Views

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Lenses for film and television: an international survey

Modern lenses for film and television are designed mainly by engineers and physicists but used by cinematographers, who see themselves as artists rather than as technicians. Thus, translating cinematographers' needs is challenging. In this article, we present a survey with which we collected data on the lens user experience and user expectations from a total of 442 cinematographers worldwide. Particular attention is paid to the transition to new technologies such as digital production and large-resolution sensors for 4K/8K displays (UHD).

Keywords: cinematography; film; lens; look; television.

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The current situation

From the beginning of cinematography at the end of the 19th century until today, lenses have been an important tool for filmmakers to create film images that touch the emotions of the audience. Lenses are used to create the 'look' of a film or a film scene. This is the perspective of the artist, but today, lenses must meet a set of new technical requirements.

In theory, a lens designer tries to develop a lens that has maximized sharpness, even for new sensors with more but smaller pixels, minimized optical artifacts, etc. Although this technical approach is challenging, it mostly ignores the customer: Which lenses do users, the cinematographers, really want to work with? What are their priorities and needs? Although the 'correct reproduction of a scene' is a technical desire, the art of movie making requires many more artistic elements, often subsumed as 'the look' of a movie. The look of an image, a scene, or a whole movie is a very complex phenomenon that summarizes all relevant parameters of the photographic/electronic reproduction of the scene, containing contrast(s), brightness(es), color rendition, flare light, acuity, contour sharpness, depth of field, the shape of blurs or the reproduction of movement, both in the scene and by the camera.

In recent years, the options for creating the look of a movie have changed significantly. In the era of digital cameras, choosing between film stock or photochemical processes, which can be used to influence the look of a picture while recording, has vanished. However, digital color grading has become increasingly important – a part of the production chain that often cannot, or not completely, be influenced by the director of photography (DoP). These changes in technical options raise an important question: Has the lens become one of the last opportunities for creating a photographic look?

These questions concern not only the functional relationship between lens manufacturers and lens users but also the value chain within a very closed market with unique uses. Lenses for cinematography are bought mainly by equipment rental companies. The lenses are typically rented by a production company for a specific production; thus, the rental companies have to invest in equipment that is wanted. However, as the survey shows, the choice of the set(s) of lenses is usually left to the cinematographers (80% of productions). Only for smaller productions, especially on TV, do producers or broadcasters choose the lens(es). Thus, the value chain is determined by the interaction of four players: the lens manufacturers, the rental companies, the production companies, and the cinematographers. It is obvious that the two ends of the chain must communicate.

As announced at the recent International Consumer Electronics Show (CES) 2015, the industry has formed a UHD alliance to 'set the bar for next generation video entertainment by establishing new standards to support innovation in video technologies including 4K and higher

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resolutions, high dynamic range, wider color range and immersive 3D audio' [1]. Therefore, the next big changes in film technology are on the way – the development of even better picture quality with 4K/8K or UHD. This development was mainly driven by the new options of ever-larger displays but not by cinematographers (as confirmed by the survey). Therefore, this development provokes the question, how do cinematographers deal with it, and what are the consequences for the development of new lenses?

To the best knowledge of the authors, the experiences with the rapid technological changes in the last decade and the expectations for the next technological steps have not been examined. In May 2014, a team from the Center of Advanced Studies of Film and Television Technology – a scientific institute of the Munich University of Television and Film (HFF) – began the survey presented in this article to record the experiences of lens users and to summarize requests for future technological improvements in the field of lens design.

The survey method

Prof. Dr.-Ing. Peter C. Slansky, director of the Technical Department of the HFF and director of the Center of Advanced Studies of Film and Television Technology, developed a questionnaire. Katrin Richthofer, manager of The Center of Advanced Studies of Film and Television Technology, developed a survey in German and English and performed the statistical analysis, assisted by Claudia Stoll. They used the software *Umfrageonline* (enuvo GmbH, Zurich, Switzerland).

