Color

Color is used in design to attract attention, group elements, indicate meaning, and enhance aesthetics.

Color can make designs more visually interesting and aesthetic, and can reinforce the organization and meaning of elements in a design. If applied improperly, colors can seriously harm the form and function of a design. The following guidelines address common issues regarding the use of color.[1]

Number of Colors

Use color conservatively. Limit the palette to what the eye can process at one glance (about five colors depending on the complexity of the design). Do not use color as the only means to impart information since a significant portion of the population has limited color vision.

Color Combinations

Achieve aesthetic color combinations by using adjacent colors on the color wheel (analogous), opposing colors on the color wheel (complementary), colors at the corners of a symmetrical polygon circumscribed in the color wheel (triadic and quadratic), or color combinations found in nature. Use warmer colors for foreground elements, and cooler colors for background elements. Light gray is a safe color to use for grouping elements without competing with other colors.

Saturation

Use saturated colors (pure hues) when attracting attention is the priority. Use desaturated colors when performance and efficiency are the priority. Generally, desaturated, bright colors are perceived as friendly and professional; desaturated, dark colors are perceived as serious and professional; and saturated colors are perceived as more exciting and dynamic. Exercise caution when combining saturated colors, as they can visually interfere with one another and increase eye fatigue.

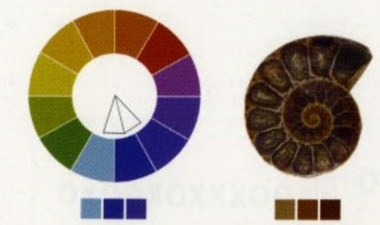
Symbolism

There is no substantive evidence supporting general effects of color on emotion or mood. Similarly, there is no universal symbolism for different colors—different cultures attach different meanings to colors. Therefore, verify the meaning of colors and color combinations for a particular target audience prior to use.[2]

See also Expectation Effect, Highlighting, Interference Effects, Similarity, and Uniform Connectedness.

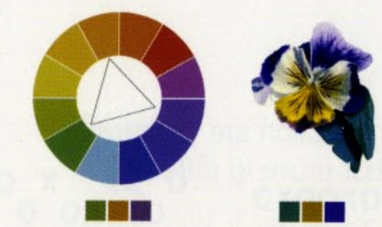
[1] A nice treatment of color theory is *Interaction of Color* by Josef Albers, Yale University Press, 1963. For a more applied treatment, see *The Art of Color: The Subjective Experience and Objective Rationale of Color* by Johannes Itten, John Wiley & Sons, 1997; and *Human-Computer Interaction* by Jenny Preece, et al., Addison Wesley, 1994.

[2] It is reasonable to assume that dark colors will make people sleepy, light colors will make people lively, and irritating colors will make people irritated. Otherwise, the only observable influence of color on behavior is its ability to lead people to repaint walls unnecessarily. For those determined to try to calm drunks and win football games through the application of color, see *The Power of Color* by Morton Walker, Avery Publishing, 1991.



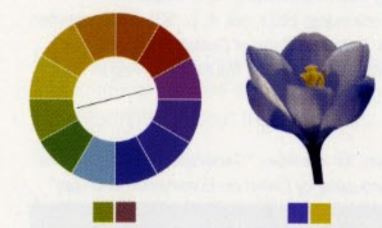
Analogous Example from Nature

Analogous color combinations use colors that are next to each other on the color wheel.



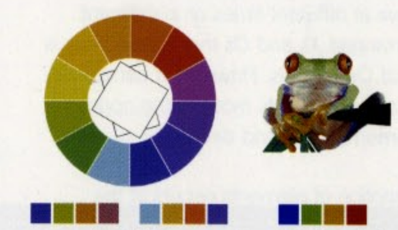
Triadic Example from Nature

Triadic color combinations use colors at the corners of an equilateral triangle circumscribed in the color wheel.



