



HÖGSKOLAN  
DALARNA

## Thesis

Master's Degree

### HDR and the Colorist

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#### How new technology affects professionals in the motion picture industry

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# Abstract

By utilizing a *Research through Design* approach this master thesis studies how technological changes might affect professionals working in the motion picture industry, specifically; how the advent of HDR (High Dynamic Range) affects the colorist. The research questions formulated are the following; (1) How can color grading in HDR be approached? (2) What effect can HDR have on visual modality? (3) What specific affordances can HDR offer the colorist? (4) How can HDR affect the creative space of the colorist? Three of the research questions are derived from the theoretical framework applied in this master thesis; starting with the social semiotic implementation of the term *modality* (models of reality), the Gibsonian term affordance (possibilities for action and meaning making) and its use in communications research, and lastly; the concept of *creative space* in motion picture production. *Analytic autoethnography* was used to generate primary data by documenting the process of color grading a 13-minute short film, and also performing semistructured interviews with four colorists. Amongst other findings, this study found that HDR offers a wider range of modality expression than SDR (Standard Dynamic Range); regarding several visual modality markers. Four HDR-specific affordances were formulated; (1) color expandability, (2) highlight differentiability, (3) tonal rangeability, (4) brightness disturbability. Relating to the concept of creative space; the colorists expressed a concern that they will have to create multiple versions when delivering HDR, but not get a bigger budget for it, therefore having less time to spend on other aspects of color grading.

## Keywords

HDR, High Dynamic Range, Colorist, Color correction, Color grading, Cinema, Motion picture, Digital video, Film, Postproduction.

*HDR is coming and it's incredibly exciting for us as colorists, [...] there's just so much we can do with HDR.  
I mean that's a new toolkit right there. That's what we should be embracing.<sup>1</sup>*

*-Kevin Shaw*

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<sup>1</sup> Petok, J. & Shaw, K. [Colorist Podcast]. (2016, July 11). *Episode 002: Kevin Shaw* [podcast]. Retrieved from <https://coloristpodcast.libsyn.com/episode-002-kevin-shaw>

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# Foreword

Do you remember the advent of High Definition video? I do. I remember a friend sending me stills of 720p HD and 1080p Full-HD video via Microsoft's MSN Messenger. This was a while ago, but actually not too long ago, and this was the latest time I was truly excited about video standards and related technology, until now. Since then we've seen a couple of technologies appear on the market. In 2012, I remember going to the cinema to watch 'The Hobbit: An unexpected Journey' to emerge myself in the experience of stereoscopic, or 3D for short. I wasn't too excited about what I thought was something of a hype; with more expensive tickets and some glasses I had to wear on top of my existing ones. The experience took a while of getting used to and although the effects could sometimes be quite cool and somewhat immersive, I didn't really like it (yes, I also saw a few other titles in stereoscopic). Another feature of this version of The Hobbit was the HFR-technology (high frame rate), which meant that instead of displaying the movie in 24fps (a common frame rate for movies) it was displayed in 48fps; which I thought made the experience less "cinematic" and more like that of a video game. Since stereoscopic video we've also seen a push towards 4K/UHD-resolution. While I was really excited for HD and Full-HD the arrival of 4K didn't excite me at all. The reason being that from the distance where I (and arguably most people) consume movies the increased resolution would at most times not really be noticeable. This might change though if TVs continue to grow bigger; making 4K-resolution more relevant. During the most recent years we've seen another technology appear on the market, namely HDR; which stands for High Dynamic Range. This is a development that I'm quite excited about and would like to compare with going from Standard Definition to High Definition, this time it's about the shift from Standard Dynamic Range to High Dynamic Range.

As you read this master thesis you might come to understand that I'm not only a consumer of motion picture content but also a creative with ambitions to work in the motion picture industry. I have a broad knowledge and experience in the audiovisual field; from music production and live performance – to recording, editing and color grading digital video. This master thesis can be seen as a part of my ambition to acquire a more specialized competence and get closer in becoming an expert in the audiovisual field. In this thesis I will try to inhabit the role of the colorist and use that as an outset to lay a groundwork for the delivery of HDR video, and shine a light on what it might entail for colorists working in the motion picture industry.

# 1. Problem definition

Historically, technological shifts has affected how movies are made and experienced. During the first half of the 20th century both recorded sound and color was introduced to the audience of cinema. These kinds of technological developments does not only affect consumers, but also those who make movies. New audiovisual technologies provide different qualities, or *affordances*, which opens up for new ways to represent reality; by expanding the range of *visual modality* expression available to filmmakers. One of the professions which is affected by the advent of HDR is the role of the colorist; who are “specialists in color design and the manipulation of motion pictures in post-production”<sup>2</sup>. Since HDR in the production of motion picture is only a couple of years old, there’s a lack of academic research into the subject. This master thesis sets out with the aim to find out how technological changes like these might affect professionals, specifically; what HDR might entail for colorists working in the motion picture industry.

## 1.1 Objective and research questions

The objective of this master thesis is to study how color grading in HDR can be approached; to find out how it can differ from color grading in SDR (Standard Dynamic Range), with the motivation to better understand how this technology can affect colorists working in the motion picture industry. This has been broken down into four research questions:

1. How can color grading in HDR be approached?
2. What effect can HDR have on visual modality?
3. What specific affordances can HDR offer the colorist?
4. How can HDR affect the creative space of the colorist?

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<sup>2</sup> Colorist Society International. (n.d.). *Role of the Colorist*. Retrieved March 15th 2019 from <https://coloristsociety.com/role-of-the-colorist>

## 2. Background

This chapter will present the reader with basic concepts regarding digital video, the colorist profession and HDR; imperative for the ability to grasp the research presented later in this thesis.

### 2.1 The five key parameters of digital video

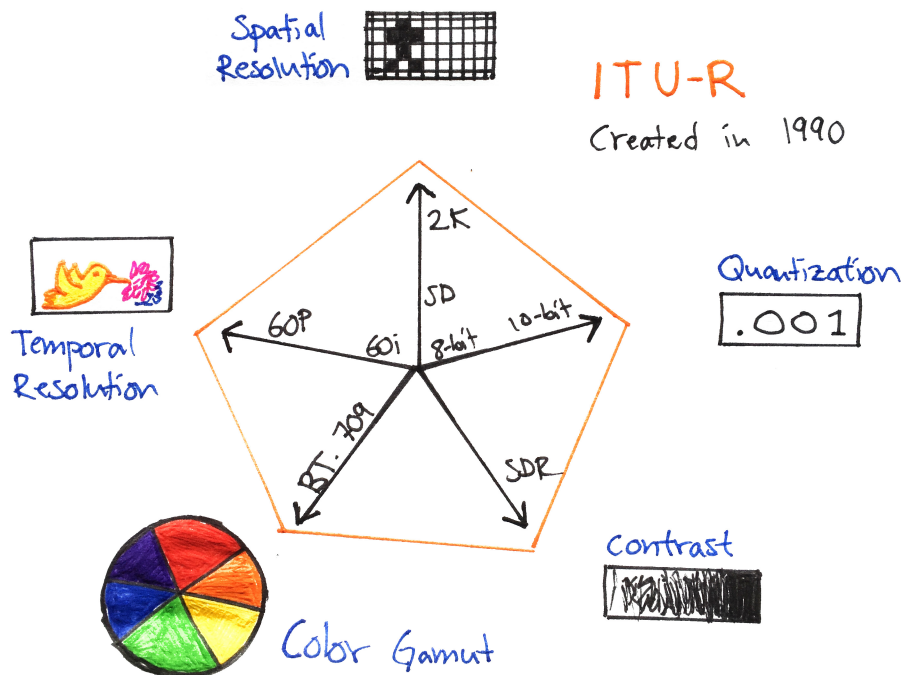


Figure 1: The five key parameters of digital video (created with inspiration from Canon Pro on Vimeo).

On the Canon Pro Vimeo channel the video *Canon Color Gamut*<sup>3</sup> defines the “five key imaging parameters” of digital image technology as; temporal resolution, spatial resolution, quantization, contrast and color gamut”. These five parameters can be divided into two categories of either contributing to the amount of pixels (temporal and spatial resolution), or the quality of the pixels (quantization, contrast, color gamut). While both the quantitative and qualitative categories are important in their own right the main focus in this master thesis lies in the qualitative part; especially regarding contrast. Although, it is essential to have an understanding of all five of these parameters, therefore, each one will be briefly presented below. Note: Encoding formats or video compression won’t be addressed since it’s outside the scope of this master thesis.

<sup>3</sup> Canon Pro. (2016, august 30). *Canon Color Gamut* [video]. Retrieved from <https://vimeo.com/180755554>



### 2.1.1 Quantitative properties

The quantitative properties are quite straight forward and easy to describe. Spatial resolution in a digital image describes the amount of pixels and is presented by the amount of horizontal and vertical rows of pixels, for example; 1920x1080 (Full-HD) or 3840x2160 (UHD) which are both HDTV standards.<sup>4</sup> Temporal resolution refers to the frequency or refresh rate of the video signal, often referred to as FPS (frames per second). As mentioned in the introduction; 24fps is common in cinema, although we have seen examples of HFR (high frame rate) for example in the 3D version of *The Hobbit*.<sup>5</sup> Raising the spatial and temporal resolutions to higher values will simply put result in more pixels more often. Finally, when you see attributes such as 1080p30, then it refers strictly to resolution, both spatial and temporal.

### 2.1.2 Qualitative properties

If higher quantitative values are described by more pixels more often, then higher qualitative values can be described as a larger volume of possible pixel brightness and color values with finer numerical gradation, let's find out why. The finer numerical gradation part refers to quantization. According to Stump<sup>6</sup> “quantization is the process of converting continuously varying analog voltages into a series of numerical values called samples”. “An 8-bit sampling resolution means that the continuous values of the input signal will be quantized to 2 to the 8th power, or 256 code values—in other words, 256 shades of red, 256 shades of green, and 256 shades of blue. When the red, green, and blue color palettes are multiplied to define the entire color palette,  $256 \times 256 \times 256$ , the result is 16,777,216— defined as 8-bit color in the digital realm.”<sup>7</sup> Even if 16,7 million colors might intuitively seem like a lot it's actually quite limiting, and can often times result in banding artifacts over areas with fine gradation, such as a sky. Since 8-bits results in 256 code values per channel there's also only 256 code values between black and white; where all three channels are used in equal amount to generate the different shades of grey. To put this into perspective; 256 shades of grey in 8-bit can be compared with 1024 in 10-bit or 4096 in 12-bit. According to Stump “practical

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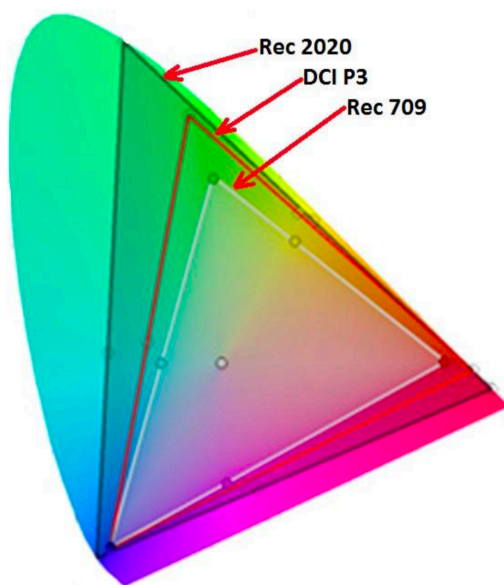
<sup>4</sup> Schulte, T. & Barsotti, J. (2016:1). HDR Demystified. In *SpectraCal*. Retrieved February 1st 2019 from [http://files.spectracal.com/Documents/White%20Papers/HDR\\_Demystified.pdf](http://files.spectracal.com/Documents/White%20Papers/HDR_Demystified.pdf)

<sup>5</sup> Laforet, Vincent. (2012, december 19). *The Hobbit: An Unexpected Masterclass in Why 48 FPS Fails*. In *Gizmodo*. Retrieved February 19th 2019 from <https://gizmodo.com/the-hobbit-an-unexpected-masterclass-in-why-48-fps-fai-5969817>

<sup>6</sup> Stump, David (2014:4). *Digital cinematography: fundamentals, tools, techniques, and workflows*. London: Focal Press.

<sup>7</sup> Ibid. (2014:6)

testing of human sensitivity to ‘just noticeable differences’ in contrast conducted recently determined the minimum quantizing level for the threshold of quantizing visibility in digital cinema to be 12 bits as a minimum”.<sup>8</sup> Quantizing is also relevant to discuss in relation to the contrast of an image; since the actual brightness difference between the code values will vary depending of the overall tonal range. This master thesis will use the terms contrast, tonal range and dynamic range interchangeably. “The dynamic range of a TV refers to its luminance, the maximum and minimum amount of light the TV is capable of producing.”<sup>9</sup> While luminance is measured in candela per square meter (cd/m<sup>2</sup>), commonly referred to as nits, dynamic range is presented as a ratio (for example 1500:1) between the brightest and darkest values a display can produce, where SDR-standards support luminance values in the range of 0.0002 to 100 cd/m<sup>2</sup>.<sup>10</sup> The last of these five parameters is color gamut (or color space), which defines the reach or richness of hues.<sup>11</sup> Different gamut’s encompass various amounts of the CIE 1931 chromaticity diagram (also called color horseshoe), which was “specifically designed to encompass all colors the average human can see”<sup>12</sup>. It’s worth noting that there are other versions of the CIE 1931 such as the 1960 and 1976 versions,



though the differences won’t be discussed here. Schulte and Barsotti explains that the legacy color space called BT.709 (also known as Rec.709) leaves “a large set of visible colors that cannot be rendered” and that “larger color spaces, such as DCI-P3 and BT.2020 can represent a much larger set of visible colors”.<sup>13</sup> The BT.709 gamut is what we are used to see from our televisions, while DCI-P3 is a standard seen in the cinema, and BT.2020 as of today can only be displayed in full by certain laser projectors.<sup>14</sup> Figure 2 is a color horseshoe with outlines of these three different gamuts.

*Figure 2: Color horseshoe with outlines of three different color spaces.*

<sup>8</sup> Ibid. (2014:9)

<sup>9</sup> Schulte, T. & Barsotti, J. (2016:1)

<sup>10</sup> Ibid. (2016:1)

<sup>11</sup> Ibid.