The survey addressed all cinematographers who were responsible for camerawork in cinema or TV productions as their main profession from 2012 to 2014. The German language version of the survey was online from June 26 to August 29, 2014 and the English language version from July 7 to August 29, 2014. The questions distinguished between the specific use of lenses for TV or cinema productions as well as different ways to create images. It also took into account that different projects have different optical requirements. The exact structure and all questions are in the detailed report published on the SFT Homepage www.filmtechnologie.de [2]. The questionnaire also contained a glossary with optical technical terms.

Who participated in the survey?

A total of 442 cinematographers worldwide participated in the survey; 171 responded to the German language version and 271 to the English language version; 51% of all participants were members of an association of camera professionals. In the production years 2012–2014, the interviewees named the following as their chief employment: fictional cinematic film including TV co-productions (26%), documentary cinematic film including TV co-productions (11%), cinematic or TV commercials (21%), fictional TV films and series (16%), documentary TV formats (features, documentaries, reports) (21%) and TV studio productions, and external mobile recording (E-camera production via control) (5%). Significantly, more English-speaking cinematographers who worked cinematic production and cinematic advertisement answered the survey. The German language version reached more cinematographers who worked in documentary TV formats, TV studio productions, and outside broadcasts. The significantly higher number of cinematographers focused on the first four categories is understandable, due to the topic of the survey.

In 2012–2014, the participants used the following types of cameras: 35-mm film (7%), 16-mm film (5%), digital one-sensor camera or S 35 sensor or similar (68%), three-CCD video camera with 2/3″ sensor or smaller (20%). This distribution shows the importance of the survey results.

General results

Before the survey discussed technical details, there were four more general questions about the development of digital cinematography in the movies and television. The first question (Figure 1) asked for a general comment on technical improvements within the last 10 years. The majority of the responses were positive. The English

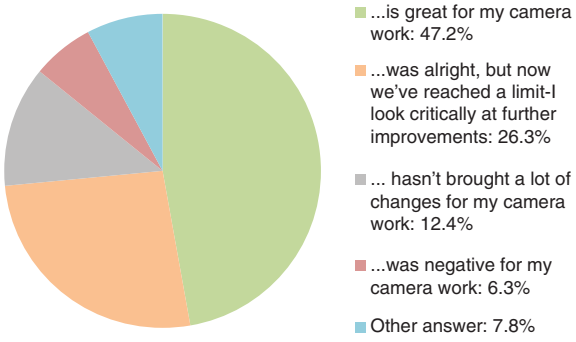

Figure 1 How do you judge the technical improvements of cinema and TV over the last 10 years with respect to your creative work? The improvement of picture quality in TV from Standard Definition to High Definition or in Cinema to Digital projection in 2K/4K.

language responses were significantly more positive than the German language responses. About every fourth interviewee raised concerns about further improvements. When asked for more details of the influence of further improvements in UHD and 4K/8K would have on the respondents' artistic work, only 15% remained completely positive. The majority of responses confirmed a mixed picture of positive and negative aspects (Figure 2).

Thus, the first set of questions asked for feedback from cinematographers regarding the changes in resolution and new technologies, in general. The next set of questions focused on the technical improvements in camera lenses over the last 10 years. The response to these questions was much more positive (Figure 3). More than 53% of the interviewees welcomed the recent and future improvements. Although these responses were related to the technical aspect of lens quality, especially focusing abilities, another question referred directly to the influence of the camera on the look of a film (Figure 4). The

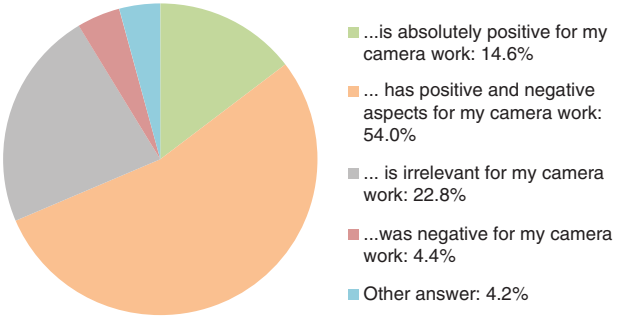

Figure 2 How do you judge further improvements like the introduction of UHD and 4K/8K with respect to your artistic work?
The introduction of Ultra High Definition and 4K/8K.

