

# How close should you sit from your TV screen

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*Or in other words, what size screen should I buy for my room?*

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Why does it matter, I hear you ask? Well, it matters more to the home-cinema buff than to the casual viewer, who watches news, soaps and reality shows. This article attempts to distill some guidelines from the various studies and recommendations that are out there plus including my own observations.

The home cinema enthusiast wants to be transported away from regular time and space into the fantasy world of the motion picture. He or she wants to be immersed and absorbed into the movie to achieve the full cinema experience. To do all this, you need a big enough TV and sit close enough to it, plus you must have the big soundscape to accompany the whole occasion.

If you have a set that is less than say 32" or even 37", you are not really in this league. OK, you could sit really really close to the TV, but all joking aside, it becomes a bit impractical. This article is more about larger screens.



Sit too close to the screen and you see the structure of the images – the pixels, the defects and the artifacts that are an inescapable part of television.

Sit too far away and you will not achieve the escape from reality and cinematic nirvana that you desire, and you might even be far enough away so that your eyes are incapable of seeing the finest details of the picture, meaning that you are wasting the definition available and for which you paid big bucks by buying the best TV at the time.

Of course, your TV is used not only for watching blockbuster movies but also for the myriad other broadcast programming of varying quality. This article discusses the various standards and recommendations out there to give a range of viewing distances which are optimum given the state of technology at the present time.

## **Domestic room constraints**

In most family situations, the room is arranged for domestic and social convenience, rather than for optimum TV viewing. Usually the head of the household does not want the TV to be a focal point of her lounge. Any attempts to rearrange furnishings so as to make the TV more dominant could be detrimental to marital harmony. This may also restrict the acceptable maximum size of a television set.

Optimally, both partners would be movie devotees and both quite willing to make everything else fit around the TV screen. The luxury of a dedicated TV room (*a home-theatre*) allows for good compromise and flexibility.

## The studies and recommendations

[No tech talk, take me to the conclusions](#)

The results of polls done in the U.S during the 1980's showed that on average, viewers sat at a distance of 10 x the picture height in a domestic lounge room. This was before DVD, blu-ray or high-definition existed and although the screen sizes are not known, it is likely that at the time, screens were typically smaller than at present.

A large study done in the U.K in 1989 (*ref 1*) revealed that people who owned 29" sets sat at an average of 8x picture height, with a range of between 6 to 11.5x picture height. (*I will abbreviate picture height to H and picture width to W from this point on.*) Those viewers who owned 40" sets averaged a distance of 5.6H and those who owned very large 50" sets were sitting at an average 5H. Over 50% of subjects in this survey sat between 4H and 6H. In all cases, those surveyed indicated they would sit closer to the screens if the room layout were no object. This study tends to separate out the aficionado with the larger set from the casuals, who own smaller sets. Enthusiasts do indeed sit closer to the screen. (*Note that screen sizes given are always across diagonal in inches, even though the test results refer to picture height multiples. Use of picture height refers to the height of displayed picture and eliminates the variables of both screen size and aspect ratios where for example, a viewer may be watching a letterboxed or pillarboxed picture at the time.*)

A more recent survey done in 2004 of BBC staff (*ref 2*) showed quite a wide variation in viewing distances but the average was a seated distance of 8.5H. In terms of absolute distance, all respondents sat between 2 metres and 4 metres from their TV screens with a strong modal value of 2.7 metres. This is interesting because it shows a preferred seating distance irrespective of screen size. The authors thought this was due to constraints of typical room sizes for urban dwellings and apartments in the U.K.

Standards that have long been in use for standard definition (SD) pictures (ITU-R recs BT654, BT1128, BT1129 and BT811) recommend 4H to 6H for critical viewing and picture assessment. For HDTV critical viewing, the ITU-R recommends a distance of 3H. Of course, these standards have long been used by professionals in order to evaluate picture defects. I have spent many hours of my working life staring at screens from a close distance in order to evaluate picture technical defects. At these distances from the screen (3H for high-definition and 4H for standard definition) any picture shortcomings, if present, will be visible. So watching from this close might be appropriate for a viewer who wants to maximise viewing pleasure without seeing technical defects, only if there are no defects.

