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Welcome to AVANCA | CINEMA 2017.

CAPÍTULO IV | CHAPTER IV
CINEMA – TECNOLOGIA | CINEMA – TECHNOLOGY

Nostalgia for Film: The Shift from Mechanical to Digital Cinema Projection

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Abstract

Today, cinema is digital: 95 percent of all movie theatres worldwide are equipped with digital projection, and, to an overwhelmingly high degree, the films are shot with digital cameras. But still, among filmmakers and critics, the debate on whether photochemical film stock and mechanical projection of film prints are aesthetically superior continues, since there is little scientific evidence to back up either point of view. To date the question as to whether narrative films are perceived in different ways by a cinema audience depending on the projection or recording technology used, has hardly been examined.

This paper focuses on the influence of analog mechanical projection and digital projection on the audience. Empirical data gained from audience experiments show that mechanical projection of film prints produced higher levels of emotional reactions. The results suggest that the specific characteristics of mechanical projection – flickering lights and image instability – has a nostalgic effect which seems related to the viewer's memory of a traditional cinema experience.

Keywords: Analog cinema, Digital cinema, Film projection, Perception, Emotion.

Introduction

Photochemical 35mm film dominated professional film production and cinema projection in the 20th century. Ever since the introduction of the 'Cinematographe' by the Lumière brothers, the principle of intermittently projecting translucent film images to a screen and thus creating the illusion of movement has been the basis for cinema experiences for large audiences. The Lumière projection technique was a further development of the 'Laterna Magica' used as early as the 17th century. The illusion of motion pictures is based on the flicker fusion capacity of the human perceptual system. A fast succession of still images of a moving object is perceived as a continuous movement, once the frequency exceeds 16 Hz. While the film strip is being moved to the next image, the projection light needs to be blocked in order to avoid the awareness of the rapid transportation process. The succession of images and black phases causes a flickering light. In the era of silent films, projectors were mostly operated by hand, which meant that the speed of projection and the perception of flicker could vary substantially from show to show. The improvement of the screening experience was an important topic from the beginning of cinema's existence. It is connected to the myth of a total cinema (Bazin, 1967/1946). All techniques for the mechanical reproduction of reality at that time, from photography to the phonograph, were dominated by the idea of an "integral realism, a recreation of the world in its own image" (Bazin, 1967/1946). The introduction of sound film was an important step and led to a standardization of motorized projection with a frame rate of 24 frames per second. This projection speed has been the standard of 35mm mechanical projection until today (Slansky, 2004; Schmidt, 2009).

Digitalization entered the film industry slowly and first started with visual effects, non-linear editing and color correction in the 1990s. Cinematography and especially projection remained analog for much longer. In 2002 seven major film studios founded a consortium to promote and develop digital cinema, which lead to the standard organization Digital Cinema Initiatives (DCI). The DCI specifications include the Digital Cinema Package (DCP) for distribution and determine standards for projection. 24 frames per second has remained the predominant projection rate, even though higher frame rates are easily possible with digital projection and are also DCI-compliant. However, the flickering light of mechanical projection as well as its slight image instability are absent in digital projection. The image appears absolutely stable and the high frequencies of the light impulses used in the projection process are not perceptible by the human system (Hewlett & Pettitt, 2001; Digital Cinema Initiatives, 2008; Schmidt, 2009).

The transition to digital projection was significantly pushed by the new wave of stereoscopic films (S3D), initiated by James Cameron's *Avatar* in 2009. Only

cinema owners equipped with digital projection could show the stereoscopic version und thus fully profit from the worldwide excitement. The 3D boom triggered by *Avatar* lead to a surprisingly quick transition to digital projection. By 2016, over 95% of cinemas worldwide were equipped with digital projection (MPAA, 2017). Even though the quality of digital recording as well as of digital projection increased continuously, a wide agreement among professionals and critics remained that digital images are technically and aesthetically inferior (e.g. Flueckiger, 2003; Prince, 2004; Slansky, 2004/2008). Film enthusiasts claim that the non-linear idiosyncrasies of human perception more closely resemble analog processing with its inbuilt fluctuations such as flicker, grain, and non-linear color rendition. In contrast, the stability and lack of flaws typical for digital images would resist human perception's requirement for constant micro-adaptation to varying stimuli (Flueckiger, 2015). Until recently, filmmakers like Christopher Nolan and Quentin Tarantino showed a distinct preference for analog recording and for mechanical projection. In December 2015, Tarantino started his Western movie *The Hateful 8* in an analog 70mm 'roadshow version' in selected theatres, before giving it a wide digital release (Marks, 2017).

