The Results of Subjective Tests on the Perceived Quality of Commercial Motion Picture Film Formats

By R. Evans Wetmore and Robert C. Hummel

It has been the authors' experience that there is a great deal of prejudice regarding the perceived quality of various motion picture film formats used in commercial motion pictures. Along with these prejudices are the assertions made by some that with today's sharper and more advanced film stocks, large area film formats are no longer necessary.

Recently an opportunity presented itself that allowed a rational, scientific examination to be made on the subject. One of the authors (Hummel) was invited by the Technical Council for Motion Pictures and Television (TCMPT) to give a seminar on the various film formats for interested members of the motion picture community. As part of this seminar, two scenes were filmed in various formats to be used as part of the seminar presentation. A viewing test, where the audience viewed a number of selections without knowing what format was being shown, was conducted at the start of the seminar. The results were tabulated and are presented as part of this paper.

Experimental Design

The viewing of various motion picture formats was conducted in a large modern theater (approximately 1,000 seats). The theater was in good repair and used modern projection lenses. Table 1 shows the light readings for the three projection formats. The projected image size for 1.85 Flat and CinemaScope was 20.9 ft (6.37 m) high. For 70mm projection, the image was approximately 1 ft (0.3 m) taller than the other two formats. (This was unavoidable due to the lack of availability of a suitable high-quality lens.) The seating in the auditorium went from 1.42 picture heights (ph) to 5.2 ph distance from the screen.

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Test films showed some image focus flutter in the center of the image. It is believed that most of this flutter was caused by the removal of the heat filters from the projector lamphouses; the filters were removed because they reduced the screen brightness. The image flutter seen in this theater is also present in some commercial motion picture theaters so that the viewing is typical if not optimum as it relates to focus stability.

Great care was taken in photographing and printing the film elements. To assure the absolute minimum error, two highly regarded cinematographers were chosen jointly to photograph the tests: Steven Poster and John Hora. In Hummel's experience working with these directors of photography, they consistently delivered well exposed negatives and are referred to as "one light" cameramen, a Hollywood lab slang expression for cinematographers who are so in control of and consistent in their exposures that the lab is able to print all of their dailies at the same printing light points.

The same emulsion (Eastman Kodak 5293) was chosen for all formats. Although in the "real world" of production, different emulsions would probably have been chosen for interior and exterior photography, the same emulsion was chosen to carry through the "level playing field" premise of the experiment and limit the variables.

Each test segment consisted of two scenes, one exterior and one interior. The scenes were replicated as closely as humanly possible with the actor repeating his moves in time to a metronome. The scenes chosen did not have great emotional impact in order to prevent bias by the viewers. All scenes were silent and without dialogue.

An exterior scene was shot on the Warner Bros. back lot and an interior one on a Warner sound stage. Each camera was on the same nodal point, and the appropriate focal length lens was used to ensure the same field of view. As 1.85, 2.2, and 2.39 aspect ratios have different fields of view horizontally, the taking lenses were selected to ensure the same vertical field of view.

Table 2 indicates the shooting setups. All cameras were 35mm Panavision Panaflex cameras, except for the Super 16 format, which used an Aaton camera. As the charts indicate, all lens aperture settings were identical, and as the printing lights clearly indicate, each negative received the same exposure. Subtle differences in printing lights are probably due to differences in lenses and the 16mm, 35mm, and 65mm emulsions. All light points are shown in the Technicolor YCM format.

The Super 16mm material was sent

Table 1 — Screen Brightness in foot-lamberts

	70mm	
12	14	12
12	17	12
11	13	11.5
	35mm Anamorphic	
9	9.5	8.5
11.5	15.5	10
11.5	10.5	9.5
	35mm 1.85:1	
9	10	8.5
12	15.5	11
10	10.5	9.5

to DuArt Laboratories in New York. DuArt's printing lights were not available, but there is no reason to assume that they are significantly different from the other formats.

Interpositive and duplicating negatives were made on Eastman 5244 intermediate stock. The prints were made on Eastman 5386. All processing was done at Technicolor in Hollywood.

Table 2—Shooting Setups

Film Formats Test Shoot And Lab Data

Exterior

Format	Camera	Lens	F-stop	Printer Lights
Super 16	Aaton	zoom	11	
35mm 1.85	Gii359	Pz31	11	39-43-46
35 Ana.	Gii359	50an	11	39-43-46
Super 1.85	Pf171px	Pz31	11	40-42-45
Super 35	Pf171px	Pz28	11	37-42-45
65/70	65Pf102	50	11	42-44-46

Notes:
1. Emulsion used for all formats was 5293/7293.
2. All exterior footage was shot using a #85 filter.

