers can create closure through transitional elements (i.e., subtle visual cues that help direct the eye to find the pattern). Generally, if the energy required to find or form a pattern is greater than the energy required to perceive the elements individually, closure will not occur.

The principle of closure enables designers to reduce complexity by using a smaller number of elements to organize and communicate information. For example, a logo design that is composed of recognizable elements does not need to complete many of its lines and contours to be clear and effective. Reducing the number of lines in the logo not only reduces its complexity, but it makes the logo more interesting to look at because viewers subconsciously participate in the completion of its design. Many forms of storytelling leverage closure in a similar way. For example, in comic books, the illustrator presents discrete scenes to the reader, who then supplies what happens in between. The storyline is a unique combination of information provided by the storyteller, and information provided by the reader.[2]

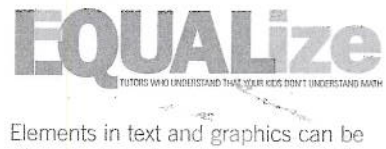
Use closure to reduce the complexity and increase the interestingness of designs. When designs involve simple and recognizable patterns, consider removing or minimizing the elements of a design that can then be supplied by viewers. When designs involve more complex patterns, consider the use of transitional elements to assist viewers in finding or forming the pattern.

See also Good Continuation, Law of Prägnanz, and Proximity.

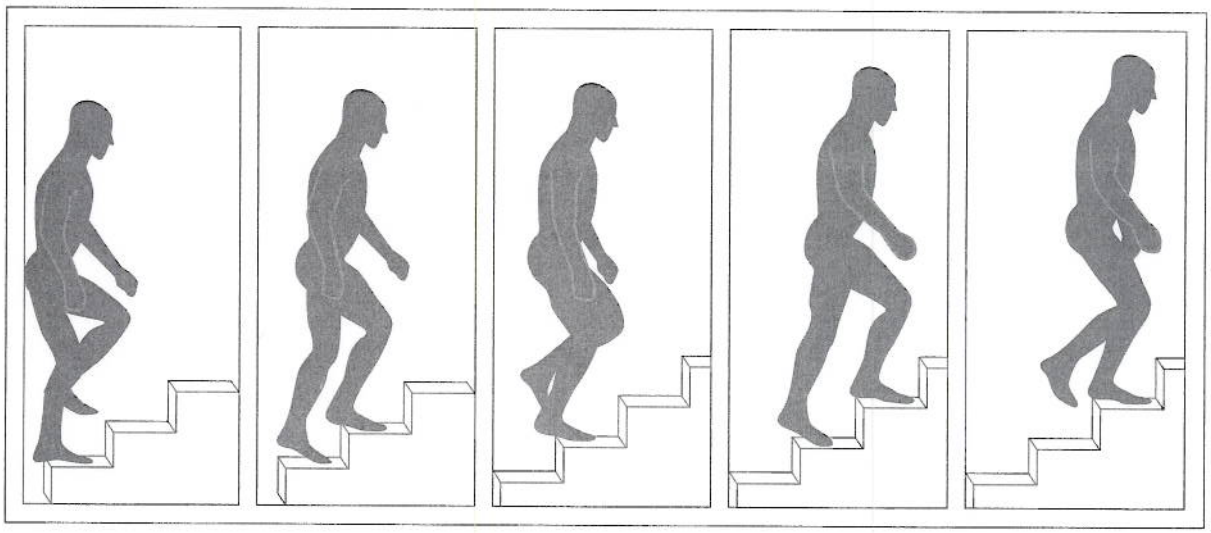
[1] The seminal work on closure is "Untersuchungen zür Lehre von der Gestalt, II" [Laws of Organization in Perceptual Forms] by Max Wertheimer, *Psychologische Forschung*, 1923, vol. 4, p. 301–350, reprinted in *A Source Book of Gestalt Psychology* by Willis D. Ellis (ed.), Routledge & Kegan Paul, 1999, p. 71–88.

[2] See, for example, *Understanding Comics: The Invisible Art* by Scott McCloud, Kitchen Sink Press, 1993.

The elements are perceived holistically as a single pattern first (circle), and then as individual elements.



Elements in text and graphics can be minimized to allow viewers to participate in the completion of the pattern. The result is a more interesting design.



Series images are understood as representing motion because people supply the information in between the images.

Consistency

The usability of a system is improved when similar parts are expressed in similar ways.

According to the principle of consistency, systems are more usable and learnable when similar parts are expressed in similar ways. Consistency enables people to efficiently transfer knowledge to new contexts, learn new things quickly, and focus attention on the relevant aspects of a task. There are four kinds of consistency: aesthetic, functional, internal, and external.[1]

[1] Use consistent approaches when possible, but do not compromise clarity or usability for consistency. In the words of Emerson, "A foolish consistency is the hobgoblin of little minds ..."

Aesthetic consistency refers to consistency of style and appearance (e.g., a company logo that uses a consistent font, color, and graphic). Aesthetic consistency enhances recognition, communicates membership, and sets emotional expectations. For example, Mercedes-Benz vehicles are instantly recognizable because the company consistently features its logo prominently on the hood or grill of its vehicles. The logo has become associated with quality and prestige, and informs people how they should feel about the vehicle—i.e., respected and admired.

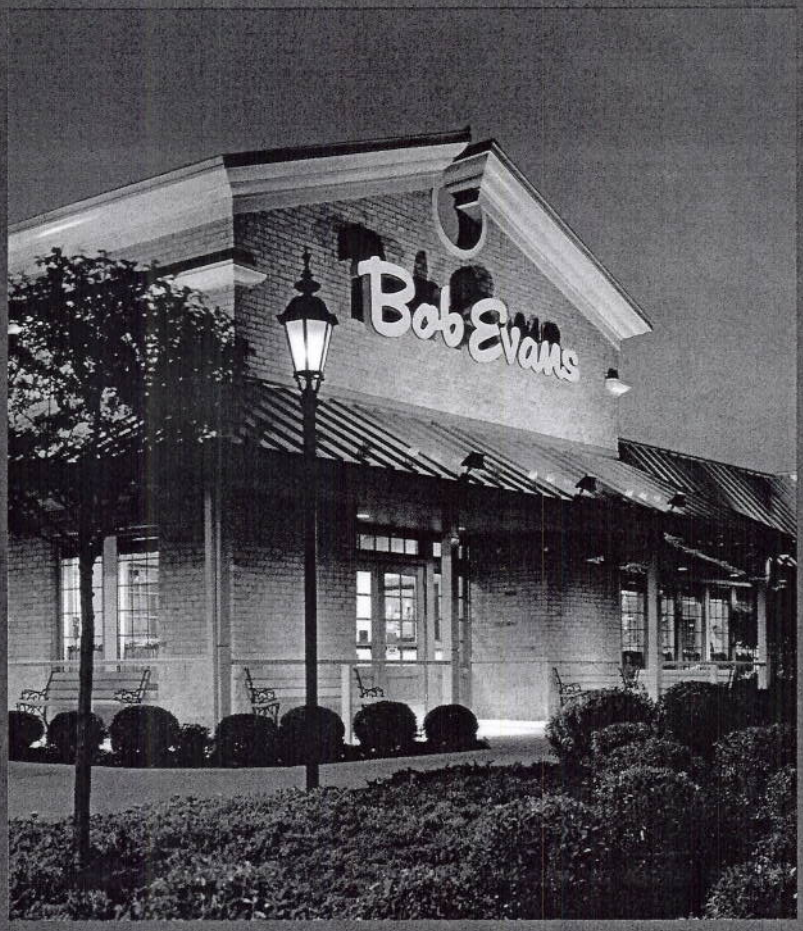
Functional consistency refers to consistency of meaning and action (e.g., a traffic light that shows a yellow light before going to red). Functional consistency improves usability and learnability by enabling people to leverage existing knowledge about how the design functions. For example, videocassette recorder control symbols, such as for rewind, play, forward, are now used on devices ranging from slide projectors to MP3 music players. The consistent use of these symbols on new devices enables people to leverage existing knowledge about how the controls function, which makes the new devices easier to use and learn.

Internal consistency refers to consistency with other elements in the system (e.g., signs within a park are consistent with one another). Internal consistency cultivates trust with people; it is an indicator that a system has been designed, and not cobbled together. Within any logical grouping elements should be aesthetically and functionally consistent with one another.

External consistency refers to consistency with other elements in the environment (e.g., emergency alarms are consistent across different systems in a control room). External consistency extends the benefits of internal consistency across multiple, independent systems. It is more difficult to achieve because different systems rarely observe common design standards.

Consider aesthetic and functional consistency in all aspects of design. Use aesthetic consistency to establish unique identities that can be easily recognized. Use functional consistency to simplify usability and ease of learning. Ensure that systems are always internally consistent, and externally consistent to the greatest degree possible. When common design standards exist, observe them.

See also Modularity, Recognition Over Recall, and Similarity.



Restaurant chains frequently use consistency to provide customers with the same experience across many locations. For example, Bob Evans uses the same logo, typefaces, color schemes, menus, staff uniforms, interior design, and architecture across its restaurants. This consistency improves brand recognition, reduces costs, and establishes a relationship with customers that extends beyond any single restaurant.

Figure-Ground Relationship

Elements are perceived as either figures (objects of focus) or ground (the rest of the perceptual field).

The figure-ground relationship is one of several principles referred to as *Gestalt principles of perception*. It asserts that the human perceptual system separates stimuli into either figure elements or ground elements. Figure elements are the objects of focus, and ground elements compose an undifferentiated background. This relationship can be demonstrated with both visual stimuli, such as photographs, and auditory stimuli, such as soundtracks with dialog and background music.

When the figure and ground of a composition are clear, the relationship is stable; the figure element receives more attention and is better remembered than the ground. In unstable figure-ground relationships, the relationship is ambiguous and can be interpreted in different ways; the interpretation of elements alternates between figure and ground.

The visual cues that determine which elements will be perceived as figure and which as ground are:

- The figure has a definite shape, whereas the ground is shapeless.
- The ground continues behind the figure.
- The figure seems closer with a clear location in space, whereas the ground seems farther away and has no clear location in space.
- Elements below a horizon line are more likely to be perceived as figures, whereas elements above a horizon line are more likely to be perceived as ground.
- Elements in the lower regions of a design are more likely to be perceived as figures, whereas elements in the upper regions are more likely to be perceived as ground.[2]

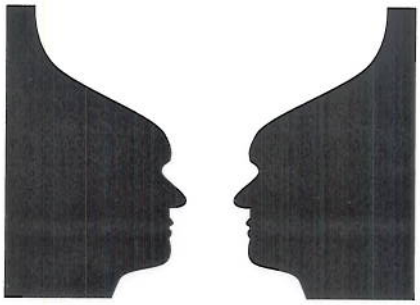
Clearly differentiate between figure and ground in order to focus attention and minimize perceptual confusion. Ensure that designs have stable figure-ground relationships by incorporating the appropriate visual cues listed above. Increase the probability of recall of key elements by making them figures in the composition.

See also Gutenberg Principle, Law of Prägnanz, and Top-Down Lighting Bias.

[1] The seminal work on the figure-ground relationship is "Synoplevede Figurer" [Figure and Ground] by Edgar Rubin, Gyldendalske, 1915, translated and reprinted in *Readings in Perception* by David C. Beardslee and Michael Wertheimer, D. Van Nostrand, 1958, p. 194–203.

[2] "Lower Region: A New Cue for Figure-Ground Assignment" by Shaun P. Vecera, Edward K. Vogel, and Geoffrey F. Woodman, *Journal of Experimental Psychology: General*, 2002, vol. 131(2), p. 194–205.

The Rubin vase is unstable because it can be perceived as a white vase on a black background or two black faces looking at each other on a white background.



Initially, there is no stable figure-ground relationship in this image. However, after a moment, the Dalmatian pops out and the figure-ground relationship stabilizes.

Placing the spa name below the horizon line in the logo makes it a figure element—it will receive more attention and be better remembered than the design that places the name at the top of the logo.

Placing the logo at the bottom of the page makes it a figure element—it will receive more attention and will be better remembered than the logo at the top of the page.

Form Follows Function

Beauty in design results from purity of function.