While production companies and distributors prefer digital technology for budgetary reasons, cameramen and filmmakers tend towards film because of the analog image's specific aesthetics. Photochemical images usually are seen as having a more naturalistic, organic look, as being more pleasing to the eye, whereas, in contrast, the digital image is often perceived as cold and sterile. In addition, analog prints and mechanical projection are described to reproduce dark or black image areas a lot better than digital projection. They seem to lead to more naturalistic colors, to a more organic look (due to film grain) and to a 'softer sharpness' (Slansky, 2004/2008).

In what can be seen as a backlash against the clean look of the digital image, many contemporary filmmakers add typical analog artefacts to their films during postproduction. Grain, dust, scratches, lens flares and the restriction of the color palette typical for specific historical processes – e.g. black and white, sepia tones or the pastel colors of the Technicolor process – are among the many possibilities which are used by directors. In some cases these modifications aim at giving the film a gritty 'realist' look, which would indicate that the very 'dirtiness' of the analog material still carries an aura of authenticity that is lacking in the clean digital image. But there is also an opposing trend: Many of these artefacts function as "markers of historicity in films" (Flueckiger, 2015: 81), i.e. they add historical patina; a nostalgic feeling of 'pastness'. They are not meant to fool the viewers, but rather function as self-reflexive and playful allusions to historical modes of film production. As different as they are, both instances manifest a high awareness of the fact that analog film is connected to a bygone, and in some ways more 'authentic' era. While the reference to this era can happen in a straightforward or in an ironic fashion, there is in both instances a sense of and nostalgic longing for lost authenticity which seems to be typical of the the digital age.

This paper focuses on the question of whether projection technology has a measurable influence on cognitive and emotional reactions, enjoyment and immersive experiences while watching a movie. It is connected to a large-scale empirical study on the emotional impact of film recording processes on the audience, which was written by the same authors (Loertscher et al., 2016). Three complete short narrative films were produced and simultaneously captured digitally and on 35mm film. The comparative study took place in regular cinemas in order to ensure a natural setting (high ‚ecological validity'). A larger portion of the participants saw the three films as a digital projection, whereas only a smaller comparison group saw the three films as analog 35mm film prints with conventional mechanical projection. However, in order to allow an equal and thus more valid comparison between the specific influences of the different types of projection, an additional experiment was conducted. It extended the number of participants who saw the films mechanically projected. This paper discusses the additional experiment. With regard to the projection type, it gave rise to a more differentiated set of results than the former study did.

Technical Premises

Beginning as early as the 1980s, the workflow of film production began to shift towards a hybrid system. While recording and projection stayed mostly analog, the whole postproduction workflow (including editing, visual effects and color grading) gradually became digital. Scanning the analog negative, processing it digitally and finally printing it to analog film for distribution was the standard procedure for almost twenty years before it was replaced by a completely digital workflow (see Figure 1). In order to minimize the variables, all the films used in this study were produced in a typical hybrid workflow. That means both the DCP for digital projection as well as the 35mm film print used for mechanical projection were created from a digital master file.

A 35mm film print is the result of laser printing a digital master file onto a film negative. The printing process is achieved frame by frame and in three steps, applying a primary color separation in red, green and blue (RGB). The film negative consists of three layers, which all have a distinct sensibility to the limited color spectra of RGB but contain the complementary color dyes of cyan, magenta and yellow (CMY). When exposed to light, silver halide crystals coupled to these color dyes are transformed into metallic silver. After the processing in chemical solutions, the resulting images are negative with complementary colors. In order to obtain a final positive print, the negative is copied to film stock with specific contrast characteristics for projection. In the mechanical projection, white light passes through the print and gets filtered, an absorption process that is based on subtractive color mixing (Slansky, 2004; Schmidt 2009).

