Recommendations for

Charts and Graphics

Print version (PDF)

Read First

1. Charts

2. Graphics, Images

3. Color and Text

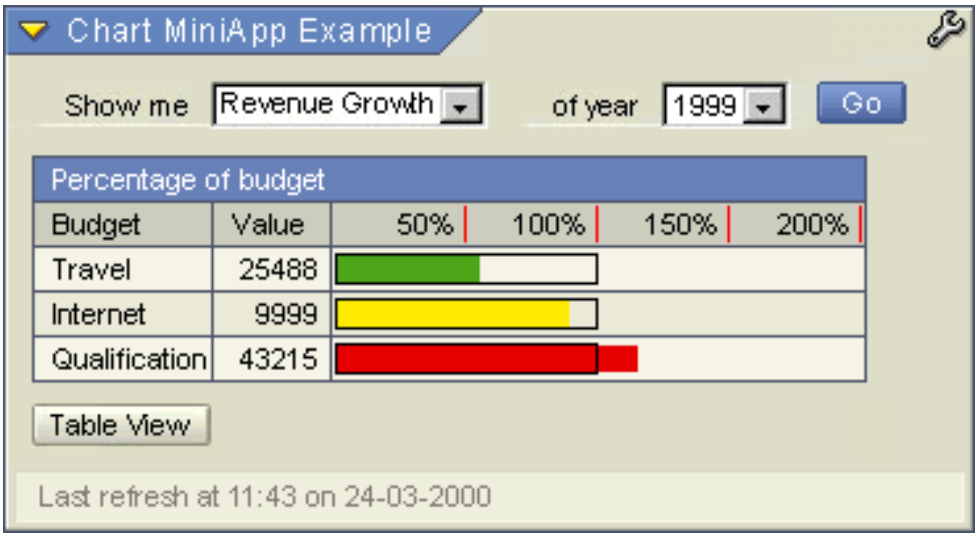
References

top

Recommendations for Charts and Graphics

The *Recommendations for Chart and Graphic* comprise guidelines for the use of charts, graphics, images, colors and text.

The material in these recommendations are collected from various sources; the sources are listed in the References section.



Note: These recommendations are **not** official SAP guidelines; they are mostly general recommendations as found in the literature, with the exception of two SAP-specific additions, such as PIG charts (Portable Interactive Graphics) and color palettes for charts.

For additional information on color and related issues, see the *Color Glossary* in the *SAP Design Guild*.

Status

The *Recommendations for Charts and Graphics* are preliminary and will be updated as necessary.

They originate from the *SAP MiniApp Guidelines* (version 1.0) which they are part of. For the future, further updates of the *SAP MiniApp Guidelines* will probably no longer contain these recommendations; they will be published separately in this document.

Version 0.9 - 30 January 2001

This guideline can be found in *Resources* on the SAP Design Guild Website (www.sapdesignguild.org).

top

Source: Recommendations for Charts and Graphics

Introduction to Charts

Charts are analog | Charts Types - Overview | Advanced Charts | Hints and Tips

Charts Are Analog!

Basic Rule: Charts show overviews - for details use tables!

Quantitative data can be represented as charts by using the following *analog* properties

- **Position** of graphical elements along a common scale; position of graphical elements along identical scales at different locations (e.g. graphs arranged in a row)
- **Distances (lengths)**
- **Slopes** and **angles**
- **Areas** (e.g. of circles, squares or other shapes)
- **Lightness** (grayscale) or **texture gradient**

People differ in their ability to estimate physical properties: They are best at estimating *positions* and *distances*, but not so good at estimating *slopes*, *angles*, and *areas* (in this order).

Charts are *images*: Good charts enable users to easily and quickly find relevant/critical data or recognize important relations between data.

For a discussion on when to use charts and when tables see Charts vs. Tables.

Chart Types - Overview

Below you find a short overview of chart types. For more information of the uses, advantages and disadvantages of different chart types see Chart Types and their Uses.

Area

Based on *areas*, shows cumulated totals (numbers or percentages) over time.

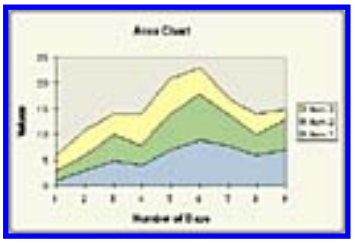


Figure 1: Area chart

Column/Bar

Based on *line lengths*; shows observations over time or under different conditions.

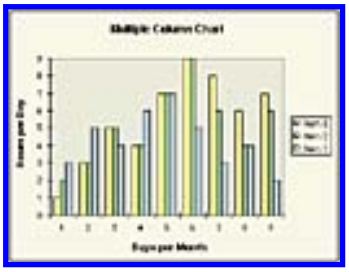


Figure 2: Multiple column chart

Segmented Column/Bar

Based on *line lengths*, but stacked; shows proportional relationships over time

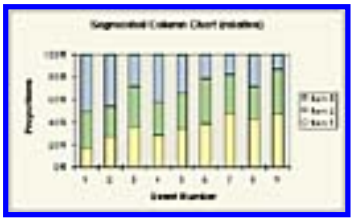


Figure 3: Segmented column chart (relative values)

Frequency Polygon, Histogram

Discrete frequency distribution based on curve chart (polygon) or column/staircase chart (histogram).

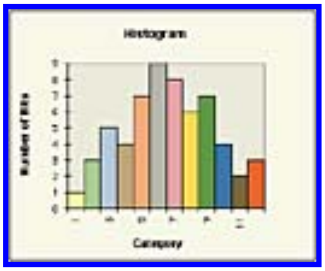


Figure 4: Histogram as frequency distribution

Line, Curve

Based on the *position* of data points; shows trends and functional relations (through the connection of the data points to a line or curve).

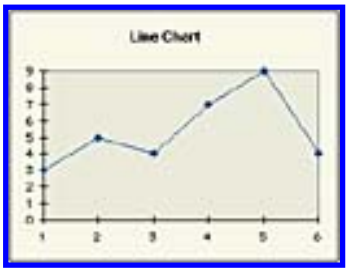


Figure 5: Line chart

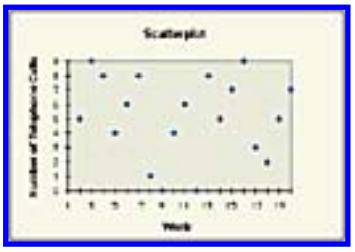
Pie

Based on *relative areas* (segments of a circle); show proportional relationships at a point in time.

Figure 6: Pie chart

Scatterplot

Based on the *position* of data points; shows the distribution of data points along one or two dimensions.



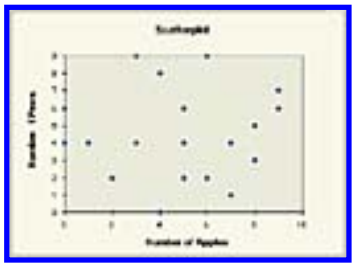


Figure 7: One-dimensional scatterplot (left), two-dimensional scatterplot (right)

Map

Based on geographical *maps*; typically used for geographical data; can also be used for parts of devices, human or animal bodies.

Advanced Charts

Above we listed basic chart types. Charts can be made even more informative if used in new ways or combinations. For example, you can combine a map with pie charts or bar charts to present the geographical distribution of certain variables.

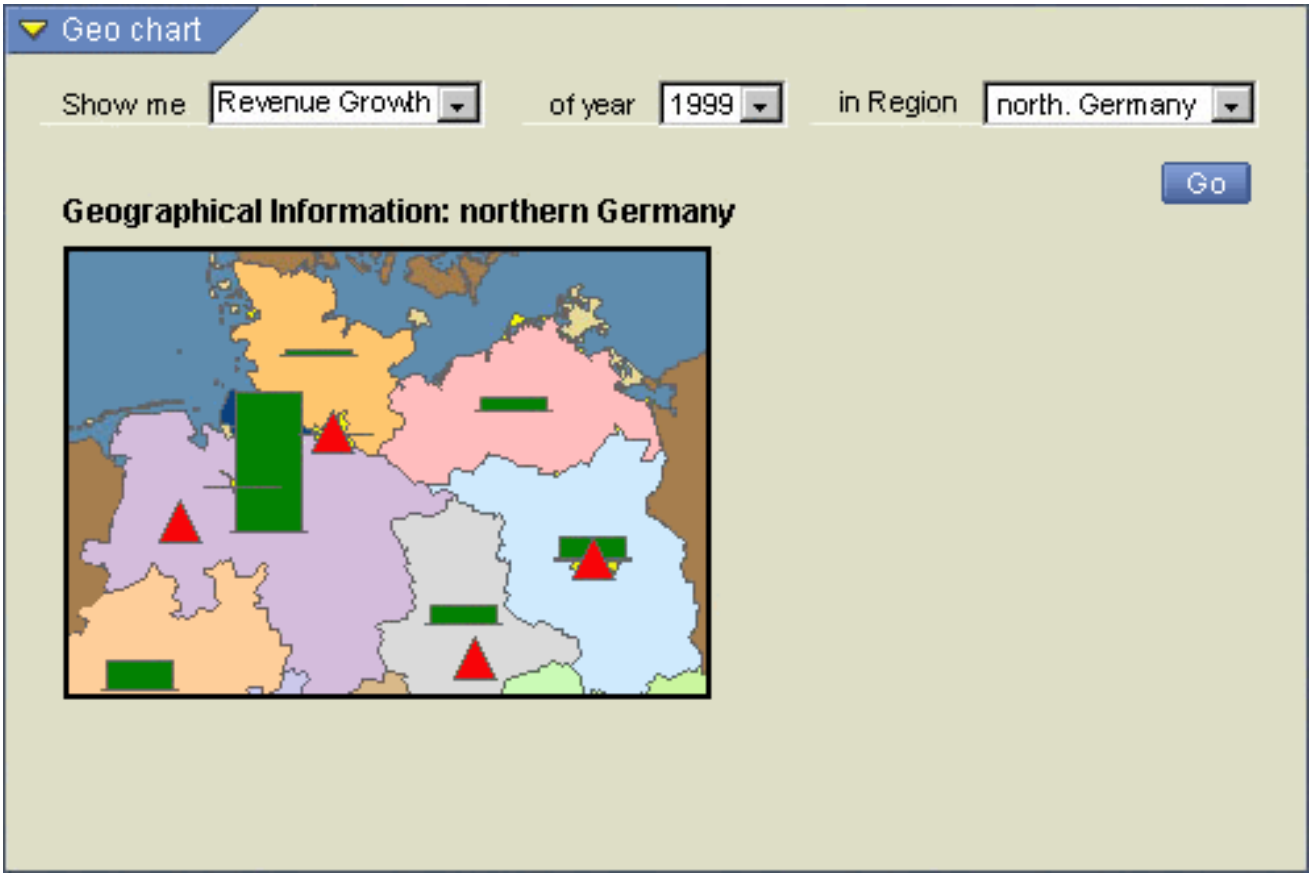


Figure 8: A geo chart showing the distribution of two variables in Northern Germany

Note: Often these charts have to be "handcrafted" and can be used as static images only.

Hints and Tips

- **Data**: Use all data, not only the ones that fit your expectations.
- **Units**: Use common units, e.g. not *pints* when *liters* are the common unit.
- **Labels**: If appropriate, add *labels* showing the exact values to avoid misinterpretations (especially valid for pie charts and segmented column/bar charts).

top

Source: Recommendations for Charts and Graphics

Chart Types and their Uses

Overview of Chart Types and their Uses

Chart Type	PIG	Typical Applications	Variants, Remarks
Area	Yes	Cumulated totals (numbers or percentages) over time	Percentage, Cumulative
Column/Bar	Yes	Observations over time or under different conditions; data sets must be small	Vertical (columns), horizontal (bars); multiple columns/bars, columns/bars centered at zero
Segmented Column/Bar	Yes	Proportional relationships over time	May be scaled to 100%
Frequency Polygon	No	Discrete frequency distribution	
Histogram	No	Discrete frequency distribution	Columns/bars without gaps
Line, Curve	Yes	Trends, functional relations	Data point connected by lines or higher order curves
Pie	Yes	Proportional relationships at a point in time	Segments may be pulled out of the the pie for emphasis (exploded pie chart)
Scatterplot	No	Distribution of data points along one or two dimensions	One-dimensional, two-dimensional
Map	No	Typically used for geographical data; can also be used for parts of devices, human or animal bodies	Useful, if an analog relation can be used for representing data

The column PIG indicates whether the respective charts types are available as Portable Interactive Graphics.

Area Chart

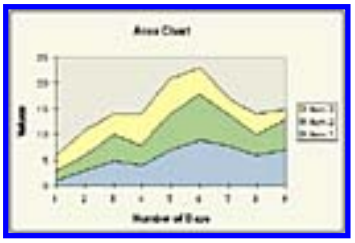


Figure 1: Area chart

Use it to...

- Display over time (or any other dimension):
  - How a set of data adds up to a whole (cumulated totals)
  - Which part of the whole each element represents

Variants

- **Percentage**: The sum always represents 100% (relative scale)
- **Cumulative**: The sum can vary according to the elements (absolute scale)

Column/Bar Chart

Use it to...

- Present few data over a nominal (e.g. countries, testing conditions, ...) or interval scale (e.g. time); useful for comparisons of data

Do not Use it for...

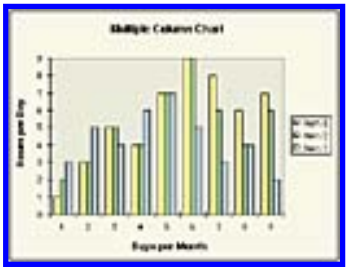
- Comparisons: Better use one-dimensional scatterplots, because these are not dominated by bars or columns.
- Larger data sets: Use line charts.