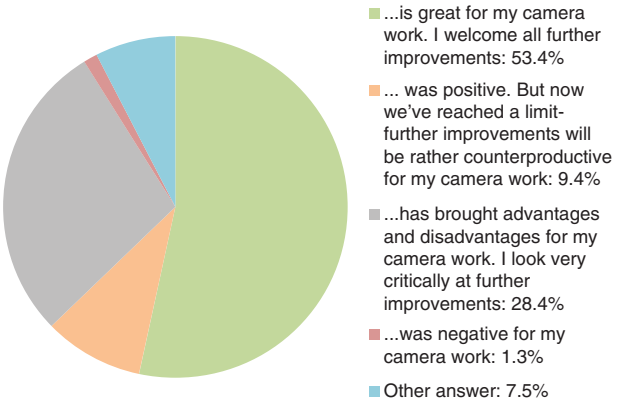

Figure 3 How do you judge the technical improvements of lenses over the last 10 years in respect to your creative work?
The improvement of the reproduction quality of camera lenses, especially of their focusing abilities.

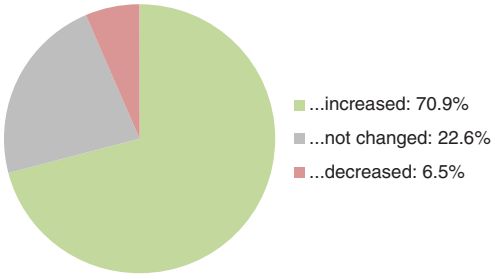

Figure 4 Has the significance of the choice of a certain model of lens changed with the technological improvements of the last years?
With the technological improvements of the last 10 years – digital cameras, postproduction, color grading, cinema projection, and High Definition flat screens – the importance of the camera lens for the look design has.

responses to this question manifested the central thesis that – with the emergence of digital cameras, post-production, color grading, cinema projection, and high-definition flat screens – the importance of choosing a specific lens model has increased. The overall acceptance rate was even higher in the German language survey [2].

Specific results

In addition to the general questions, one set of questions was related to specific technical properties and the effects of lenses and how important they are for cinematographers' personal creative work. As expected, the ratings were high overall; therefore, the differences were sometimes small. Many of the interviewees pointed out that the importance of many criteria depended on the individual project and the intended look. Because of the complexity, the parameters of the look of a film image cannot all be explained in this article. However, for a brief discussion of several parameters, please see the separate textbox. These examples of different lenses with different looks are part of a test made by Jonas Spriestersbach and Till Coester, students at the Munich University for Television and Film, as their exam in the Department of Film Technology, Prof. Dr.-Ing. Peter C. Slansky [3]. All images were shot with an ARRI Alexa with constant camera parameters, camera position, set, and lighting. These images are shown here to explain specific look parameters. The images were not shown to the respondents during the lens survey because cinematographers know these effects from their daily work and should have referred only to their own experiences.

In the following, we discuss the results of the lens survey for several different optical features of camera lenses.

Box 1 How Lenses influence the look 1.

Given a state-of-the-art digital film camera, the cinematographer has the choice between different types of lenses. Different lenses will provide a different look of the image even at the same focal length and the F-stop. The variations of the look are also highly dependent on the motive. The following examples for different looks are part of a test made by Jonas Spriestersbach and Till Coester, students of the Munich University for Television and Film, as their exam in the department for film technology, Prof. Dr.-Ing. Peter C. Slansky [3]. All images were shot with an ARRI Alexa with constant camera parameters, camera position, set and lighting. These images were NOT shown in the lens survey because the cinematographers know these effects from their daily work and should only refer to their own experiences. The images are shown here for explanation of specific look parameters.