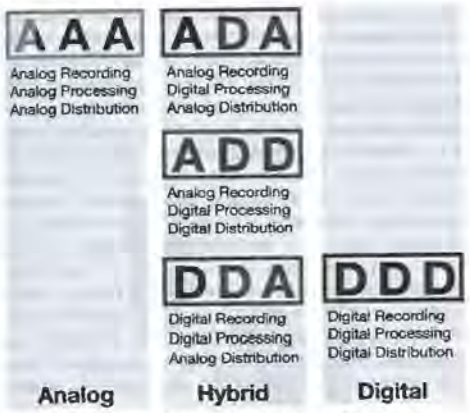

Image 1 - Overview of production workflows: fully analog, hybrid and fully digital.

In addition to the specific color reproduction, projected analog film can be recognized by its characteristic instability and flickering light. The instability goes back to the mechanical tolerance of the advance sprocket and the fact that the film perforations rarely fit the pins exactly. Therefore, the film strip does not always stop at the exact same position, which leads to a slightly unstable, jittery image. The flickering, however, is caused by a rotary shutter, which alternately blocks out light during transportation of the film strip. In order to minimize the flicker effect, a double blade shutter is used (see Image 2). It blocks out every frame twice, but transports the filmstrip only the first time. As a consequence the flicker frequency is increased to 48 Hz while the frame remains at 24 frames per second (Slansky, 2004; Schmidt, 2009).

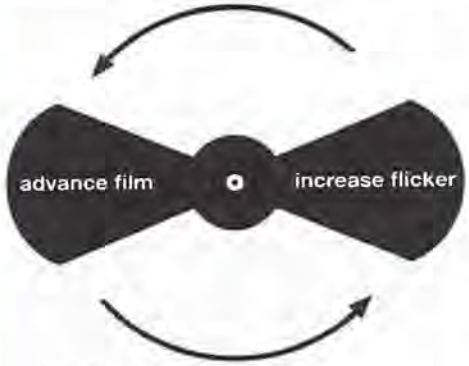

Image 2 - Rotary shutter with two blades

Newer mechanical projection systems use rotary shutters with three blades and are based on electronically steered transports. As a consequence, the flicker effect is further reduced and the image stability is increased (Schmidt, 2009). As only a small minority of cinemas are equipped with this advanced technology, the projector types used in this study were all equipped with the traditional two blade shutter, working at 48Hz.

In digital distribution, the master file is directly transferred in a DCP, which forms the basis of projection according to the DCI standard. The images are stored either in 2K, with a horizontal resolution of 2048 pixels, or in 4K, with a horizontal resolution of 4096 pixels. Both formats are based on a 12bit quantization and a JPEG2000 compression. According to DCI specifications the RGB color space of the master file is transferred into the much wider XYZ color space of the DCP (Digital Cinema Initiatives, 2008). Most digital cinema projectors currently employ digital light processing technology (DLP) based on the Digital Micro Mirror Device (DMD), which was introduced by Texas Instruments in the late 1980s. The light from a high efficiency lamp is separated by a prism into the primary colors red, blue and green and emitted on three semiconductor chips equipped with millions of movable micro mirrors. Each mirror on a DMD represents a pixel of an image in one of the RGB colors. By moving into the light beam, or away from it, the mirrors can either fully reflect the light or deflect it to a light absorbing area. In order to represent differentiated gradations of light and dark, the mirrors move back and forth up to several thousand times a second. The more often a mirror flips, and thus emits flashes of light within the given time span of a 1/24 of a second, the brighter the represented pixel appears, and vice versa. Displaying bright image areas can lead to flicker frequencies of several thousand Hertz, and to flip a mirror from 'off' to 'on' takes less than two microseconds. The sum of all mirror reflections of one DMD results in a high resolution monochromatic image in either red, blue or green. With the help of a prism they are recombined to a full color image. After the time span of one single frame comes to an end, the mirrors are released simultaneously in order to display the next image (Hewlett & Pettitt, 2001; Slansky, 2004; Schmidt, 2009).