<sup>12</sup> Stump, David (2014:53)

<sup>13</sup> Schulte, T. & Barsotti, J. (2016:1)

<sup>14</sup> Ibid. (2016:6)

## 2.2 An introduction to the colorist

“Twenty-five years ago, the term *colorist* did not exist. We lived in a world where what you shot was pretty much what you got.”<sup>15</sup> Hullfish<sup>16</sup> writes that the first colorists were engineers in the *film chain*; where a camera pointed into a projector turned the motion picture content recorded on film into a signal that could be broadcasted or recorded on to videotape. In this process, the engineers could adjust a very limited set of values on the camera to compensate for issues with the film. The film chain later developed into telecine, where instead of projection; the film was scanned using a gas electron beam. Combined with a much more gentle transport of the film this meant that instead of a print, the original film negative now safely could be used.<sup>17</sup> As the available tools developed so did the people associated with the task of correcting color; “who began to experiment with the controls, developing different looks or styles with film”<sup>18</sup>. Today, the telecine has moved into the digital domain where a datacine creates digital images (similar to frames from a digital still camera) which is called a digital intermediate (DI).<sup>19</sup> Nowadays though, it is more common to capture motion picture digitally, rather than scanning and digitalizing images captured on film stock.

### 2.2.1 Color correction and color grading

To get a better understanding of the colorist’s work; present terms, methods and goals of color grading featured in the literature will now be presented. Tutorials from Lynda.com and Blackmagic Design will also be referred to. The historical overview above was presented in the context of motion picture film, which was clearly separate from video. With the development of digital technologies these two mediums have more or less merged together, as well as their respective terminologies. In the past, color correction was associated with working on video while grading related to film. Although, Van Hurkman<sup>20</sup> argues that color correction refers to a more technical process to fix problems with the image and making it fairly neutral, while grading refers to a more intensive process of creating an appropriate *look* for the image; which he defines as “visible

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<sup>15</sup> Hullfish, Steve. (2009:222). *Color Correction for Video, 2nd edition*. New York: Focal Press.

<sup>16</sup> Ibid. (2009:224)

<sup>17</sup> Ibid.

<sup>18</sup> Ibid. (2009:226)

<sup>19</sup> Ibid. (2009: 229)

<sup>20</sup> Van Hurkman, Alexis. (2014a:xvii). *Color correction handbook: professional techniques for video and cinema, second edition*. San Fransisco: Peachpit Press.

stylizations of an image with the intent to create a clear mood of reference<sup>21</sup>. In this master thesis the two terms of color correction and color grading will be used interchangeably, which Peters<sup>22</sup> means that they also are, even if they aren't always used that way. It's relevant to point out that *color correction* can refer to both an individual correction and also a collection of adjustments, while *grading* implies several corrections which together realizes the *look* of the image. This is something Van Hurkman<sup>23</sup> brings to attention with a quote from colorist Joe Owens: “correction is a sword fight while grading is the war”.

## 2.2.2 Primary and secondary adjustments

Hullfish<sup>24</sup> distinguish two processes from color correction; primary and secondary color correction. He writes that these two processes probably always will be referred to as two distinct processes, even though “technology itself is starting to change the perception of how and why these two processes are used and when the colorist moves from one process to another”. Hullfish<sup>25</sup> describes primary color correction as general adjustments which are applied to the entire image, while secondary adjustments are applied to a specific portion of the image. Inhofer<sup>26</sup> confirms that primary color correction typically affects the whole image, and also explains that *keys* and *shapes* can be utilized to isolate specific parts of an image; to go from a broad primary adjustment to a more specific secondary adjustment.<sup>27</sup>

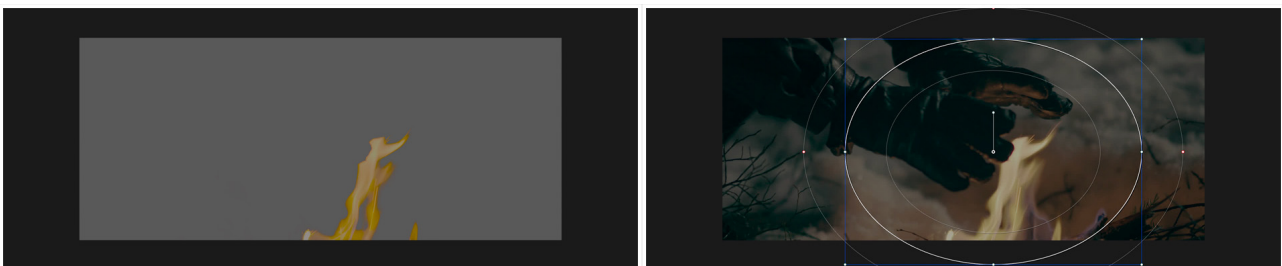


Figure 3: Example of isolating specific parts of an image using a key (left) and a shape (right) in DaVinci Resolve.

<sup>21</sup> Van Hurkman, Alexis. (2014b:1). *Color correction look book*. San Francisco: Peachpit Press.

<sup>22</sup> digitalfilms. (2014, januari 24). *Color Concepts and Terminology*. Retrieved December 26th 2018 from <https://digitalfilms.wordpress.com/2014/01/24/color-concepts-and-terminology/>

<sup>23</sup> Van Hurkman, Alexis. (2014a:xviii)

<sup>24</sup> Hullfish, Steve. (2012:1). *The art and technique of digital color correction*. Burlington: Focal Press.

<sup>25</sup> Hullfish, Steve. (2009:111)

<sup>26</sup> Lynda. (2016, februari 2). *DaVinci Resolve 12 Essential Training, Colorist lingo: What is a primary correction?* Retrieved December 12th 2018 from <https://www.lynda.com/DaVinci-Resolve-tutorials/DaVinci-Resolve-12-Essential-Training/444948-2.html>

<sup>27</sup> Lynda. (2016, februari 2). *DaVinci Resolve 12 Essential Training, Colorist lingo: What is a secondary correction?*

Van Hurkman<sup>28</sup> refers to secondary color correction as an essential part of any colorist's toolkit; which, as the name suggest, "are generally made after the primary color correction". Peters<sup>29</sup> argues that this division is something that's inherited from older technology, which is still present today because of its implementation in modern color correction software.

### 2.2.3 Goals and methods of the colorist

In *The Art of Short Form Content Cook*<sup>30</sup> identifies three general steps of color correction. The first one is to balance the image so it looks "correct", while the second step is to manipulate the image so that the viewer knows where to look. The third and final step according to Cook is to use color to evoke an emotional response amongst the audience, which he refers to as being the more mystical and subjective part of color correction; where colorists who excel at this often has somewhat of a celebrity status in the world of postproduction. Inhofer<sup>31</sup> (who applies a more tool oriented perspective) defines the work of the colorist by the use of either primary or secondary adjustments, where each contains three functions. Normalizing the image, which he calls a *base grade*, followed by *shot-matching* and the creation of a *look* makes use of the primary toolkit. Fissoun<sup>32</sup> differentiates between the terms normalizing and balancing, and points out that the former is about adjusting luminance and the latter color. Inhofer<sup>33</sup> then lists fixing specific problems, achieving creative goals and controlling the viewers eyes as functions related to secondary adjustments. Van Hurkman<sup>34</sup> also lists six labors of the colorist. The first one is to correct errors in exposure and color. This is followed by making key elements like people or products look right and balancing shots in a scene so they match each other, which is commonly referred to as shot-matching and done to enhance the continuity of a scene. Lastly, Van Hurkman<sup>35</sup> lists creating style, depth, and adhering to quality control standards. The reference manual<sup>36</sup> for the color correction software

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<sup>28</sup> Van Hurkman, Alexis. (2014a:273)

<sup>29</sup> digitalfilms. (2014, januari 24)

<sup>30</sup> Cook, Bryan. (2016:149). *The art of short form content: from concept to color correction*. New York: Focal Press.

<sup>31</sup> Lynda. (2016, februari 2). *DaVinci Resolve 12 Essential Training, Colorist lingo: What is shot matching?*

<sup>32</sup> Blackmagic Design. (2018, december 12). *DaVinci Resolve 15 - The Art of Color Grading* [video]. Retrieved from: <https://www.youtube.com/watch?v=jo0YcNRlrNA>

<sup>33</sup> Lynda. (2016, februari 2). *DaVinci Resolve 12 Essential Training, Colorist lingo: What is a secondary correction?*

<sup>34</sup> Van Hurkman, Alexis. (2014a:xviii)

<sup>35</sup> Ibid. (2014a:xix)

<sup>36</sup> Blackmagic Design. (2018, August 13:1853-1856). *DaVinci Resolve 15 Manual*. Retrieved December 10th 2018 from <https://www.blackmagicdesign.com/support/>

DaVinci Resolve 15 also lists six different goals of color correction. The first goal is to maximize the look of the image by adjusting exposure, contrast, tone and saturation, which is done to realize the intent of the director and cinematographer. Next is to guide the viewer’s eye by emphasizing what’s important in the image. To play with the expectation of the audience by isolating and adjusting specific parts of the image is also a part of the colorist’s toolbox. This can be done by changing a subject’s skin tone, the hue of foliage or the sky, or another specific object.<sup>37</sup> Finally, the reference manual also lists shot-matching, adding style and adhering to quality control standards.<sup>38</sup> Table 1 provides an overview of the above mentioned goals and methods, and is organized into four categories. Even if the sources occasionally use different words, they refer to similar functions. In the category *Secondary tools* the goals are more diverse than those of the other three categories. What brings these goals together under the same group is the use of keys and/or shapes.

	Cook	Inhofer	Van Hurkman	DaVinci Resolve
<b>Base grade</b>	Balancing the image	Normalizing	Correcting errors in color and exposure	Maximizing the look
<b>Shot-matching</b>		Shot-matching	Balancing shots in a scene to match	Balancing scenes
<b>Secondary tools</b> <i>(using keys and/or shapes)</i>	Guiding the eye	Fixing specific problems, Achieving creative goals, Controlling the eye	Making key elements look right, Creating depth	Emphasizing what’s important, Playing with expectations
<b>Creative grade</b>	Evoking emotion	Creating a look	Creating style	Adding style
			Adhering to quality control standards	

Table 1: Goals and methods of the colorist (created with inspiration from the DaVinci Resolve training book<sup>39</sup>).

*Adhering to quality control standards* didn’t fit into any of the four categories and was therefore placed on a separate row. Harris and Walker<sup>40</sup> differentiate between *color grading* and *color management*; where, in the latter group, *adhering to quality control standards* could potentially fit in. In their presentation they also mention how *color management* becomes more important today due to multiple source formats and deliverables, which they discuss in the context of HDR.

<sup>37</sup> Ibid. (2018:1857)

<sup>38</sup> Ibid. (2018:1863)

<sup>39</sup> Fissoun, Daria. (2019:228). *Color Correction with DaVinci Resolve 15*. Retrieved January 27th 2019 from <https://www.blackmagicdesign.com/products/davinciresolve/training>

<sup>40</sup> Harris, W. & Walker, D. [Autodesk]. (2016, April 21). *Autodesk Vision Series - Color Management, Grading & HDR* [video]. Retrieved from <https://www.youtube.com/watch?v=1rbIZYX5t1w>

## 2.3 HDR review

In this section, HDR and the related concepts of *color volume* and *tonal range* will be addressed, and discussed in relation to image quality and creative opportunities. To define image quality a formula created by colorist Alexis Van Hurkman<sup>41</sup> (based on the research paper *Color Reproduction and the Naturalness Constraint*) will be utilized:

“Quality = naturalness + colorfulness + discriminability”

According to Arnheim<sup>42</sup> a particular image portraying reality isn't judged in the same way as the real world is, rather, it's judged like a painting. This means that certain aspects of the image must be exaggerated for it to be perceived as being of high quality.<sup>43</sup> Van Hurkman<sup>44</sup> describes this as the viewer's tendency to favor natural rendition, alongside the desire for an attractive amount of colorfulness and need for maximum discriminability to make it easy to read an image and take in everything within the scene. In this chapter, these three aspects of image quality (naturalness, colorfulness and discriminability) will be related to HDR in an attempt to find out how image quality could be affected by this technology.

### 2.3.1 Color volume

Thorpe<sup>45</sup> writes that color volume “is a relatively new term within the current industry discussion on enhanced color reproduction”. Schulte and Barsotti<sup>46</sup> explain that “high dynamic range and wider color spaces are becoming linked by standards bodies into what is often referred to as color volume”. While a wide color gamut (also known as WCG) isn't naturally related to HDR, as Schulte and Barsotti stated; it's being included by HDR-standards, and is therefore relevant for this thesis. Dolby Laboratories<sup>47</sup> calls this combination of HDR and WCG for EDR (Extended Dynamic

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<sup>41</sup> Van Hurkman, Alexis. (2014:403)

<sup>42</sup> Arnheim, Rudolf. (2006). Remarks on Color Film. In Dalle Vacche, A. & Price, B. (Eds.), *Color: the film reader* (pp. 53-56). Routledge, London.

<sup>43</sup> Van Hurkman, Alexis. (2014:405)

<sup>44</sup> Ibid. (2014:403)

<sup>45</sup> Thorpe, Larry. (2016:7). *High Dynamic Range (HDR) What it is and what it is not*. Retrieved January 28th 2019 from [http://downloads.canon.com/nw/learn/white-papers/cinema-eos/White\\_Paper\\_HighDynamicRange.pdf](http://downloads.canon.com/nw/learn/white-papers/cinema-eos/White_Paper_HighDynamicRange.pdf)

<sup>46</sup> Schulte, T. & Barsotti, J. (2016:7)

<sup>47</sup> Brooks, D. G. (2014). *The art of better pixels*. Retrieved February 13th 2019 from <https://digital-library.theiet.org/docserver/fulltext/conference/ibc2014/20140004.pdf>

Range). One consequence which Limor<sup>48</sup> points out in his presentation is that “the combination of both allows for things like a bright blue sky”. This statement though, refers primarily to HDR, not its combination with a WCG, Shaw explains:

There's a lot of criticism about wide color gamut, about Rec.2020, because that a lot of those colors don't really... we don't see them very often, but color volume, that's something we see all the time. [...] Fire is actually the first thing that really made me understand high dynamic range; it's not that the fire is brighter, it's that the fire is brighter and it's not clipped, we've never seen that. [...] The real beauty of high dynamic range is all those colors that exists at very bright levels. Remember color gamut is chromaticity, it doesn't talk about brightness, [...] because in a RGB-system at 100 nits; if you want the color you have to drop the brightness. The only way you can get 100 nits out of your system is if the red, green and blue channels are all at maximum, and then there's no color, it's white.<sup>49</sup>

-Kevin Shaw

Brooks<sup>50</sup> writes that that we traditionally “have used the colour ‘horseshoe’ diagram to represent the colour gamut of a television signal [...] however for each colour shown there is a corresponding maximum luminance”. He further explains that the brightest color is white, which, as Shaw pointed out; is because the RGB color space is additive (visualized in figure 4). With HDR the peak white level is increased; creating the opportunity to have brighter colors than before, such as yellow fire or a bright blue sky. To summarize; color volume is a concept relevant to visualize the brightness range of available colors, and is related primarily to HDR (which moves beyond the limitations of SDR) but also WCG (which expands the range of hues that’s available).