The *form follows function* axiom is interpreted in one of two ways—as a description of beauty or a prescription for beauty. The descriptive interpretation is that beauty results from purity of function and the absence of ornamentation. The prescriptive interpretation is that aesthetic considerations in design should be secondary to functional considerations. The axiom was adopted and popularized by modernist architects in the early 20th century, and has since been adopted by designers in a variety of disciplines.[1]

The *descriptive* interpretation—i.e., that beauty results from purity of function—was originally based on the belief that form follows function in nature. In reality, however, it is quite the opposite—function follows form in nature, if it follows anything at all. (Evolution by natural selection transmits no *intention* from one generation to the next; genetic patterns are simply passed on and it is left to each organism to find use of the form that it has inherited.) Nonetheless, functional aspects of a design are less subjective than purely aesthetic aspects and, therefore functional criteria present a clearer and more objective criteria for judgement of quality. The result is designs that are more timeless and enduring, but also frequently perceived by general audiences as simple and uninteresting.[2]

The *prescriptive* interpretation—i.e., that aesthetic considerations in design should be secondary to functional considerations—was likely derived from the descriptive interpretation. The use of *form follows function* as a prescription or design guideline is problematic in that it focuses the designer on the wrong question. The question should not be, "What aspects of form should be omitted or traded for function?" but rather, "What aspects of the design are critical to success?" These success criteria, not a blind allegiance to form or function, should drive design specifications and decisions. When time and resources are limited, design tradeoffs should be based on what does the least harm to the probability of success, however *success* is defined. In certain circumstances, primary aesthetic considerations will be sacrificed, and in others, primarily functional ones will be

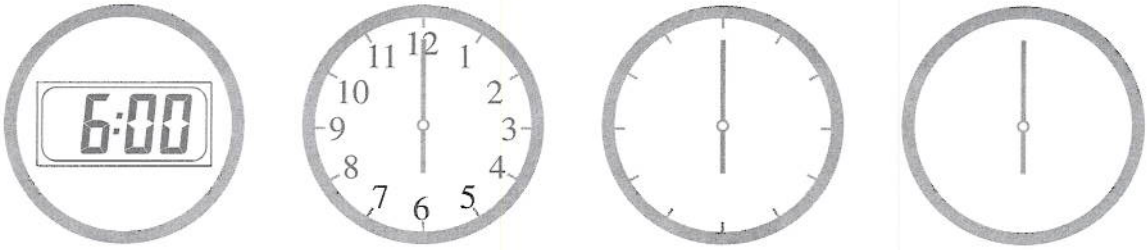
Use the descriptive interpretation of *form follows function* as an aesthetic guide, but do not apply the prescriptive interpretation as a strict design rule. When making design decisions, focus on the relative importance of all aspects of the design—form and function—in light of the success criteria.

See also Aesthetic-Usability Effect, Exposure Effect, and Ockham's Razor.

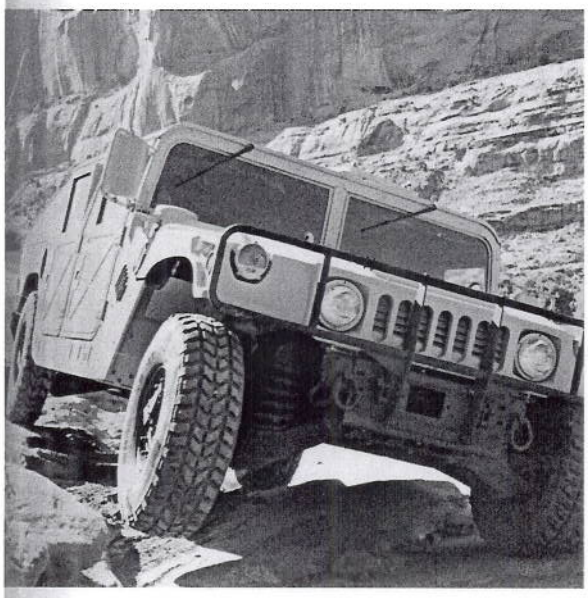
[1] The origin of the concept is attributed to the 18th century Jesuit monk Carlo Lodoli. His theories on architecture likely influenced later designers like Horatio Greenough and Louis Sullivan who then articulated the concept in popular form. The seminal works on *form follows function* are "The Tall Office Building Artistically Considered" by Louis H. Sullivan, *Lippincott's Magazine*, March 1896; and *Form Follows Fiasco: Why Modern Architecture Hasn't Worked* by Peter Blake, Little, Brown, and Company, 1977.

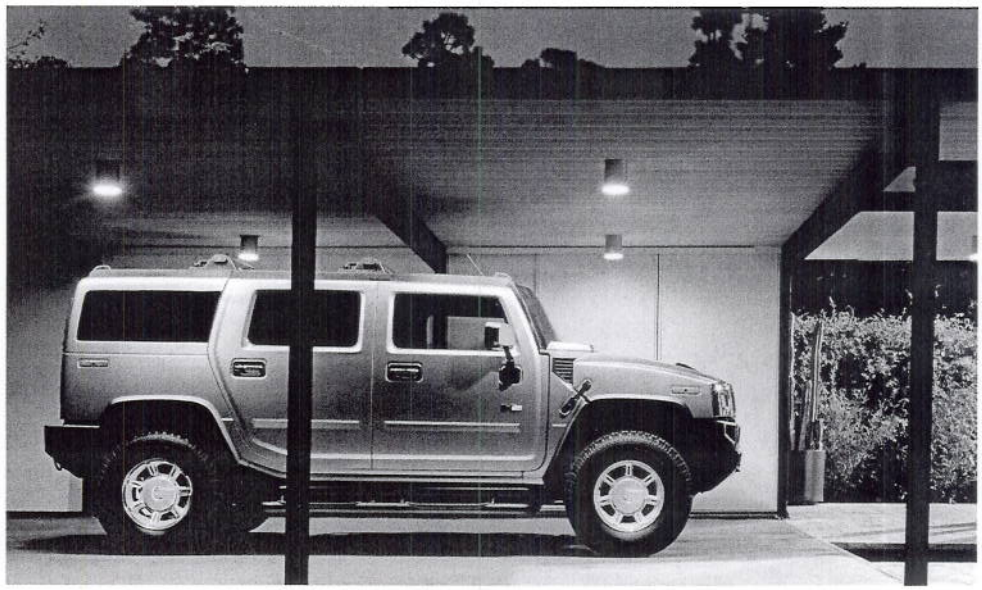
[2] The tendency of general audiences to resist the *new* is a function of their familiarity with the *old*. It often takes several generations to erode population biases sufficiently such that the merits of a new design can be objectively considered.

Defining success criteria is essential to good design. For example, if the success criteria for a watch are defined in terms of speed and accuracy, the digital display is superior. If the success criteria are defined in terms of pure aesthetics, the minimalist analog display is superior (the pure function of the digital display has not yet translated to a popular aesthetic for general audiences). In all cases, the success criteria should direct design decisions and trade-offs, and should be the primary consideration in determining the specifications for a design.



Function ——— Form





Perhaps no purer functional form exists than the original Humvee. Born out of military specifications, the success of the Humvee in combat led to the commercial successors—Hummer H1 and H2. Each represents a unique and compelling aesthetic that results from purity of function and minimal ornamentation.

Good Continuation

Elements arranged in a straight line or a smooth curve are perceived as a group, and are interpreted as being more related than elements not on the line or curve.

Good continuation is one of several principles referred to as *Gestalt principles of perception*. It asserts that aligned elements are perceived as a single group or chunk, and are interpreted as being more related than unaligned elements. For example, speed markings on a speedometer are easily interpreted as a group because they are aligned along a linear or circular path.[1]

The principle of good continuation also explains why lines will generally be perceived as maintaining their established directions, versus branching or bending abruptly. For example, two V-shaped lines side by side appear simply as two V-shaped lines. When one V-shaped line is inverted and the other is placed above it (forming an X), the shape is interpreted as two opposing diagonal lines instead of two V-shaped lines—the less abrupt interpretation of the lines is dominant. A bar graph in which the bars are arranged in increasing or decreasing order so that the tops of the bars form a continuous line are more easily processed than bar arrangements in which the tops of the bars form a discontinuous, abrupt line.[2]

The ability to accurately perceive objects depends largely on the perceptibility of the corners and sharp curves that make up their shape. When sections of a line or shape are hidden from view, good continuation leads the eye to continue along the visible segments. If extensions of these segments intersect with minimal disruption, the elements along the line will be perceived as related. As the angle of disruption becomes more acute, the elements will be perceived as less related.[3]

Use good continuation to indicate relatedness between elements in a design. Locate elements such that their alignment corresponds to their relatedness, and locate unrelated or ambiguously related items on different alignment paths. Ensure that line extensions of related objects intersect with minimum line disruption. Arrange elements in graphs and displays such that end points of elements form continuous, rather than abrupt lines.

See also Alignment, Chunking, Five Hat Racks, and Uniform Connectedness.

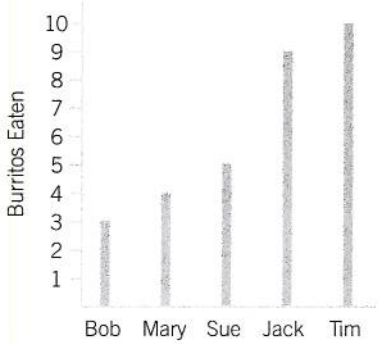
[1] The seminal work on good continuation is "Untersuchungen zür Lehre von der Gestalt, II" [Laws of Organization in Perceptual Forms] by Max Wertheimer, *Psychologische Forschung*, 1923, vol. 4, p. 301–350, reprinted in *A Source Book of Gestalt Psychology* by Willis D. Ellis (ed.), Routledge & Kegan Paul, *1999*, p. 71–88. See also *Principles of Gestalt Psychology* by Kurt Koffka, Harcourt Brace, 1935.

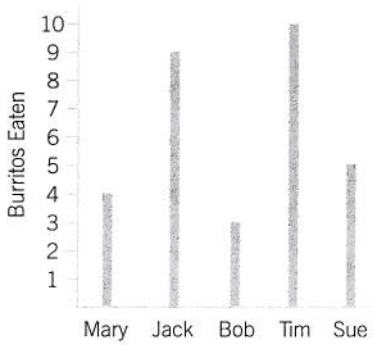
[2] See, for example, *Elements of Graph Design* by Stephen M. Kosslyn, W. H Freeman and Company, 1994, p. 7.

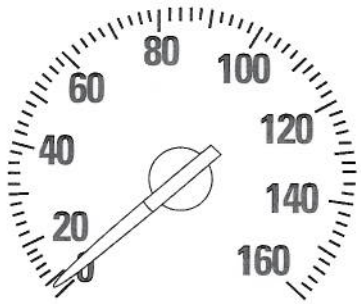
[3] See, for example, "Convexity in Perceptual Completion: Beyond Good Continuation" by Zili Liu, David W. Jacobs, and Ronen Basri, *Vision Research*, 1999, vol. 39, p. 4244–4257.

Despite the gaps, the jagged line is still seen as a single object because the occlusions can be bridged with minimal disruption.

The first graph is easier to read than the second because the end points of its bars form a line that is more continuous.







The circular alignment of the increments of this speedometer make it evident that the numbers and increments along the lines belong together.

Good continuation is commonly used in camouflage. For example, the lines on zebras continue across one another when in a herd, making it difficult for predators to target any one zebra.

Hierarchy

Hierarchical organization is the simplest structure for visualizing and understanding complexity.

Increasing the visibility of the hierarchical relationships within a system is one of the most effective ways to increase knowledge about the system. Examples of visible hierarchies are book outlines, multi-level software menus, and classification diagrams. Perception of hierarchical relationships among elements is primarily a function of their relative left-right and top-down positions, but is also influenced by their proximity, size, and the presence of connecting lines. Superordinate elements are commonly referred to as *parent* elements, and subordinate elements as *child* elements. There are three basic ways to visually represent hierarchy: trees, nests, and stairs.[1]

Tree structures illustrate hierarchical relationships by locating child elements below or to the right of parent elements, or through the use of other strategies indicating hierarchy (e.g., size, connecting lines). Tree structures are effective for representing hierarchies of moderate complexity, but can become cumbersome for large or complex hierarchies. Tree structures grow large quickly, and become tangled when multiple parents share common child elements. Tree structures are commonly used to represent overviews or high-level maps of system organization.

Nest structures illustrate hierarchical relationships by visually containing child elements within parent elements, as in a Venn diagram. Nest structures are most effective when representing simple hierarchies. When the relationships between the different levels of the hierarchy become too dense and complex to be clearly distinguishable, nest structures become less effective. Nest structures are most commonly used to group information and functions, and to represent simple logical relationships.

Stair structures illustrate hierarchical relationships by stacking child elements below and to the right of parent elements, as in an outline. Stair structures are effective for representing complex hierarchies, but are not easily browsed, and falsely imply a sequential relationship between the stacked child elements. Interactive stair structures found in software often deal with the former problem by concealing child elements until a parent element is selected. Stair structures are commonly used to represent large system structures that change over time.[2]

Hierarchical representation is the simplest method of increasing knowledge about the structure of a system. Consider tree structures when representing high-level views of hierarchies of moderate complexity. Consider nest structures when representing natural systems, simple hierarchical relationships, and grouped information or functions. Consider stair structures when representing complex hierarchies, especially if the volatility and growth of the system represented is unpredictable. Explore ways to selectively reveal and conceal the complexity of hierarchical structures to maximize their clarity and effectiveness.[3]

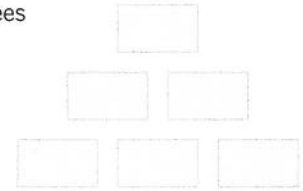
See also Advance Organizer, Alignment, Five Hat Racks, Layering, and Proximity.

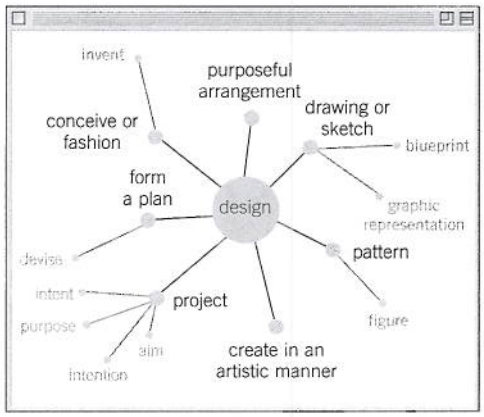
[1] The seminal works on hierarchy are "The Architecture of Complexity," Proceedings of the American Philosophical Society, 1962, vol. 106, p. 467–482; and The Sciences of the Artificial, MIT Press, 1969, both by Herbert A. Simon.

[2] Note that stair hierarchies in software are often referred to as tree hierarchies.