Figure 5 Cooke S 4 T2/50 mm, F=5.6.

Figure 6 Schneider Kreuznach/Arriflex, T2/50 mm, F=5.6.

The first example shows the difference in the resulting look between a modern and an old lens. The two images of a colorful, but medium, contrast motive show significant differences in contrast rendition and color rendition, especially at skin tones. Figure 5 was shot with a modern Cooke S 4 lens, Figure 6 with a Schneider Kreuznach/Arriflex lens from the 1960s. With the old lens, contrast and color saturation are generally reduced, the blacks are lifted to brown, all colors (see color checker) are shifted to orange-yellow, skin tone is much warmer, detail (see hairs) is much softer, and there is apparent stray light. For some films or film scenes, the cinematographer may want to achieve a soft look like that; for other ones, he or she will prefer the precise and neutral look of a modern lens – it is a question of the artistic intentions.

Acuity

Many of the free responses pointed out that from a certain point, too much detail resolution decreases the possibility of image composition and the viewing experience, as fine details draw attention from the central issue – the story.

> *"[I wish them] to stop focusing on the resolution of a lens and [go] more on the color rendition, bokeh and mechanical handling. The constant aim to go along with the increasing resolution of the sensors will always be counteracted by cinematographers through the use of optical filters."*

Optical pumping when focusing

Concerning acuity of lenses, as was expected, the criteria 'detail resolution' and 'detail contrast' were generally rated as very important. Even more important – and here, interestingly, everybody agreed – is the consistency of the framing when pulling focus. This demand is typical for film as opposed to still photography. Therefore, still photography lenses cannot be used indiscriminately.

Shape of the defocus figure

Regarding the bokeh of lenses, two thirds of all participants voted for different shapes of the defocus transition to create different looks. However, around a fifth preferred the harmonious bokeh of a perfectly round iris aperture. A nonagonal bokeh was rated as second best, lesser numbers of focus blades that reproduce a defocus figure of this shape were rated successively worse, and a triangular or rectangular bokeh was rejected.

Lens flares

If a light source shines directly into the lens (e.g., the sun), there are light spots along the optical axis due to internal reflections on the surface of the lens, 'lens flares'. Owing to different coatings on lenses, lens flares can have different colors. Leaving aside the question of the intended look or whether lens flares should be avoided at all, neutral white lens flares were generally preferred. Lens flare colors on the scale red-orange-yellow to bluish were also

Box 2 How Lenses influence the look 2.

Figure 7 Zeiss Superspeed Mk. II T1.3/18 mm, F=2.2.

Figure 8 ARRI/Zeiss Master Prime T1.3/18 mm, F=2.2.

Figure 9 Zeiss Superspeed Mk. II T1.3/18 mm, F=2.2.

Figure 10 ARRI/Zeiss Master Prime T1.3/18 mm, F=2.2.

This example shows the resulting differences in the look with backlight and without. Figures 7/9 were shot with a Zeiss Superspeed Mk. II from the middle 1980s, Figures 8/10 with a state of the art ARRI/Zeiss Master Prime. Both lenses have a high speed of T1.3. Without backlight, the look does not vary so much. But with an 800-W Tungsten light beaming directly into the lens, the resulting stray light and lens flares show significant differences in strength, color, form, and position. For some film images, the cinematographer may want to achieve the softer look with the big, bluish lens flares like that with the Superspeed (Figure 9); for another film or another scene, he or she will prefer the more precise and neutral look of the Master Prime (Figure 10). It should be noticed, that the use of optical filters can create similar look effects, but not exactly the same.

acceptable, whereas lens flares on the color scale green to purple were mostly rated negatively.

