Legibility of Projected Information

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Abstract

Projected information today contains much more data content than in the past. Unlike a photographic image or a graphic, the information being presented needs to be read and understood. This significantly changes the design parameters for information display systems, and requires more care when creating the materials to be projected.

A Shift in Content

There has been a significant shift in the content of video data used for presentations. Data that were projected using other means, are now being projected with data/graphics projectors. Today's presentations contain much more information than previously, and generally at a higher density. Audio-visual display design in the past has concentrated on the furthest viewer being able to comprehend a visual image, now they must also be able to **read and understand text and numbers**. The projection system must be carefully designed to take these requirements into account. In addition, careful attention must be given by those producing the material that is to be viewed.

Image Size

The old rule-of-thumb of the furthest viewer being up to 8 times the image height in distance from the display is no longer universally applicable. A new set of rules must be developed, **based on the program content**. Here are our recommendations:

Presentation Content	Distance to Nearest Viewer	Distance to Principal Viewer	Distance to Furthest Viewer
Critical (spreadsheets, command centre, Engineering workgroup, etc.)	1.33 X image height	3 X image height	4 X image height
General (training, presentation graphics, etc.)	2 X image height	4 X image height (if critical)	6 X image height
Entertainment (video content)	2 X image height	not applicable	8 X image height

Table 1. Recommended Viewer Distances for Different Display Uses

If the facility is multi-use, then design for the most detailed content (i.e.: shorter viewing distances).

Room Layout

Apart from the distance to the screen, the orientation of the viewers and the display must be carefully designed to avoid other legibility problems. For general applications, no viewer should be more than ±30° from the horizontal screen axis. For critical applications, the audience area must be carefully designed to ensure that no viewer has to rotate their head more than ±30° from straight ahead, or tilt their head no more than 25° from horizontal. When doing these calculations, all areas of the display surface need to be considered (e.g.: the top left corner). When these more rigorous limitations are applied, the audience area tends to shrink, and its shape may surprise you.

If a room is too wide to allow all viewers to fall within these guidelines, consider multiple displays. If physical limitations result in viewers being placed beyond the optimum viewing areas, the designer must make the client aware of the ramifications.

Contrast Ratio

When legibility of information is critical, it is mandatory to have a high contrast ratio. A study (*Shurtleff & Wuersch*) has shown that viewers will make more mistakes on a legibility test chart as contrast ratio is decreased. In addition, their reading rate will decrease. This latter fact is important, since presentations and status displays progress at a pace uncontrolled by the viewer (unlike reading printed pages).

A good contrast ratio can only be achieved by: use of rear projection; correct choice of screen material; performance of the projector; and control of ambient light.

Screen Type

For rear projection (recommended for detailed presentations), there are two common types of screen used: **diffusion** and **lenticular**. The particles that make up the diffusion coating are of micron size, while projected pixels are, typically, millimetre size – a difference of three orders of magnitude. Thus, a diffusion screen will have negligible impact on the projected display.

The same cannot be said of lenticular screens. These screens are made up of a series of vertical grooves (lenticulations). When the number of screen grooves approaches the number of horizontal pixels being projected, an interference pattern is generated. As graphics resolutions increase (i.e.: greater number of horizontal pixels), the problem becomes worse. The result is that projected detail (such as text) becomes difficult to resolve. Poor convergence of the red, green, and blue elements in the video projector will further aggravate the problem – this is not always user adjustable. Also, since lenticular screens have an inherently narrower angle of view, this effect will worsen as the viewers move off-axis.

Resolution

Graphics projectors can display material at a wide range of common computer resolutions: SVGA (800 x 600), XGA (1024 x 768), SXGA (1280 x 1024), and higher. How does this resolution contribute to legibility? It is obvious that the more pixels available to create a given character, the more accurately and distinctly it can be reproduced. Yet when looking at a monitor about 20 inches (50cm) from the eyes, the average person finds that VGA (640 x 480) resolution seems fine for even fairly detailed tasks such as spreadsheets and word processing. Do we really need greater resolution than this when projecting an image?

A typical 15 inch monitor will have an image width of about 11 inches (28cm). At 640 pixels of horizontal resolution, we are looking at a display resolution of about 58 dpi (about 1/10 that of a typical laser printer). Most people would consider this the ***minimum*** acceptable, and would prefer the 72dpi afforded by SVGA (800 x 600) resolution. A typical presentation screen in, say, a boardroom will be considerably larger than a 15 inch monitor. Assume that we have a boardroom with an 80-inch diagonal screen – the width of this screen is about 64 inches. Our 640 horizontal pixels now yield a display resolution of only 10 dpi! The larger the screen, the worse this becomes – and you will certainly want to move your viewers further away, as individual pixels will start to be resolved.

We are not advocating trying to achieve 72 dpi on your 120 inch screen – you would need a 6,900 x 5,175 resolution graphics projector! Just bear in mind that the larger the projected image, and the closer your viewers are to the screen, the more resolution you need to create crisp and legible characters and complex graphic details (such as CAD drawings).