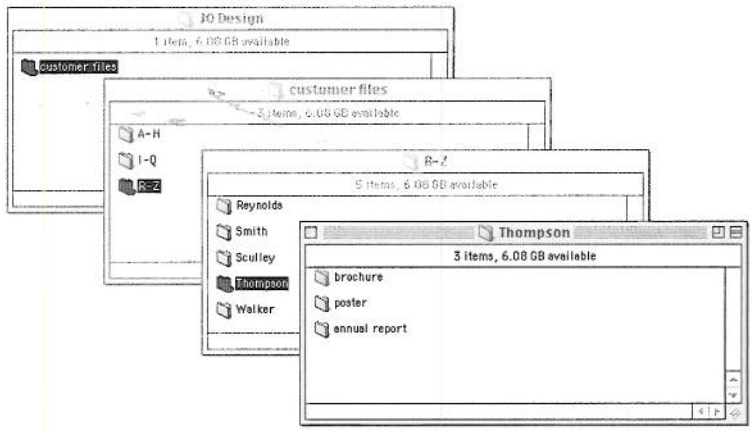
[3] Representing these structures in three-dimensional space improves little in terms of clarity and comprehensibility—though it does result in some fascinating structures to view and navigate. See, for example, "Cone Trees: Animated 3D Visualizations of Hierarchical Information" by George G. Robertson, Jock D. Mackinlay, Stuart K. Card, *Proceedings of CHI '91: Human Factors in Computing Systems*, 1991, p. 189–194.

Trees

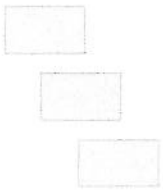


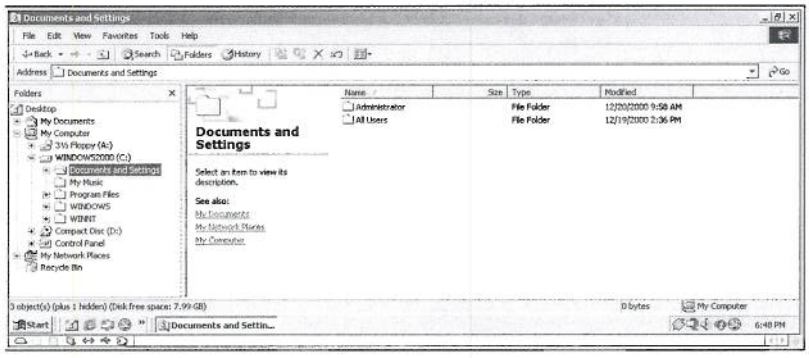


Nests



Stairs





Highlighting

A technique for bringing attention to an area of text or image.

Highlighting is an effective technique for bringing attention to elements of a design. If applied improperly, however, highlighting can be ineffective, and actually reduce performance in these areas. The following guidelines address the benefits and liabilities of common highlighting techniques.[1]

General

Highlight no more than 10 percent of the visible design; highlighting effects are diluted as the percentage increases. Use a small number of highlighting techniques applied consistently throughout the design.

Bold, Italics, and Underlining

Use bold, italics, and underlining for titles, labels, captions, and short word sequences when the elements need to be subtly differentiated. Bolding is generally preferred over other techniques as it adds minimal noise to the design and clearly highlights target elements. Italics add minimal noise to a design, but are less detectable and legible. Underlining adds considerable noise and compromises legibility, and should be used sparingly if at all.[2]

Typeface

Uppercase text in short word sequences is easily scanned, and thus can be advantageous when applied to labels and keywords within a busy display. Avoid using different fonts as a highlighting technique. A detectable difference between fonts is difficult to achieve without also disrupting the aesthetics of the typography.

Color

Color is a potentially effective highlighting technique, but should be used sparingly and only in concert with other highlighting techniques. Highlight using a few desaturated colors that are clearly distinct from one another.

Inversing

Inversing elements works well with text, but may not work as well with icons or shapes. It is effective at attracting attention, but adds considerable noise to the design and therefore should be used sparingly.

Blinking

Blinking—flashing an element between two states—is a powerful technique for attracting attention. Blinking should be used only to indicate highly critical information that requires an immediate response, such as an emergency status light. It is important to be able to turn off the blinking once it is acknowledged, as it compromises legibility, and distracts from other tasks.

See also Color, Legibility, and Readability.

[1] See, for example, "A Review of Human Factors Guidelines and Techniques for the Design of Graphical Human-Computer Interfaces" by Martin Maguire, *International Journal of Man-Machine Studies*, 1982, vol. 16(3), p. 237–261.

[2] A concise summary of typographic principles of this kind is found in *The Mac is Not a Typewriter* by Robin Williams, Peachpit Press, 1990. Despite the title, the book is of value to non-Macintosh owners as well.

General

"**You mean you can't take less**," said the Hatter, "**it's very easy to take more than nothing**."

"**Nobody asked your opinion**," said Alice.

"You mean you can't take **less**," said the Hatter, "it's very easy to take **more** than nothing."

"Nobody asked **your** opinion," said Alice.

Bold, Italics, and Underlining

Advice from a Caterpillar

"I can't explain **myself**, I'm afraid, sir" said Alice, "because I'm not myself, you see."

Advice from a Caterpillar

"I can't explain *myself*, I'm afraid, sir" said Alice, "because I'm not myself, you see."

Advice from a Caterpillar

"I can't explain myself, I'm afraid, sir" said Alice, "because I'm not myself, you see."

Typeface

"What is a Caucus-race?" said Alice; not that she wanted much to know, but the Dodo had paused as if it thought that somebody ought to speak, and no one else seemed inclined to say anything.

"What IS a Caucus-race?" said Alice; not that she wanted much to know, but the Dodo had paused as if it thought that SOMEBODY ought to speak, and no one else seemed inclined to say anything.

Color

Which brought them back again to the beginning of the conversation. Alice felt a little irritated at the Caterpillar's making such very short remarks, and she drew herself up and said, very gravely, "I think, you ought to tell me who you are, first."

Which brought them back again to the beginning of the conversation. Alice felt a little irritated at the Caterpillar's making such very short remarks, and she drew herself up and said, very gravely, "I think, you ought to tell me who you are, first."

Inversing

Who stole the tarts?

Who stole the tarts?

Iconic Representation

The use of pictorial images to improve the recognition and recall of signs and controls.

Iconic representation is the use of pictorial images to make actions, objects, and concepts in a display easier to find, recognize, learn, and remember. Iconic representations are used in signage, computer displays, and control panels. They can be used for identification (company logo), serve as a space-efficient alternative to text (road signs), or to draw attention to an item within an informational display (error icons appearing next to items in a list). There are four types of iconic representation: *similar*, *example*, *symbolic*, and *arbitrary*.[1]

Similar icons use images that are visually analogous to an action, object, or concept. They are most effective at representing simple actions, objects, or concepts, and less effective when the complexity increases. For example, a sign indicating a sharp curve ahead can be represented by a similar icon (e.g., curved line). A sign to reduce speed, however, is an action not easily represented by similar icons.

Example icons use images of things that exemplify or are commonly associated with an action, object, or concept. They are particularly effective at representing complex actions, objects, or concepts. For example, a sign indicating the location of an airport uses an image of an airplane, rather than an image representing an airport.

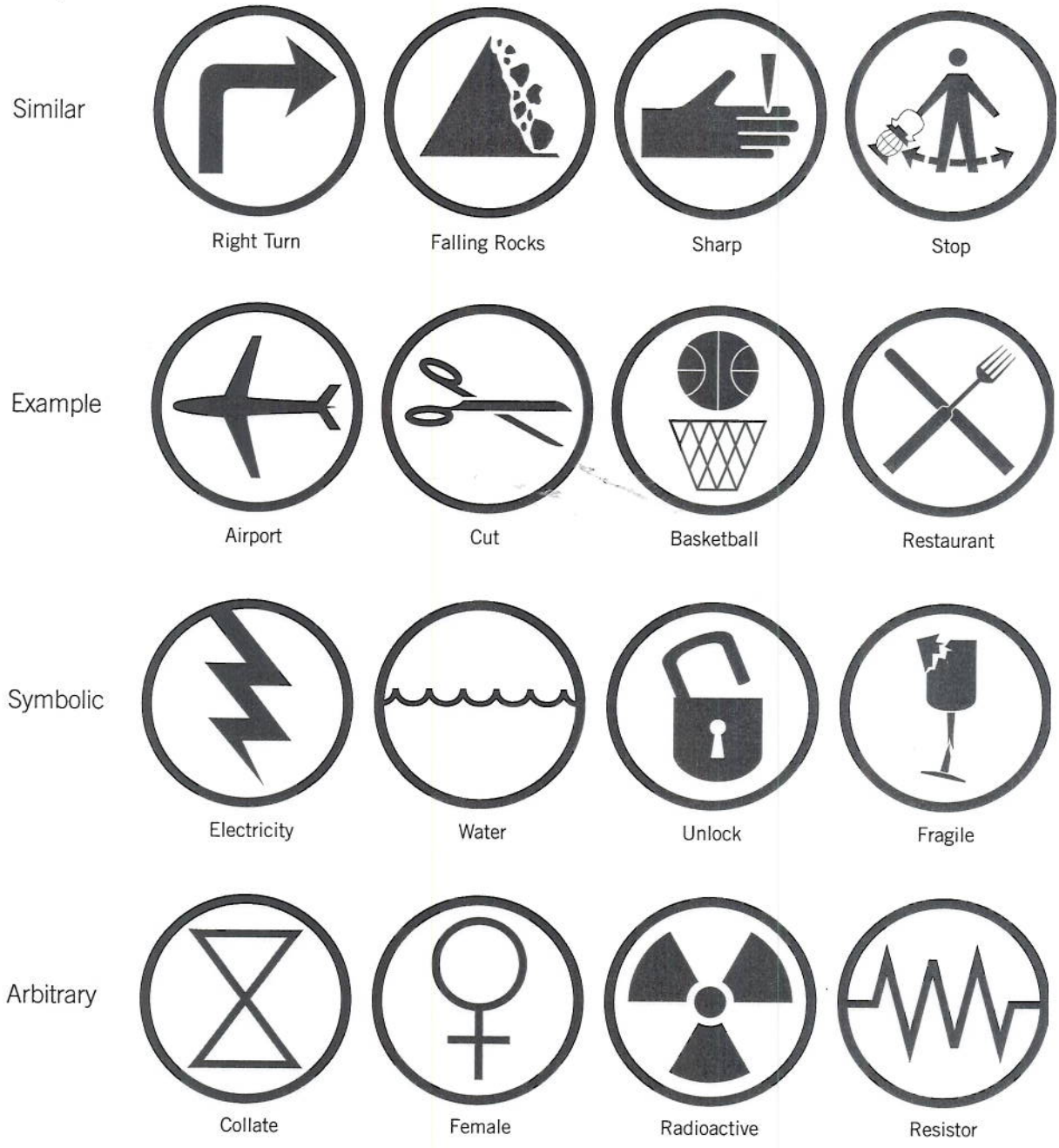
Symbolic icons use images that represent an action, object, or concept at a higher level of abstraction. They are effective when actions, objects, or concepts involve well-established and easily recognizable objects. For example, a door lock control on a car door uses an image of a padlock to indicate its function, even though the padlock looks nothing like the actual control.

Arbitrary icons use images that bear little or no relationship to the action, object, or concept—i.e., the relationship has to be learned. Generally, arbitrary icons should only be used when developing cross-cultural or industry standards that will be used for long periods of time. This gives people sufficient exposure to an icon to make it an effective communication device. For example, the icon for radiation must be learned, as nothing intrinsic to the image indicates radiation. Those who work with radiation, however, recognize the symbol all over the world.

Iconic representation reduces performance load, conserves display and control area, and makes signs and controls more understandable across cultures. Consider similar icons when representations are simple and concrete. Use example icons when representations are complex. Consider symbolic icons when representations involve well-established and recognizable symbols. Consider arbitrary icons when representations are to be used as standards. Generally, icons should be labeled and share a common visual motif (style and color) for optimal performance.

See also Chunking, Performance Load, and Picture Superiority Effect.

[1] The seminal work in iconic representation is *Symbol Sourcebook* by Henry Dreyfuss, Van Nostrand Reinhold, 1984. The four kinds of iconic representation are derived from "Icons at the Interface: Their Usefulness" by Yvonne Rogers, *Interacting With Computers*, vol. 1, p. 105–118.


Similar
Right Turn
Falling Rocks
Sharp
Stop
Example
Airport
Cut
Basketball
Restaurant
Symbolic
Electricity
Water
Unlock
Fragile
Arbitrary
Collate
Female
Radioactive
Resistor

Interference Effects

A phenomenon in which mental processing is made slower and less accurate by competing mental processes.

Interference effects occur when two or more perceptual or cognitive processes are in conflict. Human perception and cognition involve many different mental systems that parse and process information independently of one another. The outputs of these systems are communicated to working memory, where they are interpreted. When the outputs are congruent, the process of interpretation occurs quickly and performance is optimal. When outputs are incongruent, interference occurs and additional processing is needed to resolve the conflict. The additional time required to resolve such conflicts has a negative impact on performance. A few examples of interference effects include:[1]

Stroop Interference—an irrelevant aspect of a stimulus triggers a mental process that interferes with processes involving a relevant aspect of the stimulus. For example, the time it takes to name the color of words is greater when the meaning and color of the words conflict.