This is where the surveys of actual viewing habits become useful. Many of the recommendations made by SMPTE and THX, discussed below, are made assuming defect-free pictures. That is, you have a perfect playout source (DVD for SD or blu-ray for HD) and a perfect display device. This is not to say source material or display device is always perfect; only that the technology is capable of delivering pictures to

a high enough quality such that a person sitting as close as 3H to an HD screen would not be aware of a technical issue. Viewing habits as surveyed by the BBC per above include people watching broadcast material via digital terrestrial TV, cable or satellite delivery. These broadcast platforms are not normally used in a manner which delivers defect-free pictures and if a person is sensitive to picture deficiencies, they will respond by sitting further from the screen than for say, a blu-ray source.

Not everyone is aware of technical defects. To my detriment, a movie or TV show has to be either of exceptional quality or very absorbing if I am to ignore picture defects. The habits of a working life die hard. I will be busy gagging at gross panning judder, pointing out bad de-interlace or some other nasty digital artifact while at the same time my partner will be pointing out bad acting, botoxed actors, stylish clothes or shoes; things that usually escape me completely. I can, however put up with picture flaws readily enough for programmes like news, current events and even documentaries where the objectives are to provide information or education rather than entertainment.

## **SMPTE and THX recommendations**

The general recommendation for viewing distance given by SMPTE (*Society of Motion Picture and Television Engineers*) is for the width of the screen to subtend an angle of 30 degrees at the viewer. This standard is most widely quoted and used within the industry. Translated, it means that one should sit at 1.87x the screen width. For a widescreen TV, that is equivalent to 3.3x the height. This is very similar to the ITU-R recommendation of 3H for HD critical viewing.

This standard refers to high definition pictures of at least 720 pixels in height. The recommendation is made to maximise viewer emotional immersion in the movie given the spatial resolution limitations of HD display standards. This ignores the possibility of sub-standard quality either of source material or of display imperfections.

THX (A *George Lucas* company born out of the *Star Wars* legacy) provides consolidated presentation technologies from various sources into one set of design standards including standards for picture, sound and cinema layout. THX recommends a range for home-theatre seating such that the front seats have a 40 degree angle of view and the rear seats 28 degrees. The rear seat recommendation is very close to the general 30 degrees per SMPTE. 40 degrees, however is equivalent to 1.374x width and is only 2.44H for a widescreen set. Much closer than any other recommendation.

As an example for a 42" (diagonal) screen, subtending 40 degrees means sitting 1.28m from the screen and subtending 28 degrees means a distance of 1.86m. Given that this means only 0.58m between minimum and maximum distance, only two seat rows could be contemplated and they would be closer together than is used by the worlds most budget airline. It is clear these standards are meant only for the larger direct view screens and more suited for projection viewing. Seating side-by-side at these recommended distances also has difficulties, especially for LCD based direct view screens due to their reducing contrast off-axis. Plasma types are more forgiving. Although LCD TV manufacturers quote viewing angles as 175 degrees or such, these numbers are downright misleading. In reality, a significant

reduction of contrast occurs at greater than 30 degrees from perpendicular. Using the above 42" set as example; if you sat at the SMPTE location 1.75m from an LCD version, then an acceptable contrast ratio would be given for 1m each side of centre. You could seat only 3-4 medium size people shoulder to shoulder at this distance and even then, they should be friends.



Watching side by side at the SMPTE distance; not shot for a deodorant ad.

The SMPTE and THX standards are guidelines for distances to sit at for watching a high quality motion picture displayed at native pixel density on a high quality display in order to have a good level of emotional involvement with the material. They have limitations. They are impractically close for smaller screens and I would say 42" diagonal is the minimum for these distances to be useful. The standards ignore picture defects, they ignore scaling artifacts and being field-of-view based, they do not call into account the even smaller picture height displayed when a movie with aspect ratio of 2.35:1 is shown on a 16:9 screen.