Complementary Example from Nature

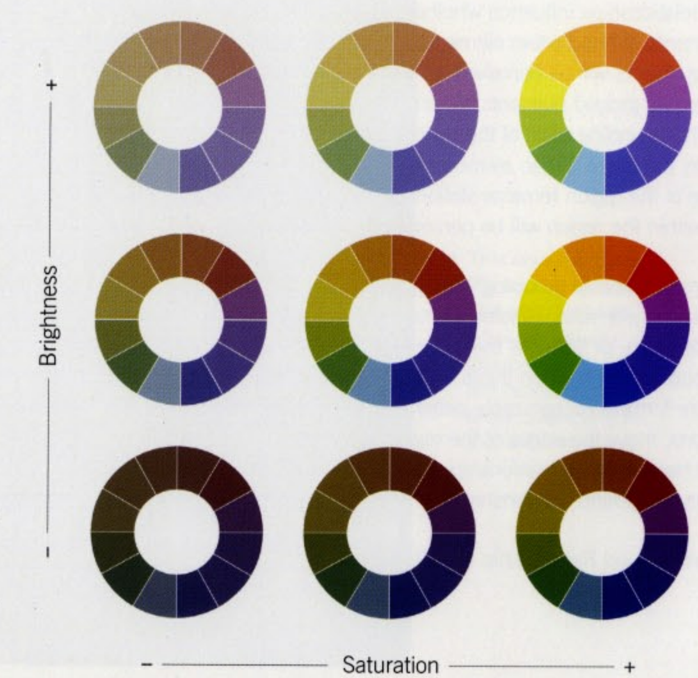
Complementary color combinations use two colors that are directly across from each other on the color wheel.



Quadratic Example from Nature

Quadratic color combinations use colors at that corners of a square or rectangle circumscribed in the color wheel.

Hues from yellow to red-violet on the color wheel are warm. Hues from violet to green-yellow are cool.



Saturation refers to the amount of gray in a hue. As saturation increases, the amount of gray decreases. Brightness refers to the amount of white in a hue. As brightness increases, the amount of white increases.

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.

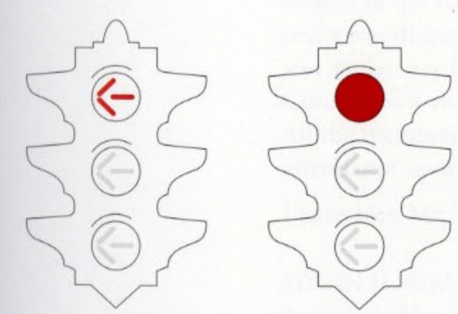
Prevent interference by avoiding designs that create conflicting mental processes. Interference effects of perception (i.e., Stroop and Garner) generally result from conflicting coding combinations (e.g., a red *go* button, or green *stop* button) or from an interaction between closely positioned elements 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.

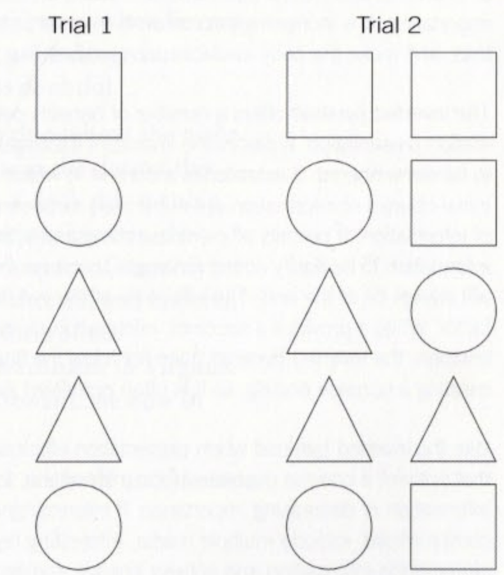
[1] The seminal works on interference effects include "Studies of Interference in Serial Verbal Reactions" by James R. Stroop, *Journal of Experimental Psychology*, 1935, vol. 28, p. 643–662; "Stimulus Configuration in Selective Attention Tasks" by James R. Pomerantz and Wendell R. Garner, *Perception & 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.

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.



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.



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.

