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As Film Goes Byte: The Change From Analog to Digital Film Perception

Miriam L. Loertscher[1,2,*], David Weibel[1], Simon Spiegel[3], Barbara Flueckiger[3], Pierre Mennel[2], Fred W. Mast[1], and Christian Iseli[2]

[1]University of Bern

[2]Zurich University of the Arts

[3]University of Zurich

Author Note

Miriam L. Loertscher, Institute of Psychology, University of Bern, and Institute of Performing Arts and Film, Zurich University of the Arts; David Weibel, and Fred W. Mast, Institute of Psychology, University of Bern; Simon Spiegel, and Barbara Flueckiger, Institute of Cinema Studies, University of Zurich; Pierre Mennel, and Christian Iseli, Institute of Performing Arts and Film, Zurich University of the Arts.

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*Correspondence concerning this article should be addressed to Miriam L. Loertscher, Institute of Psychology, University of Bern, Fabrikstrasse 8, 3012 Bern, Switzerland.

E-Mail: miriam.loertscher@psy.unibe.ch

Abstract

The digital revolution changed film production in many ways. Until the end of the 20th century, most film professionals and critics preferred celluloid film. However, no previous empirical study compared complete narrative films recorded with analog and digital cinematography. Three short narrative films were produced with an analog and a digital camera attached to a 3D rig in order to control all optical parameters. In postproduction, a third version of a digital film was created to mimic the analog film aesthetics. In a cinema experiment with 356 participants, we tested whether the three film versions are perceived differently. The two capturing technologies produced similar emotional and immersive experiences during digital projection. The study revealed significant differences in the memory of visual details, with higher recall scores for the digitally captured versions. By contrast, preference ratings of very short scenes and the comparison of projection types revealed different results. The mechanical projection of celluloid film produced higher levels of emotional reactions. The results might be of interest to film professionals and audience in general. This study shows that the gap between analog and digital aesthetics has been closed with today's advanced digital technology.

Keywords: analog film, digital cinema, film perception, cinema experiment, audience research

As film goes byte: The change from analog to digital film perception

Ever since the invention of film, the majority of commercially distributed films have been shot, edited, and projected on photochemical 35mm film. Digitization entered the film industry slowly and on different paths. While both digital non-linear editing and color correction became industry standards during the late 1990s, cinematography and especially projection remained analog for much longer. Only in recent years have cinemas replaced their mechanical analog projectors with digital models. Though digital cameras were increasingly used, until recently professionals and critics largely agreed that digitally recorded images are technically and aesthetically inferior (e.g. Flueckiger, 2003; Slansky, 2004; Prince, 2004). Also, filmmakers often showed a preference for analog recording (see interviews in Kloock, 2007; Kirchner, Prümm & Richling, 2009). While production companies preferred digital technology for budgetary reasons, directors of photography and filmmakers often chose analog film. Moreover, some qualitative case studies suggest that people without any technical background intuitively prefer analog images, because they are perceived as more vivid, less sterile, and generally more pleasing (cf. Flueckiger, 2004; Prince, 2004).

The debate focused almost exclusively on the aesthetics of the image and not on its role in a filmic narrative. Typically, standardized shots taken with different cameras were compared in terms of technical parameters such as dynamic range, color reproduction, exposure, or resolution (e.g., Clark et al., 2009; Zacuto Films, 2011). Narrative elements were not part of these comparisons. However, moviegoers never compare individual shots, but rather follow the story as it unfolds and experience the emotions thereby conveyed. The question whether narrative films are perceived differently depending on the recording mode has not yet been empirically examined. The aim of the present study is to fill this gap and to investigate whether recording technology affects cognitive and emotional reactions, enjoyment, and immersive experiences during movie-watching. For this purpose, three complete short narrative films as well as several short scenes were produced and simultaneously captured digitally and on 35mm film. Additionally, a third version, which emulated the aesthetics of the analog image, was created in postproduction. To compare the recording modes, the emotional and immersive reactions to the three films were captured in a pilot experiment and an extensive field experiment. The studies took place in regular cinemas to ensure high ecological validity. Most participants saw the three films in digital projection. Additionally, one test group saw the three films as analog 35mm versions screened using conventional mechanical projection.

Theoretical Considerations

Technical Aspects

Both digital and analog cameras capture light waves entering through a lens. In the emulsion of analog film, silver bromide crystals turn into metallic silver when exposed to light and subsequently developed in chemical baths. Exposure and development enable image formation. In digital film, electronic sensors transform light into electrical charges based on individual picture sensors in a highly resolved grid. After exposure, voltage is assigned a binary value according to an explicit rule in the quantization process. In the early days of digital video, the processing of the full color gamut and the corresponding contrast ratio posed serious challenges to the available sensors (Flueckiger, 2003). Modern digital cameras, however, feature a dynamic range of 14 f-stops (as opposed to 5-7 f-stops in early models) and can thus cope with a far larger tone range between dark and bright areas on the set. In this regard, they are actually superior to analog film stock, which is capable of processing approximately 12 to 14 f-stops (Flueckiger, 2011).

The difference between analog and digital film is not only a question of dynamic range, but rather lies in the different characteristics of film grain and pixel: While the position of individual grains is randomly distributed and changes from frame to frame, the pixel is defined by a fixed grid. Film grains cause a pseudo-movement in analog film. Random distribution, in combination with the changing position, gives the film an organic feel, which is frequently described as pleasing to the eye (Slansky, 2004). In contrast, the digital film's rock-steady stability is often perceived as cold and sterile (Flueckiger, 2003, 2015; Slansky, 2004). Another notable difference results from digital cameras' lack of mechanical movement. In analog cameras, the film strip is moved frame by frame after every exposure – normally 24 frames per second – while the electronic light sensor remains in its position (Webers, 2007; cf. Stump, 2014).

Another area where analog and digital films differ is color reproduction: Whereas digital formats are based on additive admixtures of red, green, and blue light, a film negative contains in its separate layers cyan, magenta, and yellow dyes that filter the projection light in a subtractive process. The different layers of film emulsion also capture parts of neighboring wavelengths, leading to what is called side-absorptions. As a result, analog film's rendering of color is neither linear nor neutral, but instead exhibits very distinct characteristics (Flueckiger, 2003). In contrast, the color coding of digital cameras is completely controlled by the linear or logarithmic assignment of binary values to each color channel red, green, and blue (RGB). This can result in an unfamiliar and artificial appearance of digital color (Flueckiger, 2003). Hence, considerable transformations are routinely performed in color grading to create a more pleasing color experience in tune with the established patterns of photochemical film.

Despite some problems, digital filmmaking has become the de facto industry standard, mainly due to lower costs. For instance, 88% of all feature-length films shown at the 2013 Sundance Film Festival had been shot digitally. For dramas the percentage was a bit lower (82%) whereas documentaries were shot exclusively in digital (Leitner, 2013). Generally, films with lower budgets (including documentaries) are more likely to be shot digitally. In Switzerland, a country with a comparably under-capitalized film industry, digital film production had already reached a rate of over 80% in 2007 (Flueckiger, 2008). For big-budget productions the transition occurred more slowly — until the launch of the ARRI Alexa in 2011. Not only could this camera handle a dynamic range comparable to analog film, but it was specifically designed to accommodate cinematographers accustomed to analog movie cameras. Since then, and because newer chip technology enabled higher dynamic ranges for most available cameras, the majority of film productions have turned towards a completely digital workflow.