Selecting Bars or Columns

- Use analogy as a selection criterion, if applicable; when in doubt, use columns
- Use a horizontal bar chart if the labels are too long to fit under the columns

Variants

- **Multiple Column/Bar Chart**: Use it to present data rows for several variables
- **Side-by-Side Chart**: Use it to (1) show contrasting trends between levels of an independent variable, (2) if comparisons between individual pairs of values are most important; do **not** use for more than two independent variables



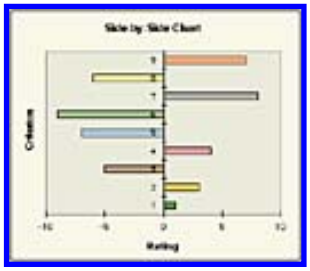


Figure 2: Multiple column chart (left), side-by-side chart (right)

Segmented Column/Bar Chart

Other Names: Divided or stacked column/bar chart

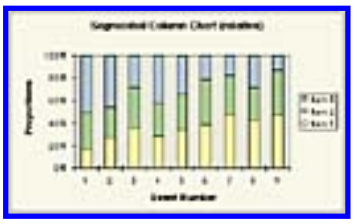


Figure 3: Segmented column chart (relative values)

Use it to...

- Present a part-whole relation over time (with accurate impression, see below)
- Show proportional relationships over time
- Display wholes which are levels on a nominal scale

Segmented column/bar charts are more accurate than pie chart, because distances can be more accurately estimated than areas.

Frequency Polygon, Histograms

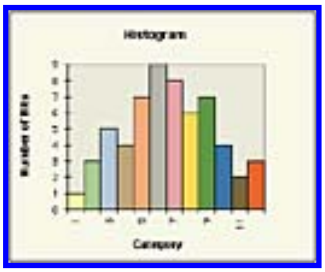


Figure 4: Histogram as frequency distribution

Variants

- **Polygon**: Connects data points through straight lines or higher order graphs
- **Histogram**: Columns/bars touch; useful for larger sets of data points, typically used for frequency distributions
- **Staircase Chart**: Displays only the silhouette of the histogram; useful for even larger sets of data points, typically used for frequency distributions
- **Step chart**: Use it to illustrate trends among more than two members of nominal or ordinal scales; do **not** use it for two or more variables or levels of a single variable (hard to read)
- **Pyramid histogram**: Two mirror histograms; use it for comparisons

Line Chart

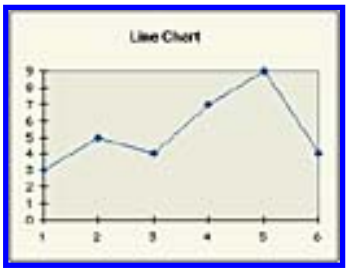


Figure 5: Line chart

Use it...

- To display long data rows
- To interpolate between data points
- To extrapolate beyond known data values (forecast)
- To compare different graphs
- To find and compare trends (changes over time)
- To recognize correlations and covariations between variables
- If the X axis requires an interval scale
- To display interactions over two levels on the X axis
- When convention defines meaningful patterns (e.g. a zigzag line)

Line graphs may consist of line or curved segments:

- Lines: Use straight lines to connect "real" data points
- Curves: Use curves to represent functional relations between data points or to interpolate data

Do not Use it...

- If the X axis has non-numeric values

Variants

- Graph with **double-logarithmic** or **half-logarithmic** scale divisions
- Graph with variance bars, stock charts (High/Low/Close) etc.

Pie Chart

Figure 6: Pie chart

Use it to...

- convey approximate proportional relationships (relative amounts) at a point in time
- compare part of a whole at a given point in time

- Exploded: emphasize a small proportion of parts

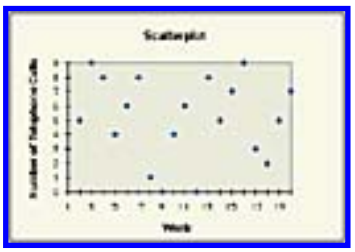
Do not Use it ...

- For exact comparisons of values, because estimating angles is difficult for people.
- For rank data: Use column/bar charts in this case; use multiple column/bar charts for grouped data
- If proportions vary greatly; do not use multiple pies to compare corresponding parts.

Caution!

- Pie charts cannot represent values beyond 100%.
- Each pie chart is valid for one point in time only.
- Pie charts are only suited to presenting quite a few percentage values.
- Angles are harder to estimate for people than distances; perspective pie charts are even harder to interpret.

Scatterplot



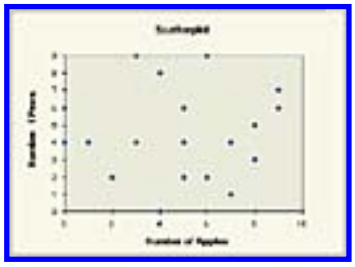


Figure 7: One-dimensional scatterplot (left), two-dimensional scatterplot (right)

Variants

1. **One-dimensional scatterplot**: Data point are drawn above a baseline (as in column/bar charts). Here the data points are not connected but remain isolated data points.
2. **Two-dimensional scatter plot**: Shows correlation between two data sets. This chart type has two dependent variables: One is plotted along the X axis, the other along the Y axis; the independent variable is the intersection of both dependent variables, realized as a data point in the diagram.

Use it to...

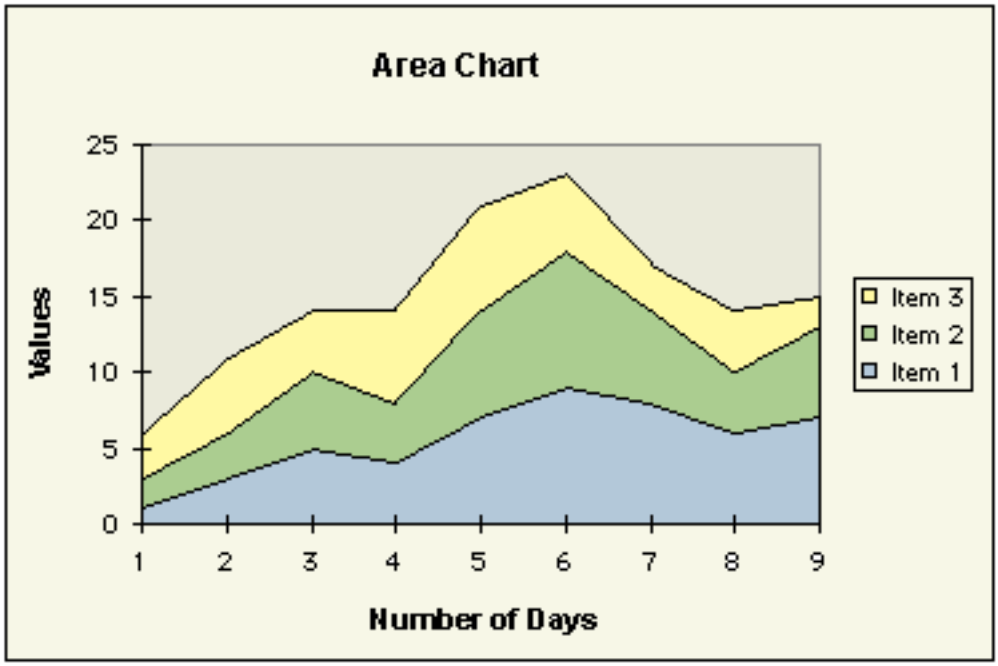
- Show measurements over time (one-dimensional scatterplot)
- Convey an overall impression of the relation between two variables (Two-dimensional scatterplot)

Do not Use it for...

- Determining and comparing trends, interpolation, extrapolation, recognition and comparison of change rates
- More than one independent variable: Avoid illustrating more than one independent variable in a scatter plot

top

Source: Recommendations for Charts and Graphics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5
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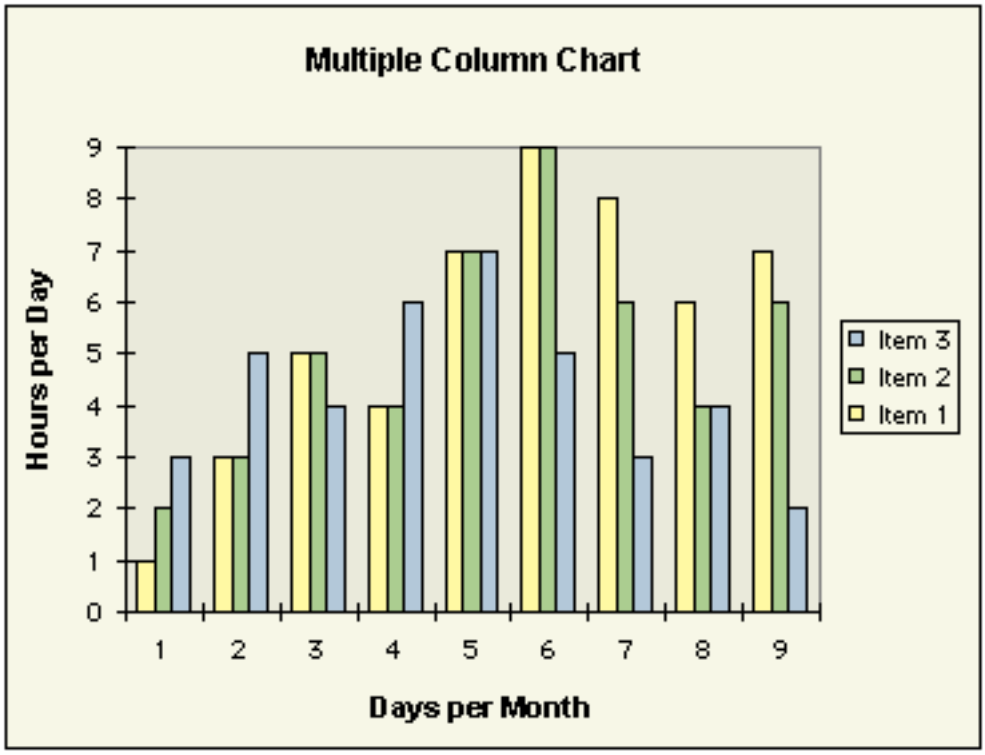
7
8
9
Number of Days
Item 3
Item 2
Item 1


Multiple Column Chart
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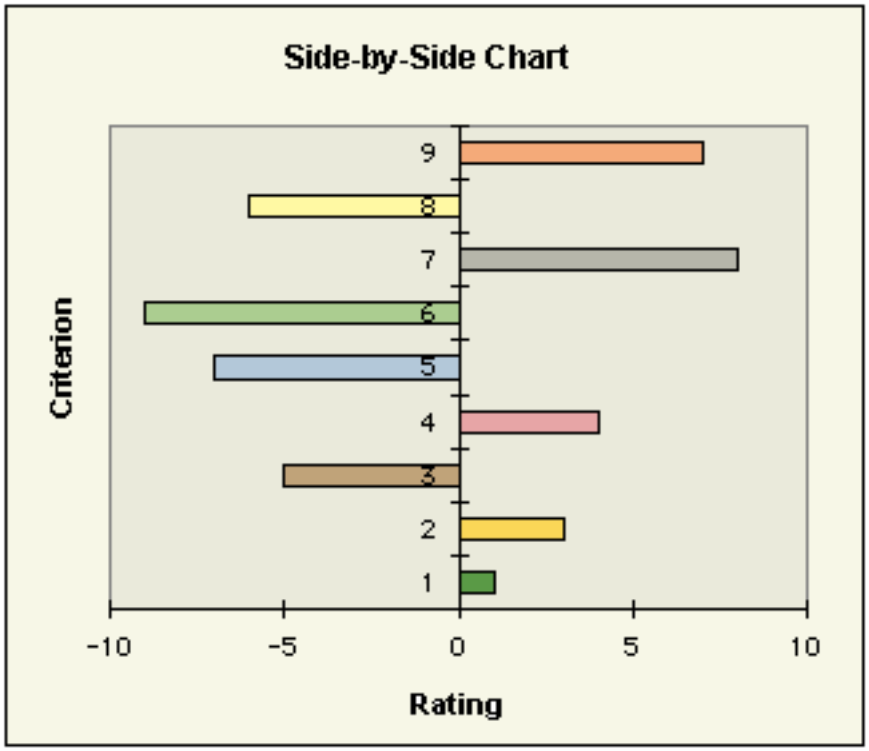
Days per Month
Item 3
Item 2
Item 1