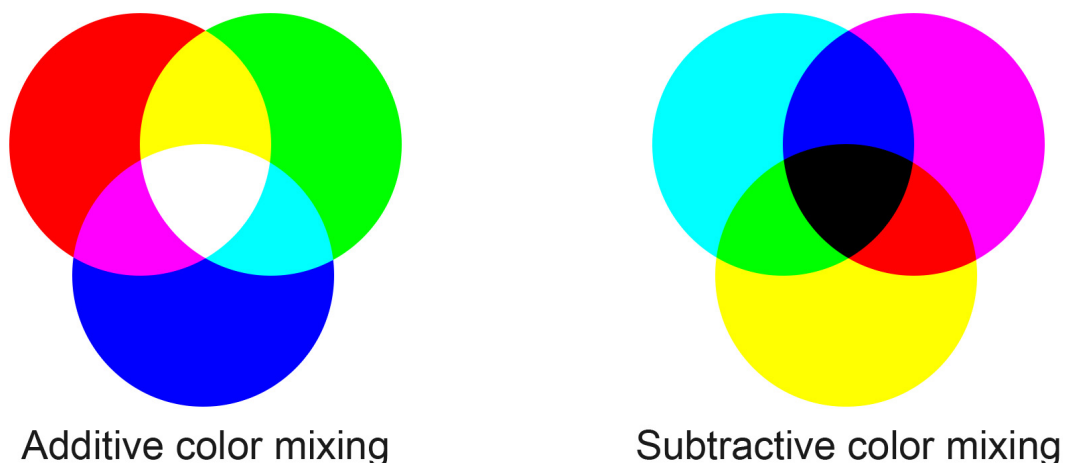


Figure 4: Additive and subtractive color mixing.

<sup>48</sup> Limor, Josh. [technicolor]. (2016, September 28). *What is HDR? - Technicolor HDR Series Workshop* [video]. Retrieved from <https://www.youtube.com/watch?v=L0pj5n1fjU>

<sup>49</sup> Petok, J. & Shaw, K. [Colorist Podcast]. (2016, July 11)

<sup>50</sup> Brooks, D. G. (2014:4)



According to the *Hunt effect* “colorfulness of a given stimulus increases with luminance level”<sup>51</sup>. If this isn’t overdone a larger color volume might also affect the perceived naturalness of an image in a positive way; since the image can display a more authentic depiction of the world. Based on these concepts, three arguments for that the added colorfulness of HDR can result in a perceived higher image quality are presented, where argument one and two are different sides of the same coin:

1. By allowing color in bright elements such as fire or sky
2. By allowing the brightness to be increased while maintaining saturation
3. By allowing richer hues (because of a wide color gamut)

### 2.3.2 Tonal range

The discussion about how the increased tonal range of HDR can affect the perceived image quality will begin by addressing a common misconception about black level. During the early research for this study a recurring statement in presentation videos was that HDR would mean darker blacks and better shadow detail.<sup>52</sup> As colorist Kevin Shaw<sup>53</sup> points out; “you know all this talk about extra blacks and stuff, that’s rubbish because the black level doesn’t actually change”. This is also something which Light Illusion<sup>54</sup> address in an article on their website, stating that “SDR is a relative standard, not absolute. The minimum level (the black level) is usually just the minimum the display can attain”. In other words; the black level is dependent on the display itself, not if the content is SDR or HDR. The article mentions that SDR is a relative standard, which means that a specific bit level value doesn’t respond to a specific brightness value of the display. On the contrary, the HDR-standards this study will focus on makes use of an absolute EOTF (Electro-Optical Transfer Function), namely the PQ<sup>55</sup> (Perceptual Quantizer) curve; where a bit value corresponds to a specific brightness output of the display.<sup>56</sup> So where does this confusion originate from? It’s only speculation but something that could be contributing is the reality that newer TV-sets (especially those with OLED panels) have the ability to attain very low black levels, a quality which might get

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<sup>51</sup> Fairchild, M. D. (2013:127) *Color Appearance Models, 3rd edition*. United Kingdom: Wiley.

<sup>52</sup> Valentic, Dado. [Colour Training]. (2016, September 22). *Secrets behind LOG and HDR* [video]. Retrieved from: <https://www.youtube.com/watch?v=JrOG7o7Gdio>

<sup>53</sup> Petok, J. & Shaw, K. [Colorist Podcast]. (2016, July 11)

<sup>54</sup> LightIllusion. (n.d.). *UHDTV - HDR and WCG*. Retrieved March 5th 2019 from <https://www.lightillusion.com/uhdtv.html>

<sup>55</sup> See the Appendix for more information about the PQ curve.

<sup>56</sup> LightIllusion. (n.d.)

mixed up with HDR due to simultaneous marketing. These characteristics of a very dark black level in combination with the high brightness levels of HDR can create a spectacular experience:

I don't know when it was, 2015, 2016, where the first HDR prototypes came out and everyone was showing like 3000 nit displays with demo footage that was shot specifically for 3000 nit viewing, and if I, I tell you, there were moments when they looked stereoscopic [3D] to me. I saw depth in these images.<sup>57</sup>

-Patrick Inhofer

Going back to Van Hurkman's formula this relates to discriminability; which is the ability to "make it easy to read an image and take in everything within the scene".<sup>58</sup> Of course, the experience presented above might not be representative for most content, but the added discriminability by the technology is still there, even if it's applied in more subtle ways by filmmakers. This also relates to the possibility of greater highlight differentiation, where before HDR; all highlights had to fit into a very narrow space of the video signal, Van Hurkman explains:

Moving into the realm of HDR, all of a sudden you're not just talking about the difference between diffused white and peak white, right, you're talking about the difference between diffused white and... say ordinary highlights, and intense highlights, and then SPECULAR highlights, and all those different highlights can be at different levels, whereas before this whole range of different kinds of highlights were smushed into 5% of the video signal, or 10% of the video signal.<sup>59</sup>

-Alexis Van Hurkman

Greater highlight differentiation relates both to added naturalness and discriminability; depicting the world more truthfully and making objects easier to distinguish. Van Hurkman gives this example:

Going farther, in an outdoor scene, it's possible have a bright white t-shirt at one level, colorful highlights on a face at a clearly differentiated level, the rim-lighting of the sun on clouds at a different, higher level, and reflected sun glints off of a lake in the distance at an even higher level, resulting in a much richer distribution of highlight tonality throughout the scene. This is what's new about grading HDR, you've finally got the ability to create dramatically differentiated planes of highlights, which finally gives the digital colorist the perceptual tools that fine artists working in the medium of painting have had for hundreds of years.<sup>60</sup>

-Alexis Van Hurkman

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<sup>57</sup> Carman, R., Inhofer, P. & D'Anna, J. [MixingLight]. (2019, January 5). *From The MailBag Episode 63* [podcast]. Retrieved March 4th 2019 from <https://mixinglight.com/color-tutorial/is-hdr-legit-should-i-invest-in-hdr-tech/>

<sup>58</sup> Van Hurkman, Alexis. (2014:403)

<sup>59</sup> Petok, J. & Van Hurkman, A. [Colorist Podcast]. (2017, September 14). *Episode 16: Alexis Van Hurkman, Part 2* [podcast]. Retrieved from <https://coloristpodcast.libsyn.com/episode-015-alexis-van-hurkman-part-2>

<sup>60</sup> Van Hurkman, Alexis. (2016, May 6). HDR, Resolve, and Creative Grading. *In Alexis Van Hurkman - Creating and Finishing*. Retrieved April 29th 2019 from <http://vanhurkman.com/wordpress/?p=3548>

Another trait of HDR and the increased tonal range is the possibility for tonal ranging:

For me the great thing about HDR is that you now have variable black and variable white [...] So, there's some research that suggests that the visual range of the human eye is actually only about 100 nits, but where we differ from a display is our eyes continually ranging that 100 nits up and down the scale. Now as colorists one of the ways of look at what we do is we do that ranging in the grade that everything is at 100 nits, but when you're working with high dynamic range you don't want to use all of the range at once but what you might do is you might say that well [during] the outside scene the blacks are up a little bit, the colors are more bright and more saturated, and then imagine you go inside, or you go into a cave, well of course the brightness drops down but you can now drop your black level, because you lifted the black level for the outside scene, and nobody will know because the dynamic range is still more than 100 nits.<sup>61</sup>

-Kevin Shaw

In the SDR world of color grading there isn't much room to move around between shots, where shot-matching is a common example of temporal grading; done to achieve continuity within a scene. Now with the advent of HDR the colorist has a new creative temporal tool to work with.

If you have a day scene and you go into a night scene you can make it really feel... Because of our eyes haven't quite adapted yet to the darker level... It's interesting what you can do kind of temporally over time, you know. [...] Your irises will kind of adjust to it being brighter and then on a cut you can go to a scene and make it just feel really dark, and it's like you haven't quite adjusted to the darkness yet and you can just kind of play with that natural thing that our brains do where we kind of adjust to the bright and bright feels normal, and adjust to the dark and then the dark feels normal.<sup>62</sup>

-Ian Vertovec

How tonal ranging might affect the perceived quality is difficult to conclude without further research, but it relates to how the human vision works; adapting to the brightness of the environment when navigating the world.<sup>63</sup> Van Hurkman's formula has so far only been referred to in terms of static images. Tonal ranging achieves a change over time, and should therefore be regarded as a temporal effect. Since the research behind this formula is based on tests using still images<sup>64</sup> it might be problematic to utilize it in this case. If tonal ranging is implemented in a "natural" way, it might enhance the naturalness of the experience; since it more closely depicts how we experience the world, and therefore add to the perceived quality. How this affects the audience's immersion into the story will have to be the deciding factor whether this holds true or not.

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<sup>61</sup> Petok, J. & Shaw, K. [Colorist Podcast]. (2016, July 11)

<sup>62</sup> Petok, J. & Vertovec, I. [Colorist Podcast]. (2018, January 16). *Episode 20: Ian Vertovec* [podcast]. Retrieved from <https://coloristpodcast.libsyn.com/episode-20-ian-vertovec>

<sup>63</sup> Fairchild, M. D. (2013:21)

<sup>64</sup> Yendrikhovskij, S. N. (1998). *Color reproduction and the naturalness constraint*. Eindhoven: Technische Universiteit Eindhoven.

# 3. Theory

This chapter will present the theoretical framework applied in this master thesis; starting with the social semiotic implementation of the term *modality*, and later the Gibsonian term *affordance* and its use in communications research. Lastly, the concept of *creative space* in motion picture production will be presented.

## 3.1 Modality

Kress and van Leeuwen<sup>65</sup> use the concept of *modality* in their social semiotic approach to a social theory of the real. They write that the term modality “comes from linguistics and refers to the truth value or credibility of (linguistically realized) statements about the world”; where verbs such as *may*, *will* and *must* are used as markers to specify a degree of modality to statements.<sup>66</sup> Kress and van Leeuwen also explain that a “social semiotic theory of truth cannot claim to establish the absolute truth or untruth of representation, it can only show whether a given ‘proposition’ (visual, verbal or otherwise) is represented true or not.”<sup>67</sup> To express modality in visual representation the image has to be related to a certain kind of reality, or coding orientation,<sup>68</sup> for example; *naturalistic*, *abstract*, *technological* or *sensory* modality.<sup>69</sup> According to Kress and van Leeuwen<sup>70</sup>, *naturalism*, conventionally understood as ‘photorealism’, is today the dominant standard which we judge realism; where the realism is judged by the correspondence between the visual representation of an object and what it normally looks like when we see it with our naked eye. Though, judgements of naturalistic modality “depend very much on the way in which the currently dominant naturalistic imaging technology represents the visual world”.<sup>71</sup> An example of this which van Leeuwen<sup>72</sup> brings to attention is the introduction of color in cinema; where black and white was the norm for naturalistic representation and color was regarded as ‘more than real’. In early cinema, serious realism drama tended to be black and white, while today, color is the norm.

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<sup>65</sup> Kress, G. & van Leeuwen, T. (2006:155). *Reading images: the grammar of visual design*. London: Routledge.

<sup>66</sup> Ibid.

<sup>67</sup> Ibid. (2006:154)

<sup>68</sup> Björkvall, Anders. (2016:113). *Den visuella texten: multimodal analys i praktiken*. Stockholm: Hallgren & Fallgren.

<sup>69</sup> Van Leeuwen, Theo. (2005:168). *Introducing Social Semiotics*. Oxon & New York: Routledge.

<sup>70</sup> Kress, G. & van Leeuwen, T. (2006:158)

<sup>71</sup> Van Leeuwen, Theo. (2005:168)

<sup>72</sup> Ibid.