The technologies of shooting and projecting film are completely independent (for an overview see Stump, 2014). A digitally captured film can be printed on 35mm stock and vice versa. The switch to digital projection happened later than that to digital filmmaking because it required cinema owners to make massive investments without any immediate economic gain. Its large-scale success was pushed significantly by the new wave of stereoscopic films (S3D), such as James Cameron's *Avatar* in 2009, since the S3D process requires digital projection. By 2013, over 80% of the world's cinemas were equipped with digital projection. However, considerable regional differences can be observed due to specific distribution systems and infrastructure. In the US, 93% of all screens were digital in 2013. At the same time, the percentage in the Asia-Pacific area only reached 76% and was as little as 69% in Latin America (MPAA, 2013). Most digital projectors currently employ DLP technology (Digital Light Processing). This features an image resolution of 2K or 4K, a high contrast ratio, and high light-emitting efficiency (Steber, Nowora, & Bonse, 2008). The result is a completely stable image. In contrast, mechanically projected analog film can easily be recognized by its characteristic instability and flickering light. This flickering is caused by a rotary shutter, which alternately blocks out light during the transportation of the film strip. The instability arises from the mechanical tolerance of the advance sprocket, i.e., the film perforations rarely fit the pins exactly. Therefore the film never comes to halt at the exact same position, which leads to a slightly unstable, jittery image when projecting the film at 24 frames per second.

Psychological Processes in Film Perception

A filmic narration needs the viewer's attention and various thought, feeling, and imagining processes to unfold as a story on the screen. Film is by definition an art of illusion and depends on characteristics of human perception. Two perceptual mechanisms are central for watching analog films in a cinema with mechanical projection (Anderson & Anderson, 1993; Thomson-Jones, 2013): (1) *Critical flicker fusion* produces an illusion of continuous light, when a rapidly flashing light flickers with high frequency; (2) *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. Flicker fusion, however, is less prominent, as there are no gaps of darkness twice a frame due to a moving shutter as in mechanical projection (Thomson-Jones, 2013).

Generally speaking, our mind interprets movies through the interplay of bottom-up (based on sensory input) and top-down processes (based on prior knowledge stored in memory). Neuroimaging studies with audiovisual stimuli suggest multisensory integration as an automated process at an early stage of parallel cortical processing, when auditory and visual events are presented at the same time (for an overview see Koelewijn, Bronkhorst, & Theeuwes, 2010). Interestingly, multisensory integration in higher-level brain processes can be modulated by selective attention and emotion (e.g., Eldar, Ganor, Admon, Bleich, & Hendler, 2007). Only objects or visual features that are fixated with the eyes are acquired in high resolution. On average, viewers direct their gaze at 3.8 % of a cinema screen (covering 40 feet and viewed from 35 feet) from one cut to the next (Smith, 2013). This highlights how important it is to guide spectatorial attention to the relevant narrative elements to ensure the story told is understood as it unfolds.

The emotions experienced while watching a movie depend on various factors, such as the individual psychological state or current mood (e.g., Weibel, Wissmath, & Mast, 2011a, 2011b), or the specific kind of film which is connected to genre expectations (e.g., Weibel, Wissmath, & Stricker, 2011; Wuss, 2007). Zillmann (1991) suggested a cognitive-appraisal theory to explain affective reactions to films: An emotion results from the cognitive interpretation of a state of bodily arousal. Oliver (2003, 2008) pointed out that people enjoy media offerings if they elicit affective reactions. Importantly, emotional valence does not determine the degree of enjoyment (Hanich, Wagner, Shah, Jacobsen, & Menninghaus, 2014; Oliver, 2003): Persons experiencing high levels of empathic distress when viewing cinematic tragedies feel more enjoyment (De Wied, Zillmann, & Ordmann, 1994). Likewise, those scared while watching a horror film are likely to report enjoyment afterwards (Weibel et al., 2011b). As soon as viewers recognize typical genre elements, they react to the displayed situations with an adapted appraisal style and feel corresponding affective reactions (Wuss, 2007).

Previous research has shown that people watch movies, television shows, or video games because they like to be immersed in another world (e.g., Bracken & Skalski, 2009; Yee, 2006).

Immersion in mediated environments has been explained through the concept of presence. It can be described as a perceptual illusion of non-mediation (Lombard & Ditton, 1997), i.e., giving the impression of being physically present in a mediated environment (Steuer, 1992). According to Wirth et al. (2007), presence is an "intensifier" of all kinds of media effects, including emotions and enjoyment. Indeed, previous studies have revealed a positive relationship between presence and enjoyment (e.g., Weibel, Wissmath, Habegger, Steiner, & Groner, 2008). A recent concept describing immersive experiences in the context of films is *in-emotion* (Suckfüll & Scharkow, 2009). In-emotion consists of two sub-dimensions: (1) Emotional involvement enables viewers to indulge their feelings while remaining in control of the situation; (2) diegetic involvement is defined as the readiness to be drawn entirely into the film (Suckfüll & Scharkow, 2009). Empathy is yet another concept related to immersive experiences (e.g., De Wied, Zillmann, & Ordman, 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). According to Green, Brock, and Kaufman (2004), empathy is needed to be transported to a narrative world.

According to Bartsch (2012) as well as Vittadini, Siibak, Reifová, and Bilandzic (2014), age is another important factor in media use. On the basis of empirical studies, Vittadini et al. (2014) identified two levels at which generational belonging affects media audience practices: (1) experience of media and technologies is learnt through education and peer culture; (2) narratives and discourses shared through media usage stabilize consumption habits and cultural identity. There is also empirical evidence that the motivations for media use change over a lifespan. Older adults seem to be more interested in contemplative entertainment experience, whereas young adults prefer emotionally intense entertainment (Bartsch, 2012). This led us to compare different age groups in our main experiment.