*Tables of these standards versus screen size located at the end of the article.*

## The question of the annoyance of sub-standard pictures

This is quite difficult to quantify because individuals vary in their acceptance of picture defects. Researchers at the University of California performed experiments (*ref 4*) that attempted to quantify the annoyance value of individual artifacts that are common in MPEG2 coded video. They used student guinea pigs to rate pictures which had introduced blocking, smearing and ringing artifacts. They acknowledged that these were only a subset of the types of artifact possible with MPEG video compression, but thought it would be too hard to make viable conclusions with more.

*Blocking* occurs when a MPEG encoder runs into bit-rate limits for the picture material it is trying to encode. This usually occurs only for sections of high detail and rapid motion. Segments of blockiness can be seen. Blocking should never be seen on a blu-ray disc but can be seen on broadcast television.

*Smearing* is usually due to the use of excess compression or is due to scaling a picture. Resampling between SD and HD formats results in a certain amount of smear or blur. Similarly, *ringing* is another artifact of excess compression and can also be caused by oversharpener a scaled picture. Poor de-interlacing can result in both these defects as well as creating 'combing' effects where vertical edges have the appearance of the teeth of a comb. The researchers concluded that blurring is more annoying than ringing where low data rates are used, but this relationship reverses at higher data rates.

Why am I mentioning this? Because it is impossible to give a definitive viewing distance for everyone to use when viewing pictures which have defects. This is because people have varying tolerance levels and that tolerance depends on the type of artifacts and the degree to which they are present. Only one thing is clear and that is, you will need to sit farther from the screen to avoid being irritated by picture imperfections. The ITU-R and BBC quote between 4 to 6 screen heights as a guideline because that is the

median and range suggested by actual viewer trials. If you 'don't' see picture faults, then sitting as close as 4H is possible. If, like me, you see everything substandard then even 6H may be too close. One wit of my acquaintance suggested that sitting in another town may be sometimes necessary.

## **The situation of viewing scaled SD(over-sampled) pictures on an HD display.**

Pictures from SD sources, whether from DVD, or broadcast television must be scaled in order to map to the fixed pixel spatial resolution of HD panel displays. Making 576 lines (or 480 NTSC) scale up to fill the typical 768 pixel or 1080 pixel high HD screens is a non-trivial task to perform well. Because hardware implementations do vary considerably again it is hard to produce a single guideline. Most simple scalers make the picture look soft. I find this hard to watch. I have seen some quite good scalers in action but in all cases I have to sit further back when watching SD pictures than when a non scaled HD picture is shown.

## **Limitations of human vision**

There is one other thing to consider and that is, the limitation of detail that can be seen by the human eye. It is widely implicit that a human with 20/20 vision can just see details that subtend 1 arc-minute. People do vary in this even though they are nominally 20/20. In fact this median value was confirmed within fairly close limits in the trial undertaken by the BBC in 2004 (*ref 3*). This trial was also used by the BBC to determine that their HD standard for transmission would be 1280 x 720 pixels. They worked out that given the size of British lounges, the likely screen size that was acceptable in such rooms and the typical viewing distances used, that anything over 1280 x 720 was a waste of bandwidth. That is a simplification of the trial data because obviously some people will have large screens and sit closer than average to them. People in this latter situation may not be satisfied with 1280 x 720 pictures.

The methodology used in this study was to restrict, by filtering, the risetime of pictures by varying amounts corresponding to various resolutions. This made the study independent of screen types and implementations. For the purposes of this document, the main conclusion to use is that for screen sizes up to 50" diagonal, a large majority of people find 1280 x 720 adequate when seated at 2.7m. For screen size 50" and up, an increased resolution is required, or viewers must sit further from the screen. As it turns out, standard definition (SD) of 576 lines is adequate only for screens up to 27.5" when a viewer is at 2.7m.