Just like in mechanical projection, flicker plays an important role in DLP projection. But here, the frequency of the rapid light flashes varies per pixel and is the basis for generating a single frame image. Between two frames, however, there are no dark gaps – the next frame rather follows immediately. In mechanical projection, on the other hand, flicker occurs between the frames in order to hide the rapid transportation of the film strip. Here, the preexistent photochemical images are always projected as a whole and need not to be generated during the projection process (Slansky, 2004; Thomson-Jones 2013).

Perceptional Premises

Motion pictures were invented based on insights into psychophysics in the late 19th century. Movies evolved to match the characteristics of human perception, especially narrative films in the Hollywood style (Cutting, 2005). As a general rule, this means that all technical manipulations in film production should go unnoticed for the general audience. Many film theorists explained the impression of motion with the so-called 'persistence of vision' similar to the psychological effect

of 'positive after-images'. This assumption was too simplistic and research by psychologists provided better explanations (see discussion in Nichols & Lederman, 1980). The perception of motion pictures is a complex interplay between the continuous stream of sensory input and mental representations as shifting construals (see Hochberg & Brooks, 1996). As outlined in our previous text (Loertscher et al., 2016), two perceptual mechanisms are essential for watching analog films in a cinema with mechanical projection (Anderson & Anderson, 1993; Thomson-Jones, 2013): (a) Critical flicker fusion produces the illusion of continuous light, when a light flickers with high frequency; and (b) apparent motion is the illusion of continuous movement in a rapidly changing visual display created by triggering the motion detectors of the visual system in an effective way (Ramachandran & Anstis, 1986). The same mechanisms produce the illusion of a stable image with continuously moving objects or patterns in digital projection. However, flicker fusion is less apparent in digital projection, as there are no gaps of darkness (Thomson-Jones, 2013).

Although the real world seems spatially and temporally continuous compared to motion pictures, our perception of space and time is not identical to its physical structure (Cutting, 2005). Our visual system selectively dims and blocks the sensory stream during fast eye movements ('saccadic suppression') or blinks in order to prevent a blurred or faded retinal image (for review see Kowler, 2015). Nevertheless, motion on the retinal image is crucial for maintaining high quality vision, as completely still objects or scenes disappear within seconds without any eye or head movements. As motion pictures are dynamic change per se, they can influence the attention of multiple viewers more strongly than stills with comparable contents do (Smith & Mital, 2013). Viewers direct their gaze at 3.8% of a cinema screen (covering 40 ft and viewed from 35 ft) from one cut to the next on average (T. J. Smith, 2013). Only visual elements that are fixated with the eyes ('foveal vision') are acquired in high resolution. This narrow focus highlights the importance of guiding spectatorial attention to relevant narrative elements.

Generally speaking, our minds interpret a film story through the interplay of bottom-up (based on sensory input) and top-down processes (based on prior knowledge stored in memory). Although neuroimaging studies with audiovisual stimuli propose that multisensory integration is an automated process at an early stage of parallel cortical processing (Koelewijn, Bronkhorst, & Theeuwes, 2010), selective attention and emotion can modulate multisensory integration in higher level brain processes (Eldar, Ganor, Admon, Bleich, & Hendler, 2007). Multiple cognitive, emotional as well as imaginary processes are activated when we comprehend a story. The individual psychological state or current mood influences both the emotions experienced while watching a movie (e.g., Weibel, Wissmath, & Mast, 2011a, 2011b), and expectations connected to specific kinds of film, e.g. different genres (e.g., Weibel, Wissmath, & Stricker, 2011; Wuss, 2007). According to Zillmann (1991) and his cognitive appraisal theory, the cognitive interpretation of physiological arousal induces affective reactions to films. In turn, affective reactions are the reason that people enjoy media offerings (cf. Oliver, 2003, 2008). Furthermore, movies, TV shows, or video games allow a user to immerse in another world (e.g., Bracken & Skalski, 2009; Yee, 2006), which is another reason for enjoyment. Immersion in mediated environments has recently been explained through the concept of presence. Presence is the impression of "being there" in a mediated environment (Steuer, 1992) and has been described as a perceptual illusion of non-mediation (Lombard & Ditton, 1997). Wirth et al. (2007) suggest that presence is a booster of all kinds of media effects such as emotions and enjoyment. Accordingly, previous studies have found that presence and enjoyment are positively related (e.g., Weibel, Wissmath, Habegger, Steiner, & Groner, 2008). In-emotion (Suckfüll & Scharkow, 2009) is another concept that describes immersive experiences specifically in the context of films. In-emotion consists of emotional involvement - the viewers' absorption in their feelings - and diegetic involvement - their readiness to immerse into the film (Suckfüll & Scharko). Empathy is also related to immersive experiences (e.g., De Wied, Zillmann & Ordmann, 1995). Cognitive and emotional empathic reactions occur when observing another person's behavior in real life or in fictitious situations (Davis, Hull, Young, & Warren, 1987; Leibetseder, Laireiter, & Köller, 2007). Green, Brock, and Kaufman (2004) suggest that empathy is a precondition to being transported into the story of a book or a movie.