Research Questions and Hypotheses

The digital revolution in the film industry has raised the question whether analog technologies still provide a benefit for the audience. Many film professionals and critics believe that digitally recorded material is aesthetically inferior and therefore prefer analog recordings (e.g., Flueckiger, 2003; Kloock, 2007; Kirchner, Prümm, & Richling, 2009; Slansky, 2004). One reason might be that the enhanced acutance and clarity of digital images increase the perceived sharpness and induce a sense of artificial hyperreality. Furthermore, digital sensors are arranged in a rectangular grid pattern and produce images that are susceptible to artifacts like moiré patterns. Because of the random orientation of its grains, this is not the case for photochemical film images (Keelan, 2002). Also, there are differences in dynamic range: Professional digital cameras capture more details in shadow areas, while highlights can lose texture and color by becoming blown out. Consequently, it is difficult for digital cameras to handle overexposure. At extreme brightness, they cut off any information above a limited range defined by 100% white (Kodak, 2007). In contrast, and due to its slow and nonlinear response to high exposure levels, photochemical film handles overexposure in a more natural-looking way (e.g., in challenging environments with natural light). It is assumed that the characteristics of digital images described above contribute to the impression of hyperrealism and thus create a sense of false reality (e.g., Prince, 2004). In turn, media contents lacking realism induce less presence, less enjoyment, and fewer emotional responses (Baños et al., 2000; Tan, 1994; Weibel et al., 2011b). Generally, higher emotional involvement, stronger emotional reactions, and greater presence are assumed to be connected with higher scores of enjoyment. Furthermore, digital recordings may enhance the exploration of peripheral details due to high sharpness and image stability. This may also influence film reception negatively: Wissmath, Weibel, Stricker, Siegenthaler, and Mast (2010) found that explorative eye movement patterns (many fixations, short fixation durations, larger saccades) are associated with low sensations of enjoyment and presence. These findings lead us to the expectation that digital recordings induce less enjoyment, fewer emotions, and also less presence compared to analog recordings. On the other hand, we expect that visual remembrance is greater for digital recordings since high sharpness and image stability may enhance the exploration of peripheral areas. Until recently, mechanical projection was the technical standard in cinemas all over the world. Due to familiarity effects, we expect that the audience is more accustomed to mechanical projections and will experience greater enjoyment and stronger emotional reactions at traditional screenings. We expect differences between age groups because of different media socialization as young people grew up with digital media. We expect older people to prefer analog recording and mechanical projection.

Pilot Experiment

To evaluate the possible relevance of our research question, a pilot experiment was carried out prior to the main experiment. The pilot experiment examined whether analog and digital film sequences are perceived differently. Isolated scenes containing hardly any narrative elements were used. The field experiment was carried out in a cinema.

Method

Participants. A total of 100 individuals participated in the experiment. All of them were undergraduate students in psychology (66 female, 34 male; age: 19 to 35 years, $M = 21.54$, $SD = 3.55$). All participants received course credits. The study was approved by the Ethics Committee of the University of Bern.

Procedure. The experiment took place in a cinema. Participants were tested in six groups of 10 to 20 participants. Participants were shown four short sequences (15 to 30 seconds) that were recorded with an analog Super 16mm camera and digitally with a RED One camera. Each participant saw each sequence in both versions, and the two versions of each sequence were presented consecutively. The order of the versions was counterbalanced, and the sequences were presented in randomized order. The sequences were originally produced as tests for the movie *Hugo Koblet – Pédaleur de Charme* (Aarburg, 2010). Since the sequences were not shot in parallel, they were not identical, but they were still highly similar. For each sequence, participants had to decide (1) which version they generally enjoyed more and (2) which version they preferred in terms of image quality. The respective items were (1) "Which version did you enjoy more?" and (2) "Which version do you prefer in terms of image quality?". No information concerning the difference of the two versions was provided. Thus, it was not clear to the participants that we were testing whether analog and digital film sequences are perceived differently.

Results

With one exception, viewers enjoyed the analog versions more than the digital version. They also judged the image quality of the analog versions as better. Binomial tests revealed highly significant effects in three out of four sequences: The analog versions were chosen more often than would be expected by chance. The exact binomial p-values (two-tailed) were .007 (sequence 1), .37 (sequence 2), <.001, (sequence 3), and <.001 (sequence 4) for enjoyment, and .007 (sequence 1), .37 (sequence 2), <.001 (sequence 3), and .007 (sequence 4) for image quality. The results are shown in Figure 1.

Discussion

Before equal dynamic-range performances between analog and digital cameras were achieved, analog films had been widely regarded as aesthetically superior (e.g., Flueckiger, 2003; Slansky, 2004; Prince, 2004). The results of the pilot clearly confirm this: Participants enjoyed analog films more and judged them to be aesthetically more pleasing than the digital recordings. This is the first empirical evidence that analog recordings are indeed preferred. However, the isolated comparison of two versions of a sequence does not reflect common film reception. Thus, the pilot study lacks ecological validity. Also, the forced-choice question may have inflated minimal difference in enjoyment or aesthetic preference. Furthermore, the two versions were only short sequences, but not complete narrative films. The digital Red One camera used in the pilot still had noticeable limitations in terms of dynamic range and color reproduction, not only compared to analog film but also to the newer digital camera used in the main experiment (described below). The original Mysterium chip of the Red One camera had a maximal dynamic range of 11 f-stops. It was introduced in 2007, several years before the substantial leap in sensor quality achieved with the ARRI Alexa's dynamic range of 14 f-stops in 2011.

Using a Super 16mm camera as an analog recording system was another essential aspect of the pilot. The relatively small film gate (7.41 x 12.52 mm) of this format leads to more grain and to a greater depth of field when compared to the image size of 35mm film cameras (film gate of 18.66 x 24.89 mm). Consequently, the analog images of the pilot exhibited considerably more grain than the analog images of the main experiment. Compared to the images produced by the Red One camera sensor, they offered greater depth of field.

We endeavored to overcome the limitations of the pilot study for the main experiment. The digital variants of the stimuli films were shot with the ARRI Alexa Camera and therefore represent a higher sensor standard and enhanced recording quality. For the analog recording, we used a 35mm film camera (ARRI LT) with optical parameters identical to the Alexa.

[Insert Figure 1 about here]

Main Experiment

In the main experiment, we compared the reactions to three short narrative films shot simultaneously, digitally and on photochemical 35mm film. Additionally, a third version based on the digital recording was created during postproduction using special filters to mimic the aesthetics of the analog image (digital filter). Each screenplay represents a different genre to control the effect of corresponding appraisal styles. The three films were then shown – via digital projection – to test audiences asked to report their emotional and cognitive reactions. Participants were not told that the films were recorded differently. To test whether the type of projection influences audience reactions, an additional 35mm film print with all three films was created and tested using a traditional mechanical projector. The field experiment was conducted in two cinemas.

Method

Participants. Three hundred and fifty six individuals (211 female, 143 male; age: 15 to 78 years, $M = 38.67$, $SD = 16.66$) participated in this experiment, which took place at two different cinemas in Bamberg, Germany ($n = 128$) and in Zurich, Switzerland ($n = 228$). Participants were recruited with flyers at universities, high schools, and cinemas, or via social networks, online newsletters, and information boards at different institutions. As an incentive, participants had the chance (50%) to win a cinema voucher.

Procedure. The field experiment was conducted in regular cinemas. First, participants read brief instructions about completing the questionnaire. Second, they watched three short films and completed one part of the questionnaire after each film. Third, they saw six short film scenes presented in pairs with forced-choice questions in-between (similar scenes as in the pilot experiment) and then completed the last part of the questionnaire (demographics, media use). This three-step procedure is illustrated in Figure 2. Most participants (*n* = 310) saw the three films via digital projection (*Experiment Part A*). A small group of participants (*n* = 46) saw the films via mechanical projection (*Experiment Part B*). All participants watched similar scenes from the pilot experiment and chose their preferred version (*Experiment Part C*). The procedure is described in more detail below and illustrated in Figure 2.