Gutenberg Diagram

A diagram that describes the general pattern followed by the eyes when looking at evenly distributed, homogeneous information.[1]

The Gutenberg diagram divides a display medium into four quadrants: the *primary optical area* at the top left, the *terminal area* at the bottom right, the *strong fallow area* at the top right, and the *weak fallow area* at the bottom left. According to the diagram, Western readers naturally begin at the primary optical area and move across and down the display medium in a series of sweeps to the terminal area. Each sweep begins along an *axis of orientation*—a horizontal line created by aligned elements, text lines, or explicit segments—and proceeds in a left-to-right direction. The strong and weak fallow areas lie outside this path and receive minimal attention unless visually emphasized. The tendency to follow this path is metaphorically attributed to *reading gravity*—the left-right, top-bottom habit formed from reading.[2]

Designs that follow the diagram work in harmony with reading gravity, and return readers to a logical axis of orientation, purportedly improving reading rhythm and comprehension. For example, a layout following the Gutenberg diagram would place key elements at the top left (e.g., headline), middle (e.g., image), and bottom right (e.g., contact information). Though designs based directly or indirectly on the Gutenberg diagram are widespread, there is little empirical evidence that it contributes to improved reading rates or comprehension.

The Gutenberg diagram is likely only predictive of eye movement for heavy text information, evenly distributed and homogeneous information, and blank pages or displays. In all other cases, the weight of the elements of the design in concert with their layout and composition will direct eye movements. For example, if a newspaper has a very heavy headline and photograph in its center, the center will be the primary optical area. Familiarity with the information and medium also influences eye movements. For example, a person who regularly views information presented in a consistent way is more likely to first look at areas that are often changing (e.g., new top stories) than areas that are the same (e.g., the title of a newspaper).

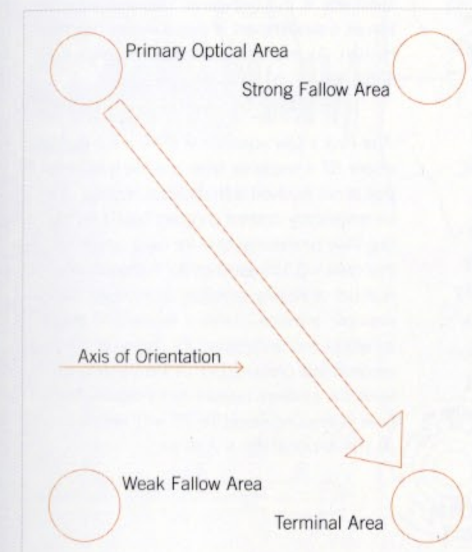
Consider the Gutenberg diagram to assist in layout and composition when the elements are evenly distributed and homogeneous, or the design contains heavy use of text. Otherwise, use the weight and composition of elements to lead the eye.

See also Alignment, Entry Point, Progressive Disclosure, and Serial Position Effects.

[1] Also known as the *Gutenberg rule* and the *Z pattern of processing*.

[2] The seminal work on the Gutenberg diagram is attributed to the typographer Edmund Arnold, who is said to have developed the concept in the 1950s. See, for example, *Type & Layout: How Typography and Design Can Get Your Message Across or Get in the Way*, by Colin Wheildon, Strathmoor Press, 1995.

Reading gravity pulls the eyes from the top-left to the bottom-right of the display medium. In homogeneous displays, the Gutenberg diagram makes compositions interesting and easy to read. However, in heterogeneous displays, the Gutenberg diagram does not apply, and can constrain composition unnecessarily.



The composition of these pages illustrates the application of the Gutenberg diagram. The first page is all text, and it is, therefore, safe to assume readers will begin at the top-left and stop at the bottom-right of the page. The pull quote is placed between these areas, reinforcing reading gravity. The placement of the image on the second page similarly reinforces reading gravity, which it would not do if it were positioned at the top-right or bottom-left of the page.

CHAPTER 1: Down the Rabbit-Hole

Alice was beginning to get very tired of sitting by her sister on the bank, and of having nothing to do: once or twice she had peeped into the book her sister was reading, but it had no pictures or conversations in it, 'and what is the use of a book,' thought Alice 'without pictures or conversation?'

So she was considering in her own mind (as well as she could, for the hot day made her feel very sleepy and stupid), whether the pleasure of making a daisy-chain would be worth the trouble of getting up and picking the daisies, when suddenly a White Rabbit with pink eyes ran close by her.

There was nothing so very remarkable in that; nor did Alice think it so very much out of the way to hear the Rabbit say to itself, 'Oh dear! Oh dear! I shall be late!' (when she thought it over afterwards, it occurred to her that she ought to have wondered at this, but at the time it all seemed quite natural); but when the Rabbit actually took a watch out of its waistcoat-pocket, and looked at it, and then hurried on, Alice started to her feet, for it flashed across her mind that she had never before seen a rabbit with either a waistcoat-pocket, or a watch to take out of it, and burning with curiosity, she ran across the field after it, and fortunately was just in time to see it pop down a large rabbit-hole under the hedge.