In *abstract* modality, visual truth is abstract truth. This means that “the more an image represents the deeper ‘essence’ of what it depicts, [...] the higher its modality from the point of view of the abstract truth”.<sup>73</sup> Kress and van Leeuwen<sup>74</sup> explain that abstract coding orientation are used by sociocultural elites - “in ‘high’ art, in academic and scientific contexts, and so on”. Practical usefulness is central when it comes to the visual truth of *technological* modality; “the more an image can be used as a blueprint or aid for action, the higher its modality”.<sup>75</sup> Finally, in *sensory* modality; “visual truth is based on the effect of pleasure or displeasure created by visuals [...] amplified beyond the point of naturalism, so that sharpness, colour, depth, the play of light and shade, etc., become – from the point of view of naturalistic modality – ‘more than real’.”<sup>76</sup> This is used in “certain contexts where the pleasure principle is allowed to be dominant: certain kinds of art, advertising, fashion, food photography, interior decoration, and so on [...] a whole psychology of colour has evolved to support this”.<sup>77</sup> Even though it should be quite clear that a naturalistic coding orientation is central in the recording of motion picture, in color grading; sensory modality can be utilized, where a scene can be graded to create “a sense of how the locations felt to the filmmaker at the time of the shoot, as opposed to neutrally and dispassionately reproducing the original quality of light”.<sup>78</sup> Kress and van Leeuwen specifies modality markers for visual modality in terms of eight scales:<sup>79</sup>

<i>Color saturation</i>	from absence of saturation - black and white - to full saturation
<i>Color differentiation</i>	from monochrome to a maximally diversified range of colors
<i>Color modulation</i>	from flat unmodulated color without any nuances to fully modulated color
<i>Contextualization</i>	from the absence of background to the most detailed and articulated background
<i>Representation</i>	from maximum abstraction to maximum pictorial detail
<i>Depth</i>	from the absence of any representation of depth to a maximally deep perspective
<i>Illumination</i>	from the absence of the play of light and shadow to its fullest representation
<i>Brightness</i>	from two brightness values to the maximum number of different brightness values

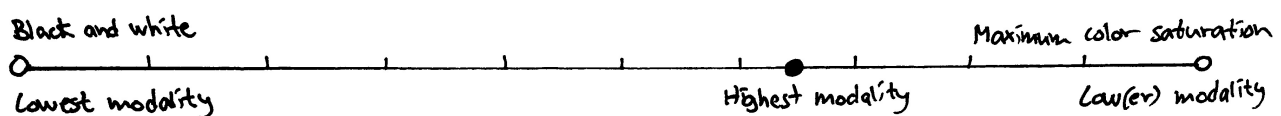


Figure 5: Naturalistic color saturation scale (created with inspiration from Kress, G. & van Leeuwen, T., 2006).

<sup>73</sup> Ibid.

<sup>74</sup> Kress, G. & van Leeuwen, T. (2006:165)

<sup>75</sup> Van Leeuwen, Theo. (2005:168)

<sup>76</sup> Ibid. (2005:170)

<sup>77</sup> Kress, G. & van Leeuwen, T. (2006:165)

<sup>78</sup> Van Hurkman, Alexis. (2014a:399)

<sup>79</sup> Kress, G. & van Leeuwen, T. (2006:160-161)

## 3.2 Affordance

In *The ecological approach to visual perception* psychologist James J. Gibson<sup>80</sup> (who coined the term *affordance*) describes *affordances* of the environment as what it offers the animal; to refer both to the environment and the animal in it. An example of this can be the affordance of *hide-ability*, which the environment affords the animal, for example a rabbit trying to get away from a fox, where a hole in the ground is just large enough to fit the rabbit but not the fox.

Another example can be the affordance of a chair, which for an adult human can be *sit-ability*, but for a child *climb-ability*. Evans et al.<sup>81</sup> discuss the use of this term in communications research; distinguishing between affordance, outcome and object/feature, and points to the importance “to recognize the agency present in technology use; the relationship between person and object”. The object of a smartphone can have the feature of a built in camera; which affords *record-ability*, where the outcome might be the documentation of an event. They continue by suggesting that a way to distinguish features from affordances is by defining features as static - and affordances as dynamic, as with the example of the chair; whose common features individuals can agree on, but where the affordances can differ depending on who interacts with it.

Redström<sup>82</sup> proposes that we make definitions through design; “consider how a chair defines the act of sitting, and how, therefore, designing a chair in a certain sense is a matter of defining what sitting is.” He also writes that design can redefine what things are, for example; by creating a new kind of “sitting device”, sitting in it, and explaining “this is also sitting” can redefine what a chair might be. Van Leeuwen<sup>83</sup> observes that the term affordance is very similar to Halliday’s<sup>84</sup> concept of *meaning potential*; “in which linguistic signifiers –words and sentences– have a signifying *potential* rather than specific meanings, and need to be studied in the social context”<sup>85</sup>. Van Leeuwen extends the concept to also involve other modes of representation beyond linguistic signifiers, and suggests that “the difference is that the term ‘meaning potential’ focuses on meanings that have already been introduced into society, [...] whereas ‘affordance’ also brings in meanings

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<sup>80</sup> Gibson, J. James (2015:119). *The ecological approach to visual perception*. New York: Psychology Press.

<sup>81</sup> Evans, S. K., Pearce, K. E., Vitak, J. & Treem, J. W. (2017). “Explicating Affordances: A Conceptual Framework for Understanding Affordances in Communication Research”. *Journal of Computer-Mediated Communication*, vol. 22 (No 1), pp. 35-52.

<sup>82</sup> Redström, Johan. (2017:31). *Making Design Theory*. London: The MIT Press.

<sup>83</sup> Van Leeuwen, Theo. (2005:4)

<sup>84</sup> Halliday, M.A.K. (1978). *Language as social semiotic: The social interpretation of language and meaning*. London: Arnold

<sup>85</sup> Van Leeuwen, Theo. (2005:5)

that have not yet been recognized, that lie, as it were, latent in the object, waiting to be discovered”<sup>86</sup>. The term *meaning potential* can therefore be related to the ‘conventional chair’, whereas *affordance*, on the other hand, relates to the innovative ‘sitting device’ Redström refers to; a device which has not yet been introduced into society. Since HDR in the production of motion picture is only a couple of years old we might not yet know all the meaning potential this technology has capacity for; as all the affordances it might offer probably hasn’t yet been fully unveiled. As this technology continues to develop so will its inherent affordances.

### 3.3 Creative Space

By addressing questions about production-related responses to the digital turn in moving image production Swenberg and Eriksson<sup>87</sup> aim to illuminate factors that affect design creativity. They introduce the concept *creative space* “in order to explain the casual chain between digital material (in the form of video files and codec) on the one hand, and production workflows and creative work (which are interdependent) on the other”<sup>88</sup>. The creative space of a moving image design-worker is in this model expressed by three dimensions; *expressive potential*, *digital information available for processing*, and *time to spend on creative work*.<sup>89</sup> The *expressive potential* is limited by the capacity of the tool and user skill, and is the dimension this thesis will relate to the most. Tool capacity can be directly related to the affordances of HDR; which the colorist can take advantage of if he or she has the skills to do so, thereby maximizing the expressive potential. *Digital information available for processing* relates to the file format and video codec, while time to spend on creative work is set by a manager, which also limits the extent of the workers creative space.

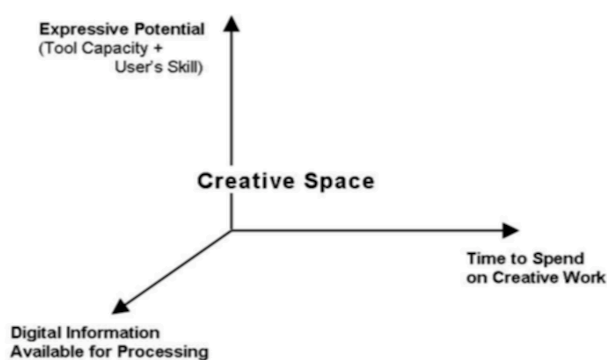


Figure 6: Dimensions of a designer’s Creative Space in moving image production (from Swenberg & Eriksson 2012).

<sup>86</sup> Ibid.

<sup>87</sup> Swenberg, T. & Eriksson, P.E. (2012). Creative space in contemporary Swedish moving image production. / *Journal of Integrated Design and ProcessScience*, 16(4), 55-72.

<sup>88</sup> Ibid.

<sup>89</sup> Ibid.

# 4. Method

This chapter will present the reader with the methodologies, methods, and their respective implementation. This study utilize a mixed-methodology approach; combining research through design and analytical autoethnography. Data was gathered both from documenting the process of color grading a short film, and also from conducting semistructured interviews with four colorists.

## 4.1 Research through design

For a long time, according to Stappers and Giaccardi<sup>90</sup>, design work has been residing in industrial practice and craft, while research has been carried out in academic experiments and reflection. They observe that during the past decades though, this division has been loosened up where research has become “a recognized part of designing products (and later services)” and design activities has become “established as the chief elements in the process of generating and communicating knowledge”<sup>91</sup>. This has become known as *research for design* and *research through design*.<sup>92</sup> Godin and Zahedi<sup>93</sup> defines the latter term - research through design (RtD) - as “an approach to scientific inquiry that takes advantage of the unique insights gained through design practice to provide a better understanding of complex and future-oriented issues in the design field”. Löwgren<sup>94</sup> lists three distinct phases of the RtD research process:

- *Pre-study*; the first phase is about going from a broad subject of interest to a limited focus of the study. This work can be *empirical* - using field studies, interviews or surveys to understand the situation for which the design work is intended, or, *analytical / theoretical* - to either find previous solutions or useful concepts and overall theories which relate to the problem area.
- *Design work*; the findings during the pre-study carries over to the design work - which can be either explorative or determinative, which means either to assess the potential of going in

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<sup>90</sup> Stappers, P. & Giaccardi, E. (n.d.). *Research through design*. Retrieved April 1st 2019 from <https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/research-through-design>

<sup>91</sup> Ibid.

<sup>92</sup> Frayling, Christopher. (1993). Research in Art and Design. *Royal College of Art Research Papers*, 1(1), 1-5

<sup>93</sup> Godin, D. & Zahedi, M. (n.d.). *Aspects of Research through Design: A Literature Review*. Retrieved April 1st 2019 from <http://www.drs2014.org/media/648109/0205-file1.pdf>

<sup>94</sup> Löwgren, Jonas. (2018:9-10). *Till en designstudent som ska göra examensarbete på kandidatnivå*. Retrieved January 29th 2019 from [http://jonas.lowgren.info/Material/kand\\_design\\_kompendium.pdf](http://jonas.lowgren.info/Material/kand_design_kompendium.pdf)



different directions or to precise and make a few different approaches more concrete. The first two phases should not be separated too strictly in the beginning as they stimulate each other.

- *Evaluation*; this phase is often seen as an empirical activity, where the intended user tests the solutions. Other approaches are *analytical* - a systematic reasoning about the properties of the object being evaluated, or *theoretical* - where these properties are tested against an overall theory to decide which properties a finished product would have.

## 4.2 Analytic autoethnography

Ethnographic traditions “are grounded in a commitment to the first-hand experience and exploration of a particular social or cultural setting on the basis of (though not exclusively by) participant observation”<sup>95</sup>. In autoethnography, “the researcher’s own experience become ‘a primary data source’”<sup>96</sup>. Hackley<sup>97</sup> notes:

For the narrative ethnographer, the data are out there to be reported on in a subjective light. The subjectivity of the researcher, and its influence on data collection, is acknowledged through reflexive writing. In contrast, in auto-ethnographic research, the introspection itself is the data source. This introspection may well be interpolated with stuff that is out there, such as memories and experiences of events, but the subjectivity of the account is itself expressly situated in the foreground. [...] In auto-ethnographic writing the reflexive narrative is the data source.

Hackley<sup>98</sup> continues by stating that autoethnography “does not imply any consistent or agreed set of conventions” but acknowledge the view of autoethnography as reflecting “a postmodernist turn in ethnography in that it is characterised by the collapse of realism and objectivity”. Anderson<sup>99</sup> confirms this by stating that “the current discourse on this genre of research refers almost exclusively to ‘evocative autoethnography’; that draws upon postmodern sensibilities and whose advocates distance themselves from realist and analytic ethnographic traditions”. Evocative autoethnography is by Ellis and Bochner<sup>100</sup> defined as “an autobiographical genre of writing”,

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<sup>95</sup> Atkinson, P., Coffey, A., Delamont, S., Lofland, J. & Lofland, L. (2007:4). *Handbook of Ethnography*. London: Sage.

<sup>96</sup> Crouch, C. & Pearce, J. (2012:91). *Doing research in design*. London & New York: Bloomsbury Academic

<sup>97</sup> Hackley, Chris. (2007). “Auto-ethnographic Consumer Research and Creative non-fiction: Exploring Connections and Contrasts from a Literary Perspective”. *Qualitative Market Research: An International Journal*, vol. 10 (No 1), pp. 98-108.

<sup>98</sup> Ibid.

<sup>99</sup> Anderson, Leon (2006). “Analytic Autoethnography”. *Journal of Contemporary Ethnography*, no. 4, pp. 373-395.

<sup>100</sup> Ellis, C., & Bochner, A. P. (2000). Autoethnography, personal narrative, reflexivity: Researcher as subject. In Denzin, N. K. & Lincoln Y. S. (Eds.), *Handbook of Qualitative Research* (pp. 733-768). London: Sage.

which, according to Anderson<sup>101</sup> “requires considerable narrative and expressive skills”; where it’s advocates “remain largely marginalized in mainstream social science venues, due to their rejection of traditional social science values and styles of writing”<sup>102</sup>. To reestablish a connection to the realist ethnographic tradition Anderson proposes the term *analytic autoethnography*; making it a distinct sub-genre within the broader practice of analytic ethnography. Anderson<sup>103</sup> lists five key features of analytic autoethnography (AA):

1. *Complete membership researcher status*; meaning that the researcher is a complete member in the social world under study. Anderson differentiate between the “opportunist” and “convert”, a distinction borrowed from Adler and Adler<sup>104</sup>. The opportunist may be born into a group, thrown into a group by chance circumstance (e.g., illness), or have acquired intimate familiarity through occupational, recreational, or lifestyle participation. The far less common convert begin with a purely data-oriented research interest but becomes converted to complete immersion and membership during the course of research.
2. *Analytic reflexivity*; entails self-conscious introspection guided by a desire to better understand both self and others through examining one’s actions and perceptions in reference to and dialogue with those of others.
3. *Narrative visibility of the researcher’s self*; meaning that the researcher is a highly visible social actor within the written text. Autoethnographers should illustrate analytic insights through recounting their own experiences and thoughts as well as those of others.
4. *Dialogue with informants beyond the self*; unlike evocative autoethnography, which seeks narrative fidelity only to the researcher’s subjective experience, analytic autoethnography is grounded in self-experience but reaches beyond it as well.
5. *Commitment to theoretical analysis*; the defining characteristic of analytic social science is to use empirical data to gain insight into some broader set of social phenomena than those provided by data themselves. Analytic autoethnography feature this value-added quality of not only truthfully rendering the social world under investigation but also transcending that world through broader generalization.