[Insert Figure 2 about here]

Experiment Part A. We applied a three factorial 3 x 3 x 4 mixed design. The first independent variable of the experiment was the *film recording*, which was manipulated at three levels (IV A: a1 *analog film* vs. a2 *digital film* vs. a3 *digital filter*). Furthermore, the *film category* was manipulated at three levels: Three films with different genre categorizations were presented (IV B: b1 *Parachutes = science fiction* vs. b2 *Irgendwie = social drama* vs. b3 *Senjor! = comedy*). We used a mixed design and all participants were assigned to three out of nine experimental conditions. Each participant saw all three films, one analog-captured movie, one digitally-captured movie, and one digitally-captured movie using postproduction filters to mimic analog aesthetics. We counterbalanced the order (Latin square design) of both factors to control for possible position effects. As a quasi-experimental factor, the *generation* was included as a third variable, with four levels referring to four different age groups (c1 *15-25 years, n* = 118, vs. c2 *26-39 years, n* = 75, vs. c3 *40-53 years, n* = 83, vs. c4 *54-78 years, n* = 77). We assessed

Enjoyment, Judgement of Narrative Quality, Presence, Positive and Negative Emotions, Diegetic Involvement, *Empathy State,* and *Visual Memory*. A detailed description of these measures is given below.

Experiment Part B. A mechanical projection of the three films on a photochemical 35mm film print was presented to one smaller group of participants (*n* = 46) in order to test the influence of projection. 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 same dependent variables as described in Part A. Each movie of the 35mm film roll shown via mechanical projection was compared to the same version shown via digital projection to keep the type of film recording constant (see Figure 3). 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 the first movie (*Parachutes*, Pillonel, 2012) while another subsample (*n* = 117) watched the same versions of the second and third movie (i.e., analog version of *Irgendwie*, Brühlmann, 2012, and digitally recorded version of *Senjor!* Hasanaj, 2012).

[Insert Figure 3 about here]

Experiment Part C (Preference Test). To replicate the findings of the pilot experiment, six short scenes were presented, with each scene presented in an analog and in a digital version. Participants then had to choose the version they enjoyed more (preference rating as the dependent variable). We used a 2 x 4 univariate design with repeated measures. The factor *film recording* was tested within-participants at two levels (*analog film* vs. *digital film)*. Furthermore, *generation* was included as a quasi-experimental factor.

Film Stimuli. All three movies described below were made in a production workshop by advanced film students from Zurich University of Arts. The three movies belong to different genres and thus address different appraisal styles and their corresponding emotional patterns:

(1) *Senjor!* (directed by Ilir Hasanaj, 2012, 9min). 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 with video game character Mario.

(2) *Irgendwie* (directed by Lisa Brühlmann, 2012, 6min). 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.

(3) *Parachutes* (directed by Wendy Pillonel, 2012, 5min). 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.

The three movies were shot simultaneously with an analog ARRICAM LT 35mm 3perf camera and a digital ARRI Alexa camera fitted with an Alev III, CMOS sensor. Both cameras were attached to a 3D-camera-rig with a semi-transparent mirror. This construction ensured that all relevant optical parameters such as focus, focal length, t-stop, and lens type were identical. Eventually, two originals were produced with the only difference being their recording system.

In postproduction, both versions were processed according to current industry standards (technical parameters are shown in Table 1). Postproduction largely included a digital workflow for both versions. In addition, a third variant simulating the most important features of analog photochemical film (i.e., photochemical grain and image instability) was also created in postproduction. Analyzing the analog image's typical instability showed that it moves by approx. 0.4 pixels from frame to frame in a given 2K pixel count of 2048x1080 pixels. The measured movement algorithm was then applied to the digital footage. Instead of the commercially available yet rather simplistic grain-adding solutions (so-called "noise generators"), a more advanced process was developed: The generated grain not only varied in size but also in frequency, angle, and density according to the color channel and image brightness.

[Insert Table 1 about here]

Apparatus. Two medium-sized movie theaters were chosen in Zurich and Bamberg. In Zurich, the three films were projected digitally for three test audiences. Mechanical 35mm film projection was used for one test group. Measuring 5.8 x 3.1 meters, the screen's aspect ratio met the DCI-projection standard of 1:1.85 (flat). Films with the cinemascope aspect ratio were shown with a vertical cache. Luminance of digital projection measured 10 foot-lambert in white areas, whereas mechanical projection read out 9 foot-lambert. In Bamberg, the films were only shown digitally on a screen measuring 11.4 x 4.8 meters for a projection standard of 1:2.39 (scope). Films with the 1:1.85 aspect ratio were shown with a horizontal cache.

Measures. The questionnaire consisted of five parts with a total of 138 questions. Parts one, two, and three were completed by participants after watching a film (one part after each film). Then the preference ratings were captured. In a last part of the questionnaire, media use and basic demographic information (age, gender, etc.) were assessed.

Dependent Variables. With the exception of visual memory and the preference ratings, participants rated all items on five-point (Enjoyment, Empathy State) or seven-point Likert scales (Judgement of Narrative Quality; Presence; Positive and Negative Emotions; Diegetic Involvement) with high values indicating high levels and low values indicating low levels. We calculated Cronbach's alpha as the reliability statistic, if we used several items to measure the same variable. Measurement reliabilities were sufficient and comparable to those reported in earlier studies. Below, the measurement of the dependent variables are described in more detail.

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 a 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).

Judgement of Narrative Quality. 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 is 0.77).

Presence. We used the presence-scale devised by Kim and Biocca (1997). This is designed to assess presence in the context of watching television in general and movies in particular. The original scale by Kim and Biocca (1997) consists of eight items that measure the extent to which someone feels present in the mediated environment or no longer present in the immediate physical environment (departure) (sample item: “When the film ended, I felt like I came back to the ‘real world’ after a journey”). Cronbach’s alpha is 0.85.

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) while 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 is 0.68 for positive emotions and 0.58 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 is 0.93.

Empathy State. To measure the experienced empathy as a state, we selected and adapted five items of the E-Scale by Leibetseder, Laireiter, Riepler, and Köller (2001; 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 is 0.83.

Visual Memory. We tested the memory of film content 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.

After the three movie parts, participants were shown short paired test sequences (analog and digital recorded shots, whose order was counterbalanced) with forced-choice questions asked in-between to replicate the measurements of the pilot experiment.

Preference Ratings. Part four of the questionnaire consisted of six forced-choice questions, where participants had to choose whether they enjoyed scene A or B more (“Which version did you enjoy more?”). For the subsequent analyses, the number of chosen analog sequences and the number of chosen digital sequences were used.