Garner Interference—an irrelevant variation of a stimulus triggers a mental process that interferes with processes involving a relevant aspect of the stimulus. For example, the time it takes to name shapes is greater when they are presented next to shapes that change with each presentation.

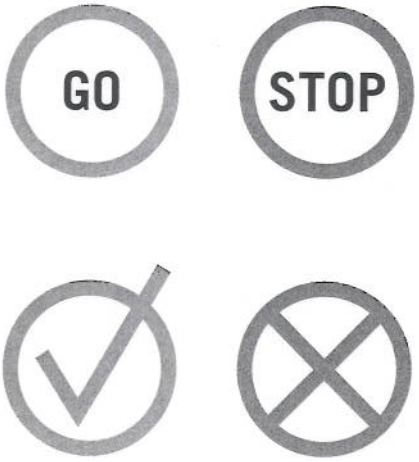
Proactive Interference—existing memories interfere with learning. For example, in learning a new language, errors are often made when people try to apply the grammar of their native language to the new language.

Retroactive Interference—learning interferes with existing memories. For example, learning a new phone number can interfere with phone numbers already in memory.

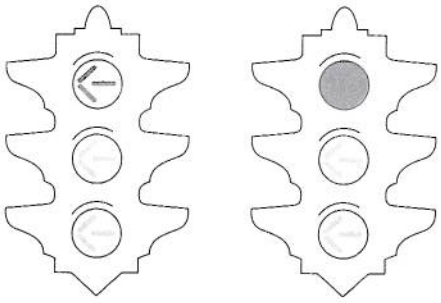
Prevent interference by avoiding designs that create conflicting mental processes. Interference effects of perception (i.e., Stroop and Garner) generally result from conflicting coding combinations (e.g., a red *go* button, or green *stop* button) or from an interaction between closely positioned elements that visually interact with one another (e.g., two icons group or blend because of their shape and proximity). Minimize interference effects of learning (i.e., proactive and retroactive) by mixing the presentation modes of instruction (e.g., lecture, video, computer, activities), employing advance organizers, and incorporating periods of rest every thirty to forty-five minutes.

See also Advance Organizer, Performance Load, Errors, and Mapping.

[1] The seminal works on interference effects include "Studies of Interference in Serial Verbal Reactions" by James R. Stroop, *Journal of Experimental Psychology*, 1935, vol. 28, p. 643–662; "Stimulus Configuration in Selective Attention Tasks" by James R. Pomerantz and Wendell R. Garner, *Perception & Psychophysics*, 1973, vol. 14, p. 565–569; and "Characteristics of Word Encoding" by Delos D. Wickens, in *Coding Processes in Human Memory* edited by A. W. Melton and E. Martin, V. H. Winston, 1972, p. 191–215.



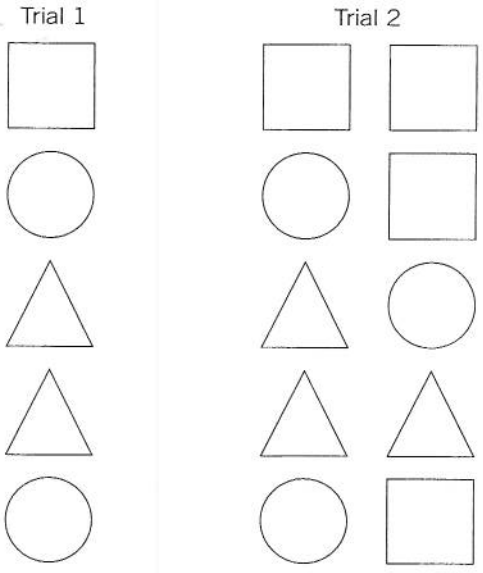
In populations that have learned that green means go and red means stop, the incongruence between the color and the label-icon results in interference.



In populations that have learned that a traffic arrow always means go, the introduction of a red arrow in new traffic lights creates potentially dangerous interference.

Red Black White
Pink Green Orange
Yellow Purple Gray

Reading the words aloud is easier than naming their colors. The mental process for reading is more practiced and automatic and, therefore, interferes with the mental process for naming the colors.



Naming the column of shapes that stands alone is easier than naming either of the columns located together. The close proximity of the columns results in the activation of mental processes for naming proximal shapes, creating interference.

Law of Prägnanz

A tendency to interpret ambiguous images as simple and complete, versus complex and incomplete.[1]

The Law of Prägnanz is one of several principles referred to as *Gestalt principles of perception.* It asserts that when people are presented with a set of ambiguous elements (elements that can be interpreted in different ways), they interpret the elements in the simplest way. Here, "simplest" refers to arrangements having fewer rather than more elements, having symmetrical rather than asymmetrical compositions, and generally observing the other Gestalt principles of perception.[2]

For example, a set of shapes that touches at their edges could be interpreted as either adjacent or overlapping. When the shapes are complex, the simplest interpretation is that they are adjacent like pieces in a puzzle. When the shapes are simple, the simplest interpretation is that they overlap one another. The law applies similarly to the way in which images are recalled from memory. For example, people recall the positions of countries on maps as more aligned and symmetrical than they actually are.

The tendency to perceive and recall images as simply as possible indicates that cognitive resources are being applied to translate or encode images into simpler forms. This suggests that fewer cognitive resources may be needed if images are simpler at the outset. Research supports this idea and confirms that people are better able to visually process and remember simple figures than complex figures.[3]

Therefore, minimize the number of elements in a design. Note that symmetrical compositions are perceived as simpler and more stable than asymmetrical compositions, but symmetrical compositions are also perceived to be less interesting. Favor symmetrical compositions when efficiency of use is the priority, and asymmetrical compositions when interestingness is the priority. Consider all of the Gestalt principles of perception (closure, common fate, figure-ground relationship, good continuation, proximity, similarity, and uniform connectedness).

See also Aesthetic-Usability Effect, Ockham's Razor, and Rule of Thirds.

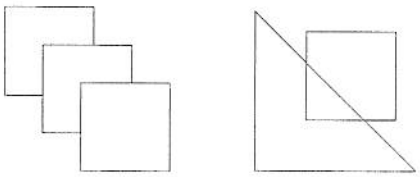
[1] Also known as the *law of good configuration, law of simplicity, law of pregnance, law of precision,* and *law of good figure.*

[2] The seminal work on the Law of Prägnanz is *Principles of Gestalt Psychology* by Kurt Koffka, Harcourt Brace, 1935.

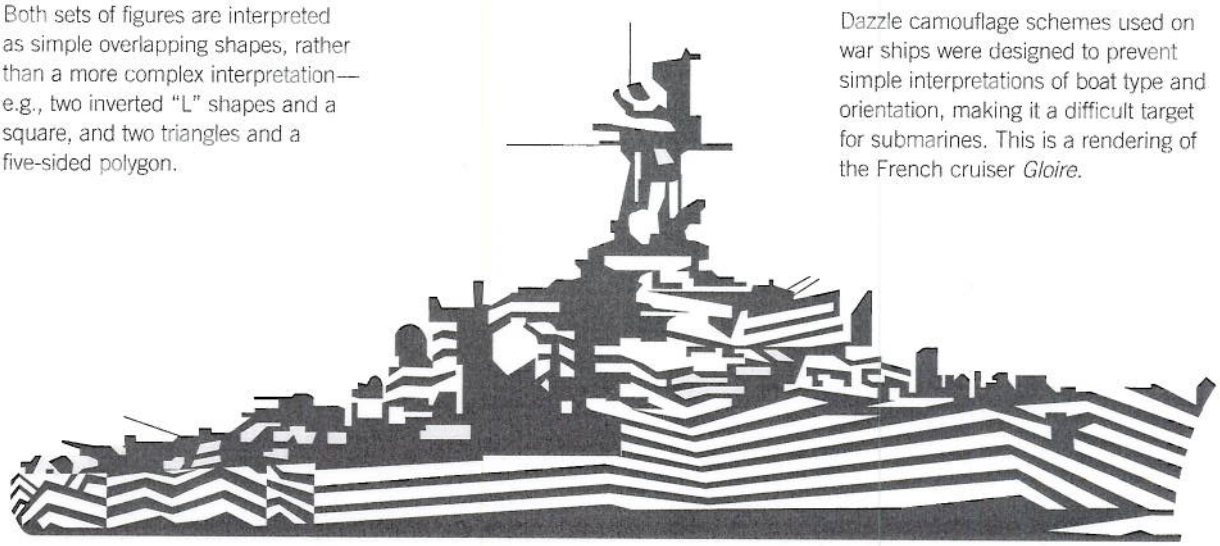
[3] See, for example, "The Status of Minimum Principle in the Theoretical Analysis of Visual Perception" by Gary Hatfield and William Epstein, *Psychological Bulletin,* 1985, vol. 97, p. 155–186.

Low resolution images (left) of a rock formation on Mars led many to conclude that intelligent life once existed there. Higher-resolution images (right) taken some years later suggest a more Earth-based explanation: Humans tend to add order and meaning to patterns and formations that do not exist outside their perception.

These sets of characters are interpreted as single faces rather than multiple independent characters.



Both sets of figures are interpreted as simple overlapping shapes, rather than a more complex interpretation—e.g., two inverted "L" shapes and a square, and two triangles and a five-sided polygon.



Dazzle camouflage schemes used on war ships were designed to prevent simple interpretations of boat type and orientation, making it a difficult target for submarines. This is a rendering of the French cruiser *Gloire*.

Layering

The process of organizing information into related groupings in order to manage complexity and reinforce relationships in the information.

Layering involves organizing information into related groupings and then presenting or making available only certain groupings at any one time. Layering is primarily used to manage complexity, but can also be used to reinforce relationships in information. There are two basic kinds of layering: two-dimensional and three-dimensional.[1]

Two-dimensional layering involves separating information into layers such that only one layer of information can be viewed at a time. Two-dimensional layers can be revealed in either a linear or nonlinear fashion. Linear layers are useful when information has a clear beginning, middle, and end (e.g., stories), and are revealed successively like pages in a book. Nonlinear layers are useful when reinforcing relationships between the layers. The types of nonlinear layer relationships can be hierarchical, parallel, or web. Hierarchical layers are useful when information has superordinate and subordinate relationships within itself (e.g., organizational chart), and are revealed top-down or bottom-up in rigid accordance with the hierarchical structure. Parallel layers are useful when information is based on the organization of other information (e.g., thesaurus), and are revealed through some correspondence with that organization. Web layers are useful when information has many different kinds of relationships within itself (e.g., hypertext), and are revealed through any number of associative linkages to other layers.

Three-dimensional layering involves separating information into layers such that multiple layers of information can be viewed at a time. Three-dimensional layers are revealed as either opaque or transparent planes of information that sit atop one another (i.e., in a third dimension). Opaque layers are useful when additional information about a particular item is desired without switching contexts (e.g., software pop-up windows). Transparent layers are useful when overlays of information combine to illustrate concepts or highlight relationships (e.g., weather maps).[2]

Use two-dimensional layering to manage complexity and direct navigation through information. Consider linear layers when telling stories and presenting sequences of time-based events, and use nonlinear layers when emphasizing relationships within the information. Use three-dimensional layering to elaborate information and illustrate concepts without switching contexts. Consider opaque layers when presenting elaborative information, and transparent layers when illustrating concepts or highlighting relationships in information.

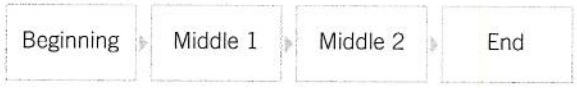
See also Chunking, Five Hat Racks, and Progressive Disclosure.

[1] A similar concept is found in *Designing Business: Multiple Media, Multiple Disciplines* by Clement Mok, Adobe Press, 1996, p. 102–107 [Organizational Models].

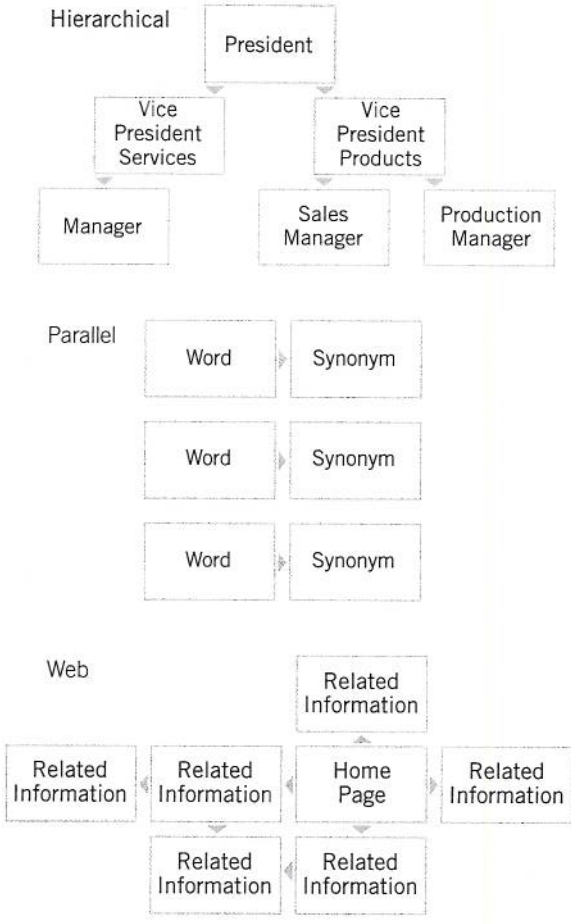
[2] See, for example, *Envisioning Information* by Edward R. Tufte, Graphics Press, 1998, p. 53–65; 81–95 [Layering and Separation; Color and Information].