Side-by-Side Chart
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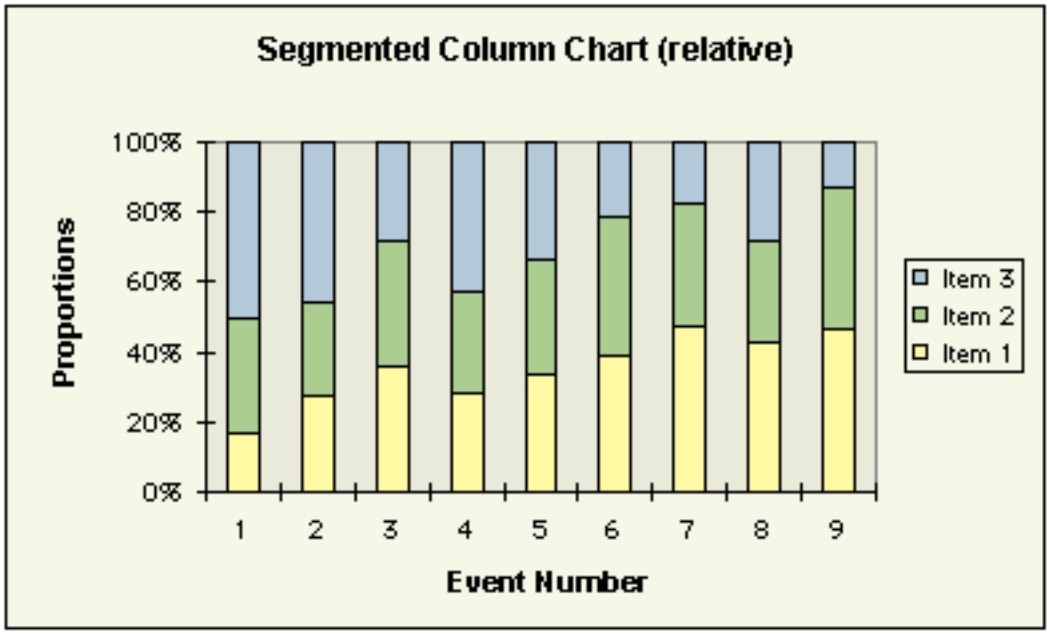
-5
0
5
10
Rating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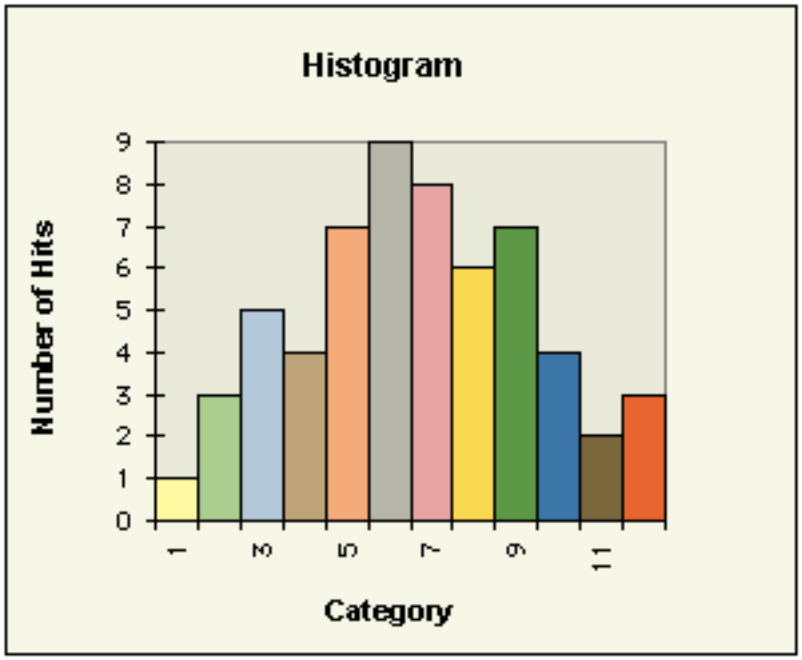
Event Number
Item 3
Item 2
Item 1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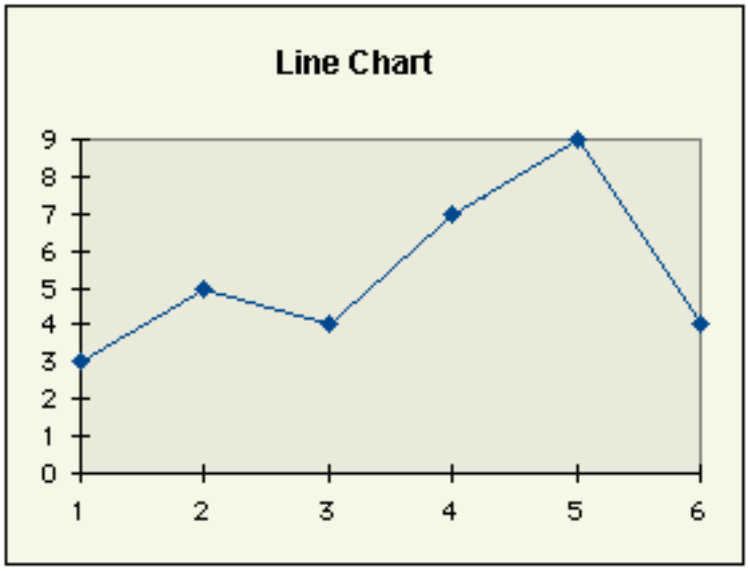
Category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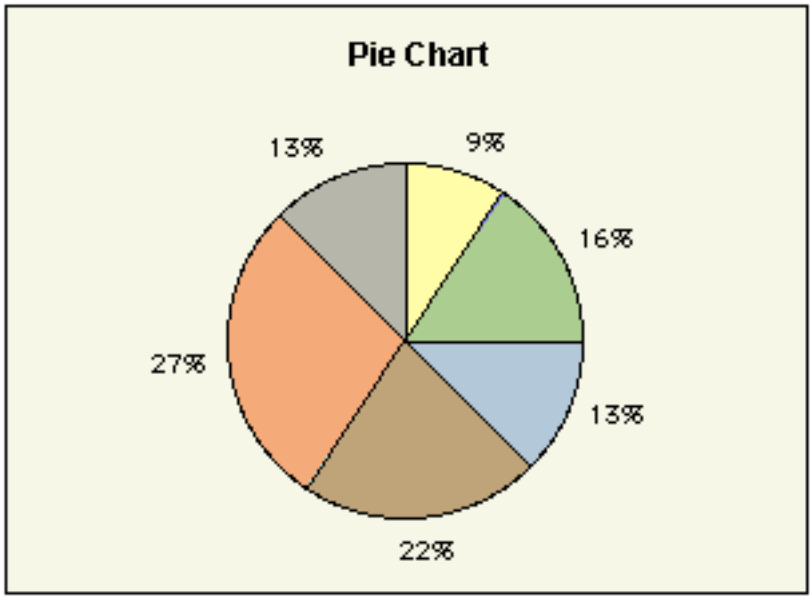
Pie Chart
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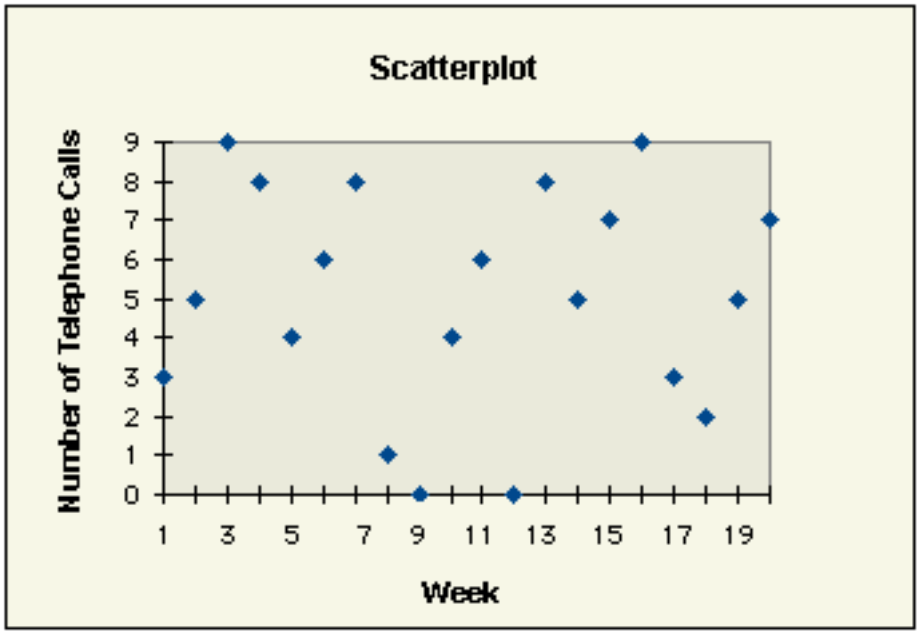
Scatterplot
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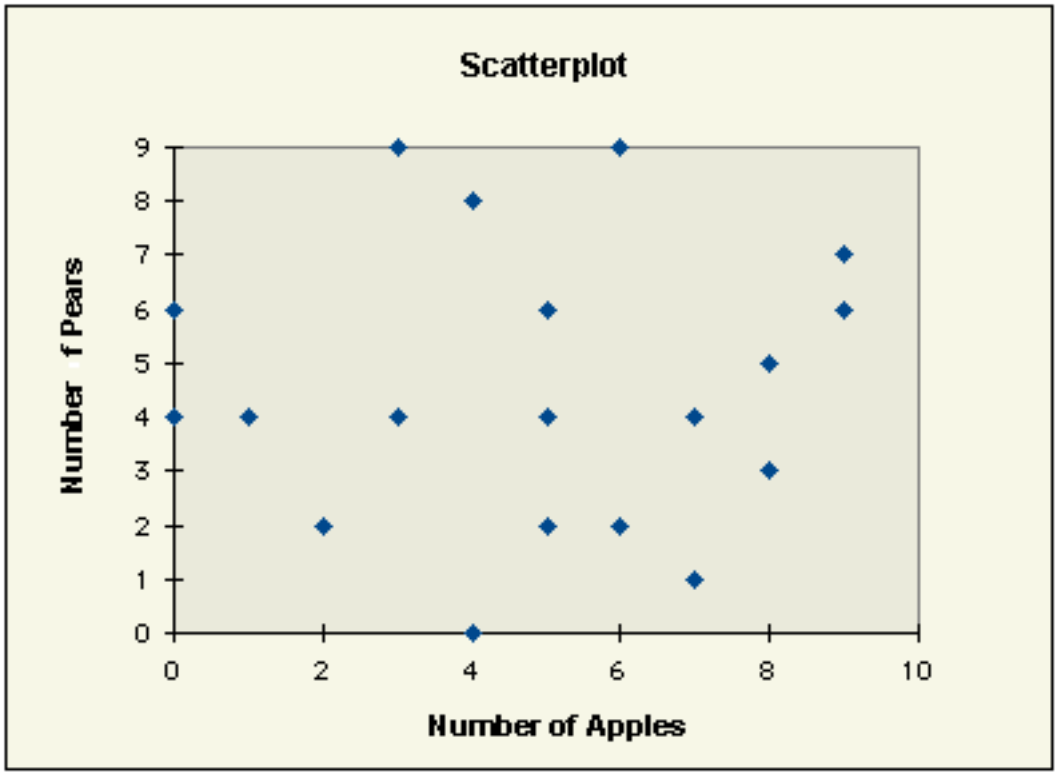
19
Week


Scatterplot
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Number of Apples
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10

Design Recommendations for Chart Types

Area Chart | Column/Bar Chart | Segmented Column/Bar Chart | Line Chart | Pie Chart | Scatter Plot

Area Chart

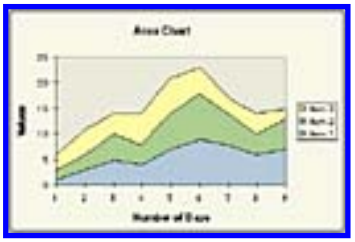


Figure 1: Area chart

Types

- Percentage: The sum always represents 100% (relative scale)
- Cumulative: The sum can vary according to the elements (absolute scale)

Layout Recommendations

- Position the largest area lowest
- Position darkest color or pattern lowest (use lighter colors when moving up)
- Emphasize data through colors (redundant coding)

Column/Bar Chart

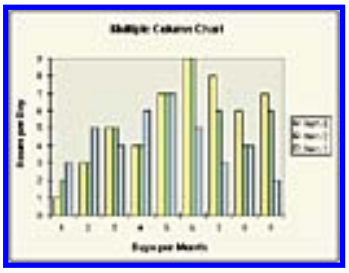


Figure 2: Multiple column chart

Layout Recommendations

- The baseline of a bar chart or column chart consists of labels (e.g. customers, regions, products), not a numerical scale, even if it sometimes looks like that.
- Types:
  - Column Chart: Vertical columns
    - Use if the values are more important than the labels (e.g. years)
  - Bar chart: Horizontal bars
    - Use if the labels for the data are very long
    - Use if the information is more important than the values themselves -> the labels are to the left and are read first

- Column/bar charts can be used to compare more than one category at a time -> multiple column/bar charts.
- Separate columns/bars through white space (for more than one categories, only the groups are separated through white space)
- Choose an organizational principle for the baseline:
  - Time, e.g. costs from January to December
  - Quantity or volume, e.g. number of sold units
  - Alphabet
  - None: order columns/bars according to rank in ascending or descending order
- If possible show comparison values like a "baseline" value or a "critical" value
- If applicable and possible show error limits

Recommendations for Labels

- Add labels to axes and columns/bars: Place scale and marks at the axis, label below (columns) or left to (bars) the baseline.
- For multiple column charts:
  - Place group labels below the baseline, left-aligned to the columns
  - Column labels:
    - Place label for each column type into the diagram area or
    - Use shading or patterns plus a key to identify the columns
- Label multiple bar charts analogously
- Bar charts
  - Short labels: Place labels to the left
  - Long labels: Right-align labels to the right chart border

Look

- Use a unique color or pattern for each value; use a contrast of at least 30% between neighboring columns or bars
- Striped patterns: Use patterns with an angle of 45° to the base line in order to avoid optical illusions; let the stripes all go into the same direction
  Better: Avoid striped patterns and use solid colors or grays
- If possible use colors or patterns that emphasize the data with similar meaning, e.g. red for "critical" or "red shirt"

Segmented Column/Bar Chart

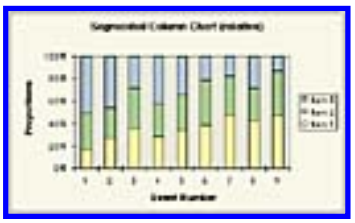


Figure 3: Segmented column chart (relative values)

Recommendations

- For scales, axes and layout see column/bar charts
- Arrange segments within each column/bar in the same order
- Do not place labels into the segments. Place them right beside the diagram or above it - or use a legend. Do not label each column/bar
- If possible, place the segment with the least change lowest and the most variable at the top; for bars do the analog. This arrangement makes comparison easier and emphasizes changes
- Make the segments easy to distinguish; use the most striking color or pattern for the most important data
- Limit the number of segments to those that are large enough to be easily recognized and labeled; combine small segments into a larger one

Line Chart

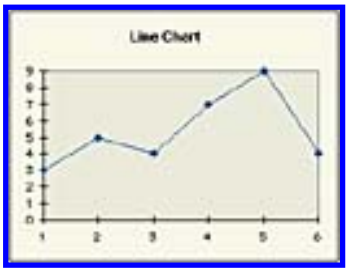


Figure 4: Line chart

Layout Recommendations

- Use the Y axis for variable (dependent), the X axis for fixed (independent) information
- For comparisons of data sets, draw each data set as a graph of its own in a common line chart (not more than 4-5 graphs - otherwise split data sets into several charts:
  - For example, compare the most important graph with every other graph
  - Plot the most important graph against a small set of other relevant graphs
- There are no rules for the interval size of the axes; however, the graph should be neither too steep nor too flat
- Label each graph, if possible (otherwise use keys)
- If appropriate, display a reference line
- For multiple graphs: Use symbols for the data points to visually set the graphs apart; make the symbol 2-3 times larger then the line

Look

- If there are several graphs within one chart, use colors or line styles to distinguish the lines (care for overlapping graphs)
- Emphasize the most relevant graph, if applicable, by using the most striking color or the thickest lines for it
- If lines cross each other, interrupt the background lines

Special Variants

- Graph with double-logarithmic or half-logarithmic scale divisions
- Graph with variance bars, stock charts (High/Low/Close) etc.