Results

Analysis Strategy. The main research question of Experiment Part A was analyzed using a three-factorial linear mixed model with the software package SPSS. Linear mixed modeling (LMM; cf. McCulloch and Searle, 2001; Stroup, 2013) is a further generalization of general linear models (GLM), but correctly models correlated errors. LMM handles data when observations are not independent (repeated measures data) and encompasses all models in the variance components (VARCOMP) procedure. This allows the implementation of hierarchical designs, where not all possible combinations (experimental conditions, respectively) can be realized for all subjects. In consequence, this results in incomplete data with missing cases for each subject. Conventional GLM procedure would omit subjects with missing measurements. In contrast, linear mixed models can handle these cases, which was necessary for our study: Each participant only performed three out of nine experimental conditions. All participants watched three different movies (IV B with the three levels b1, b2, b3) in three differently recorded versions (IV A with the three levels a1, a2, a3). For example, one third of participants saw

Irgendwie (Brühlmann, 2012) recorded with an analog camera, *Senjor!* (Hasanaj, 2012) recorded with a digital camera, and *Parachutes* (Pillonel, 2012) recorded with a digital camera plus a digital filter to simulate the "analog look" (see Figure 3 for details). We specified the linear mixed model with three IVs (A, B, C) as fixed effects, a random intercept for subjects and experimental condition as a repeated statement. SPSS dummy codes the fixed effects automatically. Idiosyncratic variation due to individual differences in film perception can cause correlated within-subject errors. LMM can handle this problem by estimating a variance parameter of the random intercepts: each subject can have his or her own individual intercept randomly deviating from the mean intercept of his or her group (Seltman, 2015). The covariance type of the random intercept for subjects was specified with "identity" and "first-order auto-regressive" for experimental condition as a repeated statement (see details in Stroup, 2013, p. 185). The data of Part B and the preference ratings (Part C) were analyzed using general linear models (GLM) for repeated measures data. An alpha level of .05 was used for all statistical tests.

Experiment Part A.

Main Effects. All main effects of the three factors (film recording, film category, generation) are summarized in Table 2.

[Insert Table 2 about here]

Film recording. One main effect of film recording on visual memory is that significantly more visual details were remembered in the digital film (M= 1.86) compared to the analog film (M = 1.67). In contrast, the mode of film recording did not influence the other variables (cf. Table 2). All means and standard deviations are shown in Table 3.

[Insert Table 3 about here]

Film category. Film category was a main effect on all dependent variables (cf. Table 2) except for judgement of narrative quality. The emotional and immersive reactions to the three films differed depending on the kind of film, but the perceived narrative quality of the three films was similar. All means and standard deviations are shown in Table 4.

[Insert Table 4 about here]

Generation. Results show that generation influences enjoyment, judgement of narrative quality, negative emotion, and visual memory (cf. Table 2). The latter effect shows that younger viewers remembered significantly more visual details than older viewers. In contrast, no effects occurred for presence, positive emotion, diegetic involvement, and empathy state. All means and standard deviations are shown in Table 5.

[Insert Table 5 about here]

Interactions. No interactions between film recording and film category were observed except negative emotions. Also, no interactions between film recording and generation were noted. In contrast, significant interactions occurred between film category and generation for enjoyment, judgement of narrative quality (JNQ), positive emotion, negative emotion and diegetic involvement. However, these two-way interactions between film category and generation are of minor interest for our study, but could influence the results as confounding variables, if they were not measured. For instance, the comedy film with slapstick elements (*Senjor!*) appealed more to younger participants, whereas older ones rated the science fiction film (*Parachutes*) higher. Furthermore, three-way interactions between film recording, film category, and generation occurred for the judgement of narrative quality (JNQ), diegetic involvement as well as empathy state. For instance, the mean of diegetic involvement at watching *Parachutes* is higher at all levels of generation combined with the three levels of film recording compared to *Irgendwie*, with one exception: viewers between 40 to 53 years (c3*, n* = 83) rated the diegetic involvement of the 35mm version of *Parachutes* lowest compared to the digital and digital filter versions and in contrast to the 35mm versions of *Irgendwie* and *Senjor!*. In contrast, *Parachutes* is rated highest in diegetic involvement by the youngest viewers in the 35mm version (c1, *15-25 years, n* = 118). All interactions are summarized in Table 6.

[Insert Table 6 about here]

Experiment Part B

Projection Type. Compared to Part A and C, a restricted number of participants were included in the analysis of Part B (see Figure 3): One group (*n* = 46) saw all three films via mechanical analog projection, and two corresponding subsamples saw the same movie versions in a digital projection (*n = 70* for *Parachutes*, *n = 117* for *Irgendwie* and *Senjor!*). Cinema projection (Table 7) influenced the dependent variables negative emotion (all films), diegetic involvement (*Senjor!*), and empathy state (*Irgendwie*, *Senjor!*). Mechanical projection evoked more negative emotions, more involvement, and more empathy.

[Insert Table 7 about here]

Experiment Part C

Preference Ratings. There is no main effect for a preference of analog recorded shots (M= 2.91) or digitally recorded shots (M= 2.81), $F(1, 233) = .47$, p= .50, $\eta^2_p = .00$. Nor is there any main effect of generation (M_{c1}= 2.91, M_{c2}=2.87, M_{c3}=2.86, M_{c4}= 2.80) with $F(3, 233) = .61$, p= .61, $\eta^2_p = .01$. The interaction between the preference for the analog or digital image and generation is not significant as well, $F(3, 233) = 2.43$, p= .07, $\eta^2_p = .03$.

Discussion

Film professionals, critics, and movie fans have discussed for decades whether analog and digital images differ. The present study is the first to examine this issue experimentally. The myth of a total cinema has existed since its invention at the end of the nineteenth century (Bazin, 1967). 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, p. 236). The digital revolution has brought forth new technologies for processing film that have changed aesthetics. Nowadays, digital postproduction processing like color grading simulates the aesthetics of analog image processing almost perfectly. Many film enthusiasts, however, remain skeptical, claiming that human perception more closely resembles analog processing. In contrast, digital images, so the critics, impose more perceptual adaptation and produce some kind of “hyperreality.” In “Bukimi No Tani” (不気味の谷, The Uncanny Valley, 1970/2012), Japanese roboticist Masahiro Mori described an interesting hypothesis in the field of robot aesthetics similar to these assumptions: Human observers have a spontaneous response of discomfort while watching robots or movie avatars that look like natural beings and move in an almost realistic, but not completely perfect manner. The viewer’s aesthetic acceptability of more realistic, anthropomorphic depictions is not a linear function, but falls off like a deep valley just before the resemblance is nearly perfect by creating negative reactions towards the stimulus (i.e., “the uncanny valley”).