Two-Dimensional Layering

Linear



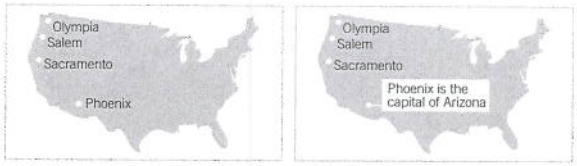
Nonlinear



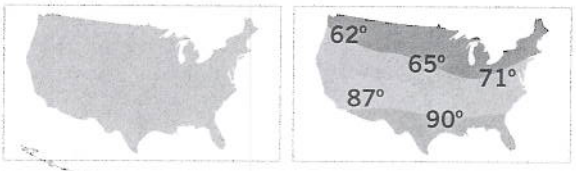
Two-dimensional layering is useful for presentation and navigation. Layers are revealed one at a time, like pages in a book.

Three-Dimensional Layering

Opaque



Transparent



Three-dimensional layering is useful for elaboration and highlighting. Relationships and patterns on one layer of information (left) are elaborated by layers of information that pop up or overlay (right).

Ockham's Razor

Given a choice between functionally equivalent designs, the simplest design should be selected.[1]

Ockham's razor asserts that simplicity is preferred to complexity in design. Many variations of the principle exist, each adapted to address the particulars of a field or domain of knowledge. A few examples include:

- "Entities should not be multiplied without necessity."—William of Ockham
- "That is better and more valuable which requires fewer, other circumstances being equal."—Robert Grosseteste
- "Nature operates in the shortest way possible."—Aristotle
- "We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances."—Isaac Newton
- "Everything should be made as simple as possible, but not simpler." —Albert Einstein

Implicit in Ockham's razor is the idea that unnecessary elements decrease a design's efficiency, and increase the probability of unanticipated consequences. Unnecessary weight, whether physical, visual, or cognitive, degrades performance. Unnecessary design elements have the potential to fail or create problems. There is also an aesthetic appeal to the principle, which likens the "cutting" of unnecessary elements from a design to the removal of impurities from a solution—the design is a cleaner, purer result.

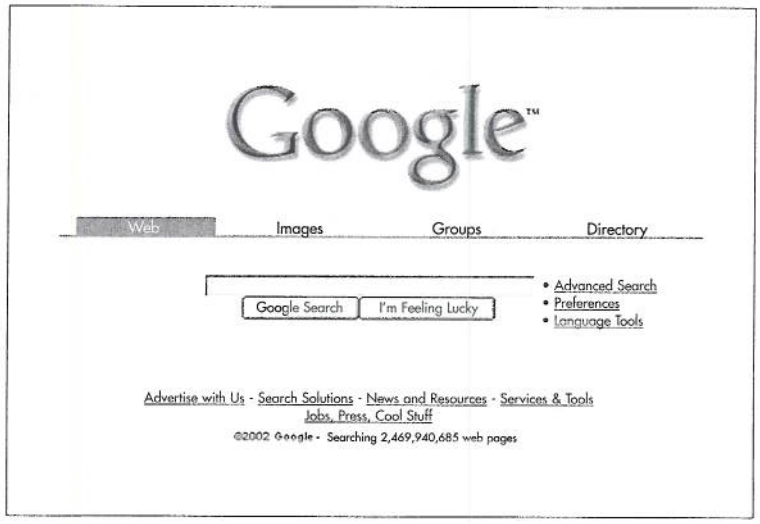
Use Ockham's razor to evaluate and select among multiple, functionally equivalent designs. Functional equivalence here refers to comparable performance of a design on common measures. For example, given two functionally equivalent displays—equal in information content and readability—select the display with the fewest visual elements. Evaluate each element within the selected design and remove as many as possible without compromising function. Finally, minimize the expression of the remaining elements as much as possible without compromising function.[2]

See also Form Follows Function, Mapping, and Signal-to-Noise Ratio.

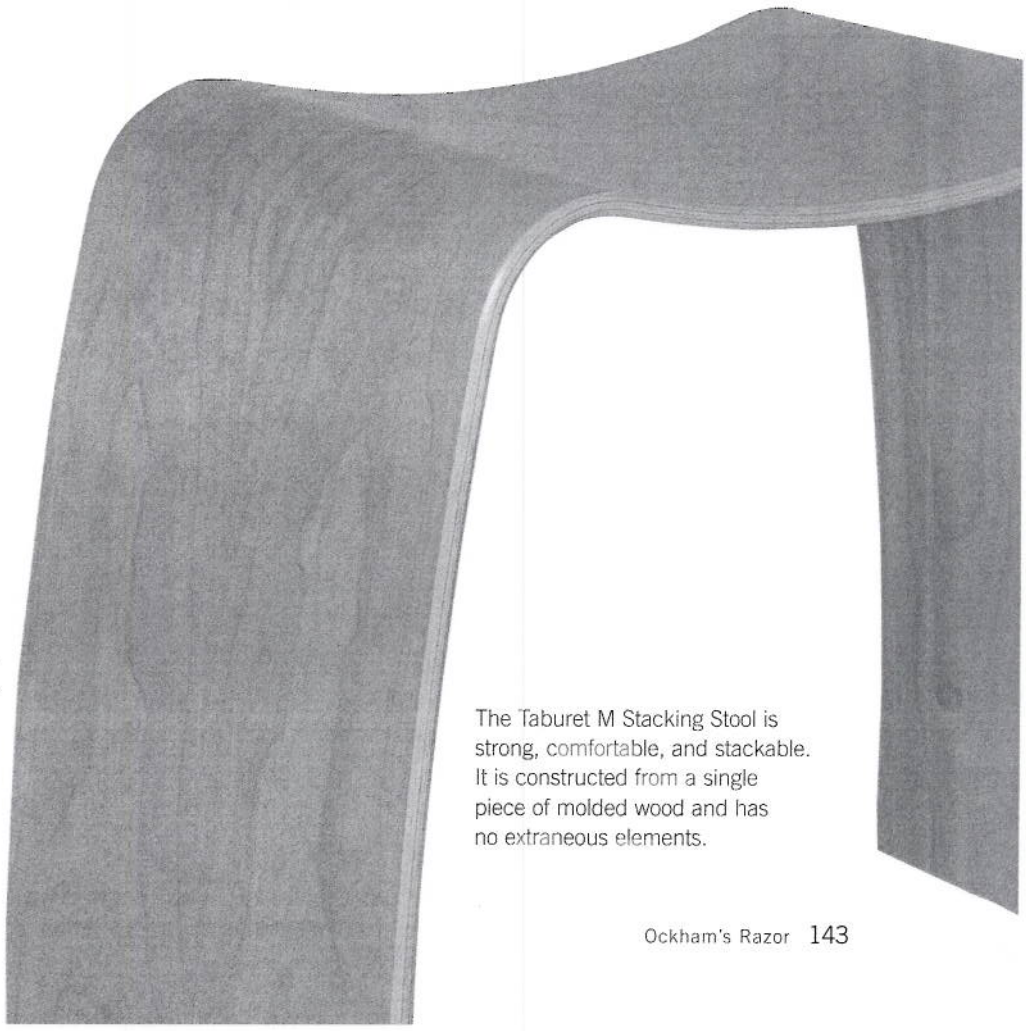
[1] Also known as *Occam's razor, law of parsimony, law of economy,* and *principle of simplicity*. The term "Ockham's razor" references William of Ockham, a 14th century Franciscan friar and logician who purportedly made abundant use of the principle. The principle does not actually appear in any of his extant writings and, in truth, little is known about either the origin of the principle or its originator. See, for example, "The Myth of Occam's Razor" by W. M. Thorburn, *Mind*, 1918, vol. 27, p. 345–353.

[2] "Make all visual distinctions as subtle as possible, but still clear and effective. " *Visual Explanations* by Edward R. Tufte, Graphics Press, 1998, p. 73.

The Yamaha Compact Silent Electric Cello is a minimalist cello with only those portions touched by the player represented. Musicians can hear concert-quality cello sound through headphones while creating little external sound, or through an amplifier and speakers for public performances. The cello can also be collapsed for easy transport and storage.



While other Internet search services were racing to add advertising and ad hoc functions to their Web sites, Google kept its design simple and efficient. The result is the best performing and easiest to use search service on the Web.



The Taburet M Stacking Stool is strong, comfortable, and stackable. It is constructed from a single piece of molded wood and has no extraneous elements.

Orientation Sensitivity

A phenomenon of visual processing in which certain line orientations are more quickly and easily processed and discriminated than other line orientations.

The efficiency with which people can perceive and make judgments about the orientation of lines is influenced by a number of factors. For example, the time displayed on a standard analog clock can be quickly interpreted because the numbers are positioned at 30-degree increments around the center. The 30-degree increment happens to correspond to the minimum recommended difference in line orientation required to be easily detectable; i.e., differences in line orientation of less than 30 degrees require more effort to detect. Orientation sensitivity is based on two phenomena that are observed in visual perception: oblique effect and pop-out effect.[1]

The *oblique* effect is the ability to more accurately perceive and judge line orientations that are close to vertical and horizontal, than line orientations that are oblique. For example, in tasks where people have to estimate the relative orientation of a line by any number of methods (e.g., redrawing from memory), the most accurate judgments are for horizontal and vertical lines, and the least accurate judgments are for oblique lines. The oblique effect is caused by a greater sensitivity of neurons to vertical and horizontal stimuli than to oblique stimuli. Additionally, people tend to make judgments about line orientation that are biased toward the nearest vertical or horizontal axis; lines oriented close to the vertical or horizontal axis will often be perceived or recalled as truly vertical or horizontal. Designs in which the primary elements are vertical or horizontal are also considered generally more aesthetic than designs in which primary elements are oblique.[2]

The *pop-out* effect is the tendency of certain elements in a display to pop out as figure elements, and as a result be quickly and easily detected. For example, in tasks where people have to identify a target line against a background of lines of a common orientation, the target line is easily detected when it differs from the background lines by 30 degrees or more. The pop-out effect is caused by a change in the visual stimuli sufficient to activate additional input neurons, which then help to detect differences in line orientation and patterns. The effect is strongest when combined with the oblique effect; it is easier to detect subtle differences in the orientation of a target line against a background of vertical and horizontal lines, than against a background of oblique lines.[3]

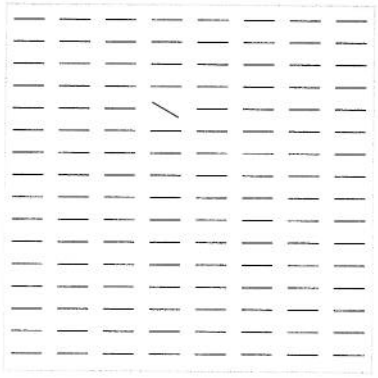
Consider orientation sensitivity in compositions requiring discrimination between different lines or textures, or decisions based on the relative position of elements. Facilitate discrimination between linear elements by making their orientation differ by more than 30 degrees. In displays requiring estimates of orientation or angle, provide visual indicators at 30-degree increments to improve accuracy in oblique regions. Use horizontal and vertical lines as visual anchors to enhance aesthetics and maximize discrimination with oblique elements.

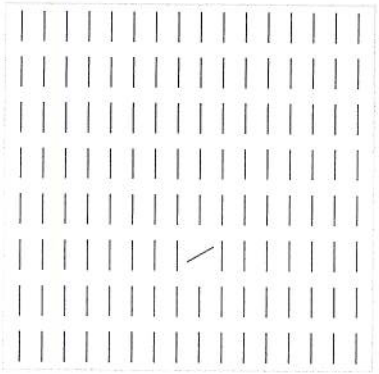
See also Closure, Constancy, Figure-Ground Relationship, and Good Continuation.

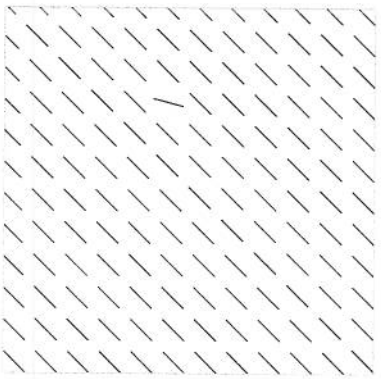
[1] The seminal works on orientation sensitivity include "On the Judgment of Angles and Positions of Lines" by Joseph Jastrow, *American Journal of Psychology*, 1893, vol. 5, p. 214–248; and "Perception and Discrimination As a Function of Stimulus Orientation: The "Oblique Effect" in Man and Animals" by Stuart Appelle, *Psychological Bulletin*, 1972, vol. 78, p. 266-278.

[2] "An Oblique Effect in Aesthetics: Homage to Mondrian (1872–1944)" by Richard Latto, Douglas Brain, and Brian Kelly, *Perception*, 2000, vol. 29(8), p. 981–987.

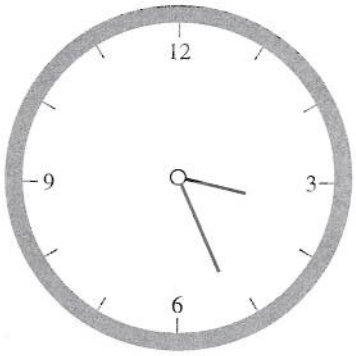
[3] See, for example, "Texture Segmentation and Pop-Out from Orientation Contrast" by Christoph Nothdurft, *Vision Research*, 1991, vol. 31, p. 1073–1078.