From my own experience, playing out the SMPTE RP133 pattern from the blu-ray DVE-HD disc via HDMI to a 46" 1920x1080 matrix LCD screen set to 1:1 mapping, I cannot resolve the 1px gratings at over 2.9m away, they are clear at 2.7m and strongly visible by 2.4m from the screen. These distances correspond to width multiples of 2.85, 2.65 and 2.35 respectively. My distance glasses have minor correction for one eye only but in the event it made little difference at these "near" distances whether I used correction, or not.

The acuity of the eye sets a maximum distance that you will benefit from having a given spatial resolution display. Or, in other words given your screen preferred screen size and seated distance, you might not gain any benefit from having the highest specification pixel density screen. This may apply to an even greater degree if your eyesight is less than perfect. Having said that, there is, these days, virtually no cost penalty in buying a "full-HD" set. This type has a screen density of 1920 x 1080 pixels.

## Tables of seating distances for various screen sizes

The tables that follow are a summary of the existing guidelines and my interpretations of realistic distance ranges to sit under various circumstances. Distances are in metres, although screen sizes are in inches diagonal because that is still the convention. (1 metre = 39.4")

Table 1: Home theatre seating distance guidelines

This table is a summary of SMPTE/THX guidelines for seating distance to provide an 'immersive' experience. These are not really practical for screen sizes of less than 37". For good quality HD sources and displays (16:9) only.

Standard	37"	42"	46"	50"	55"	63"	70"	TV size
THX 'front row' (1.37W, 2.44H)	1.1	1.3	1.4	1.5	1.7	1.9	2.1	metres
SMPTE (1.87W, 3.3H)	1.5	1.7	1.9	2.1	2.3	2.6	2.9	metres
THX 'back row' (2.0W,3.55H)	1.6	1.9	2.0	2.2	2.4	2.8	3.1	metres

The seating distances have been rounded to one decimal place because any greater accuracy is not warranted; these are guidelines. I regard the THX front row unreasonable for screens below 63".

Table 2: Recommendations to use with broadcast TV

This table gives seating distance guidelines to use when picture impairments are present, such as for digital or analogue broadcasts. They also apply for native SD pictures that are displayed on a HD screen. Use the closer recommendations if you are watching better quality native HD sources or if you don't tend to 'see' picture defects. Move toward the greater seating distances if the converse is true.

Standard	29"	32"	37"	42"	46"	50"	55"	63"	70"	TV size
ITU-R 4H (2.25W)	1.4	1.6	1.8	2.1	2.3	2.5	2.7	3.1	3.5	metres
ITU-R 6H (3.37W)	2.2	2.4	2.8	3.1	3.4	3.7	4.1	4.7	5.2	metres

Note I have assumed the picture 'fills' the screen height for this table. Strictly speaking I should use displayed picture height, which for an 2.35:1 aspect ratio movie is only 76% of a 16:9 screen. I leave it to the reader to adjust seating to 76% of the given distances for this situation.

These distances are farther than what THX and SMPTE would regard as necessary to give complete emotional involvement with a movie, but will be necessary for watching other than perfect HD quality. If you watch only news and other informational broadcasts, then being nearer to the screen is not required in any case.

Table 3: Maximum seating distances

This table lists maximum distances for each common definition standard based on eye acuity.

TV size	29"	32"	37"	42"	46"	50"	55"	63"	70"	
Maximum distance to fully benefit from 1080 pixel HD.(20/20 vision)	1.1	1.2	1.4	1.6	1.7	1.9	2.1	2.4	2.6	metres
Maximum distance to fully benefit from 720 pixel HD. (20/20 vision)	1.6	1.8	2.1	2.4	2.6	2.8	3.1	3.6	3.9	metres
Maximum distance to fully benefit from SD 576 pixels. (20/20 vision)	2.9	3.2	3.7	4.2	4.6	5.0	5.5	6.3	7.0	metres
CAO maximum recommended distance for SD 480 pixels (5*W)	3.2	3.5	4.1	4.6	5.1	5.5	6.1	7.0	7.7	metres

You will see from the above that for 1080 HD for example, you need to be seated approximately at, or closer than the SMPTE recommendations (in Table 1) for your eye to fully resolve a 1 pixel spacing. However, in practice you don't need to 'fully resolve' a pixel in order to benefit from 1080 HD. For example, I can see a 1 pixel grating clearly on a 1920 x 1080 pixel 46" screen at 2.7m. The grating is very clear at 2.4m. So although eye acuity limits suggest a 1.7m maximum in the table above, that errs on the pessimistic side because of the interpolation abilities of the eye/brain.