Pie Chart

Figure 5: Pie chart

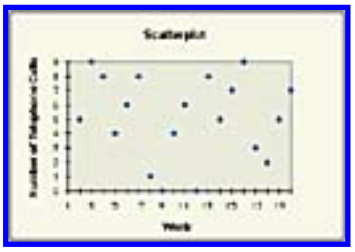
Layout Recommendations

- Start at 12 o clock (top), then follow the direction of the clock
- The values must add up to 100% (or have to be scaled accordingly)
- Do not use too small circle segments (> 18° or 5%); combine small segments intro larger ones, if applicable
- Label each segment
- Labels can be placed within segments (if these are large enough and the labels short) or outside (small segments, long labels)
- Write the values beside the segments, because angles are hard to estimate

Look

- Use highlighting methods only, if really necessary. Typical emphasizings are:
  - Pull a segment out of the pie
  - Use different colors or patterns
- Patterns: Try to alternate between patterns and solid colors; avoid vibrating patterns or patterns that produce optical illusions.
- Use perspective only, if distortions are tolerable (write values beside the segments in this case).

Scatter Plot



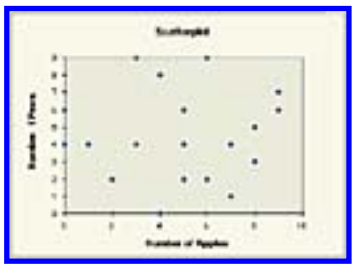


Figure 6: One-dimensional scatterplot (left), two-dimensional scatterplot (right)

Look

- Preferably use a square for the diagram; for two-dimensional scatter plots both axes should have identical scale divisions
- Use different symbols, if different sets of data are included in one scatter plot:
  - Useful symbols are:
    ○ ● □ ■ △ ▲;
    Less useful symbols are:
    ◇ ◆
  - Different colors help to distinguish symbols; circles are good distinguishable from triangles, but not good distinguishable - especially if small - from squares
  - Colors may be used "symbolically", e.g. ○ = "without treatment", ● = "with treatment"
  - All symbols should be of the same size - or at least look as if they were of same size (sometimes optical corrections are necessary)
  - Use overlapping symbols for overlapping data points, not just one symbol
  - Identical data points should be represented through special symbols which indicate this fact
- Important or critical data points should be highlighted, e.g. though more intensive color, a different color or a different shape
- If data points lie on the axes, move the axes slightly outwards

top

Source: Recommendations for Charts and Graphics

Design Recommendations for Chart Parts

Axis | Scale | Legend | Grid | User Support

Axis

- Horizontal axis (X axis, abscissa): Use for independent variable, e.g. time
- Vertical axis (Y axis, ordinate): Use for dependent variable, e.g. temperature values

Scale

- Tick marks for scale divisions should not intrude the diagram, but point outwards.
- Scale
  - Standard: Start with 0-0 at the bottom left corner; numerical scales typically start with 0
  - Exceptions:
    - all values are much larger than 0 -> let the scale start with a higher value
    - some values are negative -> move zero close to the middle of the scale
  - Add tick marks to the scale at fixed intervals (e.g. 0, 10, 20, 30, ...).
  - On scales write 0.1 instead of .1, because the decimal point is easily overlooked.
  - Use only one scale on each axis to avoid confusion.

Legend

- Center title at upper border (or left-aligned for long titles or if texts might overlap)
- Y-axis: label centered or left-aligned with scale of Y-axis
- X-axis: center label below x-axis
- If possible, mention the source of the data (e.g. in small print below the label of the X-axis)
- Further recommendations:
  - Show units
  - Do not stack letters vertically for labels
  - If possible, avoid legends and include the information within the chart
  - Do not let explanations follow the graph, arrange them horizontally
  - Use only one typeface, one font and one weight; use different font sizes for emphasis.

Grid

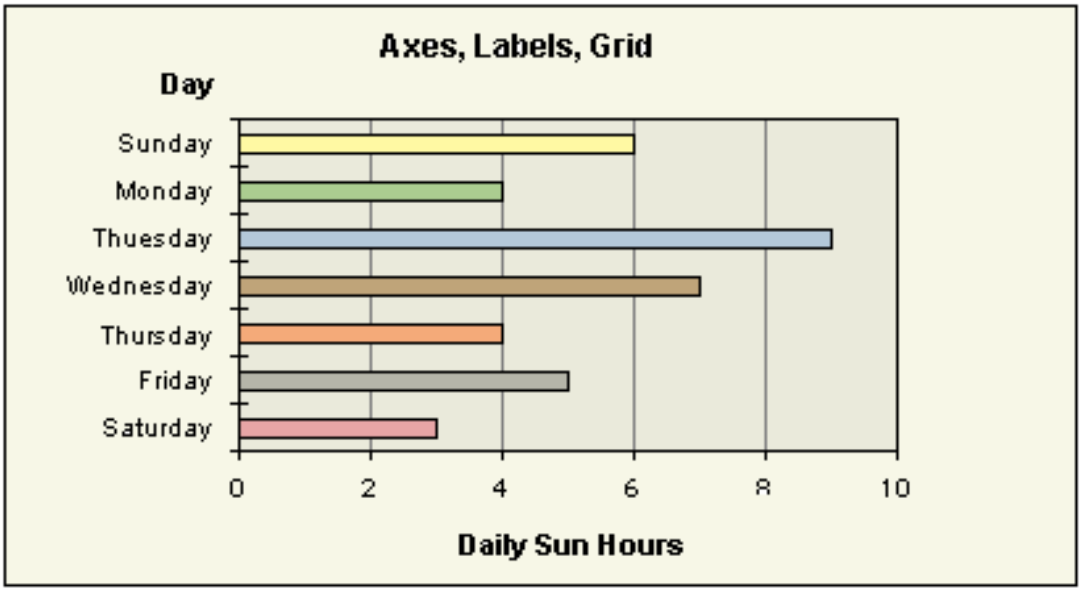


Figure 1: Example for grid, labels and axes

- If a grid is needed, do not emphasize it too much; use thin gray or dotted lines; blue is also a good grid color.
- Put the grid behind the data, not vice versa.

User Support

- Offer the option to show grid lines.
- Display exact values if users click a data point or display numerical values automatically for each data point or bar/column.
- Offer zooming facilities.
- Offer the option to toggle between chart view and table view.

top

Source: Recommendations for Charts and Graphics

Problems with Charts

Problems with Scales and Axes | Optical Effects

Problems with Scales and Axes

Improper use of scales and axes may lead to misinterpretations of charts.

- Do not exaggerate differences by *shifting the X axis* to a higher (or lower for negative values) level.
  Example: If the X axis is shifted to a value of 15, the difference between 16 and 17 seems to be very large, although it is less than 10%.
- Do not minimize differences by choosing a *range* that is too large for the actual values.
  Example: Do not use a range so that the values only fill only 20% or less of the chart.
- Do not use a *scale* that leads to wrong interpretations.
  Example: A logarithmic scale may minimize relevant differences.
- Do not use *different scales* on charts that are to be compared; different slopes for identical changes may lead to wrong conclusions.

Optical Effects

Optical effects may lead to distortions, and thus to misinterpreations of charts.

- Care for distortions in *areas* or *volumes*. Do not vary both width and height.
  Example: Be careful with 3D charts where 3D borders may add to the perceived area.
  Example: Do not increase width and height simultaneously with the data values - while size increases linearly, area is squared (see figure 1).
  Example: Be careful with pictographs that use images of different sizes to represent quantities (analog to simultaneously increasing width and height).
- Do not use *brightness* to exaggerate areas.
  Example: If the largest area is lightest and the smallest area darkest, the perceived differences between the areas are increased (see figure 2).
- *3D graphs* are fancy, but mostly misleading, especially if pie charts are used (see figure 3 and 4).
- Avoid *patterns* and *textures*, e.g. striped patterns, that cause optical illusions or perspective effects that distort areas.
- Do not *combine* distortions.
  Example: Do not combine brightness variations with area distortions like simultaneously varying width and height (see figure 2).

Examples

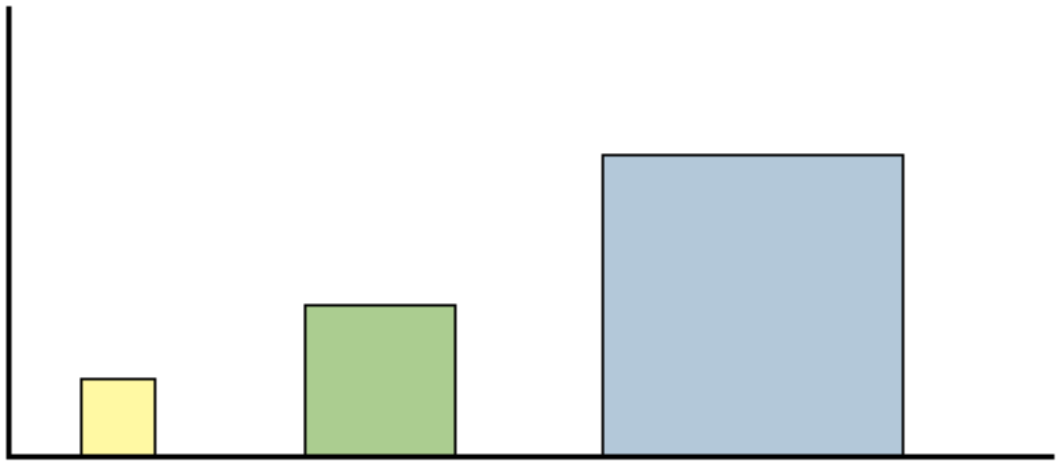


Figure 1: Areas quadruple, if lengths double; the effect may even be worse with realistic images.

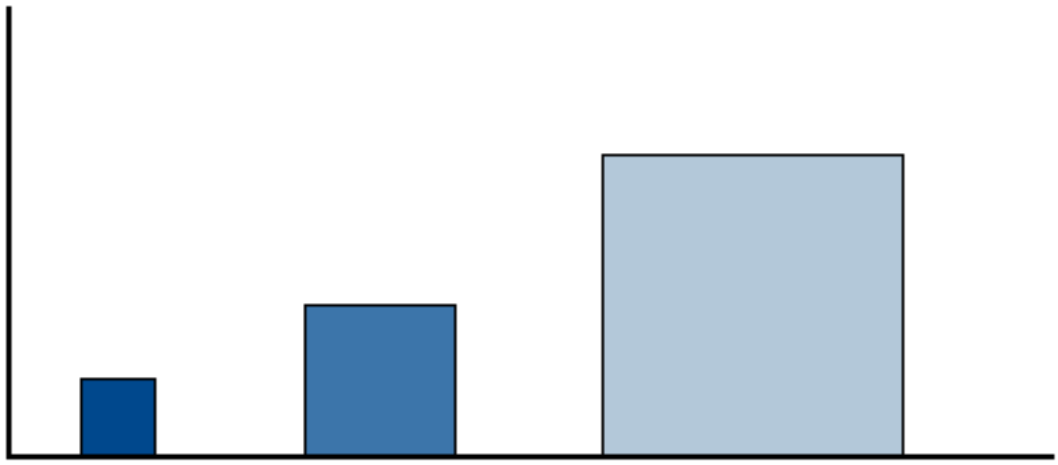


Figure 2: Changing width and height simultaneously as in figure 1, as well as varying brightness, may exaggerate the increase even more.

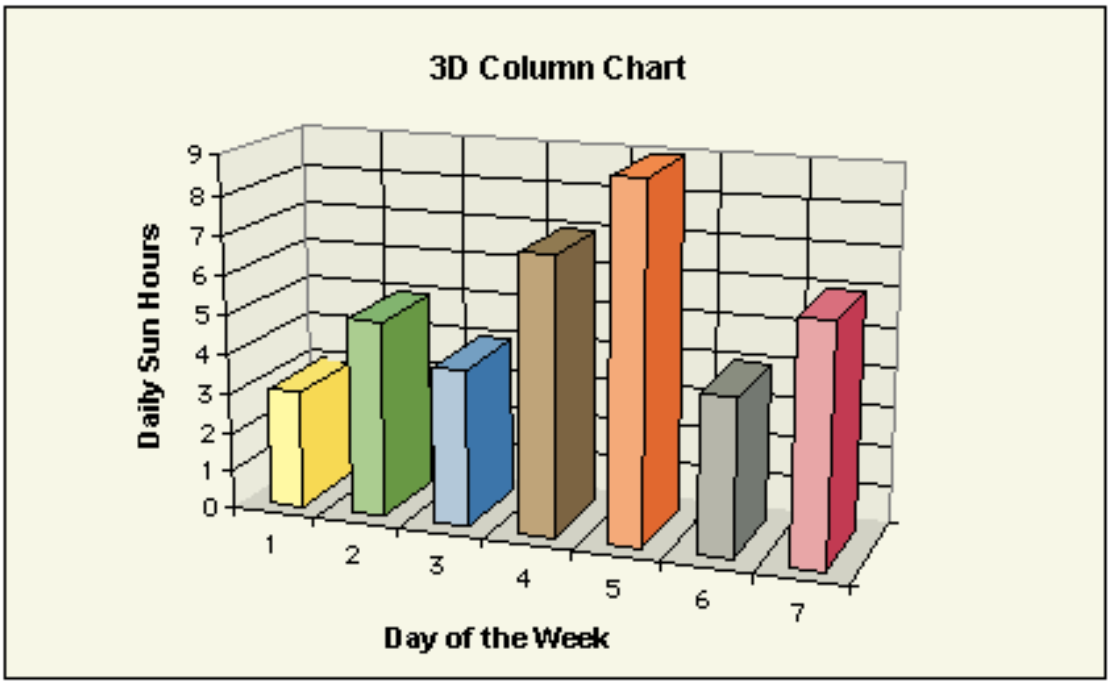


Figure 3: A 3D column chart makes it hard to compare actual lengths; moreover, perspective may let columns in the background appear larger than columns of the same size in the foreground (size constancy)

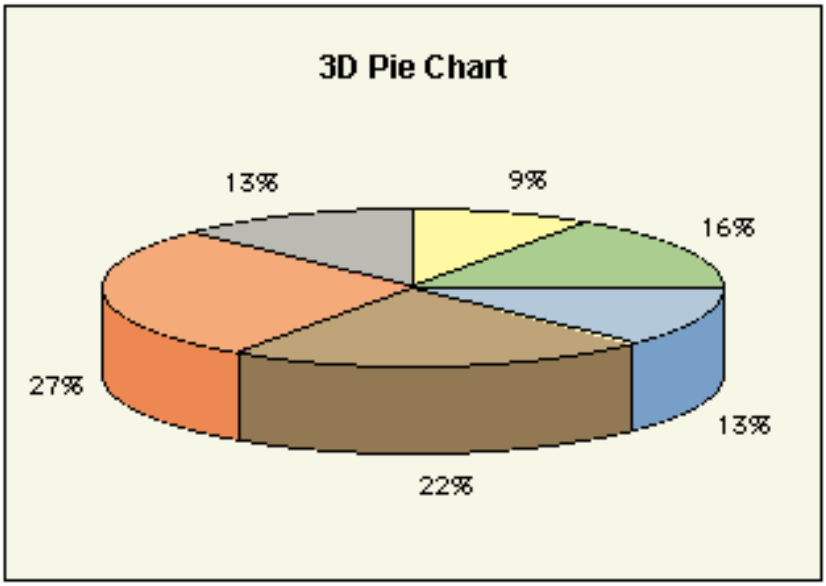


Figure 4: Perspective makes it impossible to reliably compare the sections of a pie; furthermore, 3D borders may add to the area of segments. Also angles are much harder to estimate than distances.

top

Source: Recommendations for Charts and Graphics

Charts vs. Tables

Advantages of Charts | Chart and Table Alternatively

Advantages of Charts

Charts should be preferred to *tables* whenever it is important for the users to quickly and easily recognize characteristics of data. Scanning data in tables takes longer, and important data are easily overlooked in tables.