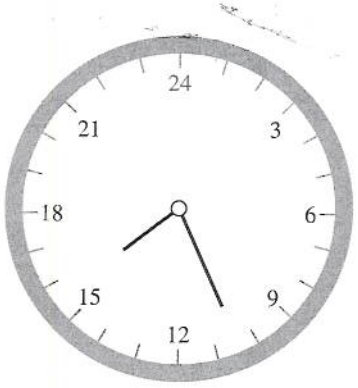




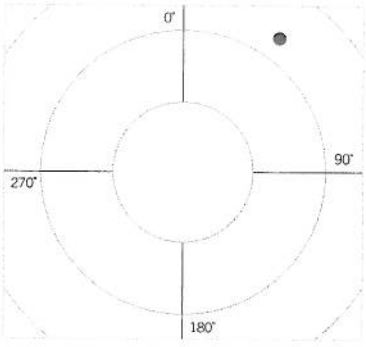


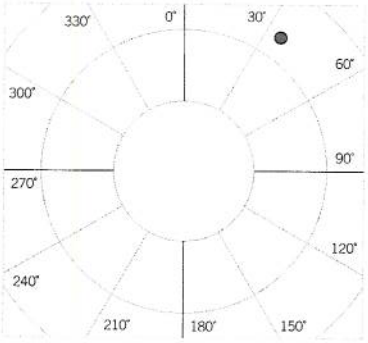
Differences in line orientation are most easily detected when set against vertical or horizontal lines.





Standard analog clocks are easily read because numbers are separated by 30 degrees. However, the same time on a twenty-four hour clock is more difficult to read because numbers are separated by only 15 degrees.





Systems that require precise estimation of orientation and position should be designed to accommodate orientation sensitivity. For example, radar-tracking displays should indicate orientation by providing markers in 30-degree increments or less. Without the markers, estimates in oblique regions of the display will be prone to error.

Picture Superiority Effect

Pictures are remembered better than words.[1]

It is said that a picture is worth a thousand words, and it turns out that in most cases, this is true. Pictures are generally more easily recognized and recalled than words, although memory for pictures and words together is superior to memory for words alone or pictures alone. For example, instructional materials and technical manuals that present textual information accompanied by supporting pictures enable information recall that is better than that produced by either the text or pictures alone. The picture superiority effect is commonly used in instructional design, advertising, technical writing, and other design contexts requiring easy and accurate recall of information.[2]

When information recall is measured immediately after the presentation of a series of pictures or words, recall performance for pictures and words is equal. The picture superiority effect applies only when people are asked to recall something after more than thirty seconds from the time of exposure. The picture superiority effect is strongest when the pictures represent common, concrete things versus abstract things, such as a picture of a flag versus a picture depicting the concept of freedom, and when pictures are distinct from one another, such as a mix of objects versus objects of a single type.

The picture superiority effect advantage increases further when people are casually exposed to information and the exposure time is limited. For example, an advertisement for a clock repair shop that includes a picture of a clock will be better recalled than the same advertisement without the picture. People not interested in clock repair who see the advertisement with the picture will also be better able to recall the brand if the need for clock repair service arises at a later time. The strength of the picture superiority effect diminishes as the information becomes more complex. For example, people are able to recall events from a story presented as a silent movie as well as events from the same story read as text.[3]

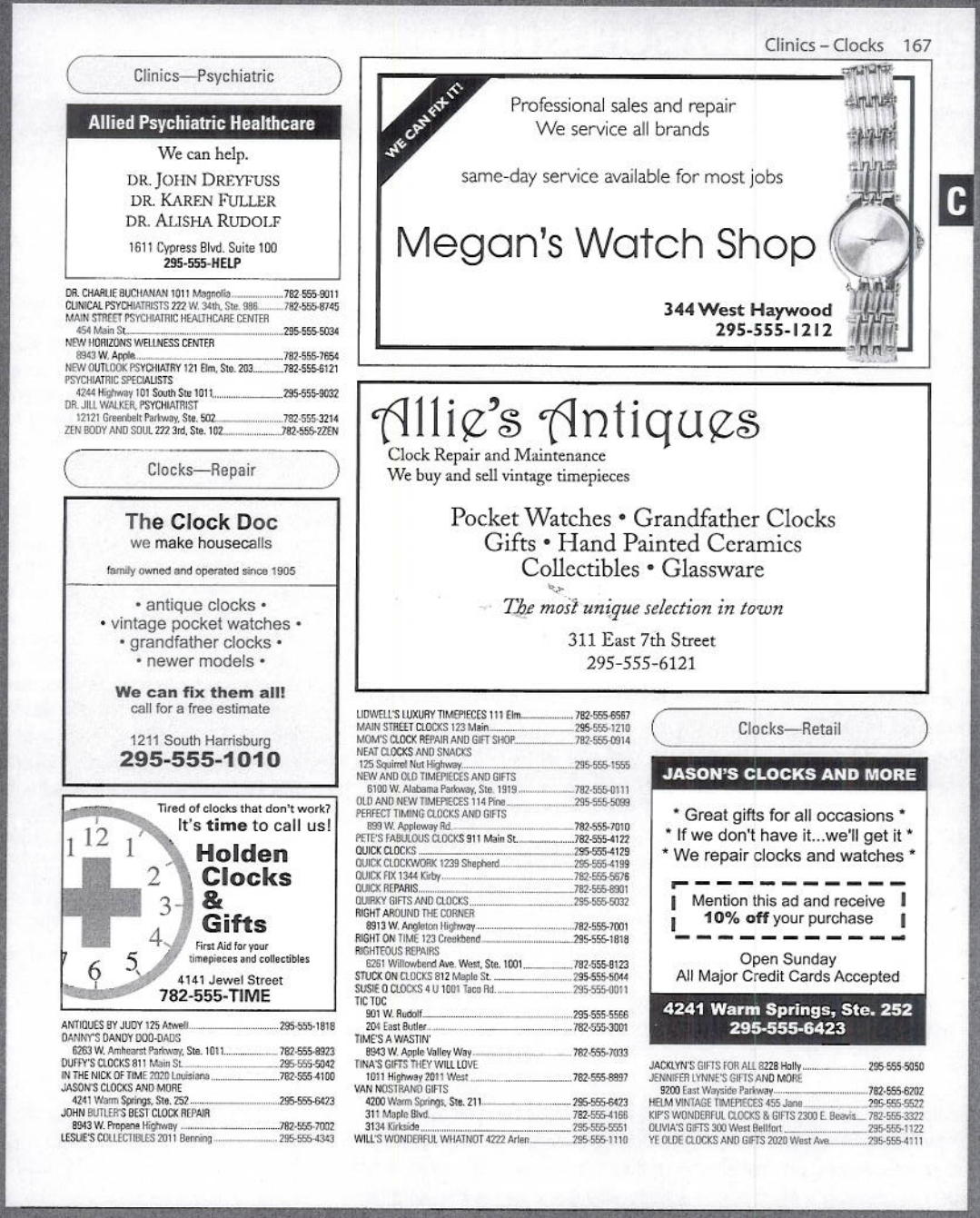
Use the picture superiority effect to improve the recognition and recall of key information. Use pictures and words together, and ensure that they reinforce the same information for optimal effect. Pictures and words that conflict create interference and dramatically inhibit recall. Consider the inclusion of meaningful pictures in advertising campaigns when possible, especially when the goal is to build company and product brand awareness.

See also Advance Organizer, Iconic Representation, Serial Position Effects, and von Restorff Effect.

[1] Also known as *pictorial superiority effect.*

[2] The seminal work on the picture superiority effect is "Why Are Pictures Easier to Recall than Words?" by Allan Paivio, T. B. Rogers, and Padric C. Smythe, *Psychonomic Science*, 1968, vol. 11(4), p. 137–138.

[3] See, for example, "Conditions for a Picture-Superiority Effect on Consumer Memory" by Terry L. Childers and Michael J. Houston, *Journal of Consumer Research*, 1984, vol. 11, p. 643–654.



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Advertisements with text and pictures are more likely to be looked at and recalled than advertisements with text only. This superiority of pictures over text is even stronger when the page is quickly scanned rather than read.

Proximity

Elements that are close together are perceived to be more related than elements that are farther apart.

The principle of proximity is one of several principles referred to as *Gestalt principles of perception*. It asserts that elements close together are perceived as a single group or chunk, and are interpreted as being more related than elements that are farther apart. For example, a simple matrix of dots can be interpreted as consisting of multiple rows, multiple columns, or as a uniform matrix, depending on the relative horizontal and vertical proximities of the dots.[1]

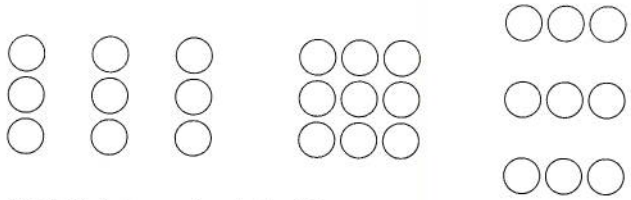
The grouping resulting from proximity reduces the complexity of designs and reinforces the relatedness of the elements. Conversely, a lack of proximity results in the perception of multiple, disparate chunks, and reinforces differences among elements. Certain proximal layouts imply specific kinds of relationships, and should be considered in layout design. For example, connecting or overlapping elements are commonly interpreted as sharing one or more common attributes, whereas proximal but non-contacting elements are interpreted as related but independent.[2]

Proximity is one of the most powerful means of indicating relatedness in a design, and will generally overwhelm competing visual cues (e.g., similarity). Arrange elements such that their proximity corresponds to their relatedness. Ensure that labels and supporting information are near the elements that they describe, opting for direct labeling on graphs over legends or keys. Locate unrelated or ambiguously related items relatively far from one another.

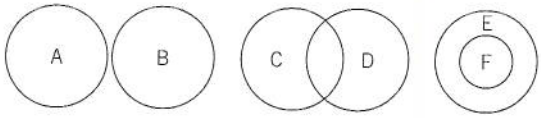
See also Chunking, Performance Load, and Similarity.

[1] The seminal work on proximity is "Untersuchungen zür Lehre von der Gestalt, II" [Laws of Organization in Perceptual Forms] by Max Wertheimer, Psychologische Forschung, 1923, vol. 4, p. 301–350, reprinted in *A Source Book of Gestalt Psychology* by Willis D. Ellis (ed.), Routledge & Kegan Paul, 1999, p. 71–88. See also *Principles of Gestalt Psychology* by Kurt Koffka, Harcourt Brace, 1935.

[2] Euler circles and Venn diagrams (methods of illustrating the relationships between sets of things in logic and mathematics) utilize this principle.

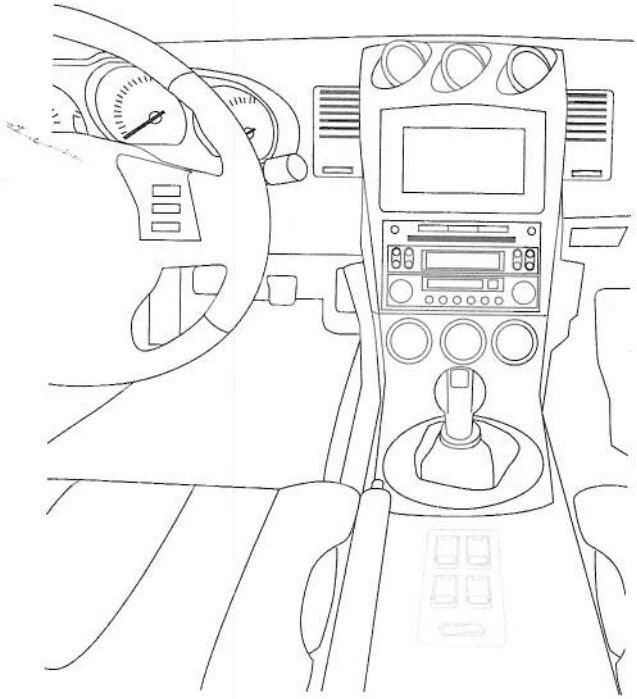


Proximity between the circles influences how they are grouped—as columns, a square group of circles, or rows.

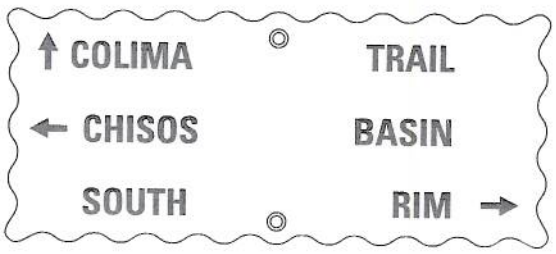


Circles *A* and *B* are perceived as independent and sharing no attributes. Circles *C* and *D* are perceived as partially dependent and sharing some attributes. Circle *F* is perceived as dependent on Circle *E* and sharing all of its attributes.

Window controls are often placed on the center console between seats. The lack of proximity between the controls and the window makes it a poor design. A better location would be on the door itself.



This rendering of a sign at Big Bend National Park has undoubtedly sent many hikers in unintended directions (two hikers for certain). The proximity between unrelated words (e.g., *Chisos* and *South*) lends itself to misinterpretation. Positioning the related words closer together corrects the problem.



Rule of Thirds

A technique of composition in which a medium is divided into thirds, creating aesthetic positions for the primary elements of a design.[1]

The rule of thirds is a technique derived from the use of early grid systems in composition. It is applied by dividing a medium into thirds both vertically and horizontally, creating an invisible grid of nine rectangles and four intersections. The primary element within a design is then positioned on an intersection of the grid. The asymmetry of the resulting composition is interesting to look at, and generally agreed to be aesthetic.