Text Size

Unfortunately, it is not sufficient to simply provide a good contrast, rear projected display using a diffusion screen and falling within the guidelines in Table 1. Only so much burden may be assumed by the design of the delivery system. The content producer must also take responsibility for ensuring that the material to be projected will be legible. It is vital that the text height on the display fall within minimum standards. **Failing this, the best designed system will fail to convey the information content to the viewer**. If the projected characters are not large enough, the furthest viewer simply will not be able to read them.

The smallest object that a normal human eye can discern subtends 1 minute of arc (1/60 of a degree) on the retina of the viewer. Empirical studies have shown that, for legibility, the height of a lower case character must subtend at least 10 minutes of arc. As the eye moves off-axis (important to note, since most presentations involve groups of people), this figure needs to be increased. In fact, the ANSI standard calls for a ***minimum*** of 16 minutes of arc, and ***recommends*** 20 to 22 – the US military standard calls for 15 minutes of arc at the principal viewer and 10 minutes at the maximum viewing distance. **Note that this has nothing whatever to do with the screen size or display technology**. Here is an example of how this works:

Viewing Distance	Minimum Character Height Needed	
	16 minutes of arc	21 minutes of arc
5 feet	0.28 inches	0.37 inches
10 feet	0.56 inches	0.73 inches
15 feet	0.84 inches	1.10 inches
20 feet	1.12 inches	1.47 inches
25 feet	1.40 inches	1.83 inches
30 feet	1.68 inches	2.20 inches
35 feet	1.96 inches	2.57 inches
40 feet	2.24 inches	2.93 inches

Table 2. Minimum Character Height For Legibility

How do you determine if the text in your presentation meets these criteria ***before*** you arrive at the presentation site? Unfortunately, the traditional method of measuring text height in point size has no meaning when dealing with a computer monitor and subsequent projection. When you select "**12pt Helvetica**" as your typeface, it will not likely measure 12pts. in height on either your monitor or laptop display – and certainly not when projected. The point sizes refer to the text size when you ***print*** your document, not when you view it on screen. The actual on-screen height will vary depending upon the size of your monitor, and the graphics resolution you are using.

If you think of the projected image as a magnified version of your monitor, you will see that all you have to do is determine the magnification factor. For example, assume that you typically project your work onto a 5'-4" x 4'-0" screen (80-inches diagonal). If you are preparing your presentation on a 15 inch monitor, the total available image height is about 8 inches (you should measure yours). Since this will become 48 inches when projected, the magnification factor is 6. If your furthest viewer is 20 feet away, we can see from Table 2 that the projected character height should be at least 1 1/8 inches, and preferably 1 1/2 inches. **Thus, you must ensure that the lower case characters on your monitor are at least 0.2 inches high, and preferably 0.25 inches**. Select a readable font and a point size that meet these minimum requirements. This height may be hard for you to measure on your screen. If so, adjust the font size until the lower case letter "**n**" is ten times the needed height (in our example, it would be 2.5 inches) then divide this point size by ten, and set the smallest font in your presentation to at least this size. You can readily see that trying to display a dense spreadsheet to a huge audience is likely futile. Here is a table with some typical values:

Monitor Size	Average Height of Monitor Image Area	Magnification Factor (apply to Table 2)			
		3' high screen (60" diagonal)	4' high screen (80" diagonal)	5' high screen (100" diagonal)	6' high screen (120" diagonal)
14"	8.0"	4.5	6.0	7.5	9.0
15"	8.3"	4.5	6.0	7.0	9.0
17"	9.5"	4.0	5.0	6.5	7.5
19"	10.8"	3.5	4.5	5.5	6.5
21"	11.9"	3.0	4.0	5.0	6.0
overhead projector	10.0"	3.5	5.0	6.0	7.0

Table 3. Magnification Factors for Various Sized Monitors

Typography

In addition to text height, other factors also affect text legibility: the font used, leading, the font colour, and the background colour. Basic typography rules should always be observed: serif type faces are much easier to read than sans serif; mixed upper and lower case is easier to read than all caps; and script and other fancy fonts decrease legibility. For projected text, and the larger the text, the leading (spacing) between lines should be increased from the standard 15% of character height to as much as 50%.

Audience Make Up

All of these recommendations and guidelines are based on the dubious concept of "normal vision." In the real world, all of our viewers don't have 20/20 vision. As people age, their visual acuity will suffer. A designer would be wise to add an appropriate fudge factor to any design to take into account who the anticipated audience is. If your average viewer will be in the 45 to 60 age range, you will definitely want to hedge your bet.

Summary

Current display requirements are such that the projected material must be read and understood, not simply seen. **This demand requires a more rigorous projection system design, that has been carefully calculated**. Given that the display systems and viewing areas have been correctly designed, additional onus is placed on the content producer to ensure that the information is legible when projected.