Audience Experiments

Three movies, made in a production workshop by advanced film students at Zurich University of the Arts, served as film stimuli. Each belongs to a different genre and thus addresses different appraisal styles and corresponding emotional patterns.

- *Senjor!* (directed by Ilir Hasanaj; Zurich University of the Arts & Hasanaj, 2012; 9 min): A comedy with slapstick elements. During a road trip in Spain, a couple consumes drugs, only to be questioned by a policeman who has a striking resemblance to the video game character Super Mario.
- *Irgendwie* (directed by Lisa Brühlmann; Zurich University of the Arts & Brühlmann, 2012; 6 min): An interpersonal drama. A young man tries to get drunk because he wants to forget a girl he is in love with. A woman twice his age challenges him, and they end up sharing alcohol and memories.
- *Parachutes* (directed by Wendy Pillonel; Zurich University of the Arts & Pillonel, 2012; 5 min): A dystopian science fiction film. In a future world with an artificial beach, a boy approaches a girl and takes her to a hidden place. He convinces her to take a pill to enter a world where nature still exists.

All three movies were shot simultaneously with an analog camera (ARRICAM LT 35mm) and a digital camera (ARRI Alexa). Both cameras were mounted on a special 3D-camera rig with a semitransparent mirror (see Image 3). This construction ensured that all relevant optical parameters were identical (focus, focal length, t-stop, and lens type). With this method, the only difference between the two originals was the recording system (analog film negative and digital data).

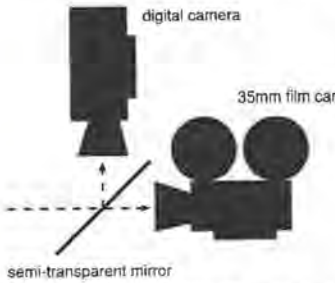

Image 3 - A semi-transparent mirror between the analog 35mm film camera and the digital camera enables the parallel recording of the same perspective.

In postproduction, both versions were processed according to current industry standards (technical parameters are shown in Table 1). This included a hybrid workflow for the analog recorded version as described above (see Technical Premises).

The audience experiments took place in medium-sized movie theaters in Bamberg, Zurich and, as part of the extended experiment, in Bern. In Bamberg the films were projected digitally, in Zurich both projection types were used, and in Bern additional mechanical projections took place. The experiments were divided into different sessions, during which the audience saw different variants of the three films. However, none of the participants saw any of the films more than once. A total number of 281 participants (175 women,104 men, age between 15 to 78 years with M = 37.6, SD = 16.3) took part in the experiments (cf. Image 4). The variants were:

A1 analog recording in digital projection
A2 digital recording in digital projection
B1 analog recording in analog projection
B2 digital recording in analog projection

The mechanical projection of the three films on 35mm film print was presented to a total number of 94 participants. The type of cinema projection figures as the independent variable of this experimental setting and was tested between participants with two levels (digital projection vs. mechanical projection) with the different recording formats (analog or digital) as dependent variables. Each movie of the 35 mm film roll shown with mechanical projection was compared with the same version presented by digital projection to keep