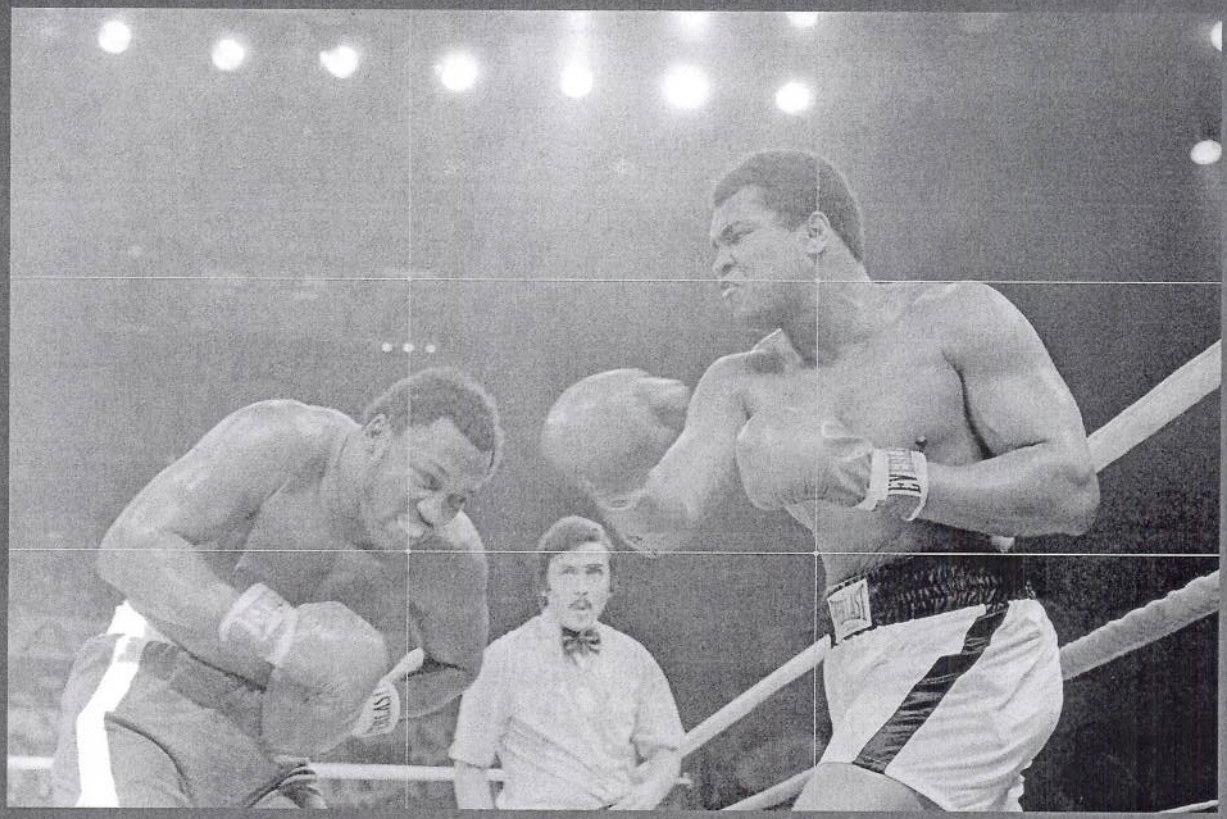
The technique has a loyal following in design circles due to its use by the Renaissance masters and its rough relationship to the golden ratio. Although dividing a design into thirds yields a ratio different from the golden ratio (i.e., the 2/3 section = 0.666 versus golden ratio = 0.618), the users of the technique may have decided that the simplicity of its application compensated for its rough approximation.

The rule of thirds generally works well, is easy to apply, and should be considered when composing elements of a design. When the primary element is so strong as to imbalance the composition, consider centering the element rather than using the rule of thirds—especially when the strength of the primary element is reinforced by the surrounding elements or space. If the surrounding elements or space do not reinforce the primary element, use the rule of thirds and add a secondary element (known as a counterpoint) to the opposing intersection of the primary element to bring the composition to balance. In designs where there is a strong vertical or horizontal element, it is common practice to align the element along one of the grid lines of corresponding orientation.[2]

See also Alignment, Golden Ratio, and Symmetry.

[1] Also known as *golden grid rule*.

[2] A nice introduction to compositional concepts is *Design and Composition* by Nathan Goldstein, Prentice-Hall, 1997.



This photograph (above) from the Muhammad Ali–Joe Frazier fight in Manila, Philippines (1975) makes excellent use of the rule of thirds, placing the heads of both fighters at opposing intersections on the grid.

This photograph (right) from the Muhammad Ali–Sonny Liston fight in Lewiston, Maine (1965), by contrast, is an excellent example of when not to use the rule of thirds—strong primary element that is reinforced by the surrounding space.

Scaling Fallacy

A tendency to assume that a system that works at one scale will also work at a smaller or larger scale.[1]

Much is made of the relative strength of small insects as compared to that of humans. For example, a leafcutter ant can carry about 50 times its weight; whereas an average human can only carry about half its weight. The standard reasoning goes that an ant scaled to the size of a human would retain this strength-weight advantage, giving a 200-pound ant the ability to lift 10,000 pounds. In actuality, however, an ant scaled to this size would only be able to lift about 50 pounds, assuming it could move at all. The effect of gravity at small scales is miniscule, but the effect increases exponentially with the mass of an object. This underscores the basic lesson of the scaling fallacy—systems act differently at different scales. There are two basic kinds of scaling assumptions to avoid when *growing* or *shrinking* a design: load assumptions, and interaction assumptions.[2]

Load assumptions occur when designers scale a design by some factor, and assume that the working stresses on the design scale by that same factor. For example, initial designs of the Trident 2 missile, designed to be launched from submarines, underestimated the effects of water pressure and turbulence during launch. The anticipated estimates for pressure and turbulence were based largely on the Trident 1 missile, which was much shorter and roughly half the weight of the Trident 2. When the specifications for the Trident 1 were scaled to meet the specifications for the Trident 2, the working stresses on the missile did not scale by the same factor as its physical specification. The result was multiple catastrophic failures in early tests, and a major redesign of the missile.[3]

Interaction assumptions occur when designers scale a design, and assume that the way people and other systems interact with the design will be the same at other levels of scale. For example, the design of very tall buildings involves many possible interactions that do not exist for buildings of lesser size—problems of evacuation in the case of fire, people seeking to commit suicide or base-jump off of the roof, symbolic target for terrorist attacks, to name a few. These kinds of interaction effects are usually an indirect consequence of the design, and therefore can be difficult to anticipate and manage.

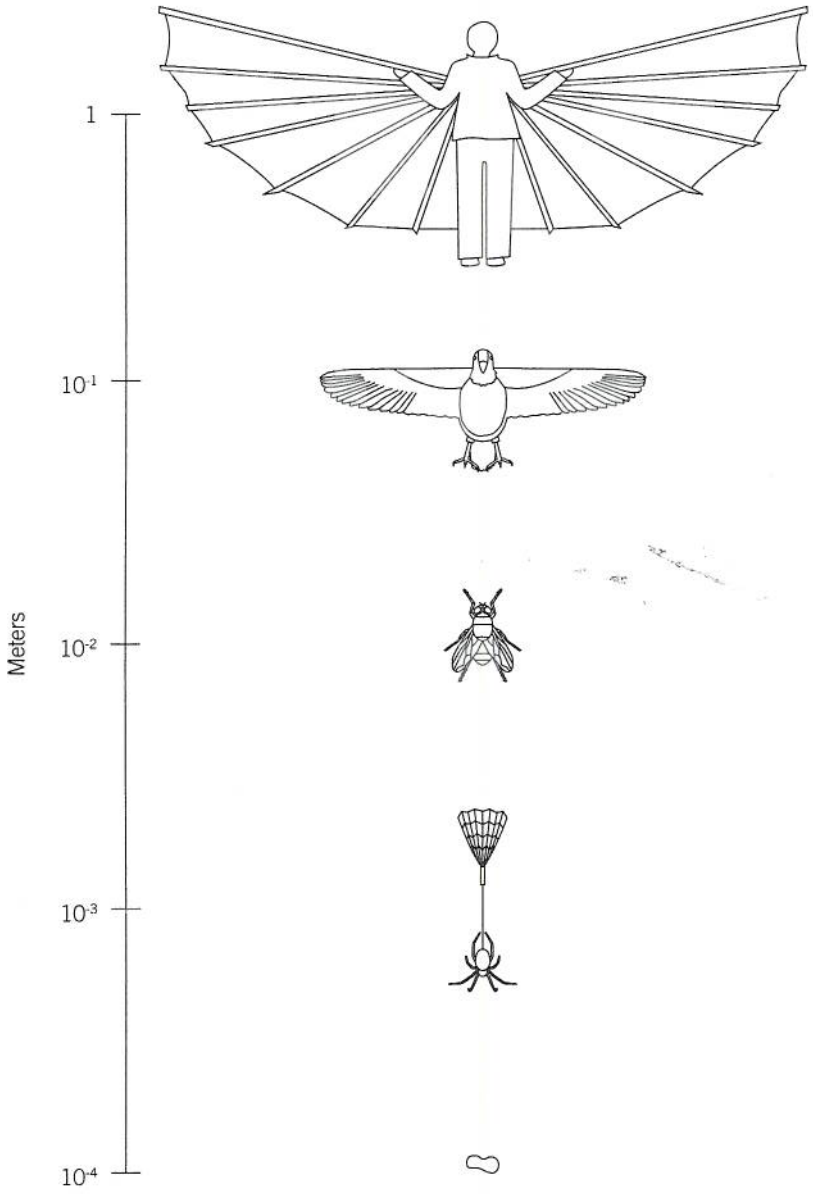
The best way to avoid the scaling fallacy is to be aware of the tendency to make scaling assumptions. Therefore, raise awareness of load and interaction assumptions in the design process. Verify load assumptions through the use of careful calculations, systematic testing, and appropriate factors of safety. Minimize incorrect interaction assumptions through careful research of analogous designs, and monitoring of how the design is used once implemented.

See also Factor of Safety, Feedback Loop, Modularity, and Structural Forms.

[1] Also known as *cube law* and *law of sizes.*

[2] The seminal work on scaling is *Dialogues Concerning Two New Sciences* by Galileo Galilei, Prometheus Books [reprint], 1991.

[3] "Design Flaw Seen as Failure Cause in Trident 2 Tests" by Andrew Rosenthal, *New York Times,* August 17, 1989, p. 1.



The scaling fallacy is nowhere more apparent than with flight. For example, at very small and very large scales, flapping to fly is not a viable strategy. At very small scales, wings are too small to effectively displace air molecules. At very large scales, the effects of gravity are too great for flapping to work—a painful lesson learned by many early pioneers of human flight. The lesson is that designs can be effective at one scale, and completely ineffective at another.

The images from small to large: aeroplankton simply float about in air; baby spiders use tiny web sails to parachute; insects flap to fly; birds flap to fly; humans flap but do not fly.

Similarity

Elements that are similar are perceived to be more related than elements that are dissimilar.

The principle of similarity is one of several principles referred to as *Gestalt principles of perception*. It asserts that similar elements are perceived as a single group or chunk, and are interpreted as being more related than dissimilar elements. For example, a simple matrix comprising alternating rows of dots and squares will be interpreted as a set of rows only, because the similar elements group together to form horizontal lines. A complex visual display is interpreted as having different areas and types of information depending on the similarity of color, size, and shape of its elements; similar elements are interpreted as being relevant to one another.[1]

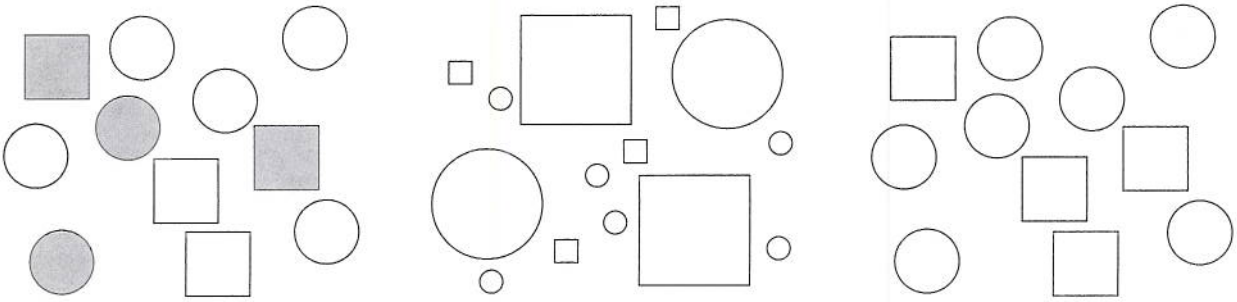
The grouping resulting from similarity reduces complexity and reinforces the relatedness of design elements. Conversely, a lack of similarity results in the perception of multiple, disparate chunks, and reinforces differences among the elements. Certain kinds of similarity work better than others for different situations. Similarity of color results in the strongest grouping effect; it is strongest when the number of colors is small, and is decreasingly effective as the number of colors increases. Similarity of size is effective when the sizes of elements are clearly distinguishable from one another, and is an especially appropriate grouping strategy when the size of elements has additional benefits (e.g., large buttons are easier to press). Similarity of shape is the weakest grouping strategy; it is best used when the color and size of other elements is uniform, or when used in conjunction with size or color.[2]

Use similarity to indicate relatedness among elements in a design. Represent elements such that their similarity corresponds to their relatedness, and represent unrelated or ambiguously related items using different colors, sizes, and shapes. Use the fewest colors and simplest shapes possible for the strongest grouping effects, ensuring that elements are sufficiently distinct to be easily detectable.