Interior

Format	Camera	Lens	F-stop	Printer Lights
Super 16	Aaton	zoom	3.8	
35mm 1.85	Gii359	Pz31	3.8	24-44-41
35 Ana.	Gii359	50an	3.8	24-44-41
Super 1.85	Pf171px	Pz36	3.8	25-44-41
Super 35	Pf171px	Pz36	3.8	24-44-42
65/70	65Pf102	50	3.8	32-48-44

Notes:
1. Emulsion used for all formats was 5293/7293.
2. All interior footage was shot with no filter.

The tests were specifically designed for assessing commercial motion picture formats running at 24 frames/sec. All projection formats were either 4-perf 35mm or 5-perf 70mm. No specialty formats such as Showscan or Imax were investigated. The formats tested were as follows:

- Super 16
- 1.85 Flat
- CinemaScope
- Super 1.85
- Super Techniscope (aka, Super 35)
- CinemaScope blown up to 70mm
- 65mm printed on to 70mm

These were chosen as the most common formats in commercial use.

Each format was shown twice so there were a total of 12 sequences. The order of presentation was random as far as the audience was concerned. The first two cuts were Super 16 and 65mm/70mm. This was done to show the audience the extremes of quality that would be encountered during the test. The order of remaining cuts was chosen randomly by drawing slips of paper from a pile.

Figure 1 shows a copy of the ballot used by each viewer. The row and seat number were used to ascertain how far a given viewer was from the screen. Also serial numbers were placed on the ballots.

In a test of this sort, the type of rat-

Table 3—Basic Statistics of the Test Results

Film Format (In order)	0 to 2 PH Mean	0 to 2 PH Std Dev	2 to 3 PH Mean	2 to 3 PH Std Dev	3 to 4+ PH Mean	3 to 4+ PH Std Dev	All PH Mean	All PH Std Dev	Neg Area (sq In)	Ln (Neg Area)	AR >2.0 (Y or N)
Super 16	1.45	0.69	1.21	0.69	1.00	0.69	1.16	0.74	0.118	−0.928	N
65/70	3.64	0.50	3.59	0.65	3.62	0.56	3.59	0.61	1.877	0.273	Y
Scope/70	2.81	0.60	2.43	0.74	2.39	0.64	2.40	0.70	0.638	−0.195	Y
65/70	3.55	0.52	2.98	0.67	3.00	0.62	3.00	0.70	1.877	0.273	Y
1.85 Flat	0.91	0.54	1.14	0.81	1.07	0.70	1.10	0.77	0.368	−0.434	N
Super TS	1.64	0.92	1.70	0.91	1.78	0.87	1.72	0.87	0.368	−0.434	Y
Super 16	0.82	0.60	1.06	0.92	1.08	0.78	1.03	0.85	0.118	−0.928	N
Scope	2.55	0.69	2.57	0.82	2.55	0.73	2.55	0.76	0.638	−0.195	Y
Super 1.85	2.18	0.40	1.96	0.81	2.15	0.68	2.00	0.77	0.530	−0.276	N
Scope	2.55	0.69	2.57	0.92	2.76	0.68	2.63	0.81	0.638	−0.195	Y
1.85 Flat	2.09	0.54	2.19	0.77	2.25	0.76	2.17	0.76	0.368	−0.434	N
Super TS	2.27	1.00	2.56	0.92	2.84	0.68	2.67	0.81	0.368	−0.434	Y

TCMPT/SMPTE Film Format Seminar

Row Number______________ Seat Number____________________

1 [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad	**2** [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad	**3** [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad
4 [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad	**5** [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad	**6** [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad
7 [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad	**8** [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad	**9** [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad
10 [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad	**11** [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad	**12** [ ] Excellent [ ] Good [ ] Fair [ ] Poor [ ] Bad

Figure 1. The ballot used by participants of the film formats test.

ing scale used by the viewers is important and has been the subject of much scientific investigation over the years. In this case we used the CCIR 5-point scale, which uses five verbal descriptions of quality: Excellent, Good, Fair, Poor, and Bad. Each viewer had to use one of these five categories to rate the quality. Viewers were not allowed to vote for values in between.