In another moment down went Alice after it, never once considering how in the world she was to get out again.

'Well!' thought Alice to herself, 'after such a fall as this, I shall think nothing of tumbling down stairs! How brave they'll all think me at home! Why, I wouldn't say anything about it, even if I fell off the top of the house!'

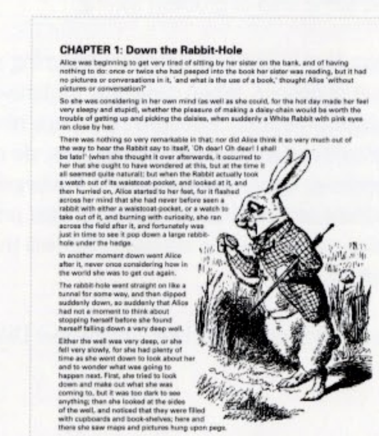
The rabbit-hole went straight on like a tunnel for some way, and then dipped suddenly down, so suddenly that Alice had not a moment to think about stopping herself before she found herself falling down a very deep well.

Either the well was very deep, or she fell very slowly, for she had plenty of time as she went down to look about her and to wonder what was going to happen next. First, she tried to look down and make out what she was coming to, but it was too dark to see anything; then she looked at the sides of the well, and noticed that they were filled with cupboards and book-shelves; here and there she saw maps and pictures hung upon pegs. She took down a jar from one of the shelves as she passed; it was labelled 'ORANGE MARMALADE', but to her great disappointment it was empty: she did not like to drop the jar for fear of killing somebody, so managed to put it into one of the cupboards as she fell past it.

'Well!' thought Alice to herself, 'after such a fall as this, I shall think nothing of tumbling down stairs! How brave they'll all think me at home! Why, I wouldn't say anything about it, even if I fell off the top of the house!' (Which was very likely true.)

Down, down, down. Would the fall never come to an end!

Alice's Adventures in Wonderland, by Lewis Carroll, first appeared in print in 1865.



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THE WALL STREET JOURNAL.

Last Rights

Saudis Welcome Foreigners to Work —But Not to Die

What's News—

Business and Finance

World-Wide

Bush Says Rising Price of Oil Could Hurt Pace of Recovery

He Hopes to Forestall That, He Says in an Interview, Assailing Iraq's Cutoff

Softening Support

Side Effect

Insurer's Tactic: If You Get Sick, The Premium Rises

What's New in Today's Journal

PERSONAL JOURNAL

The redesign of the *Wall Street Journal* leads the eyes of readers, and does not follow the Gutenberg diagram. Additionally, recurring readers of the *Wall Street Journal* tend to go to the section they find most valuable, ignoring the other elements of the page.

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]

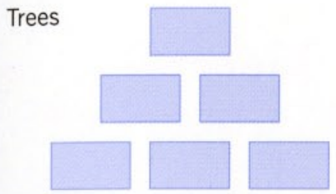
See also Advance Organizer, Alignment, Five Hat Racks, Layering, and Proximity.

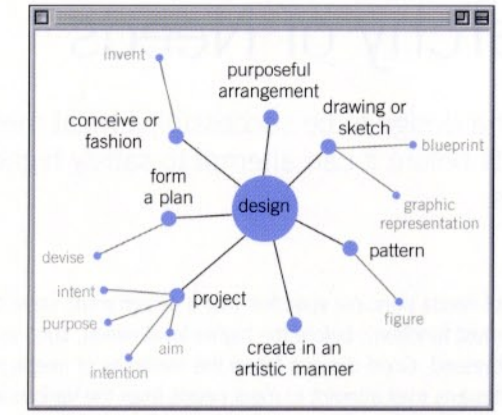
[1] The seminal works on hierarchy are "The Architecture of Complexity," Proceedings of the American Philosophical Society, 1962, vol. 106, p. 467–482; and The Sciences of the Artificial, MIT Press, 1969, both by Herbert A. Simon.