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<sup>101</sup> Anderson, Leon. (2006)

<sup>102</sup> Ibid.

<sup>103</sup> Ibid.

<sup>104</sup> Adler, P.A. & Adler, P. (1987). *Membership roles in field research*. Newbury Park, CA: Sage.

Chang<sup>105</sup> describes the divide between analytic and evocative autoethnography as part of a bigger anthropological war of two positions; objectivity vs. subjectivity. She comments that “this war between objectivity and subjectivity is likely to continue, shaping the discourse of autoethnography”.

### 4.3 Semistructured interviews

Mann<sup>106</sup> lists three degrees of structure when it comes to interviews. The structured interview, he says: “relies on a detailed script that is prepared and usually piloted before the interview”. The unstructured interview “relies on a few open-ended questions” where there “might be one or two themes that the interviewer wants to focus on”. The semistructured interview often relies on a guide (important to cover most of), although, there is room for some deviation, Mann<sup>107</sup> explains:

This form of data collection involves the researcher having a series of predetermined but usually open-ended questions, usually written up as an interview guide. The topic or topics that the interviewer wants to explore should be reflected on before the interview, in order to form the interview guide. [...] The greater freedom (cf structured interviews) allows for probing and clarification. The researcher also has more control of the sequence of questions than in unstructured interviews.

Because of these characteristics, a semistructured approach was utilized in this study, and can be implemented “when the researcher knows enough about the topic or phenomenon to identify the domain [...] but does not know and cannot anticipate all of the answers”<sup>108</sup>. Adams<sup>109</sup> explains that these interviews are conducted with one respondent at a time, where the interviewer “employs a blend of closed- and open-ended questions, often accompanied by follow-up *why* or *how* questions”. To minimize fatigue for both interviewer and respondent Adams recommend the duration of an interview to be no longer than about one hour. He also writes that semistructured interviews are “time-consuming, labor intensive, and require interviewer sophistication”<sup>110</sup>.

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<sup>105</sup> Chang, Heewon. (2008:45). *Autoethnography as method*. London & New York: Routledge.

<sup>106</sup> Mann, Steve. (2016:91). *The research interview: Reflective practice and reflexivity in research processes*. Hampshire & New York: Palgrave Macmillan.

<sup>107</sup> Ibid. (2016:102)

<sup>108</sup> Morse, Janice. (2012). The Implications of Interview Type and Structure in Mixed-Method Designs. In Gubrium, J. F., Holstein, J. A., Marvasti, A. B. & McKinney, K. D. (Eds.), *The SAGE Handbook of Interview Research: The Complexity of the Craft* (pp. 193-204). Thousand Oaks, Ca: Sage Publications.

<sup>109</sup> Adams, C., William. (2015). Conducting semi-structured interviews. In Newcomer, K. E., Hatry, H. P., Wholey, J. S. (Eds.), *Handbook of Practical Program Evaluation, 4th edition* (pp. 492-505). New Jersey: Wiley.

<sup>110</sup> Ibid.

## 4.4 Implementation and execution

No matter the project, it will be essential for researchers to explore every possibility for using a range of methods to add depth to their understandings and make their studies more credible.<sup>111</sup>

According to Crouch and Pearce<sup>112</sup>, methods for collecting quantitative and qualitative data is increasingly being combined. This combination is one of the defining characteristics of *mixed method*<sup>113</sup> studies. On the other hand, in a *multimethod* study; the researcher “collects, analyzes, and mixes multiple forms of either qualitative or quantitative data”<sup>114</sup>.

In this *multimethod* study, qualitative data was collected by the means of writing a production diary and performing interviews. This study also implements *multimethodology*<sup>115</sup>; meaning two structured sets of guidelines or activities to assist in undertaking research or intervention<sup>116</sup>, in this case RtD and AA. The pre-study had an analytical / theoretical approach, and was carried out by assembling a foundation on HDR based on secondary data; such as white-papers, research papers and technical books (chapter 2.3). This was also accompanied by tutorials, articles and podcasts from colorists with experience of working in HDR. This knowledge carried over into the design work (i.e. color grading process) of a 13-minute short film, which had a determinative approach; where the concepts from the pre-study were concretized and tested to generate primary data. This process was documented thoroughly and is presented in chapter 5. With the aim to extend and deepen the knowledge on color grading in HDR and the colorists perspective even further; four interviews with colorists in Sweden were performed, and is presented in chapter 6. Lastly, an analysis is presented in chapter 7; intended both as a general evaluation of the primary data as well as an empirical analysis, which connects to the theoretical framework of this study. Figure 7 visualizes this process.

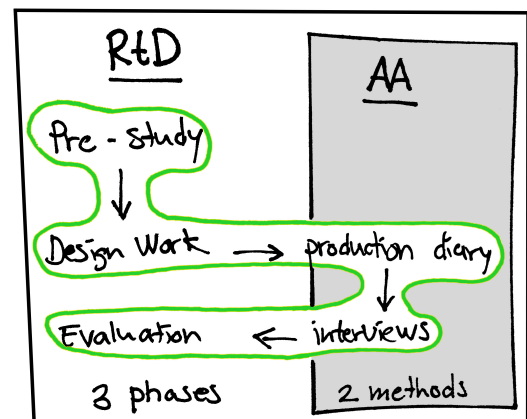


Figure 7: The RtD and AA multimethodology process.

<sup>111</sup> Crouch, C. & Pearce, J. (2012:130)

<sup>112</sup> Ibid.

<sup>113</sup> Creswell, J. W. & Plano Clark, V. L. (2017:5). *Designing and conducting mixed methods research, Third edition*. Los Angeles: Sage.

<sup>114</sup> Creswell, J. W. & Plano Clark, V. L. (2007:12). *Designing and conducting mixed methods research*. Los Angeles: Sage.

<sup>115</sup> Mingers, J. & Brocklesby, J. (1997). “Multimethodology: Towards a Framework for Mixing Methodologies”. *Omega*, vol. 25 (No 5), pp. 489-509.

<sup>116</sup> Ibid.

#### **4.4.1 Data generation 1: Production diary**

To generate data from the color grading process an autoethnographic approach was utilized. Even though I'm not a professional colorist, I have several years of experience with color grading using the software DaVinci Resolve, as well as being a Blackmagic Design 'color grading certified end user' of this very software. According to Anderson<sup>117</sup>, a key feature of analytic autoethnography is *complete research membership status*. It's difficult for me to assess when someone would achieve such status in this particular case, but I believe that I come very close, without actually being a professional colorist.

The 13-minute short film was graded in 2-3 hour evening sessions over a period of about 2 weeks, although not every day. It happened a few times that I took field notes<sup>118</sup> during a grading session. The morning after each session I would write about and reflect over the work I had done the night before, resulting in an autoethnographic production diary. When writing, I would sometimes also open the project and look at the recent adjustments I had made. The initial reason for working at night was that I didn't have any darkening curtains for my windows, and wanted to work without any light interfering from outside. I think this worked out well; as I had (for most of the time) an adequate amount of documentation to do after 2-3 hours of working on the production.

#### **4.4.2 Data generation 2: Interviews**

Ethnographers rarely use observation alone in their research, and often supplement observation data with interview texts, documents or other artefacts to enrich, clarify and validate their observations.<sup>119</sup>

A part of the approach of analytic autoethnography consists of performing interviews.<sup>120</sup> The only requirement for the selection of informants in this study was that they would all be established colorists working in Sweden. The number of interviews which could be performed was limited to two factors; (1) time available for the study, and (2) the number of colorists working in Sweden who could be located, and would agree to participate in the study. Initially, 12 colorists were contacted by e-mail, 8 of them replied. Two of these declined to participate, one initially said yes but then

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<sup>117</sup> Anderson, Leon. (2006)

<sup>118</sup> Crouch, C. & Pearce, J. (2012:84)

<sup>119</sup> Ibid. (2012:92)

<sup>120</sup> Anderson, Leon. (2006)

didn't reply to any further e-mails, one wanted to participate but had a busy schedule during the period which the interviews were carried out. This resulted in that four interviews were performed. Since HDR is still a new technology to the industry it's difficult to find colorists in Sweden who has experience with working in HDR. Only one of the interviewees had experience of doing a project in HDR for a client, and two had done tests on borrowed equipment. Even so, the opinions of all the colorists were regarded as valuable for this study; since they all had substantial experience of the profession. Their expectations of HDR is also interesting to put in relation to the other findings of this study. Five basic topics were formulated to use as a thematic outset during the interviews, which also gave the conversations more defined structure.

The topics created are; (1) Experience of HDR, (2) Attitudes towards HDR, (3) Possibilities and creative opportunities, (4) Potential problems related to HDR, (5) Specific demands to be able to work in HDR.

The interviews had a duration of about 40 to 60 minutes each, and were carried out over the phone. There are two main reasons for the latter: (1) costs, it would have been too expensive to travel and perform the interviews in person, (2) flexibility, since the colorists prioritize their clients I needed to be flexible. I chose to utilize the phone over *Skype* due to practical reasons for both parties. Mann<sup>121</sup> writes that "interviewees speak proportionately for less time on the phone", making telephone interviews shorter than face-to-face interviews. In this study, one of the interviews lasted about 40 minutes, where the other lasted 10-20 minutes longer, which might have affected the results.

This study has followed the ethical codex of the *Swedish Research Council*.<sup>122</sup> The informants were notified about the purpose of the interviews and of this study. They were also made aware that they could abort the interview at any time without giving any motivation, and that their names wouldn't be published in the thesis. They also gave their consent to be recorded, after receiving information about how the recorded interview would be stored, and for how long.

Transcription was done the same day or the day after an interview had taken place. Only those parts containing relevant information for this study were transcribed – which was done in the original language of the interview. Quotes which needed to be translated from Swedish to English was approached with caution, and the main focus was to maintain the original spirit of a statement.

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<sup>121</sup> Mann, Steve. (2016:90)

<sup>122</sup> <http://www.codex.vr.se/en/index.shtml>

# 5. Production

This chapter will present the autoethnographic data generated from documenting the process of color grading a 13-minute short film in HDR. How this documentation was done is described in chapter 4.4.1. It's important to point out that the primary emphasis of this study is on the process, not the finished artifact. The content presented is mainly of descriptive kind, although, an effort was made to also motivate choices and decisions taken during this process. Before committing to this chapter it is recommended to visit 'HDR formats' in the Appendix to get acquainted with relevant HDR-specific technical information.

## 5.1 Getting started with HDR

To find out what software and hardware to utilize I searched the internet for information; reading blog posts, articles and online forums. I also watched tutorial videos and listened to podcasts. To get familiar with HDR I decided to first consume HDR content, before taking up the production.

### 5.1.1 Hardware and software

HDR is something closely related to modern display technology, where SDR is defined by old CRT-technology; relating to both the color gamut and brightness of HDTV-standards.<sup>123</sup> Therefore, I found it logical to start my own HDR production by looking at options of displaying HDR content. According to Carman<sup>124</sup> "it is a requirement, not an option, to have a dedicated HDR reference monitor or HDR TV for doing [color grading in HDR]". Since the grading monitors here at *Dalarna university* are only capable of displaying SDR, this meant that I would have to buy an HDR-monitor myself. After looking at a few different options I soon realized that a proper grading monitor made for mastering HDR content is very expensive; where the cheaper Eizo Prominence CG3145 has a suggested retail price of \$30,995 US<sup>125</sup>, and the Flanders Scientific XM310K is priced at \$45,000 US<sup>126</sup>. The only realistic approach here would be to get a consumer TV-set with HDR capabilities,

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<sup>123</sup> Brooks, D. G. (2014:1)

<sup>124</sup> Carman, Robbie. [MixingLight]. (2015, December 11). *HDR Essentials: Getting Setup In DaVinci Resolve* [video]. Retrieved March 5th 2019 from <https://mixinglight.com/color-tutorial/hdr-essentials-getting-setup-in-davinci-resolve/>

<sup>125</sup> Eizo. (2018, April 2). *ColorEdge PROMINENCE CG3145 DCI-4K HDR Reference Monitor Now on Sale*. Retrieved March 18th 2019 from <https://www.eizo.com/news/2018/04/02/coloredge-prominence-cg3145-dci-4k-hdr-reference/>

<sup>126</sup> FlandersScientific. (n.d.). *XM310K*. Retrieved March 18th 2019 from <https://www.shopfsi.com/XM310K-p/xm310k.htm>

where the 55” models of the popular LG OLEDs has come down a lot in price during the last year or two.<sup>127</sup>

While no one can make the argument that there is **NOT** difference between grading on a \$30k HDR reference monitor vs. a \$2500 consumer TV, I’d like to make the argument that if you’re looking to get your feet wet with HDR grading, there is little reason that you can’t do it now if you’re willing to spend money on a consumer HDR set.<sup>128</sup>

-Robbie Carman

I had already thought of buying a 55” OLED from LG since it seems to be very popular amongst colorists to use as a client monitor (calibrated for SDR) during grading sessions; where the colorist work on a smaller grading monitor while the clients view the larger display. Having a nice OLED TV-set at home and be able to consume HDR content on it could also potentially benefit my own production; by learning how existing movies and tv-series graded in HDR can look. I finally decided to buy a 55” LG OLED, namely the C7V model released in 2017, which I bought for a corresponding value of circa \$1100 US<sup>129</sup>.