In line with these hypotheses and opinions, the direct comparisons of the pilot study show that most individuals intuitively favor analog images when both variants are shown. The direct comparisons in the pilot experiment reveal that young participants prefer scenes that were captured with analog film compared to less sophisticated digital film. In contrast, the young participants of the main experiment – who are comparable with the sample of the pilot study – show no preference for the analog image. It is likely that the use of different cameras can account for this difference. The digital Red One camera used in the pilot has limitations in terms of dynamic range and color reproduction, not only compared to analog film but also to the digital ARRI Alexa camera used in the main experiment. This suggests that – at least for younger individuals – the advantage of an analog camera has disappeared with the progress of digital cameras in recent decades. Thus, these findings only partly agree with the assumptions of Flueckiger (2004) and Prince (2004), who claimed that analog images appear more vivid, less sterile, and therefore generally more pleasing. Moreover, the direct comparisons are based on a rather artificial situation and lack ecological validity for two reasons: Usually, individuals (1) do not watch isolated scenes without narrative elements and (2) they hardly ever watch the same scene twice in two different versions. Thus, the direct comparisons did not reflect common film reception. Therefore, we also presented whole narrative films in an analog, a digital, or a digital-filter version. This procedure meant that the comparison was between, but not within, participants. Surprisingly – and unlike the hypotheses and results reported above – 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 to the analog versions. Enhanced acutance and clarity of the digital versions lead to an increase in perceived sharpness as a result of image stability and edge enhancement within signal processing. Moreover, superior color separation of digital images makes it easier to detect details. The data also shows that spectators remembered fewer details of the filtered digital versions, which contained artificial grain and were slightly destabilized. The effect of the recording mode on memory could also be a hint towards a more cognitively controlled central processing in the elaboration likelihood model (ELM) by Petty and Cacioppo (1986). If viewers are able to attend to minute details in the background, they might be less attached to plot and character development. In line with these assumptions, Subramanian, Shankar, Sebe, and Melcher (2014) found empirical evidence that emotions modulate eye movement patterns and subsequent memory for the gist and details of movie scenes. However, more data would be necessary to test this explanation.

In contrast to the effect on visual memory, emotional responses and immersive experiences were not influenced by the recording mode. Also, the perceived quality of the narrative (JQN) was not affected. These results were similar for all three films. Our findings suggest that the emotional experience of watching narrative films does not differ depending on the technology used to capture the image. The preference for analog images found in isolated sequences seems to disappear in a narrative context. It is likely that narrative elements override subtle differences between analog and digital images. At least for the genres used in our tests, these results can be accepted as valid since we tested a large sample. Statistical power was high and would have allowed us to detect small effects.

In contrast to the recording mode, the type of cinema projection seems to exert a certain influence on the audience. Our results suggest that the difference between digital and conventional mechanical projection is visually more striking and thus rather noticeable than the difference between the capturing processes (cf. Stump, 2014). Even though only few participants watched the films via analog projection and statistical power was thus low, we found effects for the type of cinema projection. Those participants who watched mechanical projections reported more emotional reactions, more involvement, and more empathy compared to those who watched digital projections. This could be explained by the fact that the characteristics of mechanical projection – flickering lights and image instability – are seen as an essential part of a traditional cinema experience. These variable properties of mechanical projection feed the visual system constantly with minor changes from frame to frame. 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. It would be interesting to assess this type of influence in future research.

The biggest difference between analog and digital films results from projection. Concerning the movie-capturing processes, the results of this study 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. In the last ten years, digital cinematography has managed to deliver results similar to analog technologies in terms of resolution and dynamic range. Digital workflows and versatile digital cameras open up new creative ways in filmmaking. However, it should be noted that digital aesthetics is still highly influenced by photochemical standards established in the first century of film history. Color grading routinely applies several steps to emulate a film look's color and contrast characteristics. From a filmmaker's point of view, it is reassuring that the technology in use causes no measurable difference in the viewer's emotional response. This is also in line with current research on emotions in film studies, which emphasizes empathetic and sympathetic processes related to the film's characters (e.g., Bartsch, Eder, & Fahlenbrach, 2007; Bruun Vaage, 2008; Smith, 1995; Suckfüll & Scharkow, 2009).

Limitations

The study is of high ecological validity, because the experiments were conducted in real cinemas. The results can be generalized to other individuals due to the large sample size with different generations and sufficient statistical power to detect small effects. However, differences between the different conditions might be subtle and thus not detectable by means of self-report. Furthermore, participants provided these judgments not while but after having watched a movie. To gain insights into less conscious processes of perception and emotional reactions, it might be useful to additionally measure objective physiological indicators like eye movements, pupil dilation, facial mimicry, pulse or skin conductivity.

Conclusions

There were no differences in terms of the emotional and immersive experiences of the audience depending on the recording technology: Analog and digital cinematography produced similar movie experiences. Our study reveals an interesting difference in visual memory: The audience remembered visual background details better when watching the digital version. The detection of visual details can be highlighted because the digital versions have enhanced acutance and clarity due to edge enhancement within the signal processing and due to the superior color separation of digital images. This effect could be unwanted from a filmmaker's point of view, as the spectator is distracted by irrelevant details. In contrast, the type of projection does matter: Compared to digital projection, higher levels of emotional reactions were achieved with mechanical projection. Therefore, cinema owners may decide to preserve their mechanical projectors in addition to digital models.

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Tables

Table 1

Postproduction Workflow

Version 1: Digital Output (DCP)							
Source	Offline Editing	A/D-Conversion	Conforming	Color Grading	Master	Distribution Master	Projection Format
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 EDL	DPX-Files, application of 'Print Preview'-LUT	DPX-Files, 2K, uncompressed	2K DCDM according to DCI Standard	2K DCP
DIGITAL ARRI Alexa camera*	Source material transcoded into Proxy-files ProRes 422 LT, HD-format		Alexa source files according to EDL, transformed into uncompressed DPX 12 bit log	DPX-Files 2K, application of 'Print Preview'-LUT and ARRI 'Film Matrix'	DPX-Files, up-scaled to 2K uncompressed	2K DCDM according to DCI Standard	2K DCP
Version 2: Analog Output (35mm Film Strip)							
Source	Offline Editing	A/D-Conversion	Conforming	Color Grading	Master	Distribution Master	Projection Format
ANALOG 35mm negative	WORKFLOW ENTIRELY IDENTICAL TO PROCESS ABOVE					35mm negative gained by laser-printing process (ARRI-Laser)	35mm print (positive)
DIGITAL ARRI Alexa camera*	WORKFLOW ENTIRELY IDENTICAL TO PROCESS ABOVE					35mm negative gained by laser-printing process (ARRI-Laser)	35mm print (positive)

Note: * HD-Quicktime, ProRes 4:4:4, 12bit /log; DCDM = Digital Cinema Distribution Master; DCP = Digital Cinema Package; EDL = Edit Decision List; LUT = Look-up Tables.