Distortion

For the parameter 'optical distortions', many of the free text responses pointed out that there is a contradiction, especially for wide-angle lenses. If the lens is optimized for exact planarity, a two-dimensional test chart is rectangular and parallel, whereas in a scene, a round object at the edges of the frame – a head, for example – is distorted. Therefore, for scenic use, wide-angle lenses with a 'mild harmonic' barrel distortion were preferred. A perfectly plane lens was preferred only for shots in which, for example, architecture is the main image content.

> *"Straight lines [...] are less important than undistorted faces near the edges of the frame."*

Color reproduction

An important result is that a visually pleasing rendition of skin tones was rated as the most important parameter of all, even more important than the overall color reproduction.

Balance behavior

Constant optical parameters for all lenses of a set of fixed focal length lenses were rated as very important. This refers to their optical reproduction characteristics as well as to measurements, weight, and handling.

The same applies – even more importantly – to constant optical parameters within the focal lengths of a zoom. Zoom objectives used in still photography that changed the length and center of gravity when zooming was rated critically.

Use of old lenses

The majority of the participants stated they had used old lenses. Old lenses are not used because they are economical but, instead, to record a special look while filming. Many participants agreed that, previously, lenses had to reproduce reality as accurately as possible, whereas today, they should give the image 'character' that has been lost.

> *"Lenses are chosen for a project. Some for their accuracy, some for the beauty of their aberrations and flares."*

Anamorphotic lenses for the 2.37:1 format

The question about the 2.37:1 format evoked an interesting divergence between the German- and English-speaking participants. Only 40% of the German-speaking group used this format, but 55% of the English-speaking participants did. This can be partially explained by the higher rate of cinematic and commercial productions. Overall, 79% of the 2.37:1 productions were shot with spherical lenses and 21% with anamorphotic lenses. The participants blamed this distribution as necessary due to budget or workflow reasons; however, many participants wanted to shoot with anamorphotic lenses more often due to creative reasons.

Cinematographers' requests for lens manufacturers

In several free text fields, the participants made requests for innovations from lens manufacturers. Out of the vast variety of answers, some trends were evident.

Variety of lenses

There was a strong wish among the creative designers of images for various lenses with differing imaging properties to create different looks, including new constructions as well as old lenses. Only a minority wished for the 'perfect lens'. The majority emphasized that for them, the choice of a certain model of lens was an important design element.

> *"Optical performance: high luminosity, good sharpness, realistic colour rendition, but a unique 'character' constant through the whole set of lenses. To me that is more important than maximal sharpness and illumination in the edge areas. Pumping when pulling focus is inacceptable to me. Zooms have to keep their focus when zooming!"*

> *"Individuality!!! A wider range of real differences in the optical reproduction!!!"*

> *"Like most of this survey, this question aims at choosing general characteristics for all lenses one works with. It's very important though that the look of different cameras is getting more and more similar. Aside from grading, the choice of a certain model of lens is the only possibility to crucially influence the look of a film. An emotional chamber play, living completely from its characters, has completely different needs for the pictorial design than a science fiction film with lots of special effects. Therefore, for one project it can be important to use vignetting lenses with low contrast and focus but a warm, cinematic rendering of skin tones. For a different project, 8K and a technically extremely precise lens can be exactly the right choice. What was done earlier by the choice of film stock and lenses, is done today a lot more by the choice of a certain lens."*

> *"The lens is my first tool for creating moods and I take the decision on creative needs. In commercials, I often offer the sharpest image I can achieve. On every project, I try to ask for different lens series."*

> *"The development of two categories of lenses. Besides the existing, perfected, high resolution, hyper-luminosity lenses, a second set that takes focus and harshness from the picture. It's no coincidence that it's almost impossible to find [...] old sets of lenses worldwide any more, and that more and more of those old lenses are adjusted to modern standards with motorized focus pulling. No optical filter in front of the lens can simulate the silken soft focus, the focus decrease towards the edges of the picture and the soft vignetting that those old lenses produce. These technical 'inadequacies' don't just reproduce technically correctly but give back a 'soul' to the objects on film."*

Compact ENG-type zooms

Many participants wanted a compact, light zoom lens for S-35 in the medium zoom range. The existing range was seen as too limited. Frequently, an ENG typical design with integrated handgrip was requested for documentary work with one-sensor cameras.