There are different kinds of software, both professional grading applications and NLE’s, that can deliver HDR-content.<sup>130</sup> This thesis has a focus on not just HDR-delivery but also on the work of the colorist; therefore, it seems rational to use a dedicated color correction software. Since I’m a certified ‘color grading end user’ of DaVinci Resolve it was the first application I started looking at for HDR-delivery. This software from Blackmagic Design is also what nearly all colorists I’ve been in contact with here in Sweden use in their daily work. Another part I would need for grading in HDR is a video card that supports HDMI 2.0a (HDMI 2.0b is needed for HLG).<sup>131</sup> Normally when using HDR-grading monitors it is possible to choose different HDR-modes in the menu system. Because I decided to grade on a consumer TV-set (where the metadata of the content triggers its HDMI mode) the situation is a bit different. There are solutions like the AJA Hi5-4K-Plus; which

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<sup>127</sup> Prisjakt. (n.d.). *LG OLED55C7V*. Retrieved March 18th 2019 from <https://classic.prisjakt.nu/produkt.php?pu=4095124>

<sup>128</sup> Carman, Robbie. (2018, June 28). In MixingLight. *10 Things I’ve Learned (So Far) About HDR Grading*. Retrieved March 5th 2019 from <https://mixinglight.com/color-tutorial/10-things-about-hdr-grading/>

<sup>129</sup> *Converted from SEK to USD on March 19th 2019.*

<sup>130</sup> Videomaker. (2018, September 10). *An Editor’s Guide to Working with HDR Video*. Retrieved March 19th 2019 from <https://www.videomaker.com/how-to-work-with-hdr-video>

<sup>131</sup> Digital Trends. (2018, October 15). *What is HDMI 2.0b? Here’s everything you need to know*. Retrieved March 18th 2019 from <https://www.digitaltrends.com/home-theater/what-is-hdmi-2-0/>



takes an SDI-signal from the computer's video card and converts it to HDMI 2.0, with the ability to ingest HDR metadata.<sup>132</sup> While this is a nice solution for those who already have a more expensive video card, it has a MSRP of \$595 US<sup>133</sup>. A more affordable option for someone like me is the DeckLink Mini Monitor 4K from Blackmagic Design. It has a HDMI 2.0a connection which means that it supports both Dolby Vision and HDR10/HDR10+. Blackmagic Design<sup>134</sup> markets this product as “the world's most affordable HDR playback solution available” at a price of \$195 US.

DaVinci Resolve comes in two versions; the limited free version and the fully featured studio version (which costs \$299 US).<sup>135</sup> Several of the features in Resolve related to a HDR-specific workflow is only available on the paid version; for example the ability to send metadata over HDMI<sup>136</sup> (which I will need to activate the HDR-mode on the display), and HDR-specific scopes<sup>137</sup> (to monitor the full waveform). For this project I decided to use DaVinci Resolve studio and the DeckLink Mini Monitor 4K, both from Blackmagic Design. The total cost for this setup ended up at circa \$1600 US (*LG TV \$1100, DeckLink card \$195, DaVinci Resolve studio \$299*).

### **5.1.2 Consuming HDR content**

Before starting with color grading the short film I first wanted to understand what HDR could look like. Once I had received my OLED TV I started by streaming videos on the already installed YouTube app. I also upgraded my Netflix subscription to enable HDR-streaming, and watched both tv-series and movies in HDR to get a better sense of the medium. I thought this was vital; whereas my creation of a HDR-master could otherwise be compared to an audio engineer mixing for stereo while previously having only consumed the medium in mono. I find this comparison relevant because (to my ears); stereo audio is more true to life than mono audio, and HDR video is also more true to life than SDR video (or has the capability to be). The first thing I noticed were the stronger colors of the image; especially regarding red, but also green, which is related to the wider color gamut. The deep blacks of the display was also something that made a big impression on the

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<sup>132</sup> AJA. (n.d.) *Hi5-4K-Plus*. Retrieved March 18th 2019 from <https://www.aja.com/products/mini-converters/hi5-4k-plus>

<sup>133</sup> Ibid.

<sup>134</sup> Blackmagic Design. (2016, September 9). *Blackmagic Design Announces new DeckLink Mini 4K models*. Retrieved February 26th 2019 from <https://www.blackmagicdesign.com/se/media/release/20160909-04>

<sup>135</sup> Blackmagic Design. (n.d.). *DaVinci Resolve 15*. Retrieved March 19th 2019 from <https://www.blackmagicdesign.com/products/davinciresolve/>

<sup>136</sup> Blackmagic Design. (2018:113)

<sup>137</sup> Ibid. (2018:93)

viewing experience; especially when combined with the brightness of HDR in the movie *Life of Pi*, where this combination contributed to the emotional impact I felt in a scene of a starlit night sky, and a scene of luminescent jellyfish illuminating the dark night ocean – combined with a bright green glowing color outlining a boat and a raft. A tv-series where I also noticed the presence of HDR was Marvel’s *Daredevil*. Here, the filmmakers made use of strong bright colors, and also bright specular highlights (reflections) in otherwise often dark and low key scenes. This made the image stand out when I compared an HDR and SDR version of the same episode. Since I like to watch movies and tv-series in the dark a problem I encountered during brighter scenes in HDR was the fact that my room got lit up (and fairly bright) by the TV. This problem is commonly referred to as *flare*; where the light bounces around in the room and back onto the screen, making the blacks brighter and harder to distinguish.<sup>138</sup> This is something colorist Peter Doyle<sup>139</sup> considers when color grading for HDR; as he tries to emulate those situations within the software to “tailor the flare and the tone mapping of an image as it moves through the different display mediums”. A solution would be to have a completely black room, and wear black clothes. While this can work in a home-cinema environment arguably most people (and even I) would not want our living rooms to look that way.

## 5.2 Color grading a short film

The 13-minute short film I’m about to color grade in HDR is called *Livsgnistan* (The spark of life), and is created by students at Dalarna University. It’s written by Axel Odevik, directed by Jonas Wik and shot by Erik Hjärkéus. The story is about a young man who buys a painting from an ill artist; with the intention to (with the help from his friend) make money from later selling it, maybe after the artist has deceased. Driving home on the icy winter roads the car skids and ends up in a ditch. The young man is injured, he calls his friend who refuses to help. It’s cold, and soon dark, it’s just him, the painting, and the forest.

### 5.2.1 Initial setup and test

To get a first ‘hands-on’ experience and also to assure that I would be able to create, upload, and view my own HDR video on YouTube, I decided to perform a test; using two clips from the short

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<sup>138</sup> Siragusano, Daniele. [FilmLight]. (2018, October 31). *International Cinematography Days 2018, Stuttgart Managing Colour in a Multi-Delivery Production* [video]. Retrieved March 19th 2019 from <https://vimeo.com/298131298>

<sup>139</sup> Doyle, Peter. [technicolor]. (2017, March 1). *Peter Doyle on HDR color finishing* [video]. Retrieved from [https://www.youtube.com/watch?v=Z-ljmv8\\_T78](https://www.youtube.com/watch?v=Z-ljmv8_T78)

film I would grade as a part of this study. In the first clip a young man in a bathrobe sits on a couch in a white room with a bright window behind him. He's filling up the two wine glasses on the table in front of him, which is accompanied by two lit candles, cheese and crackers. The camera tracks from left to right during the shot. The second clip is shot locked down on a tripod and shows a man in a dark forrest, sitting beside a small bonfire; lit by the fire in front of him and moonlight from behind, which is reflecting on his leather jacket.

After importing the two clips to DaVinci Resolve and placing them on a timeline I adjusted the project settings to work in HDR by utilizing a *color managed workflow*, and choosing to output in ST.2084. This setting can be accompanied by an optional maximum brightness value of 300 - 500 - 800 - 1000 - 2000 - 3000 or 4000 nits. The difference between those brightness values are at which point Resolve will “impose a hard clip at the maximum nit value supported by that setting”<sup>140</sup>. There's also an option to specify the brightness output in the metadata stream by activating the *HDR mastering is for X nits* checkbox and input the chosen brightness to let the TV know this value.<sup>141</sup>

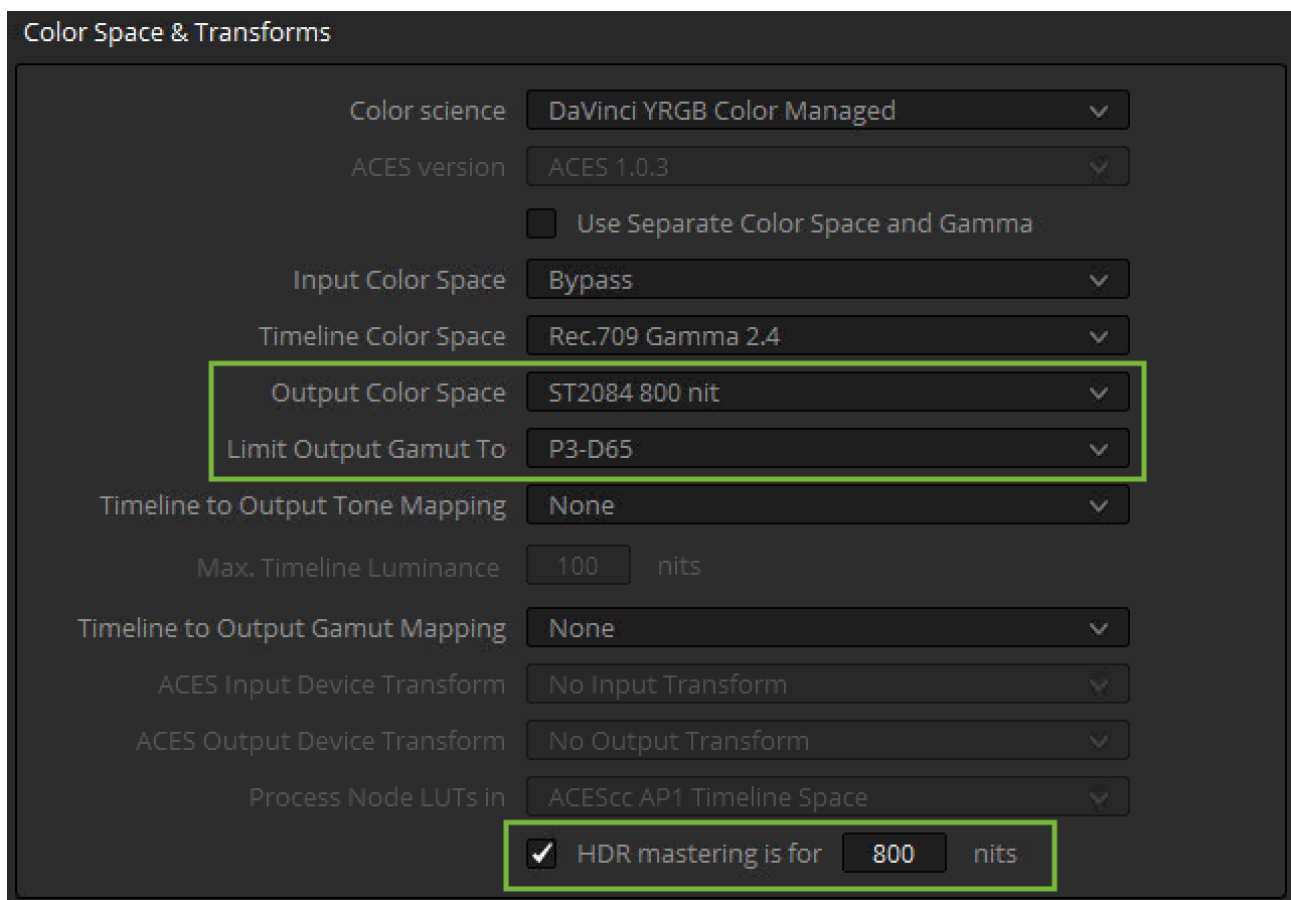


Figure 8: Color managed workflow settings in DaVinci Resolve.

<sup>140</sup> Blackmagic Design. (2018:192)

<sup>141</sup> Blackmagic Design. (2018:197)

On a grading monitor the peak brightness would be visible in the image as a hard cut (clipped without detail) when exceeded, whereas a consumer TV-set (which utilize a roll-off to lower the brightness values) makes the display less ideal for color grading due to the lack of precision this contributes to. This is where the imposed hard cut of DaVinci Resolve can help (if it matches the capabilities of the display). According to RTINGS<sup>142</sup> the “HDR Real Scene Peak Brightness” of my display would be 718 nits (which gets lower as the bright area gets larger). Based on this value I decided to master in 800 nits; because I wanted the extra latitude compared to 500 nits for areas of specular highlights and illuminating objects. This is done at a cost of having less control and precision due to sacrificing the hard cut functionality (which would ideally be set lower than the display’s capabilities, i.e. 500 nits). In my case, when the brightness becomes too high for the display to handle, it will utilize the roll-off function (which might look different if the video would be played back on another HDR capable display).

DaVinci Resolve also lets users specify a limitation to the color gamut separate from the overall color space (which in HDR is Rec.2020). I chose the P3-D65 setting to get a wider color gamut than Rec.709, where, according to RTINGS<sup>143</sup>; my TV can display 96.15%<sup>144</sup> of its colors. This color space, which for example Netflix<sup>145</sup> specifies for their HDR masters, will provide more vibrant colors than Rec.709. Once the settings had been adjusted I needed to activate *deep color*<sup>146</sup> for the HDMI input used on TV for it to recognize the HDR feed from the video card as a HDR feed, then, I could successfully monitor in HDR.

Both clips were shot on a Sony FS7 camera. While they were overall well exposed – the content of the window behind the man in the first shot was almost completely *blown out*; meaning that only outlines of some branches of a tree could be seen. In SDR I would probably have put the window very near 100 nits (to almost clip the signal) but in HDR it’s expected to see more latitude, meaning, also seeing out the window. Of course, completely white windows (without much or any detail) can be an artistic decision, but if it’s not, then HDR places higher demands on cameras and their

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<sup>142</sup> Rtngs. (2017, April 13). *LG C7 OLED Tv Review*. Retrieved March 28th 2019 from <https://www.rtings.com/tv/reviews/lg/c7-oled>

<sup>143</sup> Ibid.

<sup>144</sup> *Compared to DCI-P3 on a CIE 1931 color space diagram (described in chapter 2.1.2).*

<sup>145</sup> Netflix. (n.d.). *Color Grading: Dolby Vision / HDR*. Retrieved March 28th 2019 from <https://partnerhelp.netflixstudios.com/hc/en-us/articles/360000599948-Color-Grading-Dolby-Vision-HDR>

<sup>146</sup> Forbes. (2017, November 30). *Quick Tip: How To Enable HDR On An LG TV*. Retrieved March 28th 2019 from <https://www.forbes.com/sites/kevinmurnane/2017/11/30/quick-tip-how-to-enable-hdr-on-an-lg-tv>

dynamic range, and also set design; where you might be even more compelled to place filters on windows to not ‘clip’ the video signal. I graded the scene fairly bright; as I thought would fit the mood, and also as a contrast to the next scene. I graded the second scene very dark compared to the previous one; utilizing the tonal ranging concept. What I found most interesting was how I could make the fire very bright while maintaining the yellow color of the flames. After grading this second scene I went back into SDR mode by applying a conversion *LUT*<sup>147</sup> (Look up table) in Resolve, and this effect could not be replicated on my regular SDR grading monitor.