Version 1 - Digital Output (DCP)							
Source	Offline Editing	A/D-Conversion	Conforming	Color Grading	Master	Distribution	Projection
ANALOG 35mm negative	Quicktime files gained by Telecine - Process, Codec: ProRes 422, HD-format	Frame by frame scanning, resulting in uncompressed DPX-files 2K, 12bit log	DPX-files according to Edit Decision List (EDL)	DPX-files, 2K, uncompressed	DPX-files, 2K, uncompressed	2K Digital Cinema Distribution Master (DCDM) according to DCI Standard	2K DCP
DIGITAL ARRI Alexa camera: HD - Quicktime, ProRes 4:4:4, 12bit /log	Source material is transcoded into Proxy-files, ProRes 422 LT, HD-format		Alexa source files according to EDL, transformed to uncompressed DPX 12bit log	DPX-files, 2K, uncompressed	DPX-files, 2K, uncompressed	2K Digital Cinema Distribution Master (DCDM) according to DCI Standard	2K DCP
Version 2 - Analog Output (35mm Print)							
Source	Offline Editing	A/D-Conversion	Conforming	Color Grading	Master	Distribution	Projection
ANALOG 35mm negative	WORKFLOW ENTIRELY IDENTICAL TO PROCESS ABOVE					35mm negative gained by laser-printing process (ARRI-Laser)	35mm Print
DIGITAL ARRI Alexa camera: HD - Quicktime, ProRes 4:4:4, 12bit /log	WORKFLOW ENTIRELY IDENTICAL TO PROCESS ABOVE					35mm negative gained by laser-printing process (ARRI-Laser)	35mm Print

Table 1 – Production workflows for analog and digital output.

the type of film recording constant (see Image 2). Two subsamples of the digital projection matched the exact same movie version: One subsample (n = 70) viewing the digital projection saw the same digitally recorded version of *Parachutes* (2012), while another subsample (n = 117) watched the same versions of the second and third movie (i.e., analog version of *Irgendwie* (2012), and digitally recorded version of *Senjor!* (2012). Image 4 gives an overview of the comparison between the projection types, which are discussed in this paper.

Image 4 – Comparison of projection type. The dotted lines indicate the comparison of the subsamples

Measurements

The field experiments consisted of the following procedure: First, participants read brief instructions concerning the questionnaire. Subsequently, they watched three short films and completed one part of the questionnaire after each film. Finally, they completed the last part of the questionnaire (demographics, media use). The questionnaire consisted of 138 questions. With the exception of visual memory and preference ratings, participants rated all items on 5-point (enjoyment, empathy state) or 7-point Likert scales (judgment of narrative quality, presence, positive and negative emotions, diegetic involvement), with high values indicating high levels and low values indicating low levels.

Enjoyment

Considered as a meta-emotion (Bartsch, Vorderer, Mangold, & Viehoff, 2008; Oliver, 2003), enjoyment determines whether a particular media content is selected or rejected. The degree of enjoyment results in the motivation to either maintain and approach emotions or to control and avoid them. In line with other studies (e.g., Knobloch & Zillmann, 2002; Weibel et al., 2008), we measured enjoyment with one single item ("Did you enjoy the movie?"; 1 = not at all, 5= very much).

Judgment of Narrative Quality (JNQ)

To assess the perceived quality of the narrative as an aesthetically pleasing story, we created five items about general narrative features (composition: "The composition of the film appealed to me"; acting: "The acting was convincing"; coloring: "The colors looked natural"; narrative rhythm: "The rhythm of the film was pleasing"; storyline: "I liked the narrative of the movie") that are important in Hollywood storytelling (cf. Berliner, 2013). For the subsequent analyses, we used the mean values of these five items (Cronbach's alpha = 0.67).

Presence

We used the presence-scale devised by Kim and Biocca (1997) that is designed to assess presence in the context of watching TV in general, and movies in particular. The original scale by Kim and Biocca consists of eight items that measure the extent to which someone feels present in a specific mediated environment or no longer present in the immediate physical environment (e.g., departure; sample item: "When the film ended, I felt like I came back to the 'real world' after a journey"). Cronbach's alpha was 0.79.