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

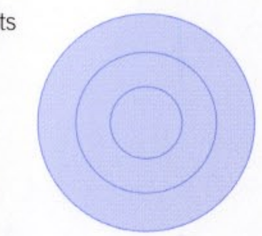
[3] Representing these structures in three-dimensional space improves little in terms of clarity and comprehensibility—though it does result in some fascinating structures to view and navigate. See, for example, "Cone Trees: Animated 3D Visualizations of Hierarchical Information" by George G. Robertson,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

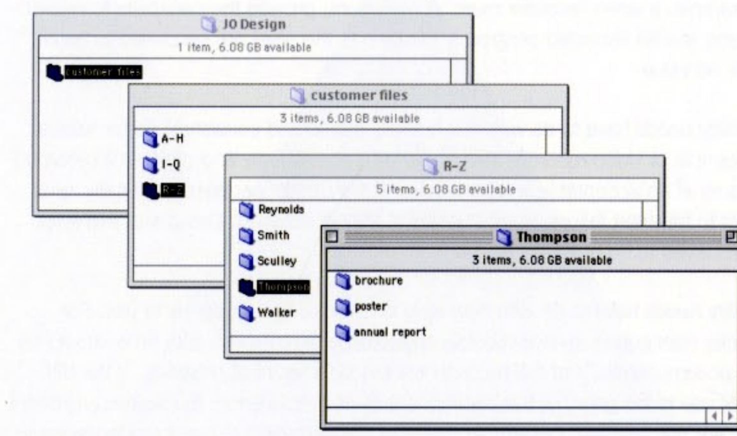
Trees



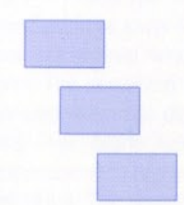


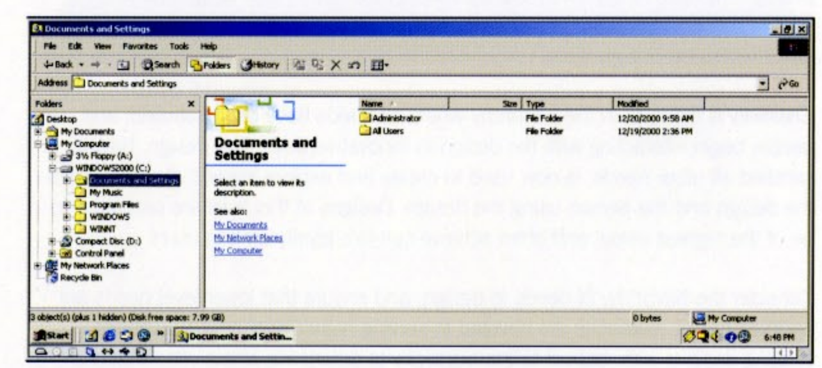
Nests





Stairs





Common Fate

Elements that move in the same direction are perceived to be more related than elements that move in different directions or are stationary.

The principle of common fate is one of a number of principles referred to as *Gestalt principles of perception*. It asserts that elements that move together in a common direction are perceived as a single group or chunk, and are interpreted as being more related than elements that move at different times or in different directions. For example, a row of randomly arranged *X*s and *O*s that is stationary is naturally grouped by similarity, *X*s with *X*s, and *O*s with *O*s. However, if certain elements in the row move in one direction, and other elements move in the opposite direction, elements are grouped by their common motion and direction.[1]

Perceived relatedness is strongest when the motion of elements occurs at the same time and velocity, and in the same direction. As any of these factors vary, the elements are decreasingly related. One exception is when the motion exhibits an obvious pattern or rhythm (e.g., wave patterns), in which case the elements are seen as related. Although common fate relationships usually refer to moving elements, they are also observed with static objects that flicker (i.e., elements that alternate between brighter and darker states). For flickering elements, perceived relatedness is strongest when the elements flicker at the same time, frequency, and intensity, or when a recognizable pattern or rhythm is formed.[2]

Common fate relationships influence whether elements are perceived as figure or ground elements. When certain elements are in motion and others are stationary, the moving objects will be perceived as figure elements, and stationary ones will be perceived as ground elements. When elements within a region move together with the bounding edge of the region, the elements and the region will be perceived as the figure. When elements within a region move together, but the bounding edge of the region remains stationary or moves opposite to the elements, the elements within the region will be perceived as the ground.[3]