Therefore it is important not to use chart types that are fancy, but distort relations between data, like 3D charts. Such charts should be used with care, and the data should be accompanied by numbers in order to avoid misinterpretations.

This is especially important, if time pressure or high risk are involved.

Chart and Table Alternatively

In cases where charts help to easily grasp the essence of the data but where also exact values are needed, you may consider to provide both a chart view and a table view.

Start with the chart view and offer a button (below the chart or table) for toggling between the views:

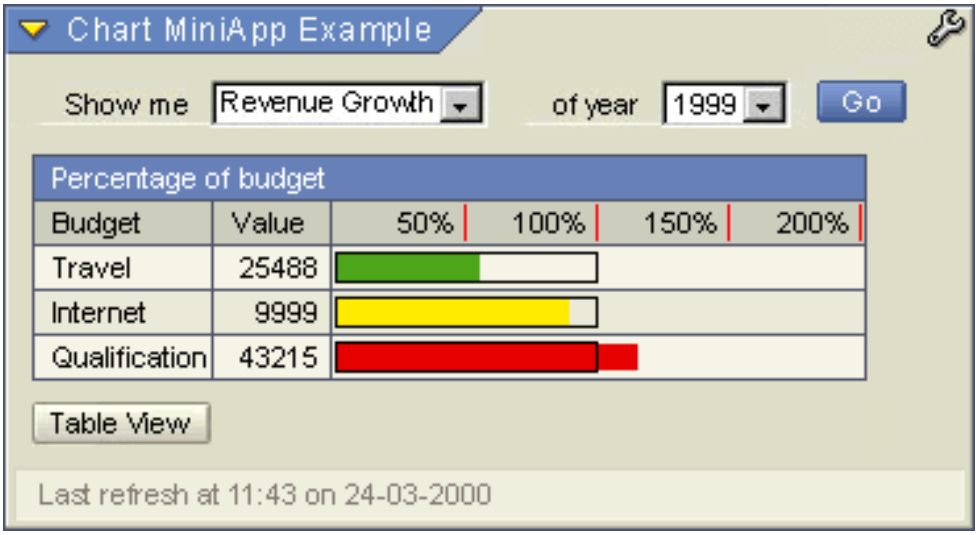


Figure 1: The chart view

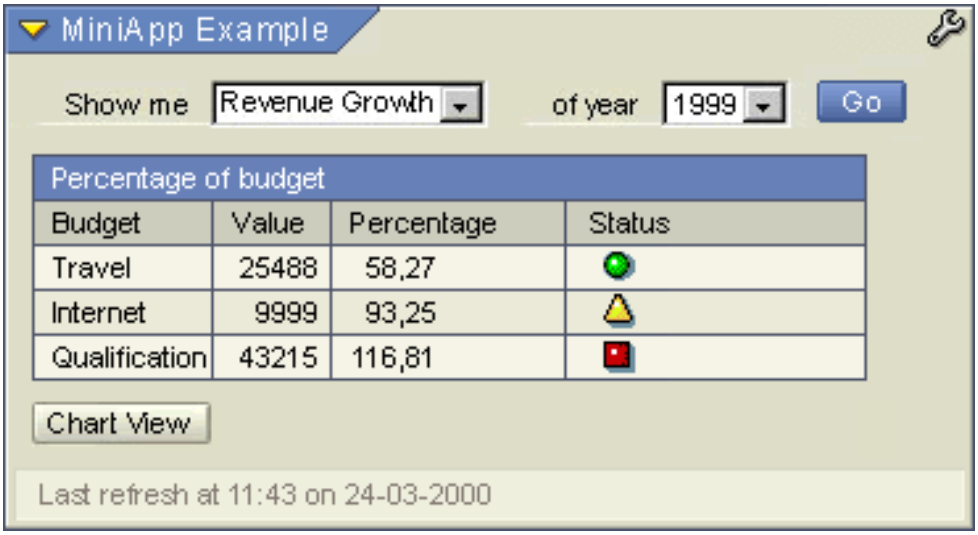


Figure 2: The alternative table view (with additional status column)

Note: Typically, status columns are arranged to the left of the table; this example deviates from this rule in order to keep the layout stable. In other cases there will be less similarity between the table view and the chart view (here a bar chart table).

top

Source: Recommendations for Charts and Graphics

Portable Interactive Graphics (Charts)

Pie Charts | Curve Charts | Vertical Bar Charts (Column Charts) | Horizontal Bar Charts (Bar Charts)

Portable Interactive Graphics (PIG) provide an easy to use interface for implementing charts in MiniApps or other SAP applications. The following chart types are available as PIG charts for SAP developers:

- Pie charts
- Curve charts: Lines, areas, stacked
- Vertical bar charts (column charts): 2D, 3D, stacked
- Horizontal bar charts (bar charts): 2D, 3D, stacked

Below we present examples using these chart types. See Charts - Types and their Uses for information of the usage of the different chart types.

Note: The actual charts may differ from the charts shown here, depending on the version of the PIG charts.

Pie Charts

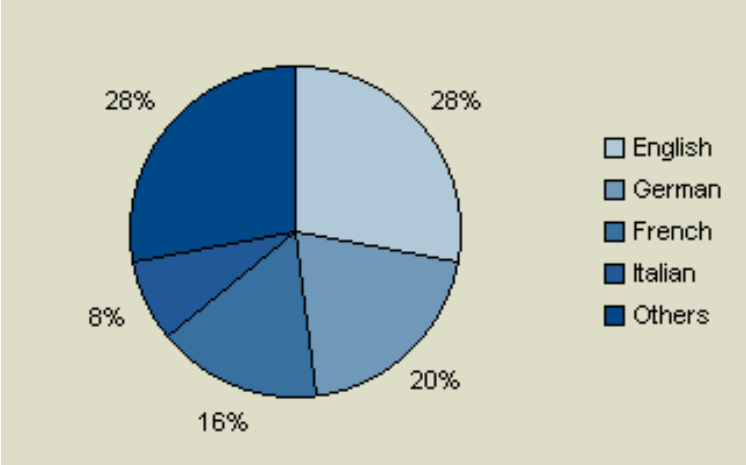


Figure 1a: Pie chart

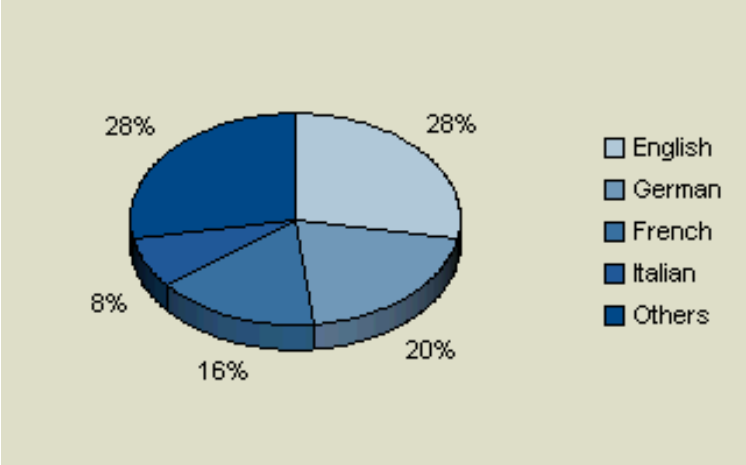


Figure 1b: 3D pie chart (not recommended)

Curve Charts

Lines

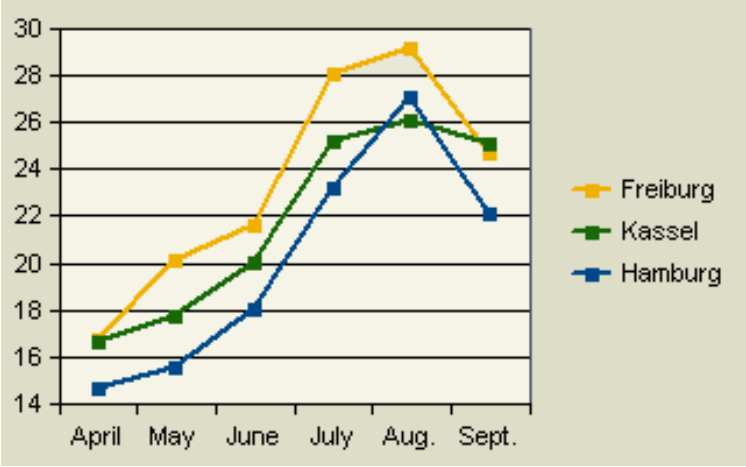


Figure 2a: Line chart

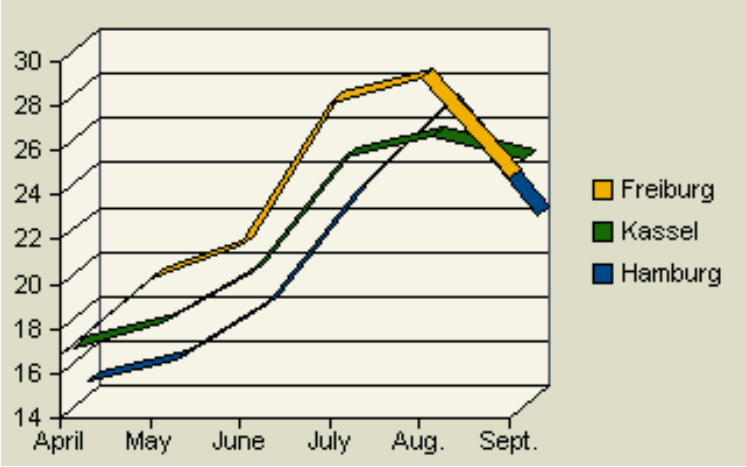


Figure 2b: 3D line chart (not recommended)

Areas

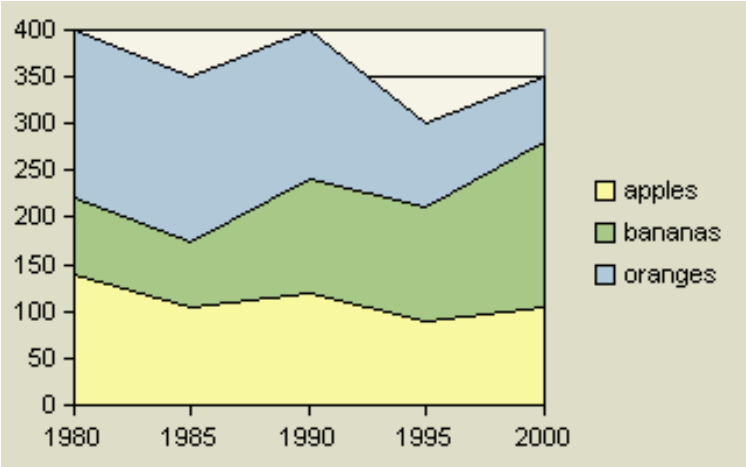


Figure 3a: Cumulative (stacked) area chart

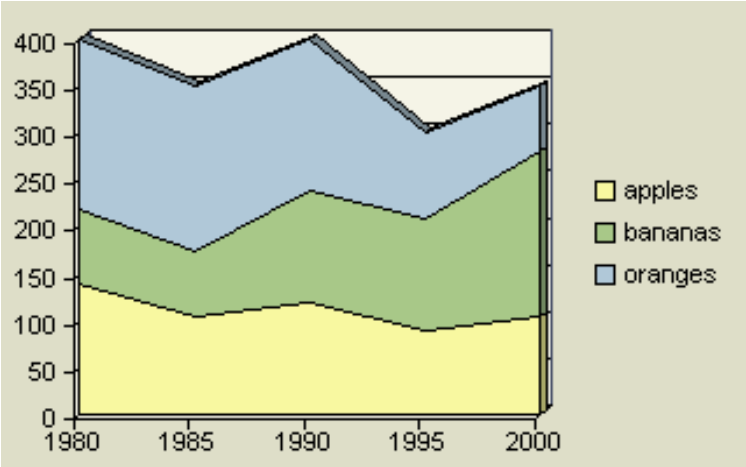


Figure 3b: Cumulative (stacked) 3D area chart (not recommended)

PIG also offers non-stacked area charts. However, we do not recommend to use these charts, because the colored areas provide a wrong impression of the actual data values (which relate to the x-axis and not to the nearest line).