In the analysis of audience responses, numerical values were assigned to the descriptions of picture quality. The assignments were as follows: 4, Excellent; 3, Good; 2, Fair; 1, Poor; 0, Bad. These relationships were used throughout the subsequent analysis.

Two hundred sixty-two ballots were returned by the audience.

Conclusion

The data showed that there were differences in perceived quality depending on the viewing distance from the screen. For this reason one of the first issues investigated was where people choose to sit in a motion picture theater. In other words, where does the audience feel most comfortable in relation to the screen? We intentionally left the curtains open as the audience came into the theater so that seating decisions would be based on the apparent size of the screen. The histogram (Fig. 2) shows where the audience chose to sit by distance from the screen expressed in image picture heights (ph). Two factors are immediately obvious: the "spike" in sitting at about 2.1 ph and the small number of people sitting at about 3.5 ph. The 2.1 ph "spike" is probably due to the fact that part of the film format presentation was given at a podium and the audience wished to be in proximity to the speaker. The "valley" at 3.5 is probably due to the fact that there was a large control console in the theater that prevented people from sitting at this distance. In general, the distribution appears normal with a mean seating distance of about 3.5 ph with a slight asymmetry biased toward the front of the auditorium.

Table 3 shows the basic statistics of the test results. The results are shown graphically in Fig. 3.

Some facts may immediately be inferred from this data.

- The "wide" formats, CinemaScope and 70mm, scored better than the "narrow" 1.85 aspect-ratio format.
- The order of presentation to a modest degree affected the results, i.e., after 65mm/70mm sequences, the audience rated the 35mm formats poorly as reflected in the results for the first showing of 1.85 Flat and Super-Techniscope. After the audience became accustomed to 35mm, the results improved as they "forgot" the 65/70mm images.
- The larger the negative area, the better the perceived quality.

Additional study of the data using factor analysis showed that there were two discrete factors affecting the perceived quality of the various formats. These two factors were 1) the log of the area of the camera negative and 2) the width of the projected format. Figure 4 shows a tabulation of some of the data and two graphs arising from analysis of the data. We found that perceived quality may be predicted