A still image from each scene with corresponding waveform representations has been brought together (figure 9) to accompany the text. In this document the images will have a much flatter look compared to how they look when displayed on a HDR display. This is because the user interface of DaVinci Resolve (where the stills were captured) can’t display HDR images properly; which might be possible (to a certain extent) in the future if operating systems and computer displays embrace HDR. This is why “it is a requirement, not an option, to have a dedicated HDR reference monitor or HDR TV for doing this type of work” as Carman<sup>148</sup> points out. Compared to color grading in SDR; where I can just pick up my laptop and start color grading on it (even if it’s not the best idea due to accuracy considerations), that’s not even a possibility in HDR.

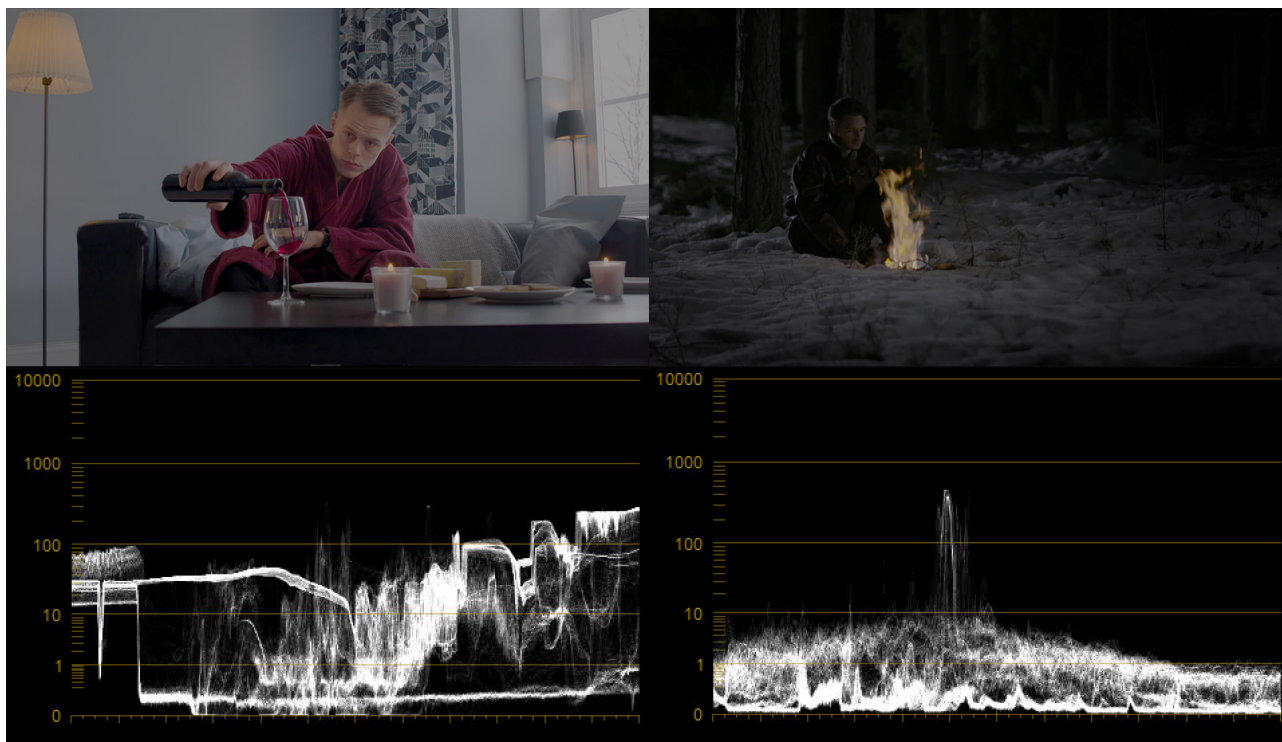


Figure 9: Stills from two clips with corresponding waveform representations.

<sup>147</sup> *ST.2084 800nits to Rec.709 Gamma 2.4*

<sup>148</sup> Carman, Robbie. [MixingLight]. (2015, December 11)

A problem I came across was when using a plugin called *False Color*. This plugin layers certain colors on top of the image depending on the brightness values of the image. It is commonly used to help with evaluating camera exposure when recording images, but can also be used while adjusting the tonal range during grading. While it worked for adjusting the shadows and mid-tones of the forrest scene it only goes up to 100 nits, so I can't use this tool when grading above the brightness values of SDR. I contacted the company who made the plugin which said that that they would look at making it work for HDR. An example of how this plugin was used is presented in chapter 5.2.4.

Before rendering this test video I looked up Google's requirements<sup>149</sup> for video compression and codecs regarding HDR. This is a bit of a jungle and won't be discussed in too much detail, but for test purposes I used an DNxHR compression in a .MOV container and rendered the video exactly as I would do when rendering an SDR-video. Because of the color managed workflow selected earlier; Resolve added the basic metadata needed to flag the video as HDR.<sup>150</sup> After uploading it to my private YouTube account I could access the video by logging in to the YouTube app on the TV. The video played back in HDR-mode and it looked good. For comparison, it would be interesting to see how it would play back and look on another HDR TV-set.

## 5.2.2 Conforming the timeline

The colorist's goals and methods (see Table 1) presented in chapter 2.2 was used as a basis to structure the color grading process. Before that work could begin I had to *conform*<sup>151</sup> the timeline, and get the movie with all 120 clips to play back properly. This was done with the assistance of a reference movie, which Inhofer<sup>152</sup> explains is the only way to guarantee that the colorist works with the timeline that previously has been approved by the filmmakers. In this case, since the original short film was just finished, I used that as a reference. One important thing to note is that I was involved as consultant colorist during postproduction of the original movie. This means that I've spent some time with the director and quite a few hours (at least one working day in total) with the cinematographer, who was also the colorist during the SDR grade. Therefore, I already had an idea of how the movie can look, and what the original intentions of the director and cinematographer

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<sup>149</sup> Google. (n.d.). *Upload High Dynamic Range (HDR) videos*. Retrieved March 28th 2019 from <https://support.google.com/youtube/answer/7126552>

<sup>150</sup> Mystery Box. (2016, November 2). *HDR Video Part 5: Grading, mastering, and delivering HDR*. Retrieved April 4th 2019 from <https://www.mysterybox.us/blog/2016/10/27/hdr-video-part-5-grading-mastering-and-delivering-hdr>

<sup>151</sup> Van Hurkman, Alexis. (2014a:18)

<sup>152</sup> Lynda. (2016, February 2). *DaVinci Resolve 12 Essential Training, Checking the conform with a reference movie*.

were. I'm uncertain how this will affect my work during the color grading process, though, it might limit me if I only adhere by the original intentions, or, it can be used to further build on. Either way, this is something I have to be aware of during the color grading process, and reflect over.

### 5.2.3 Starting out in SDR

After the tedious conform process of not only getting all clips to play back properly but also adjusting and animating the framing (zoom, pan and tilt) to correspond with the original grade, I could begin color grading. I set up the project exactly as in the test run,<sup>153</sup> and decided to use my regular SDR grading monitor to white-balance and also shot-match the clips. This works since the P3-D65 and Rec.709 gamuts has the same white point of 6500 kelvin. I kept the color management settings but added a conversion LUT<sup>154</sup> to the output to get a viewable image in SDR. This way, I could work with my calibrated grading monitor in SDR and occasionally verify the success of this approach by deactivating the LUT and look at the TV for a representation in HDR.

Normally, when doing SDR grading, I would also have 'normalized' the image at this stage by adjusting brightness and contrast, which completes the base grade. Because I choose to work with balancing and shot-matching in SDR the normalizing process of the cameras flat looking *log-image*<sup>155</sup> was left undone for now.

### 5.2.4 Maximizing the look

With the balancing and shot-matching done I moved to work in front of the TV-set. I began by playing back the whole 13-minute sequence to see that everything was working fine in HDR (both playback and previous adjustments), which it was. I then started to work from the beginning of the film with an outdoor scene; following the young man in a car as he drives home to the artist to retrieve the painting. During the previous work of adjusting the white balance and shot-matching I had organized similar clips and scenes into groups; where these clips were placed in a group called *outside-cloudy*, which also contains outdoor clips right after the painting has been retrieved. I decided to start working with the clips of this group probably for the reason that I didn't know where else to start, and these clips were situated at the beginning of the sequence.

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<sup>153</sup> *ST.2084 at 800 nits with a P3-D65 color gamut*

<sup>154</sup> *ST.2084 800 nits to Rec.709 Gamma 2.4*

<sup>155</sup> *A log-profile is a digital video camera function which applies a logarithmic curve to the image, making it look flat.*

I created a ‘post group’-level adjustment node to affect all the clips in the group, which, as previously stated, were similar clips which had been shot-matched. When adjusting the brightness and contrast controls I found it difficult to decide how the images should look. I knew that I wanted these outdoor clips to be fairly bright; to achieve a difference (and utilize the tonal ranging concept) compared to the indoor and night scenes. Even though I typically like to make my grades a bit ‘muted’ (by lowering the brightness to create a more ‘moody’ look) I still wanted to test this concept. After some initial adjustments I was dissatisfied and had problems to get to a point where the adjustments felt right. I thought that the colors were looking bad and distracting, so I decided to instead work in a desaturated representation to help me focus on the brightness adjustments alone. I have previously found that it’s easier for me to make bold contrast adjustments when working in black and white, which also was the case this time; maybe because displeasing colors tend to look even more displeasing (they become more apparent) after ‘normalizing’ the image. I made the contrast fairly large by having quite dark shadows (not totally crushed) and bringing up the whites (snow and cloudy sky) to about 300 nits. To accomplish this, I had ‘boosted’ the whites by using the *log highlight*-wheel; which targets a more narrow part of the image and doesn’t affect the mid-tones or shadows (which the regular *master gain*-wheel does). This made the snow and sky ‘pop’ a bit from the rest of the image, hence looking less flat, which these overcast images did benefit from.

One thing I discovered after ‘normalizing’ the images was that the brightness between some of the clips no longer matched. Maybe I had focused mostly on balancing the colors during the shot-matching process earlier, but I also think that differences (which previously were fairly small) became more substantial and apparent as the contrast got larger due to these newly made adjustments. Therefore, I had to revisit some of the shot-matching adjustments made earlier to make the brightness match between the clips.

Once I was finished with these initial brightness and contrast adjustments of the *outside-cloudy* group I switched back to a representation in color to see if I could tackle the colors I found unpleasing; which consisted mainly of a strange green hue present in the trees, but also an overall “coldness”. The first problem could be solved fairly quickly by utilizing the *hue vs hue* and *hue vs saturation* adjustments. Because I was now in a sort of creative state I decided to continue with trying to build a ‘creative grade’. I didn’t really know what I was after, so I started by making curve adjustments to the individual RGB-channels; which I have found is a good way to quickly find different directions to go. In this case, I found a warmer look that I liked. I dialed it in even further



by using the *primaries bars* (which I feel more comfortable with using rather than the *primaries wheels*) where each RGB-channel can be adjusted individually for the shadows, mid-tones and highlights (called *lift*, *gamma* and *gain* in Resolve). Finally, I ended up with something which (during these overcast scenes) had a quite nice green/yellowish look to it.

I later continued with ‘normalizing’ the other scenes (also organized into groups) for the rest of the film by moving forward in the timeline. I started the work on these groups in black and white but soon got curious to see if the previously made ‘creative grade’ would work for the indoor scenes as well. I therefore copied the look from the *outside-cloudy* group and made it a timeline level adjustment. To my delight this look also worked on the indoor scenes, though, I did tweak it a bit and dialed it back some to make it less obvious. I also lowered the saturation to get a more naturalistic representation, or, in social semiotic terms, higher modality in a naturalistic coding orientation (which before the saturation adjustment was in the realm of sensory modality). I now felt excited for how the work was coming along and how the grade was starting to take form, I therefore continued the ‘normalizing’ process in color.

To support the narrative and (motivated by the situation which is about to unfold) I thought that it would make sense to have the world of the main character darker than that of his friend. There are only three indoor scenes in this film; (1) when the main character retrieves the painting from the artist, (2) when his friend talks to him on the phone the first time, and (3) when the friend talks to him on the phone the second time. Since the old artist has some kind of sickness (and is possibly dying), as a result of the events which is about to unfold (with the main character together with the painting) and because the friend seems to have it pretty nice in his home, I thought it would be motivated to have this difference in brightness. To demonstrate the difference I’ve put a *false color* overlay on two stills from the first two indoor scenes (figure 10). It’s important to note that there’s one clip in between these two (when the main character goes back to the car after having retrieved

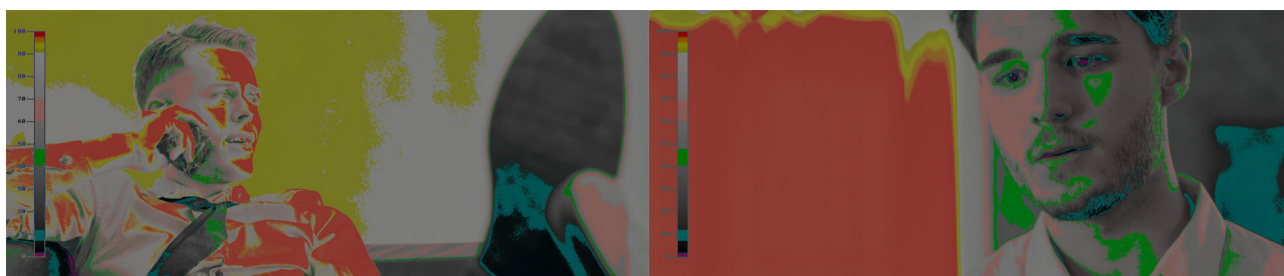


Figure 10: A false color overlay applied to two clips.

the painting), therefore, it's more about the feeling you get for the characters rather than a direct 'tonal ranging' effect. I don't think the difference is large enough to classify as something specific to HDR either, and could more or less be replicated in an SDR grade. Later when we see the friend the second time, he will still be at the same brightness level as before, but the main character has at that point gotten himself into trouble, and his world is about to get really dark.