Vertical Bars Charts (Column Charts)

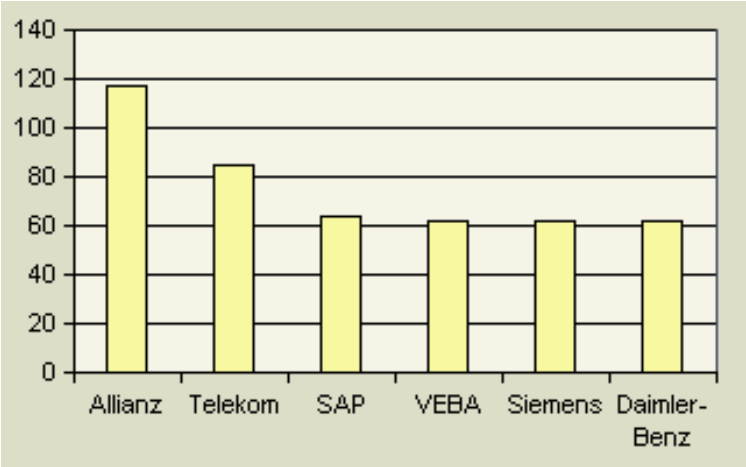


Figure 4a: Column chart

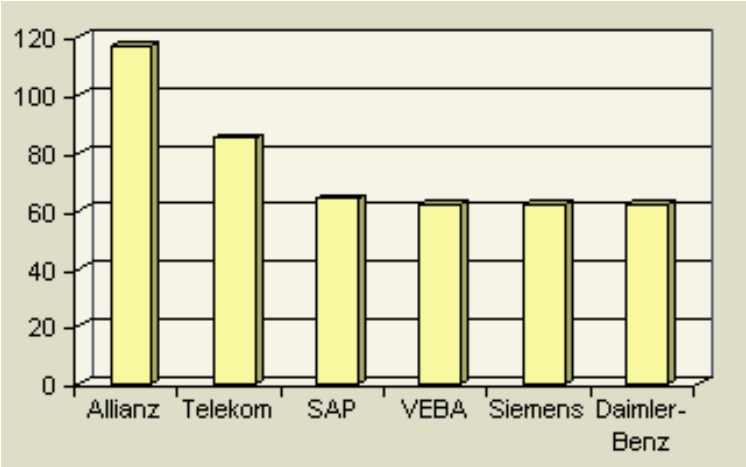


Figure 4b: 3D column chart (not recommended)

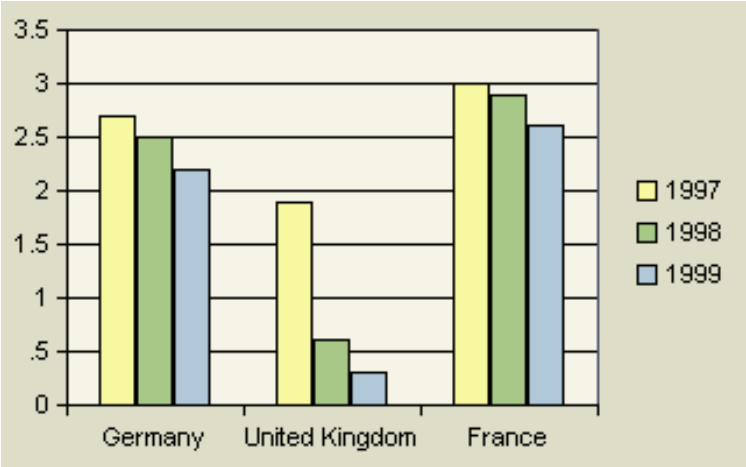


Figure 4c: Multiple column chart

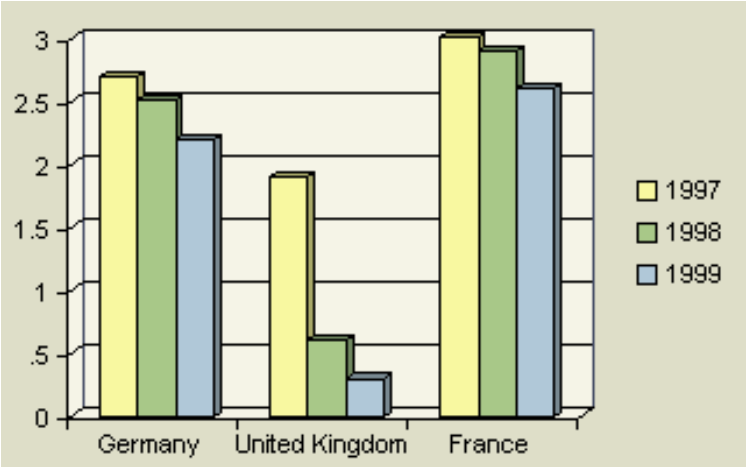


Figure 4d: Multiple 3D column chart (not recommended)

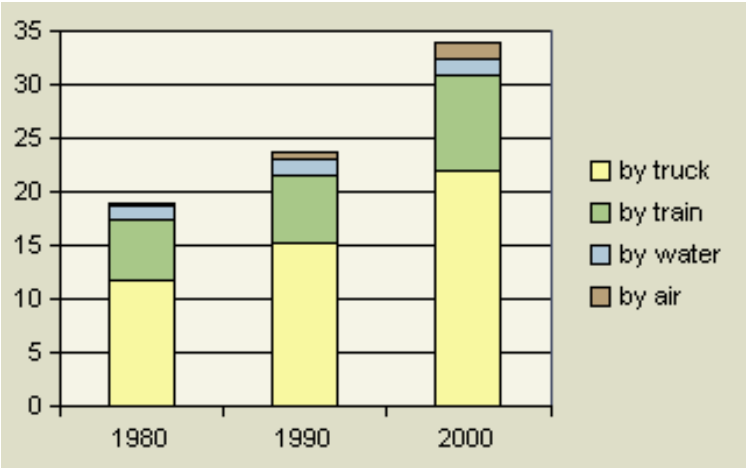


Figure 4e: Stacked column chart

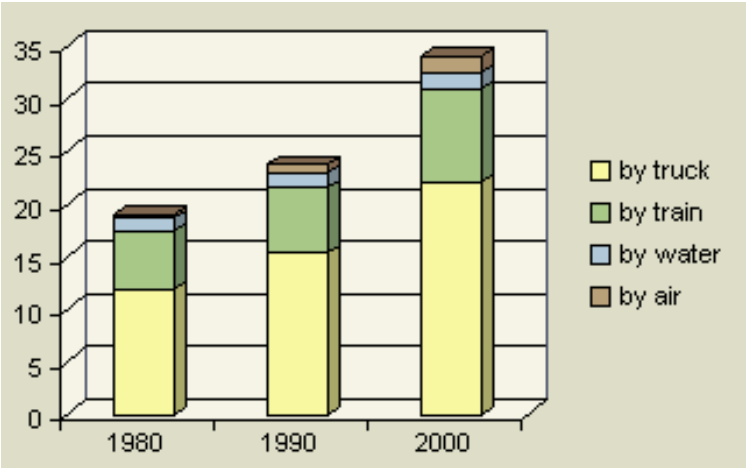


Figure 4f: Stacked 3D column chart (not recommended)

Horizontal Bar Charts (Bar Charts)

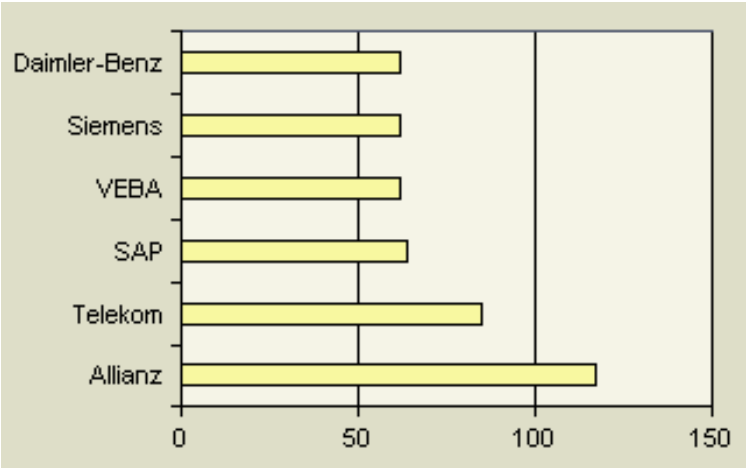


Figure 5a: Horizontal bars

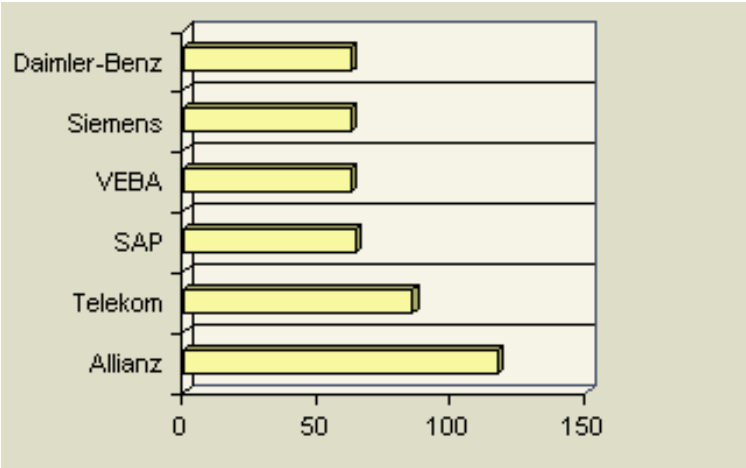


Figure 5b: 3D horizontal bars (not recommended)

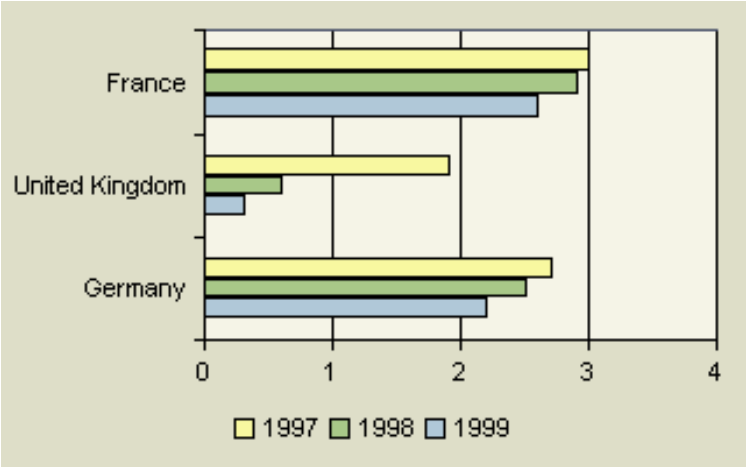


Figure 5c: Multiple horizontal bars

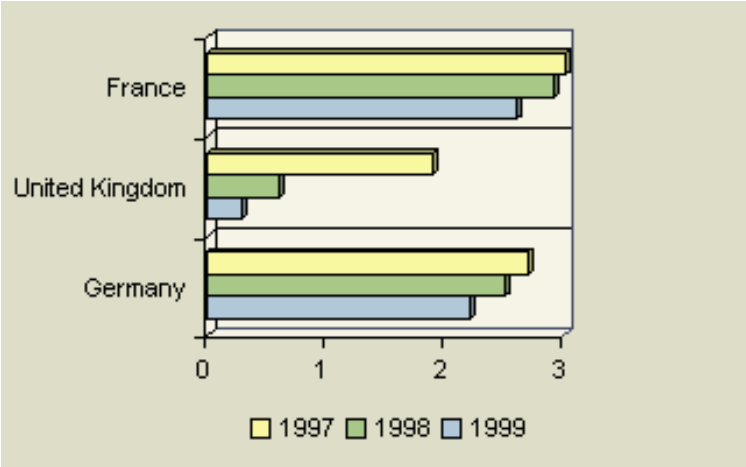
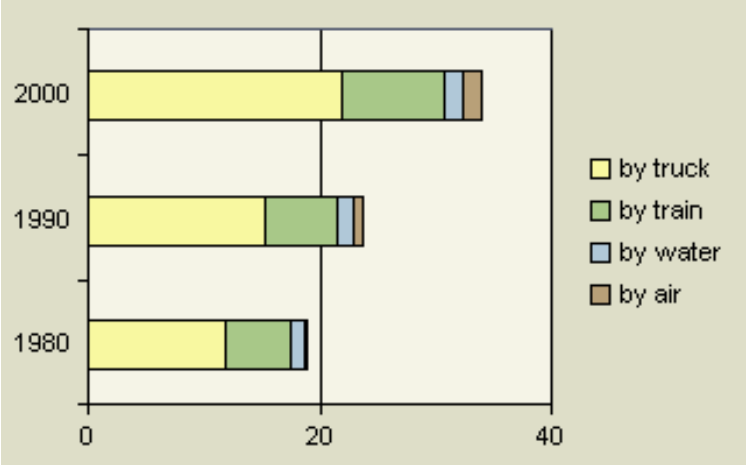


Figure 5d: Multiple 3D horizontal bars (not recommended)



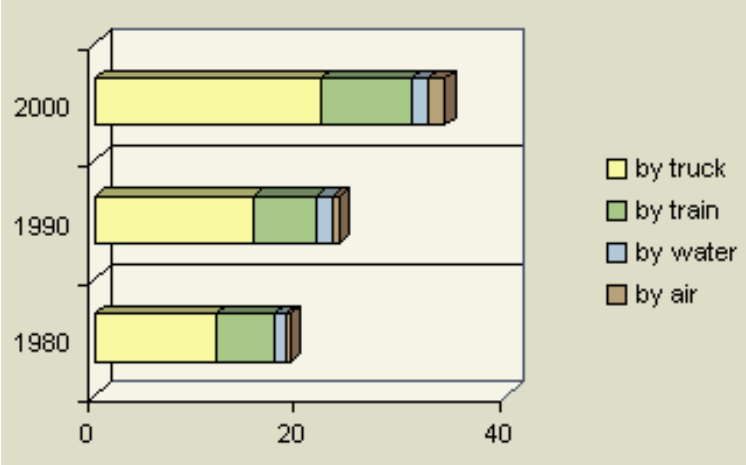


Figure 5e: Stacked horizontal bars

Figure 5f: Stacked 3D horizontal bars (not recommended)

top

Source: Recommendations for Charts and Graphics

Color Palettes for Charts

Overview | Monochrome Scale | Multicolor Scheme (Straight) | Multicolor Scheme (Straight Reverse)

Overview

For charts in MiniApps or other SAP applications the color codings described below are to be used - irrespective of whether the charts are created using Portable Interactive Graphics (PIG) or any other method.