Integrated gray filters

Many of the participants stressed that – with the higher sensitivity of cameras of usually more than 800 ISO – many recording situations require the use of ND filters. This should be taken into account by lens and/or camera manufacturers (the requests differed) and be integrated in the construction design, instead of frequently having to use big front lens filters. The latter is regarded as critical for the color reproduction, as well as the handling of the camera.

Budget anamorphotic lenses

Many cinematographers wanted to use anamorphotic lenses more often for widescreen formats. In the past, this often failed due to budget reasons.

> *"Anamorphotics have their own look, especially when pulling focus (asymmetrical bokeh)"*

> *"I am fascinated by the optical, cinematic character of anamorphic lenses. They produce a stronger feeling of depth and their character creates some kind of 'non-naturalistic alienation effect' that opens up a space for interpretation."*

> *"I often shoot cars, there they like anamorphic lenses. The typical lens flares are part of the look. Especially if the camera shows the cars headlights at night."*

Better communication between lens manufacturers and cinematographers

Many participants rated the survey as an important step in better communication between image designers and lens manufacturers. Many of the free text answers lamented that there is a big barrier between the two worlds that must be broken down to sustain the truly desired lens products.

> *"Understanding that cinema production is an art form, and lenses should have personality and idiosyncrasies which can be used to help tell the story."*

> *"Detailed and honest information about their lenses with different tests available."*

> *"To continue the excellent work in lens design for modern 4K/8K cameras and beyond."*

Summary

A total of 442 cinematographers worldwide participated in the survey: 38% responded to the German language version and 62% to the English-language version. Half of the respondents were members of a camera association of professionals.

The participants' productions covered all creatively challenging genres such as fictional cinematic film (26%), documentary cinematic film (11%), cinema or TV commercials (21%), and fictional TV films and series (16%) compared to documentary TV formats and TV studio productions (26%). Twelve percent of all the productions were still shot on film, but the overwhelming majority (88%) was made with digital technology: 68% with digital S-35 single-sensor cameras, and 20% with three-CCD broadcast cameras.

As the first key result, the majority of the cinematographers saw significant problems with increasing the sharpness of the film image, which leads the attention of the audience unintentionally to details and away from the story. The cinematographers see a strong need for many different lens sets with the same focal length and aperture but different photographic characteristics to achieve different looks. The 'perfect lens' – the goal of many lens designers – was just one of the options. The bokeh of a lens was considered most important; in cinematography, the lens is used dynamically instead of statically. Thus, parameters such as focus pumping or the transition from sharpness into blur is significantly more important than in still photography. The majority of the cinematographers used old lenses, not for financial, but for creative, reasons. In contrast to the request for variety, several optical features were preferred, such as the round shape for a blur rather than a triangular or square or neutral and bluish or orange lens flares instead of greenish or magenta ones. The uniformity of the optical characteristics for all focal lengths of a set of lenses especially for the whole range of the focal length of a zoom lens was very important. One of the most desired lens quality was a visually pleasing skin tone rendition.

A significant number of survey participants requested better communication between lens manufacturers and lens users. Supporting this exchange was one objective of this project, and the authors will work further on this goal.

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[3] Spriestersbach, Jonas/Coester, Till: Prime Time – a comparison of fixed focal length lenses for cinematography. HFF Munich 2014 In March 2015, the SFT will organize a Lens Workshop at the Munich University of Television and Film (HFF). www.filmtechnologie.de or sft@hff-muc.de