Positive and negative emotions

Numerous studies have used film stimuli to elicit emotional reactions with different arousal and valence in an experimental setting (e.g., Schaefer, Nils, Sanchez, & Philippot, 2010). Out of the 16-item Self-Report Emotion Inventory (Gross & Levenson, 1995), we chose eight items that were suitable for our movies (sample item: "During the movie, I felt contentment"). Four items assessed positive emotions (amusement, contentment, interest, and surprise), whereas another four assessed negative emotions (confusion, embarrassment, sadness and tension). For the subsequent analyses, the mean value for the positive and the mean value for negative emotions were computed. Cronbach's alpha was 0.71 for positive emotions and 0.81 for negative emotions.

Diegetic involvement

Diegetic involvement is a subdimension of in-emotion, which constitutes one of the four dominant modes of reception for fictional films. We used the scale by Suckfüll and Scharkow (2009), which consists of three items (sample item: "I let myself be swept away by the film"). Cronbach's alpha was 0.81.

Empathy state

To measure the experienced empathy, we selected and adapted five items of the E-Scale by Leibetseder, Laireiter, Riepler, and Köller (2001; Leibetseder et al., 2007) to the situation of watching a movie. For the subsequent analyses, we used the mean values of these five items (Item 1: "During the movie, I put myself in the principal actor's place"; Item 2: "During the movie, I felt like the principal actor"; Item 3: "I could understand the feelings of the characters"; Item 4: "During the movie, I tried to imagine how I would get on in such a situation"; Item 5: "During the movie, I tried to imagine how I would feel in the actor's place"). Cronbach's alpha was 0.85.

Visual memory

We tested how well the films were remembered by asking three multiple-choice questions about visual details after each film (recall method with five options, e.g., "What country emblem did the police officer have on his sleeve? Mexico, Portugal, Peru, Spain or Colombia."). Before the experiment, we prepared 21 questions and tested them with 13 persons at the University of Bern. We selected three medium-difficulty questions for each film.

Results

		U	N_1	N_2	*p*	*r*
Irgendwie	Presence	6.75	117	94	.005**	0.2
	Negative Emotions	6.44	117	94	.032*	0.15
	Diegetic Involvement	7.35	117	94	.001**	0.29
	Empathy State	4.19	117	93	.004**	0.2
Senjor!	Presence	6.65	117	94	.009**	0.18
	Negative Emotions	6.73	117	94	.005**	0.19
	Diegetic Involvement	7.35	117	94	.001**	0.29
	Empathy State	4.23	117	94	.004**	0.2

Notes: N_2'S ranges from 93 to 94 due to missing data. *p<.05, **p<.01

Table 2 – Significant results of the Mann-Whitney Test

Regarding the recording formats, hardly any difference in subjective spectatorial experience was found between the different versions, no matter whether participants were old or young. The only significant difference occurred in terms of visual memory: With the digital versions of the films, more visual details from the background were remembered compared with the analog versions. For more results on the differences of analog and digital recordings (cf. Loertscher et al., 2016).

Regarding the projection type, one group (n = 94) watched all three films in a mechanical projection, and two corresponding subsamples saw the same film versions in a digital projection (n = 70 for *Parachutes*, n = 117 for *Irgendwie* and *Senjor!*). The projection type significantly influenced the dependent variables of two films, namely presence (*Irgendwie, Senjor!*) negative emotion (*Irgendwie, Senjor!*) diegetic involvement (*Irgendwie, Senjor!*), and empathy state (*Irgendwie, Senjor!*). No significant differences in the dependent variables were found for the film *Parachutes*. In general, mechanical projection evoked more enjoyment, more negative emotions, more diegetic involvement, and more empathy (see Table 2).

Discussion

The results of our experiments suggest that the difference between digital and mechanical analog projection is of higher visual importance and more easily recognizable than the difference between the recording processes (cf. Stump, 2014; Loertscher et al., 2016). The participants who watched mechanical projections reported more emotional reactions, more diegetic involvement, and more empathy compared to those who watched digital projections. This observation can be explained in two ways – by the way the image is processed by the cognitive system and by lifelong habituation to the characteristics of analog projection. Mechanically projected images are characterized by minor changes between each frame. This constant micro-variation feeds additional input into the visual system which could lead to stronger engagement.