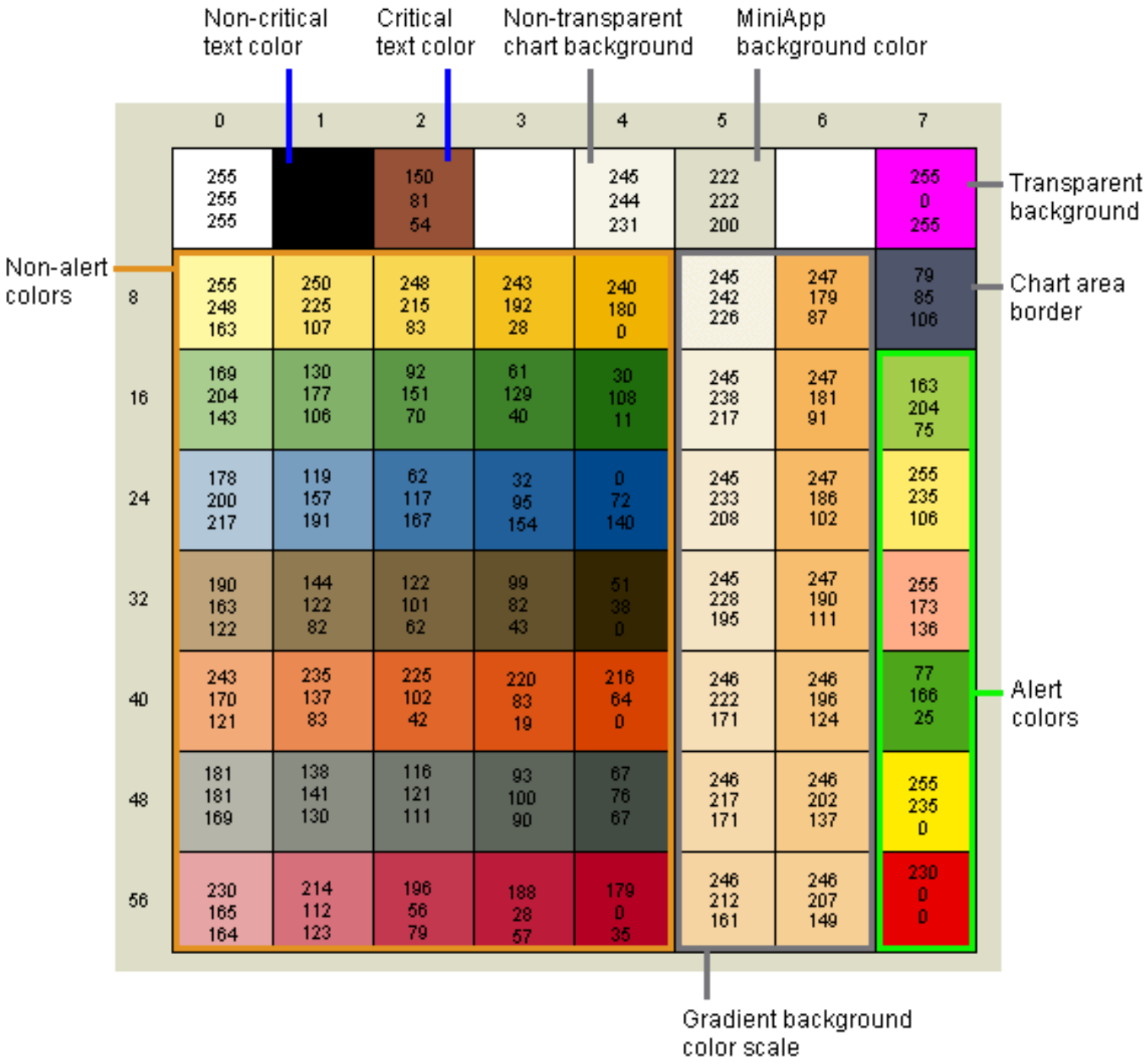


Figure 1: Overview of the chart colors and their uses

Monochrome Scale

This scale is the default for charts with alert function.

Colors are used in this order:

1. 24, 25, 26, 27, 28,
2. 52, 51, 50, 49, 48,
3. 32, 33, 34, 35, 36

Note: The monochrome scale is just an additional option.

It is possible to go on in the following order:

1. 20, 19, 18, 17, 16
2. 8,9,10,11,12
3. 44, 43, 42, 41, 40
4. 56, 57, 58, 59, 60

But it makes no sense to show such a great number of values in a Miniapp. It is better **not** to enable the second group. So, a maximum of 15 values in a monochrome chart is recommended.

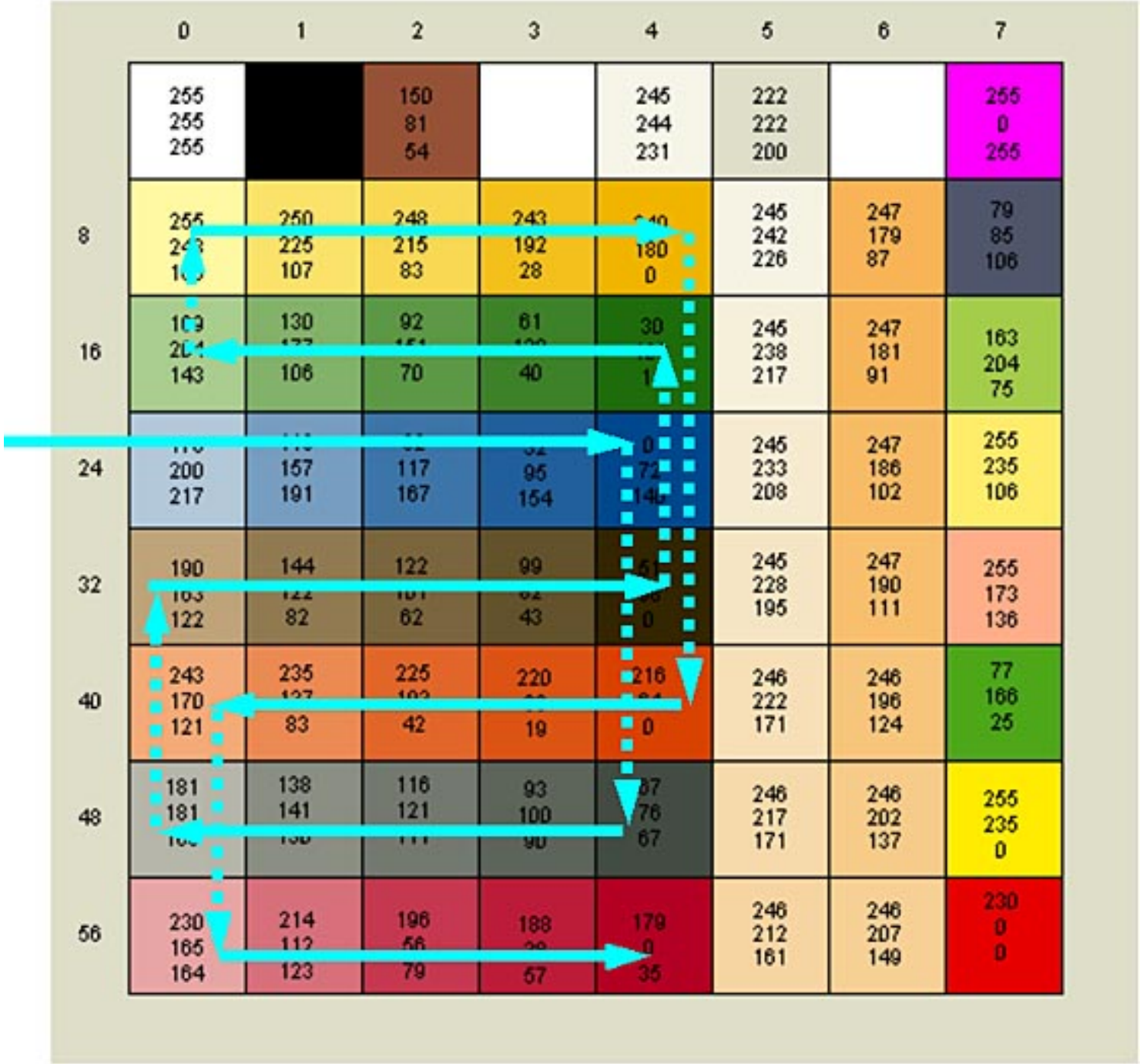


Figure 2: Monochrome color scales and their construction

Multicolor Scheme (Straight)

Use this color schema for all chart types **except** curve/line charts.

Color columns used in the order are shown beneath the color table.

A maximum of 35 values is possible.

However, it is hard to distinguish or compare more than 3 different shades of the same color, since they are not standing next to each other.

This means that any chart showing more than 21 values will be very difficult to read.

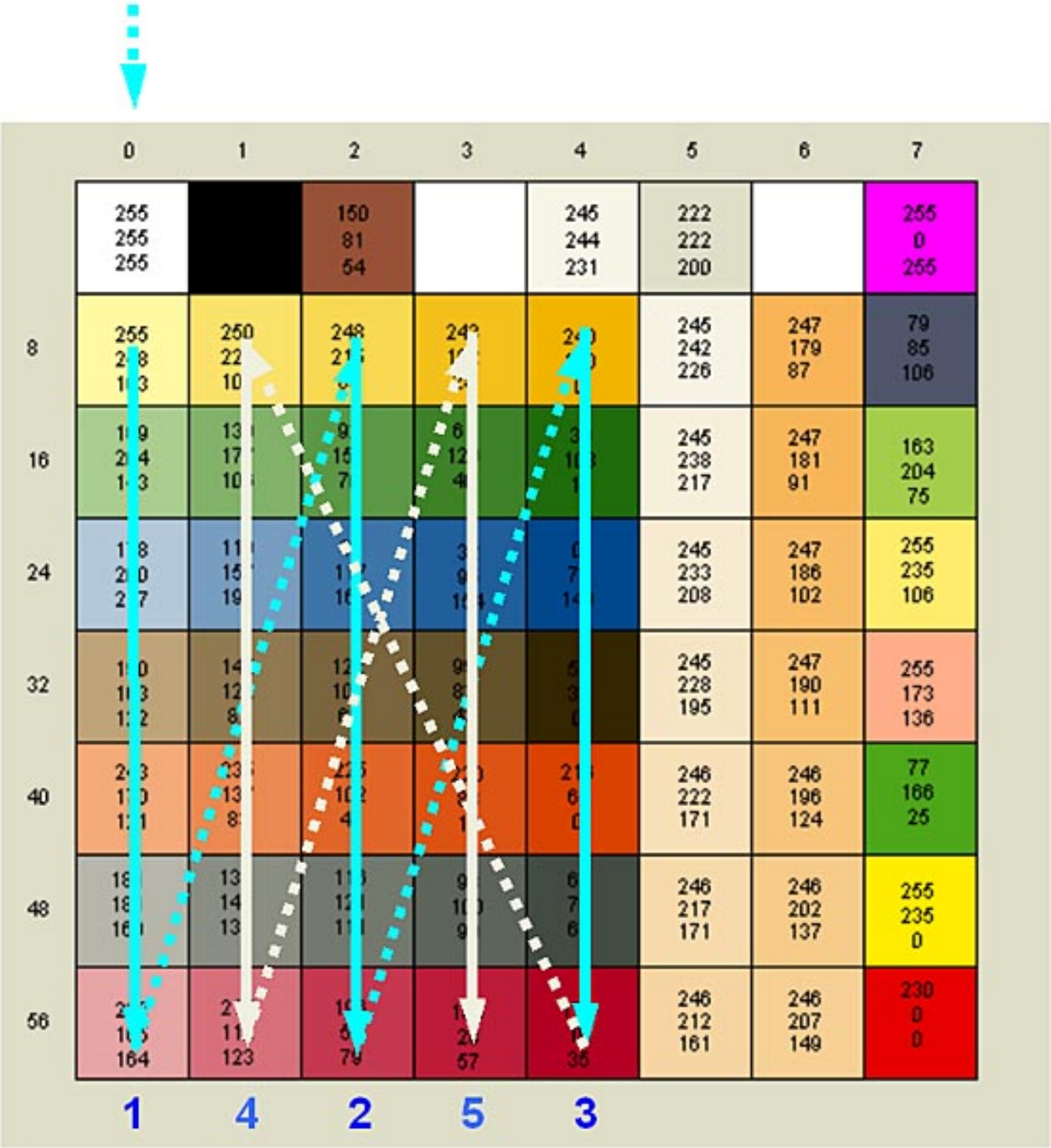


Figure 3: Multiple color coding scheme for most charts types

Multicolor Scheme (Straight Reverse)