Table 2

Main Effects of Film Recording, Film Category, and Generation on all Dependent Variables

Dependent Variable	Film recording	Film category	Generation
Enjoyment	F(2, 500) = .59	F(2, 517) = 3.97*	F(3, 268) = 4.36**
Judgement of narrative quality	F(2, 572) = 1.39	F(2, 585) = 2.22	F(3, 295) = 5.54**
Presence	F(2, 571) = .49	F(2, 586) = 5.55**	F(3, 295) = .90
Positive Emotion	F(2, 570) = 1.15	F(2, 584) = 19.09**	F(3, 295) = .03
Negative Emotion	F(2, 554) = 1.20	F(2, 569) = 35.16**	F(3, 293) = 2.81*
Diegetic Involvement	F(2, 571) = 1.02	F(2, 586) = 8.93**	F(3, 295) = .77
Empathy state	F(2, 569) = .22	F(2, 584) = 8.76**	F(3, 295) = .15
Visual memory	F(2, 572) = 1.39*	F(2, 586) = 53.69**	F(3, 295) = 10.43**

Note: * $p < .05$; ** $p < .01$

Table 3

Means and Standard Deviations (SD) of Film Recording for all Dependent Variables

Dependent Variable	Analog Film	Digital Film	Digital Filter
Enjoyment	3.64 (.92)	3.70 (.77)	3.62 (.89)
Judgement of narrative quality	4.94 (1.01)	5.03 (.92)	4.90 (1.04)
Presence	3.68 (1.38)	3.73 (1.29)	3.76 (1.40)
Positive Emotion	4.36 (1.12)	4.41 (.95)	4.30 (1.17)
Negative Emotion	2.10 (.89)	2.06 (.93)	2.15 (.97)
Diegetic Involvement	3.81 (1.46)	3.96 (1.38)	3.88 (1.55)
Empathy state	2.64 (.91)	2.68 (.94)	2.64 (1.03)
Visual memory	1.67 (.90)	1.86 (.93)	1.78 (.94)

Note: Scores could range from 0-3 (Visual Memory), from 1-5 (Enjoyment, Empathy State), or from 1-7 (all the others). Standard deviations are in parentheses.

Table 4

Means and Standard Deviations (SD) of Film Category for all Dependent Variables

Dependent Variable	*Parachutes*	*Irgendwie*	*Senjor!*
Enjoyment	3.77 (.88)	3.55 (.82)	3.62 (.86)
Judgement of narrative quality	4.96 (1.04)	4.97 (.93)	4.88 (1.00)
Presence	3.87 (1.34)	3.59 (1.33)	3. 62 (1.39)
Positive Emotion	4.02 (1.12)	4.36 (.97)	4.55 (1.09)
Negative Emotion	2.34 (.97)	2.13 (.94)	1.83 (.82)
Diegetic Involvement	4.09 (1.51)	3.72 (1.37)	3.68 (1.48)
Empathy state	2.62 (.96)	2.75 (.95)	2.51 (.96)
Visual memory	1.46 (.87)	2.17 (.88)	1.75 (.90)

Note: Scores could range from 0-3 (Visual Memory), from 1-5 (Enjoyment, Empathy State), or from 1-7 (all the others). Standard deviations are in parentheses.

Table 5

Means and Standard Deviations (SD) of Generation for all Dependent Variables

Dependent Variable	15-25 years	26-39 years	40-53 years	54-78 years
Enjoyment	3.59 (.83)	3.50 (.87)	3.73 (.82)	3.83 (.89)
Judgement of narrative quality	4.87 (.92)	4.74 (1.09)	5.07 (.90)	5.11 (1.03)
Presence	3.59 (1.28)	3.74 (1.33)	3. 70 (1.40)	3. 86 (1.43)
Positive Emotion	4.35 (1.04)	4.32 (1.08)	4.29 (1.04)	4.34 (1.15)
Negative Emotion	2.26 (.92)	2.14 (.90)	1.96 (.91)	2.0 (.97)
Diegetic Involvement	3.77 (1.35)	3.81 (1.48)	3.85 (1.48)	4.02 (1.56)
Empathy state	2.62 (.91)	2.63 (1.01)	2.59 (.98)	2.73 (.95)
Visual memory	1.93 (.90)	1.95 (.85)	1.74 (.96)	1.50 (.93)

Note: Scores could range from 0-3 (Visual Memory), from 1-5 (Enjoyment, Empathy State), or from 1-7 (all the others). Standard deviations are in parentheses.

Table 6

Interactions between Film Recording, Film Category, and Generation for all Dependent Variables

	R x FC	R x G	FC x G	R x FC x G
Enjoyment	F(4, 450) = 1.90	F(6, 500) = .20	F(6, 516) = 4.28**	F(12, 450) = .74
JNQ	F(4, 503) = .85	F(6, 572) = .27	F(6, 585) = 5.14**	F(12, 504) = 1.78*
Presence	F(4, 455) = .67	F(6, 571) = 1.22	F(6, 586) = 1.80	F(12, 455) = 1.59
Pos. Emotion	F(4, 488) = 2.03	F(6, 571) = .45	F(6, 584) = 7.01**	F(12, 489) = 1.31
Neg. Emotion	F(4, 464) = 2.60*	F(6, 554) = .56	F(6, 569) = 6.73*	F(12, 464) =.63
Dieg. Involv.	F(4, 477) = 1.48	F(6, 572) = .64	F(6, 585) = 2.53*	F(12, 490) = 1.89*
Empathy state	F(4, 471) = 1.75	F(6, 569) = .27	F(6, 583) = 1.87	F(12, 474) = 1.92*
Vis. memory	F(4, 497) = .74	F(6, 573) =.93	F(6, 586) = .81	F(12, 497) = 1.16

Note: Film recording (R), Film category (FC), Generation (G), Judgement of narrative quality (JNQ).

Table 7

Effects of Cinema Projection on the Dependent Variables for each Film Category

	Parachutes	*Irgendwie*	*Senjor!*
Enjoyment	F(1, 85) = .52	F(1, 91) = 1.78	F(1, 91) = 2.75
JNQ	F(1, 96) = .10	F(1, 103) = 1.37	F(1, 103) = 3.41°
Presence	F(1, 96) = .56	F(1, 103) = 1.22	F(1, 103) = 1.73
Positive Emotion	F(1, 96) = 1.17	F(1, 103) = .30	F(1, 103) = 2.95°
Negative Emotion	F(1, 96) = 5.22*	F(1, 103) = 8.24**	F(1, 103) = 5.65*
Diegetic Involvement	F(1, 96) =.79	F(1, 103) = 2.50	F(1, 103) = 4.10*
Empathy state	F(1, 94) =3.63°	F(1, 103) = 6.93**	F(1, 103) = 11.36**
Visual memory	F(1, 96) = .00	F(1, 103) = 1.06	F(1, 103) = 1.36

Note: * p < .05; ** p < .01; ° p < 0.10; JNQ = Judgement of narrative quality.