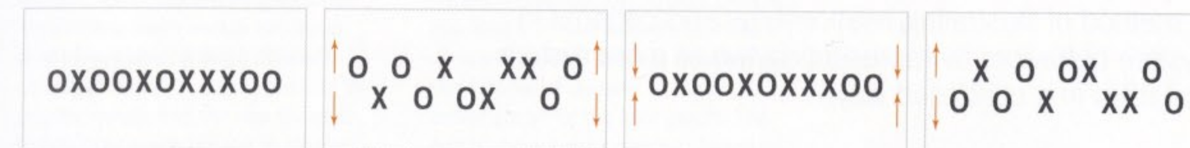
Consider common fate as a grouping strategy when displaying information with moving or flickering elements. Related elements should move at the same time, velocity, and direction, or flicker at the same time, frequency, and intensity. It is possible to group elements when these variables are dissimilar, but only if the motion or flicker forms a recognizable pattern. When moving elements within bounded regions, move the edges of the region in the same direction as the elements to achieve a figure relationship or in the opposite direction as the elements to achieve a ground relationship.

See also Figure-Ground Relationship and Similarity.

[1] The seminal work on common fate 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. 71v88.

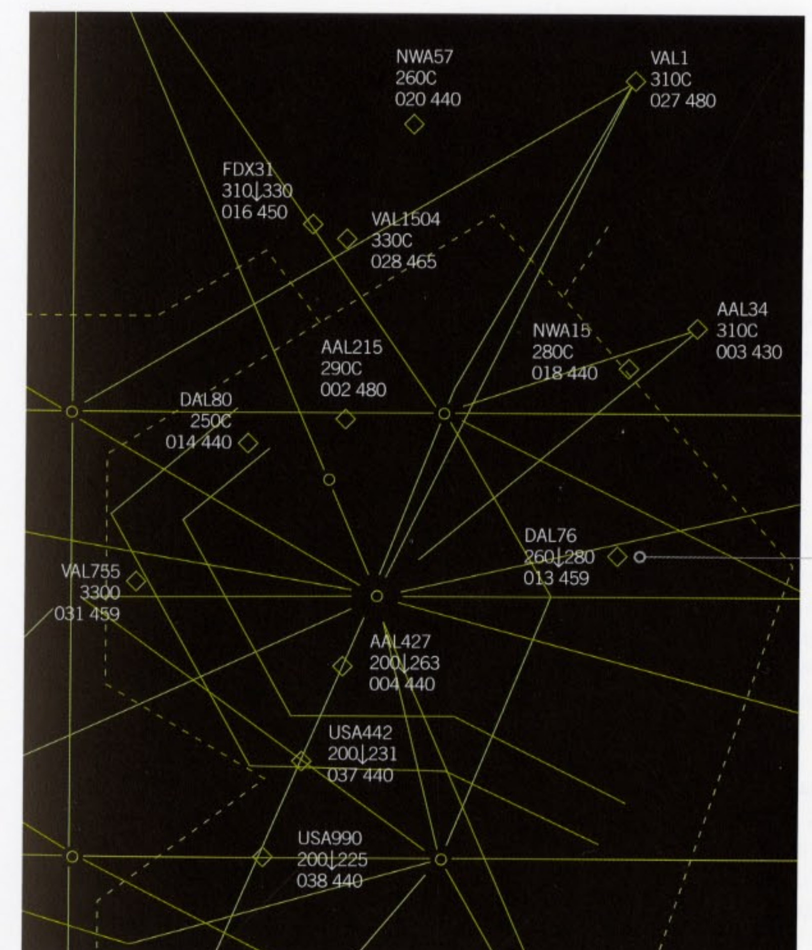
[2] See, for example, "Generalized Common Fate: Grouping by Common Luminance Changes" by Allison B. Sekuler and Patrick J. Bennett, *Psychological Science*, 2001, Vol. 12(6), p. 437–444.

[3] "Common Fate as a Determinant of Figure-Ground Organization" by Joseph Lloyd Brooks, Stanford-Berkeley Talk, 2000, Stanford University, May 16, 2000.



The *X*s and *O*s group by similarity when stationary, such as *X*s with *X*s, *O*s with *O*s. However, when a mix of the *X*s and *O*s move up and down in a common fashion, they are grouped primarily by common fate.

Radar tracking displays use common fate to group tracked aircraft with key information about their identities and headings.



This object is being tracked by radar. The object and its label are visually grouped because they are moving at the same speed and in the same direction.