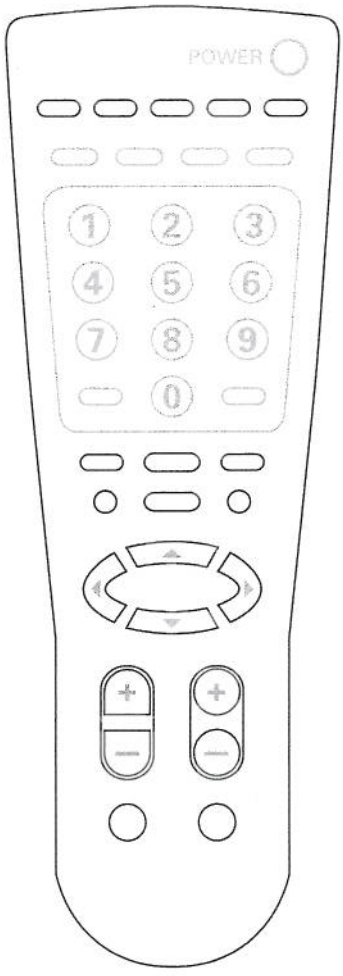
See also Chunking, Mimicry, and Self-Similarity.

[1] The seminal work on similarity is "Untersuchungen zür Lehre von der Gestalt, II" [Laws of Organization in Perceptual Forms] by Max Wertheimer, *Psychologische Forschung*, 1923, vol. 4, p. 301–350, reprinted in *A Source Book of Gestalt Psychology* by Willis D. Ellis (ed.), Routledge & Kegan Paul, 1999, p. 71–88. See also *Principles of Gestalt Psychology* by Kurt Koffka, Harcourt Brace, 1935.

[2] Note that a significant portion of the population is color blind, limiting the strategy of using color alone. Therefore, consider using an additional grouping strategy when using color.



Similarity among elements influences how they are grouped—here by color, size, and shape. Note the strength of color as a grouping strategy relative to size and shape.



This remote control uses color, size, and shape to group functions. Note the relationship between the anticipated frequency of use of the buttons and their relative size and shape.

Similarity is commonly used in camouflage. For example, the mimic octopus can assume the color, pattern, and approximate form of one of its fiercest predators—the highly poisonous sole fish—as well as many other marine organisms.

Symmetry

A property of visual equivalence among elements in a form.

Symmetry has long been associated with beauty, and is a property found in virtually all forms in nature. It can be seen in the human body (e.g., two eyes, two ears, two arms and legs), as well as in animals and plants. Symmetry in natural forms is largely a function of the influence of gravity, and the kind of *averaging* of form that occurs from merging genetic information in reproduction. There are three basic types of symmetry: reflection, rotation, and translation.[1]

Reflection symmetry refers to the mirroring of an equivalent element around a central axis or *mirror line*. Reflection symmetry can occur in any orientation as long as the element is the same on both sides of the mirror line. Natural forms that grow or move across the Earth's surface have evolved to exhibit reflection symmetry. For example, a butterfly exhibits reflection symmetry in its body and wings.

Rotation symmetry refers to the rotation of equivalent elements around a common center. Rotation symmetry can occur at any angle or frequency as long as the elements share a common center. Natural forms that grow or move up or down a perpendicular to the Earth's surface have evolved to exhibit rotation symmetry. For example, a sunflower exhibits rotation symmetry in both its stem and petals.

Translation symmetry refers to the location of equivalent elements in different areas of space. Translation symmetry can occur in any direction and over any distance as long as the basic orientation of the element is maintained. Natural forms exhibit translation symmetry through reproduction—creating similar looking offspring. For example, a school of fish exhibits translation symmetry across multiple, independent organisms.[2]

Aside from their aesthetic properties, symmetric forms have other qualities that are potentially beneficial to designers. For example, symmetric forms tend to be seen as figure images rather than ground images, which means they receive more attention and be better recalled than other elements; symmetric forms are simpler than asymmetric forms, which also gives them an advantage with regards to recognition and recall; and symmetric faces are perceived as more attractive than asymmetric faces.[3]

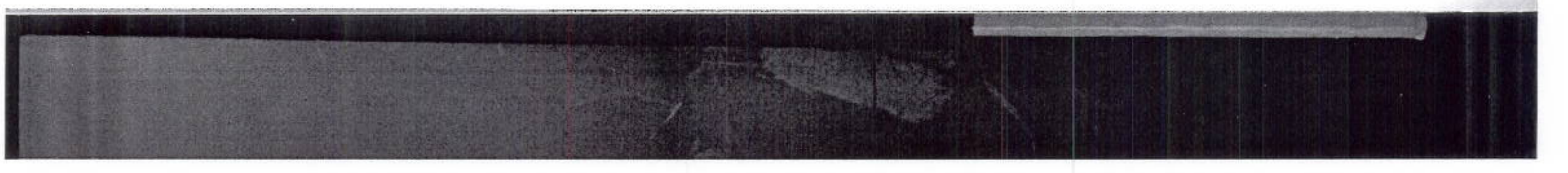
Symmetry is the most basic and enduring aspect of beauty. Use symmetry in design to convey balance, harmony, and stability. Use simple symmetrical forms when recognition and recall are important, and more complex combinations of the different types of symmetries when aesthetics and interestingness are important.

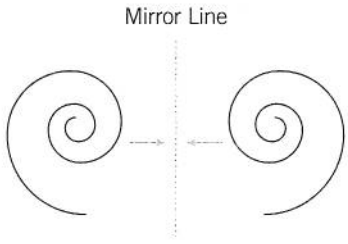
See also Figure-Ground Relationship, Golden Ratio, Most Average Facial Appearance Effect, and Self-Similarity.

[1] A seminal work on symmetry in design is *Elements of Dynamic Symmetry* by Jay Hambidge, Dover Publishers, 1978.

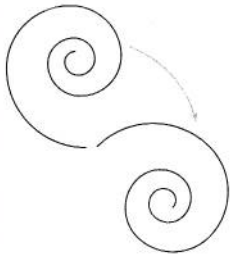
[2] A nice source for various combinations of types of symmetries in natural and human-created forms is *Handbook of Regular Patterns* by Peter S. Stevens, MIT Press, 1984.

[3] See, for example, "The Status of Minimum Principle in the Theoretical Analysis of Visual Perception" by Gary Hatfield and William Epstein, *Psychological Bulletin*, 1985, vol. 97, p. 155–186; and "Facial Resemblance Enhances Trust" by Lisa M. DeBruine, *Proceedings of The Royal Society: Biological Sciences*, vol. 269(1498), p. 1307-1312.

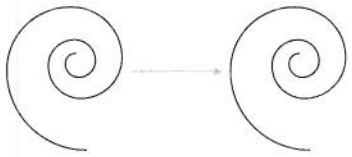




Reflection

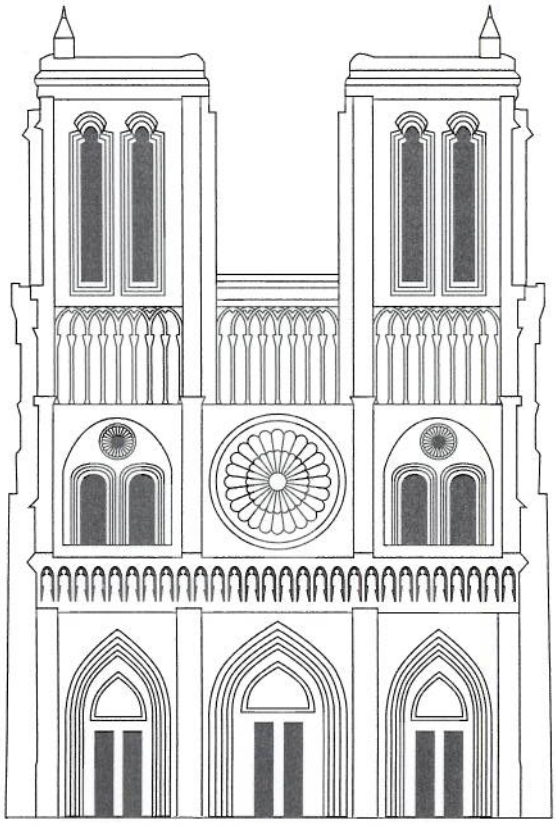


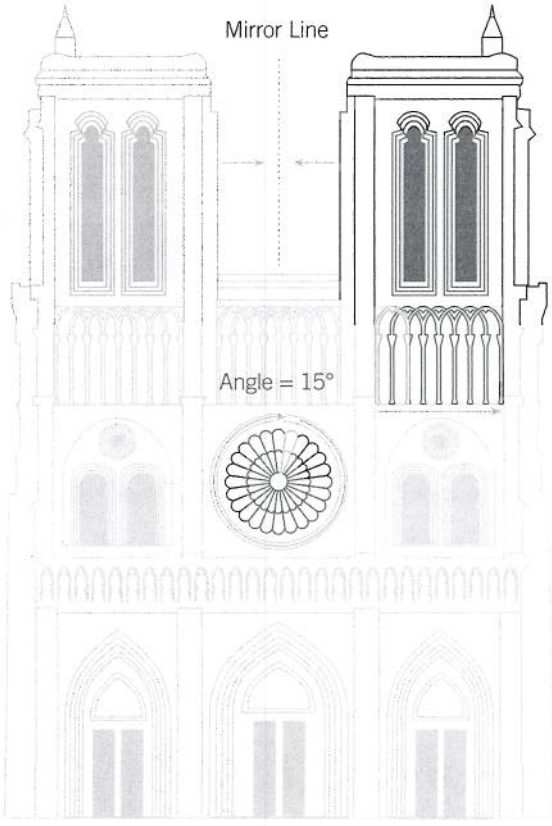
Rotation



Translation

Combinations of symmetries can create harmonious, interesting, and memorable designs. For example, the Notre Dame Cathedral incorporates multiple, complex symmetries in its design, resulting in a structure that is both pleasing and interesting to the eye.





Reflection

Translation

Rotation

von Restorff Effect

A phenomenon of memory in which noticeably different things are more likely to be recalled than common things.[1]

The von Restorff effect is the increased likelihood of remembering unique or distinctive events or objects versus those that are common. The von Restorff effect is primarily the result of the increased attention given to the distinctive items in a set, where a set may be a list of words, a number of objects, a sequence of events, or the names and faces of people. The von Restorff effect occurs when there is a *difference in context* (i.e., a stimulus is different from surrounding stimuli) or a *difference in experience* (i.e., a stimulus is different from experiences in memory).[2]

Differences in context occur when something is noticeably different from other things in the same set or context. For example, in trying to recall a list of characters such as *EZQL4PMBI*, people will have heightened recall for the *4* because it is the only number in the sequence—compare the relative difficulty of recall of the *4* to the *T* in a similar list, *EZQLTPMBI*. The difference between the *4* and the text characters makes the *4* more memorable than the *T*. Differences in context of this type explain why unique brands, distinctive packaging, and unusual advertising campaigns are used to promote brand recognition and product sales—i.e., difference attracts attention and is better remembered.

Differences in experience occur when something is noticeably different from past experience. For example, people often remember major events in their life, such as their first day of college or their first day at a new job. Differences in experience also apply to things like atypical words and faces. Unique words and faces are better remembered than typical words and faces.[3]

Take advantage of the von Restorff effect by highlighting key elements in a presentation or design (e.g., bold text). If everything is highlighted, then nothing is highlighted, so apply the technique sparingly. Since recall for the middle items in a list or sequence is weaker than items at the beginning or end of a list, consider using the von Restorff effect to boost recall for the middle items. Unusual words, sentence constructions, and images are better remembered than their more typical counterparts, and should be considered to improve interestingness and recall.

See also Highlighting, Serial Position Effects, and Threat Detection.

[1] Also known as the *isolation effect* and *novelty effect*.

[2] The seminal work on the von Restorff effect is "Analyse von Vorgangen in Spurenfeld. I. Über die Wirkung von Bereichsbildung im Spurenfeld" [Analysis of Processes in the Memory Trace: On the Effect of Region-Formation on the Memory Trace] by Hedwig von Restorff, *Psychologische Forschung*, 1933, vol. 18, p. 299–342.

[3] Unusual words with unusual spellings are found in abundance in the Harry Potter books of J. K. Rowling, and are among the frequently cited reasons for their popularity with children.

Items in the middle of a list or a sequence are harder to remember than items at the beginning or end. However, the middle items can be made more memorable if they are different from other items in the set.

Word List
milk
eggs
bread
lettuce
butter
flour
ostrich
orangutan
penguin
cheese
sugar
ice cream
oranges
apples
coffee

The unique paint schemes on certain Southwest Airlines planes are very distinct and memorable. The paint schemes differentiate Southwest Airlines from their competitors, promote vacation destinations and partners, and reinforce their reputation as a fun, people-centered airline. This is a photograph of the Shamu One, a Southwest Airlines Boeing 737.

The Chick-fil-A billboards use a combination of dimensionality and humor to attract attention and increase memorability. The billboards effectively command attention in visually noisy environments, clearly and intelligently promote the Chick-fil-A brand, and are quickly read and understood. As billboard design goes, it does not get much better.