Figures

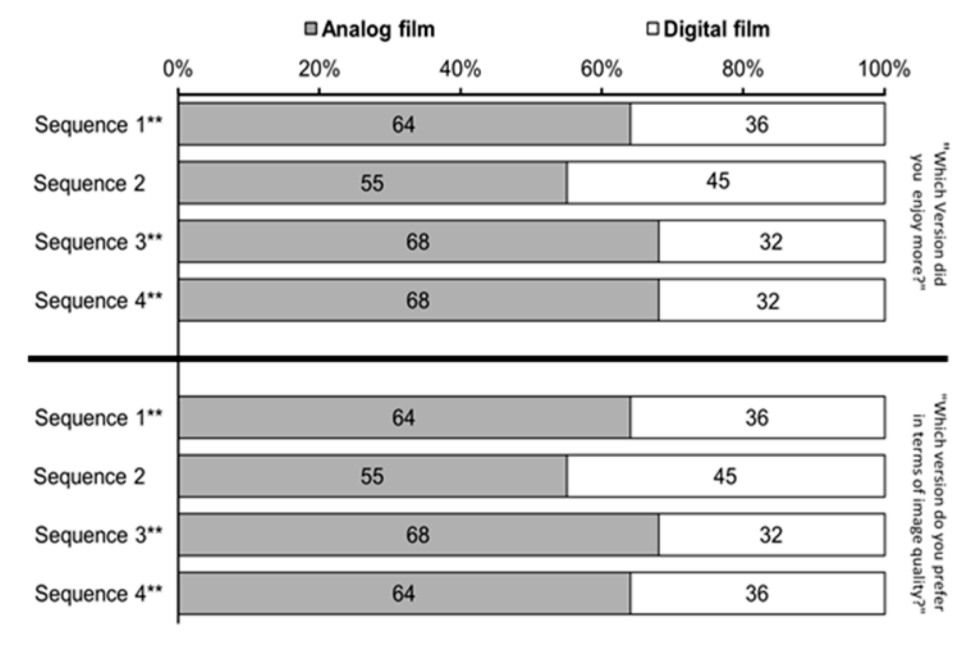

Figure 1. Results of the pilot experiment show that participants enjoyed the analog film version more and also preferred the analog version in terms of image quality (*$p < .05$; **$p < .01$).

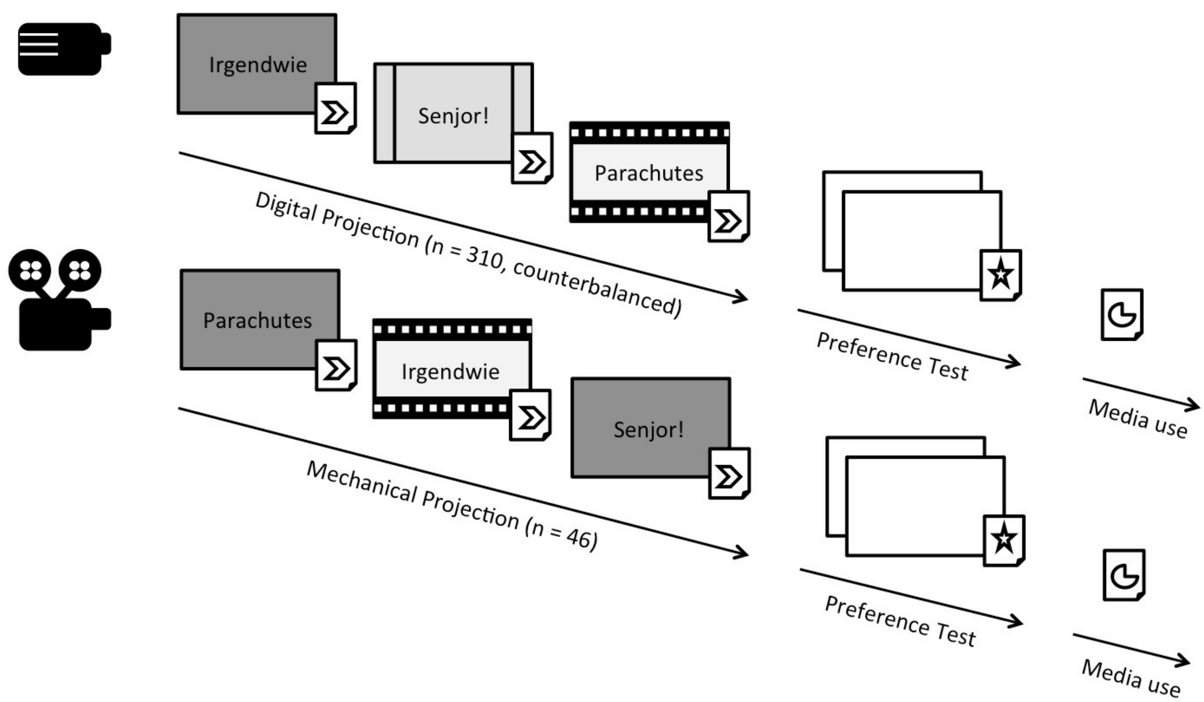

Figure 2. Procedure of the main experiment with two types of projection.

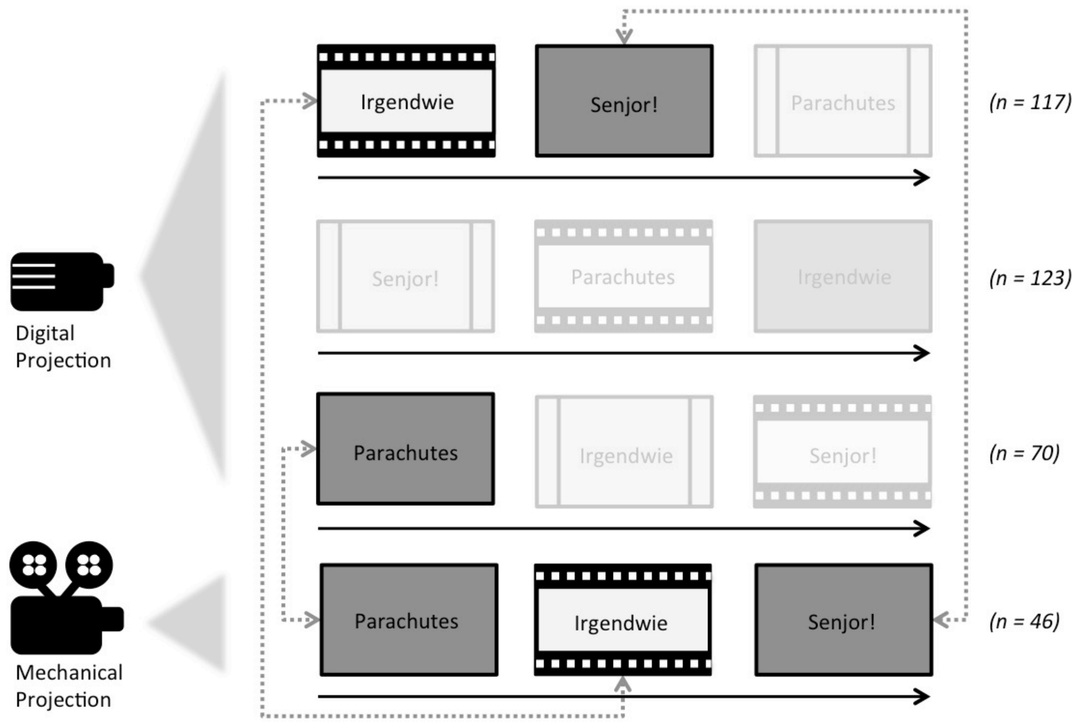

Figure 3. Comparison of projection type in the main experiment Part B. The dotted lines indicate the comparison of the subsamples.