A second major difference between analog and digital projection is the black intermittant phase introduced by a mechanical shutter. As outlined above, two of these black phases occur during the projection of each single frame, one in the middle and one at the end. This double flash reduced the usage of film stock – which was very expensive in the analog era – by adjusting the films' frame rate of 24 fps to the native temporal resolution of the visual system which is assumed to be above 40 Hertz, depending on the brightness (Slansky, 2004). One hypothesis which could explain the influence of the black phase on human film perception is called "black noise". Cinematographer Michael Ballhaus introduced the term in a panel discussion at the Berlinale film festival in 2004, but it has not been scientifically investigated yet. The black noise hypothesis states that the interruption of the image stream creates headroom for psychological processes in the realm of imagination, thus enhancing viewers' individual engagement. The process could be likened to the difference between hot and cold media as suggested by Marshall McLuhan (1964). In McLuhan's view, hot media were overly determined by their high resolution, while cold media are underdetermined by either lower resolution or other flaws resulting from less than perfect media apparatuses (McLuhan 1964, 24f). As a result, according to McLuhan, the ambiguity of cold media give viewers more liberty for their own interpretations. Noël Carroll has stressed the importance of underdetermination on several occasions. In his *Philosophy of Mass Art* (1998) Carroll describes a long tradition in art criticism that favors artworks that allow for aesthetic autonomy on the part of the recipient, a critical stance that he labels the "freedom argument". However, Carroll partly contradicts this notion by positing a more complicated interaction between

form – the representation of the artwork – and its conceptual basis – the artwork's content.

From a cultural point of view, mechanical screening transforms filmic representation in a very specific way. It positions a viewer's experience in a specific cultural and institutional framework, namely, the cinema as a public space and watching a film as a communal experience. For decades, the specific "flaws" of mechanical projection (which also didn't exist in older CRT TVs) were a unique marker for films watched in a cinema. In other words, the experience of watching a film in a cinema, was closely linked to the characteristics of mechanical projection. The results of our experiments suggest that for many viewers this link still exists – mechanical projection means "going to the movies" which in itself probably leads to a higher degree of enjoyment and emotional involvement.

If this conclusion is correct, it would also mean that this effect varies according to age, since younger viewers are less or not at all used to mechanical projection. Until 2008, the vast majority of cinemas used analog projection, which means that at the time when we conducted our experiments, basically all participants were socialized with 35mm film and therefore used to its characteristics. It would be interesting to assess whether a younger generation of cinema viewers – who had their first cinema experiences after 2008 and therefore almost exclusively encountered digital projection – exhibits different preferences.

Even though the results of the experiment show clearly that mechanical projection leads to higher emotional involvement, they also reveal a differentiation regarding individual films and genres. The comedy (*Senjor!*) and the drama (*Irgendwie*) have significant higher emotional reactions. With the dystopian science fiction film (*Parachutes*), however, no significant differences could be found. An explanation might be, that the specific characteristics of *Parachutes* are affine to the perfect and stable look of digital projection. For the most part the film shows a highly artificial setting, consisting of a white beach, brightly lit in high-key. These aesthetic choices aim at generating an artificial and sterile atmosphere best suited to digital recording and projection.

Conclusion

The transformation from analog to digital recording does not impair the emotional experience of cinema. The results of the former study (Loertscher et al., 2016) show that with today's advanced digital technology, the gap between analog and digital aesthetics has been closed, at least when it comes to whole narrative films and not only isolated scenes. Despite the fears of many filmmakers, the digital turn has no collateral effects on the audience's emotional experience.

The strongest difference between analog and digital films, however, results from projection. Now that 95 percent of the cinemas worldwide have switched to digital projection, the results reveal clearly that analog mechanical film projection has effects on the emotional reactions of the audience after all. The audience groups who viewed the films as 35mm photochemical prints in a mechanical projection exhibited significantly higher emotional reactions.

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