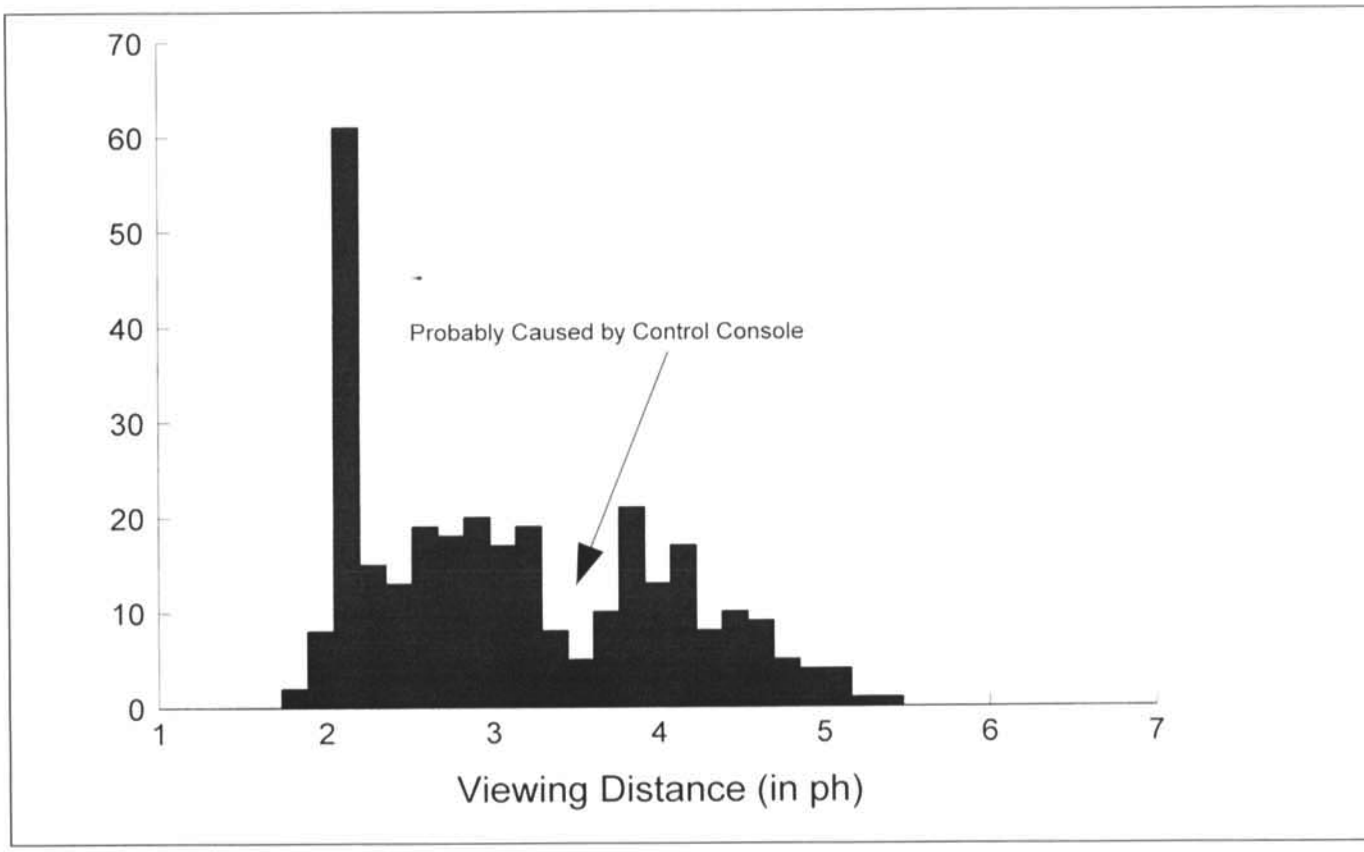


Figure 2. TCMPT viewing preference histogram.

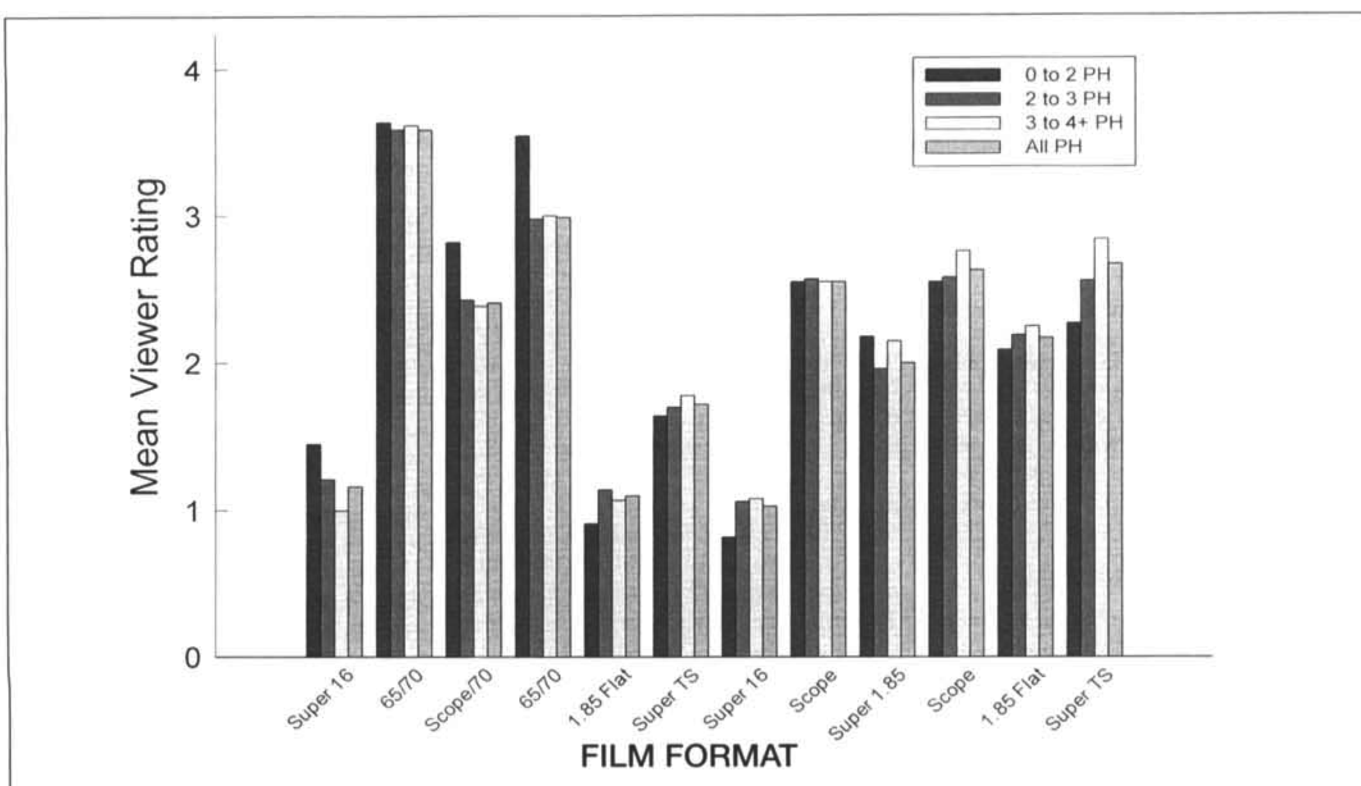
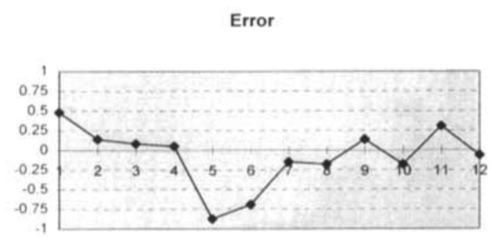