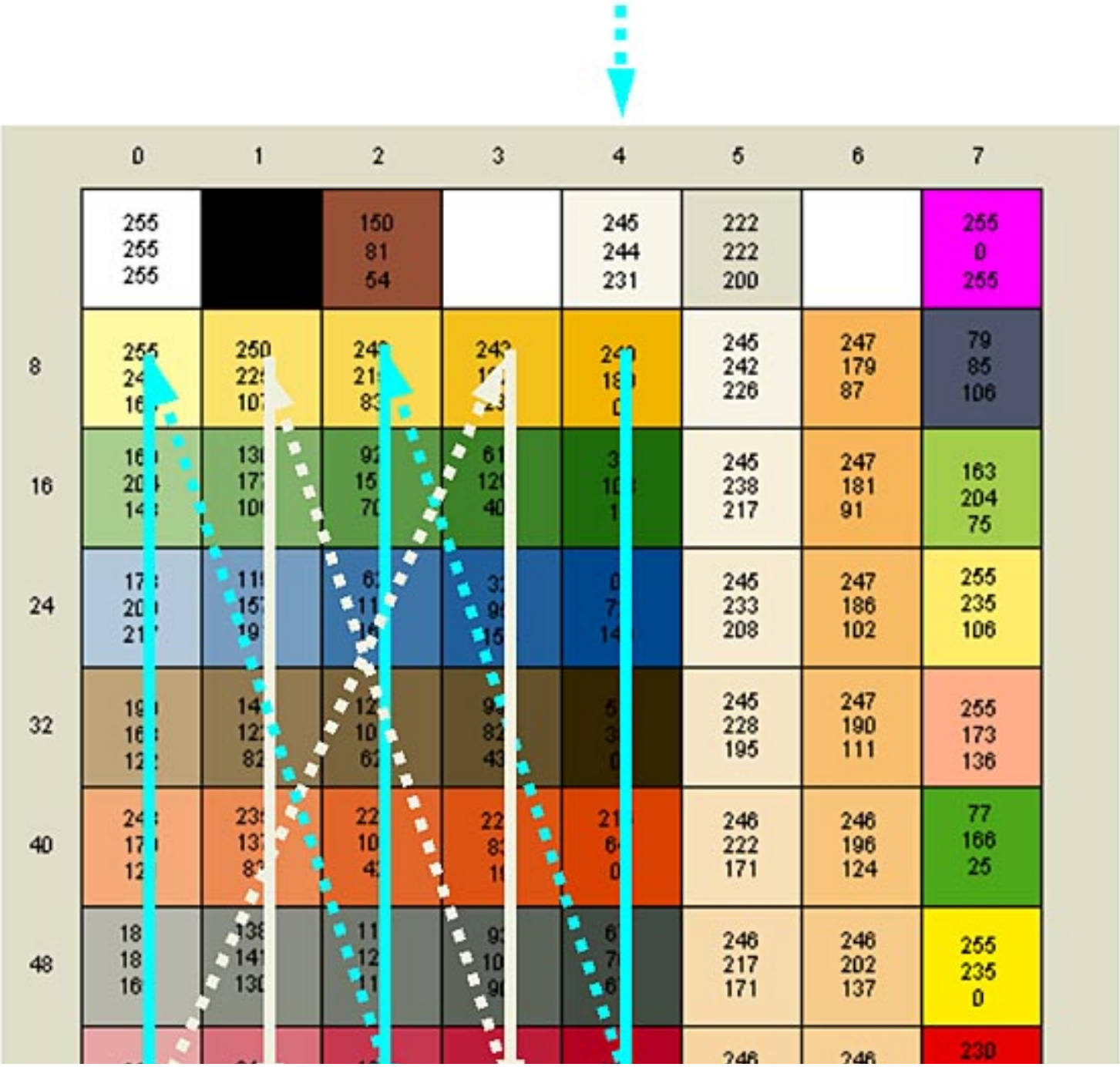
Use this color scheme **only** for curve/line charts.

Color columns are used in the order shown beneath the color table.

A maximum of 35 values is possible.

However, it is hard to distinguish or compare more than 3 different shades of the same color, since they are not standing next to each other.

This means that any chart showing more than 21 values will be very difficult to read.



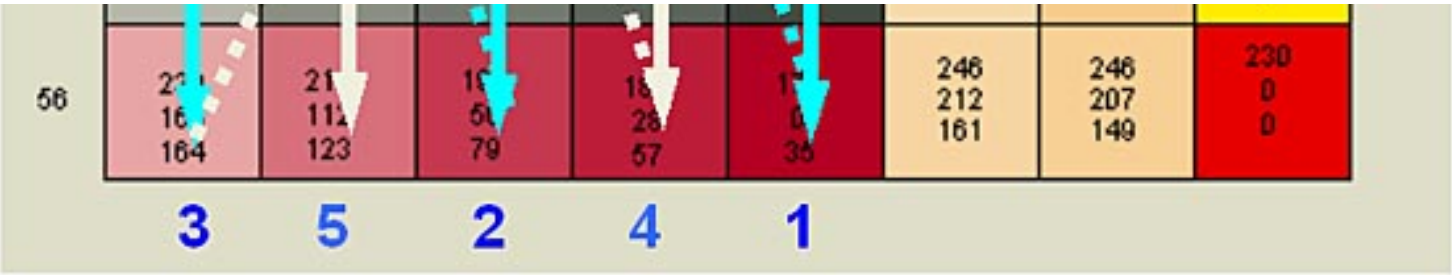


Figure 4: Color scheme in reverse order for curve/line charts

top

Source: **Recommendations for Charts and Graphics**

Using Graphics - When and How

When | How

When

- Use graphics instead of text when they easily and effectively convey information.
  Example: A floor plan is more efficient for describing the structure of a building than a text description.
- Use graphics when they need less space than equivalent textual information.
  Example: The description of a procedure may be much longer than an equivalent diagram.
- Use graphics for decoration or fun, but only if it is appropriate for an application. Do not decorate applications just because you think it looks nice.

How

- Align graphics so that their main contents points towards the text, not away from it.
- Crop graphics to the relevant section; make them as small as possible and avoid irrelevant and distracting elements.
  Example: Do not show a US map, if you want to illustrate data in Michigan - use a Michigan map instead.
- Use high quality graphics.
  Example: Do not draw graphics by yourself, involve graphic designers.
- Care for the corrects format of the graphics.
  Example: Use JPEG for photos, images with many colors and gradations; use GIF for diagrams, images with straight lines and images with less than 256 colors. Typically screen dumps work better in GIF format.

For more information see Use of Images!

top

Source: Recommendations for Charts and Graphics

Use of Images

Human Abilities | Towards Understandable Images | Uses of Images | Tips for Optimal Use of Images

Human Abilities

For processing images humans can

- perceive them as a whole, that is, in parallel - while text is processed sequentially,
- automatically group elements (Gestalt laws),
- put the focus on different groupings, that is, switch between foreground and background information.

Towards Understandable Images

Motto: A picture tells more than a thousand words - but sometimes a word tells more than a thousand pictures...

Prerequisites of the Reader

Appropriate prior knowledge is a prerequisite for understanding images, as can easily be proven with technical drawings, medieval symbols, or scenes from foreign cultures. Information is also implicit in images - they have to be "interpreted". Thus, it depends on the reader how much information he or she can extract from an image.

In addition, image readers need competence for

- recognizing relevant parts in an image
- organizing the information in the image
- interpreting the meaning of an image systematically

Also note that many people have difficulties in reading diagrams or images, because there is no "primary" reading direction as in texts.

Last not least, readers need motivation to look at an image.

Image Quality and Embedding

Image interpretation is supported by good image quality and the proper embedding into the context. Good image quality means

- sufficient technical quality,
- appropriate complexity of the presentation (not too high, not too low), and
- correctness

Appropriate embedding into the surrounding text means, a.o.

- proper figure captions
- proper alignment of image elements with respect to the text (see tips)
- proper cropping of the image in order to avoid irrelevant image parts (see tips)

Uses of Images

Decoration

- Images increase the attractiveness of texts or screens.
- Images may direct the attention to the text.
- Images support fun and motivation.

Presentation

- Images may repeat information in the text.
- Images may make the text information more vivid.
- Images may convey information that is absent from an equivalent text.

Organization

- Images can clarify or convey the structure of a text.
- Images may help to organize large quantities of knowledge or data.
- Images help to focus on relevant or critical aspects of data.

Interpretation

- Images clarify facts through image-based analogies.
- Images support (often fast) interpretations that are not easily possible with text (e.g. determining angles or distances).

Memory

- Images help to better memorize (text) information.

Tips for Optimal Use of Images

Layout

- Divide the screen into a grid and decide where to place text and where images.

Attention

- The upper left corner of a screen or page gets most attention.

Alignment

- Align images so that they point towards the text (if necessary and possible, use a mirror image), not away from it.

Cropping

- If appropriate, cut the image (like in many famous paintings) or let the image loom into the text; this saves space, but can also make the screen look more attractive.
- Cropping (II): Crop images to the relevant section; make them as small as possible and avoid irrelevant and distracting elements.

top

Use of Colors

Advantages of Using Color | Rules for the Use of Color

Advantages of Using Color

The use of colors can effectively support human performance in visual information processing. Even if this is not the case, users find colors more pleasant, more aesthetically pleasing, inspiring or useful than a monochromatic presentation. Colors can increase the users' self-assurance to find their way around and to find the information they are searching for.

Use of colors improves the following abilities:

- Separating figure from ground, that is, separating the important from the less important
- Discerning the inner structure of objects, finding groupings
- Searching, discovering, and localizing objects
- Recognizing and remembering

For more complex tasks like reading, memorizing, drawing conclusions, or deciding the effect of color cannot as easily proven.

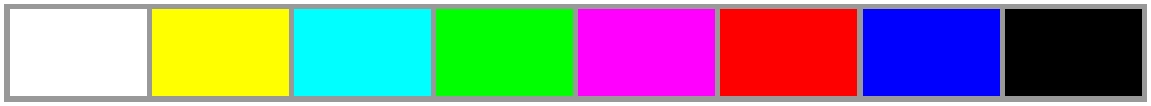
Rules for the Use of Color

General Rules

- When designing a screen, diagram or graphic, start with a black-and-white design.
- Use colors consistently.

Colors and Color Differences

- Lightness Ranking of the most-used screen colors: White, yellow, cyan, green, magenta, red, blue, black



- Color differences may be distracting; therefore use them only sparingly and intentionally.
- Avoid using highly saturated complementary colors, because users have to focus differently for these colors; less saturated colors are less straining.
- If you want to use small hue differences, use yellow or blue, do not use red or purple.
- Use complementary colors (red-green, blue-yellow) if differentiation of colors is intended.

Color Blindness, Elderly Users

- Color blindness: A colored presentation may be better than a monochromatic one, but check the effect with color blind users.
- Code colors redundantly to support color blind users: Do not rely on hue differences alone, but add also lightness differences.
- Elderly users need more brightness in order to differentiate colors.

top

Colored Text

Designing Legible Text | Text and Background Color

Designing Legible Text

Colored Text Against White and Black Backgrounds

- Colored text does not have the same legibility as black and white text.
- The table below shows a **ranking** of the legibility of colored text (primary colors and their complementaries) depending on background.
- The **dark** versions of some colors demonstrate how the legibility of these colors can be improved under certain conditions.

Legibility	Black Background	White Background
Best	**White**	**Black**
	Yellow , Dark Yellow	**Blue, Dark Blue**
	Cyan , Dark Cyan	**Red, Dark Red**
Medium	**Green, Dark Green**	**Magenta**
	Magenta	**Green, Dark Green**
	Red, Dark Red	**Cyan , Dark Cyan**
Poorest	**Blue, Dark Blue**	**Yellow , Dark Yellow**
None		

Bold Type

On a white background use **bold** type for better legibility, especially if you use a color with poorer legibility (the white surround tends to spread into the letters).

Bold Type	Plain Type
Black on White, Bold	Black on White, Plain
Dark Blue, Blue on White, Bold	Dark Blue, Blue on White, Plain
Dark Red, Red on White, Bold	Dark Red, Red on White, Plain
Dark Green, Green on White, Bold	Dark Green, Green on White, Plain

Lightness and Hue Differences

For readable text (or graphics) always provide a significant lightness difference between the information and the background (the acuity of the eye is much higher for lightness changes than for changes in hue and saturation).

Do	Do not
Black on White	**Black on Dark Grey**
Dark Grey on White	**Middle Grey on Light Grey**
Black on Light Grey	**Dark Grey on Middle Grey**

Discrimination on the basis of hue and/or saturation differences alone is not adequate in any situation where there is fine detail.

Do: Hue/Saturation and Lightness	Do not: Hue/Saturation Only
Blue on Cyan (Hue)	**Blue on Cyan (Hue)**
Blue on Blue (Saturation)	**Blue on Blue (Saturation)**

Guideline: Allow a contrast ratio of at least 5:1 between text and background (ISO 9241 demands at least 3:1, but 10:1 is preferred).

Maximum Lightness Difference	Little Lightness Difference
Black on White, Bold	**Blue on Green, Bold**
Black on White, Plain	Blue on Green, Plain
White on Black, Bold	**Green on Magenta, Bold**
White on Black, Plain	Green on Magenta, Plain

In the case of little lightness difference, the color values have been manually adjusted to be similar. However, depending on the display, the difference may be more or less apparent.

Inappropriate Text Colors

- Beware of blue: Blue is inappropriate for discerning small shapes like alphanumeric characters, dots etc. on a dark background. However, blue is a good background color.
- Light greens are as well inappropriate as text colors on light backgrounds.

Blue	Blue	**Red**	Red	**Green**	Green
Blue	Blue	**Red**	Red	**Green**	Green

Text and Background Color

Blue Text on Red Background and Vice Versa

Do not use **blue** text on a **red** background or vice versa - the colors are seen at different depths.

Blue on Red	**Red on Blue**

Put Colored Text on Neutral Background

For maximum **legibility**, avoid colored text with colored background (the hue changes through color contrast or hue induction.)

-> Place colored text on a neutral background (white, black, or grey) or use black or white text on a colored background.

Do	Do not
Blue on Grey	Blue on Green
Black on Yellow	Black on Blue
White on Blue	White on Yellow

Rules for Choosing Black and White Text

- Background lightness between 0% and 20%: Use white text
- Background lightness between 40% and 100%: Use black text

Background Lightness	White Text	Black Text
20%	White	Black
50%	White	Black
80%	White	Black

Improving Color Consistency

Color **consistency** can be improved (if color is necessary, e.g. for a corporate color scheme) by using backgrounds which are desaturated and either of a closely similar hue to the text or, for increased contrast, of a complementary hue.

Similar Hue	Complementary Hue
Blue on Light Blue	Blue on Light Yellow
Red on Light Red	Red on Light Cyan
Green on Light Green	Green on Light Magenta

Note: There must also be a sufficient difference in lightness between text and background to ensure good readability!

top

Source: Recommendations for Charts and Graphics

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  Chapter 9 "Graphische Darstellung"

top

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