Similarly, when viewing native SD pictures oversampled on to a HD screen, you do benefit over the case where those same SD pictures were to be viewed on a SD screen. It is not necessary to use the SD maximum viewing distance in that situation. Somewhere intermediate, (say the 720px limit) is viable for when SD pictures are displayed on a 1080px high screen. Of course, the visibility of picture defects comes into this choice as previously discussed.

Table 4: Screen size to buy for a given room

The corollary to all the above is that you may need to decide the smallest and largest size screens to buy for a given room. The UK study showed a strong preference for sitting 2.7m from their TV, dictated by the room rather than the TV. Many people in that survey, when asked, said they would sit a bit closer if the room layout permitted.

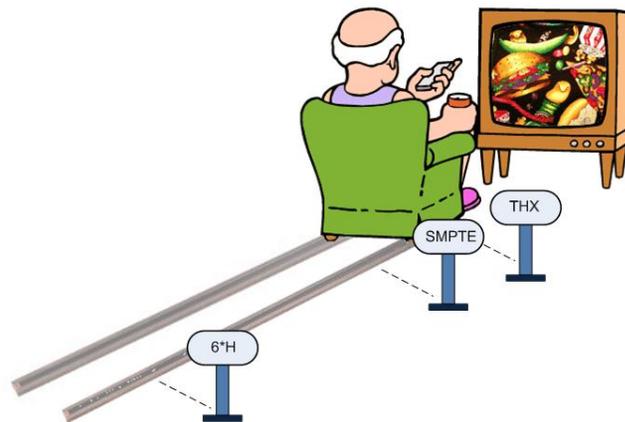
New Zealand housing has some similarities to the U.K although we do not yet have quite the same density of in-fill and apartment living. That gap is closing rapidly and our typical urban dwellers would be in a corresponding situation to the U.K.

Activity	Small apartment room	Medium suburban dwelling	Large Lounge
Enjoy blockbuster movies	37" to 50"	42" to 55"	46" to 70"
Mainly broadcast TV-HD	32" to 42"	37" to 50"	37" to 55"
Mainly broadcast TV-SD	29" to 37"	32" to 42"	37" to 50"

Choices can be made depending on your mix of activity. If you really want to be 'immersed' in movies then go for the larger sizes. If a movie is just an occasional activity, you can choose the smaller size sets.

## The compromise seating distance

In an ideal world, you would sit as close as the THX or SMPTE recommendations when watching big budget movies and sit as far away as necessary to avoid being annoyed by sub standard picture quality from broadcast TV. My solution follows....



### Sources

1. BBC RD report HDTV displays Subjective effects of scanning standards and domestic picture sizes *N.E Tanton*
2. BBC RD WHP090 Report on a survey of viewing distances *N E Tanton*
3. BBC RD WHP092 Visual acuity to determine TV resolution *Drewery and Salmon*.
4. Annoyance of Individual Artifacts in MPEG-2 Compressed Video and Their Relation to Overall Annoyance *Chin Chye Oha, Sanjit K. Mitraa, John M. Foleyb, and Ingrid E.J. Heynderickx* c a Department of Electrical and Computer Engineering,b Department of Psychology,University of California, Santa Barbara, CA 3106 USA c Philips Research Laboratories, Eindhoven, The Netherlands
5. [http://en.wikipedia.org/wiki/Optimum\\_HDTV\\_viewing\\_distance](http://en.wikipedia.org/wiki/Optimum_HDTV_viewing_distance)
6. <http://carltonbale.com/1080p-does-matter>
7. <http://www.clarkvision.com/imagedetail/eye-resolution.html>
8. <http://webvision.med.utah.edu/KallSpatial.html>

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