Figure 3. TCMPT viewing test—mean ratings at different distances.

Format	Wide	Wide Val	Ln(A)	Pred	0 to 2 ph	Error	Sq Err
Super 16	0	0	-0.928	0.9688	1.45	0.4812	0.231553
65/70	1	0.55	0.273	3.50045	3.64	0.13955	0.019474
Scope/70	1	0.55	-0.195	2.72825	2.81	0.08175	0.006683
65/70	1	0.55	0.273	3.50045	3.55	0.04955	0.002455
1.85 Flat	0	0	-0.434	1.7839	0.91	-0.8739	0.763701
Super TS	1	0.55	-0.434	2.3339	1.64	-0.6939	0.481497
Super 16	0	0	-0.928	0.9688	0.82	-0.1488	0.022141
Scope	1	0.55	-0.195	2.72825	2.55	-0.17825	0.031773
Super 1.8	0	0	-0.276	2.0446	2.18	0.1354	0.018333
Scope	1	0.55	-0.195	2.72825	2.55	-0.17825	0.031773
1.85 Flat	0	0	-0.434	1.7839	2.09	0.3061	0.093697
Super TS	1	0.55	-0.434	2.3339	2.27	-0.0639	0.004083

Width Mulitplier =	0.55
Constant =	2.5
Log Muliplier =	1.65

RSS=	1.306585



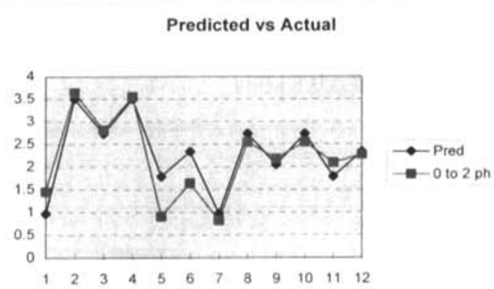


Figure 4. Analysis of data obtained on the perceived quality of various formats.

within reasonable limits by the following formula:

$$Q = 1.65 \cdot \log_{10}(A) + W + 2.5 \qquad (1)$$

where Q is the quality based on the CCIR 5-point scale (0 to 4); A is the area of the camera negative in square inches; and W is the width variable, which equals 0.55 if the aspect ratio is $\not<2.0$ and equals 0.0 if the aspect ratio is <2.0.

Some Corollary Observations

Each of the camera negatives was very carefully photographed and well-exposed, as evidenced by the artistic quality of the images and their laboratory printing lights. It has been the authors' experience that in normal production situations optimum exposure is often difficult to obtain, and under-exposure occurs. In this case, formats using small negative areas, Super 16, 1.85 Flat, and Super-Techniscope, deteriorate in quality very quickly as compared with the large negatives of CinemaScope and 65mm. This fact was demonstrated to the TCMPT seminar audience with some intentionally underexposed material.

It has also been the authors' experience that the small negative problem of Super 16, 1.85 Flat, and Super-Techniscope also extends to high-speed stocks that will not yield the same relative quality levels as those occurring with low and medium-speed camera-negative stocks.

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