When the main character drives on his way home with the painting he gets another phone call, the car loses traction on the slippery winter road and ends up in a ditch. I thought that this would be a good point in which to start lowering the brightness, slightly. From the moment he then tries to get the car unstuck the maximum brightness is ranging between 100 - 200 nits, where snow and sky previously were placed at around 300 nits. A problem at this stage is that the sun was starting to come out from the clouds in some of the clips, therefore, clips with sky or sunlight reflecting on the snow was placed around 200 nits, whereas I adjusted overcast clips to be closer to 100 nits. Even if this wasn't optimal I think it works, though consistent dull and overcast images would have supported the story better.

The main character fails to get unstuck and calls his friend for help, who refuses to do so and tells him to call for a tow truck instead. During this scene I kept the brightness of the friend at the same levels as earlier, and the difference between his relaxed and cozy situation to that of the main character now becomes apparent. The source footage of the main character during this scene was shot underexposed by the DP; which I believe contributes to it having a darker feeling (even though the brightness of the snow and sky still is located at 100 - 200 nits after 'normalizing'). My thinking is that this result relates to how the contrast and colors was affected by the camera's exposure during the recording. The main character then takes his friend's advice and calls for a tow truck. The sun is setting as he's waiting in the car, freezing, while his phone is starting to malfunction as the display is flickering. Here, I lowered the brightness even more to accentuate the cold and harsh situation.

Finally, we see the car from outside, as the sun has almost set. This last clip before the night takes over was meant by the filmmakers as a transition. During this clip I therefore animated the brightness to go from right below 100 nits for the sunset sky and about 20 nits for the snow – to 40 nits for the sky and just below 10 nits for the snow, which was done with the coming night-scenes in mind. It took a few attempts to get this transition right, and even though I reference the brightness levels in this text (which I also used as reference during the grading process) in the end it's all about making it feel right, which I find more difficult to put into words.

The main character leaves the car to make a small bonfire in the forest. I knew that I wanted these clips to be dark, and ended up placing the brightness of the images lit by moonlight right under 10 nits. At this point I was still working in color with the ‘creative grade’ that I had created earlier, which, as I quickly discovered; applied a cyan/teal look to the images when the brightness was lowered to this point. This was good news because it meant that I could use the adjustments of the ‘creative grade’ over the whole film; since this look was what I was after and similar to what we had done during the original SDR grade. The effect was a bit too strong though, as I had to apply a correction to the different groups containing night clips to reintroduce some warmth into the image; mainly to warm up the skin of the main character slightly, but also to lower the overall teal/cyan color cast. This was done by raising the red RGB-channel in the mid-tones and shadows slightly by using the *primaries bars*.

After having problems with maintaining the bonfire the main character walks to a road crossing and discovers that he has given faulty information about his location when calling for the tow truck earlier. He tries to call again but the phone is not working properly. He’s upset and runs back to the car to rip out a piece of fabric from the passenger seat in a desperate attempt to then try to restart the fire, which fails. In his desperation he takes the painting from the trunk of the car and lights it on fire, but immediately regrets it and extinguish the flames with help of the snow. He then falls asleep with his back against a tree, holding the painting in his arms.

When the main character later awakes he is very cold, hypothermic, and starts to undress because the hypothermia makes him feel overheated. Here, the filmmakers wanted to convey his subjectivity to the audience through the color grading. To make it clear that he feels warm when he’s actually hypothermic there are two cuts which shows the remains of the old fire, and also the painting lying on the ground as he throws his clothes besides it. Both these clips contains the original cold teal/cyan night grade. I put the clips of him feeling warm and taking his clothes off in a separate group. This way, I could warm these images up; making him look overheated. I also made his skin looking a bit more ‘reddish’ than what’s normal to further point to the seriousness of his situation. When he then walks out of the forest with the painting in front of him we see him again in the cold cyan/teal “objective” state as before. He walks on the road towards a light which becomes brighter and brighter, we see his cold face, the end.

The meaning of the light was from the filmmakers unclear, because they wanted to keep the ending open. It could be an approaching vehicle with its headlights illuminating him, or it could be him walking towards “the light” for his death. Either way, I found this a good opportunity to utilize the dynamic range available due to HDR. Since the later half of the film has been very dark, I thought that it could be a nice effect (and also appropriate for the story) to make both the light and the last closeup of his face quite bright. I adjusted the clips so that the light starts off at around 100 nits, during its approach the brightness levels increase to almost 300 nits. I didn’t want to go any higher because in the last shot the light takes up a fairly large portion of the screen (assisted by the bright falloff from the light source) which creates an overall bright image. One thing that wasn’t as big of an issue during the original SDR grade (where the light was put at maximum 100 nits) is that the light source is clipped; meaning that there’s no information or gradient inside the light itself. The light was shot out of focus so it has some nice halation and soft falloff surrounding the source, but it would have been nice with some more detail inside the light itself for a fuller HDR-experience and immersion.

### *Reflective commentary*

When reflecting and writing about the light (which I did the morning after working on those clips) and going back to check the adjustments I made the night before I got the idea to blur the clipped (brightest) part of the light to give it a more rounded and organic look. I think the idea came up at the point when I wrote about the light being shot out of focus. This made me think something like “if it’s already out of focus, why not apply some more blur?”. Since I was now finished with the ‘normalizing’-pass (accompanied by the making of a ‘creative grade’) I thought that this adjustment would be a good place to start with working on the secondary corrections.

### **5.2.5 Secondary corrections**

To make the light during the ending scene look less clipped I rounded off the edges by applying blur to only the brightest (clipped) part of the image; utilizing a secondary correction *luma-key*. How this affected the video signal can be seen in figure 11; where the peak of the video signal has gone from being flat to slightly rounded and more organic. After completing this correction I went back to the beginning of the timeline to start with the secondary corrections; applying adjustments to individual clips. My thinking when approaching the secondaries was to ask myself: what is important in this particular clip, and how can the overall lighting be improved to enhance the experience?

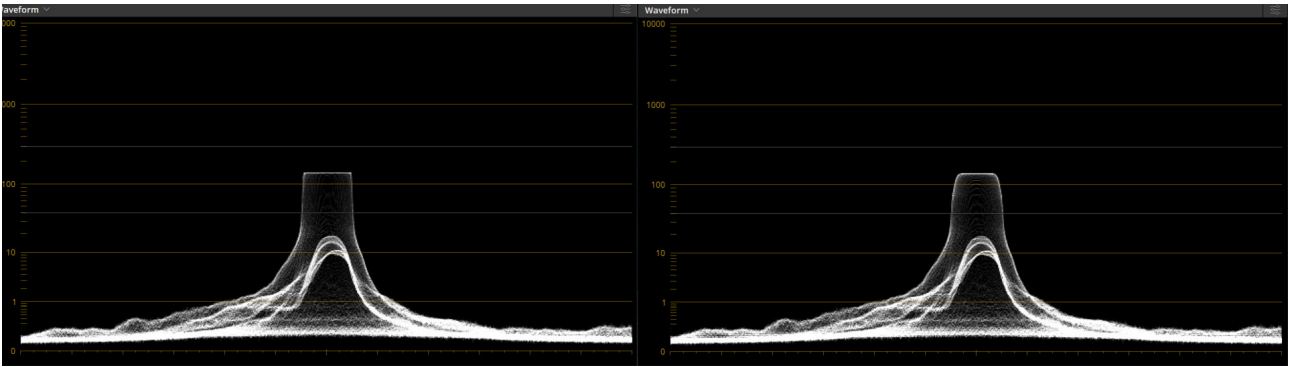


Figure 11: Before the secondary adjustment to the left, after the adjustment to the right.

### Reflective commentary

I have noticed that I tend to “instinctively” focus primarily on the brightness of the image to begin with, during secondary corrections; by isolating specific parts of a clip and making those brighter, darker, or have more / less contrast. This insight came when writing the above text and reflecting on my work, which have led me to embrace this approach by separating secondary adjustments into two passes; a brightness pass and a color pass. This means that I will go through all the clips twice; applying brightness corrections the first time and color corrections the second time.

Relating back to Table 1 in chapter 2.2 the objectives of this pass will be to create depth and guide the eye / emphasize what’s important in the scenes. During this pass only a few adjustments made



were HDR-specific; all relating to the small bonfire in the forrest, where the other adjustments would have been made very similar in an SDR grade. An example of this can be seen in figure 12 where a round shape was used to mask the part of the image containing the artist; to make him brighter, and also darkening the surroundings slightly.

Figure 12: Upper; before the secondary adjustments, lower; after the adjustments.

In figure 13 the lower part of the image was made darker, an overall vignette was applied and the brightness of (and around) the person walking was brought up slightly, as well as the moon.



Figure 13: Before the secondary adjustments to the left, after the adjustments to the right.

Even though the differences made in these images can be hard to distinguish here, hopefully, they might bring some clarity to the reader by complementing the written word. To really take advantage of HDR in the clips containing the bonfire I utilized a *luma-key* to affect only the fire, and raised the brightness to a point where I found that the fire felt more real (without overdoing it), which, in this case was 400 nits. I could have gone higher but I wanted to keep the overall feeling of darkness; which became more compromised with a brighter fire. One amazing thing with HDR (demonstrated by this example) is how I could make the fire bright and still maintain its colors. Besides adjusting the brightness of the fire, I also added a brightness falloff to the ground surrounding the fire, an overall vignette, and brightness to the main characters body and face.



Figure 14: Before the secondary adjustments to the left, after the adjustments to the right.

I did not find any adjustments to color that I wished to approach by utilizing secondary corrections, therefore, I was now done with color grading this short film, almost...



## 5.2.6 Managing graphics

Finally, the last section of this chapter will discuss graphics in HDR. Actually, although I didn't present it earlier in the text, during the 'normalizing' process I also adjusted the brightness of the intro graphics present in this short film. From consuming movies and tv-series in HDR I knew that bringing up the brightness levels above common SDR values was something often done in HDR. In SDR, the brightness of titles and credits per default sits at the maximum brightness of 100 nits (if they are white); since white is made up of all three RGB-channels being at their maximum 255 value. In this case, there was also a red burning logo (figure 15) during the intro graphics, displaying the title of the film. The title sparked my interest to also take advantage of the possibilities of HDR-grading in regards to graphics. The burning logo starts of fairly desaturated at a level of 60 nits, which gets lower as it turns red and ends up at 10 nits at full saturation. After my brightness adjustment the logo starts of at almost 300 nits and ends up at 60 nits after it has turned red. This brightness adjustment was done based solely on preference. At this time, I had no guidelines for how bright the white graphics should be, therefore, I had put the intro graphics (except the burning logo) at 350 nits by preference and left the closing titles untouched for the time being. Later, when researching the HDR standard Dolby Vision, I stumbled upon a video where Robbie Carman<sup>156</sup> explains that a maximum brightness level of around 200 nits for white text and graphics works well, which he says is also what the ITU BT.2408-0<sup>157</sup> guidelines recommends.



Figure 15: From the intro graphics of 'Livsgnistan'; a red burning movie title logo.

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<sup>156</sup> Dolby Laboratories. (n.d.). *Creating in Dolby Vision, Part 8: Source Footage & HDR Grading Workflows*. Retrieved May 1st 2019 from <https://www.dolby.com/us/en/professional/content-creation/tutorial-series.html>

<sup>157</sup> ITU. (2017, October 27). *Operational practices in HDR television production*. Retrieved May 1st 2019 from <https://www.itu.int/pub/R-REP-BT.2408>

Before re-adjusting the brightness of the graphics I had to fix a problem with the ‘creative grade’. Since I had made the ‘creative grade’ a timeline level adjustment it was also affecting the graphics; making white text a bit yellow. To solve this I copied the ‘creative grade’ to all the different groups, making it a ‘post-clip’ group adjustment and therefore no longer affecting the graphics. To be on the ‘safe side’ I lowered the brightness of the burning logo to reach a maximum of 200 nits, while at the same time maintaining the brightness of the latter red portion at 60 nits (where I had put it earlier). This was done by animating the key (opacity) of the brightness adjustment using keyframes. I then adjusted the brightness of the white intro graphics and closing credits to 200 nits.

This chapter has described how I chose to approach color grading in HDR, it has also presented the process of color grading a 13-minute short film. I found it interesting and fun to grade in HDR; with less limitations than SDR. Instead of bringing down the highlights to 100 nits or lower I could now expand them into the brighter realm of HDR, and at the same time keep bright objects saturated. With that said, after the technical specifics of HDR had been taken care of the color grading process was otherwise fairly similar to what I was used to from working in SDR. I don’t know if working in even higher brightness levels will introduce any further qualities to color grading other than those which I have experienced, and documented, or, if even higher brightness levels only would result in plain quantitative gains.

To widen the perspective of color grading in HDR even further, and to get the perspective of professionals in the industry; chapter 6 will present data generated from four interviews with colorists in Sweden.



# 6. Interviews

This chapter will present data generated from four interviews with colorists working in Sweden. As with the previous chapter, it is recommended to visit ‘HDR formats’ in the Appendix to get acquainted with relevant HDR-specific technical information before committing to this chapter.

## 6.1 Informant 1

I1 (Informant 1) has seen HDR content on trade shows, and has also done a test grade on a borrowed HDR-monitor, but has very limited experience of otherwise consuming HDR; consisting of watching some Netflix content on a HDR compatible TV-set in a colleague’s grading suite. I1 has explored the subject by viewing HDR-related videos by industry people on YouTube and by searching the internet for relevant information.

I1 thinks that HDR is here to stay and that it will arrive like a storm once it takes off. This will be due to the implementation of HDR by mobile phones and apps like Facebook and Instagram; where the advertising industry will pick up on this technology. Once that happens, I1 says, postproduction companies will have to invest in HDR compliant equipment in their grading suites. At the same time, I1 acknowledges a risk in that these social media platforms develops technology for automatic conversion from SDR to HDR, and if it looks good “then nobody will produce content in HDR”.

I1 says that HDR is going to be a different way of working, where the colorist will have to do several versions of a video; especially if it’s being delivered as Dolby Vision or HDR10+ with metadata to support different brightness levels. This work will take up extra time, and I1 thinks that the time available to do the work will be the same as before, since budgets will be the same as before. At the same time, I1 says that “every software update is a new tool, which makes everything faster”. As an example, I1 mentions the built in noise reduction tool in DaVinci Resolve, which speeds up the work, because after its introduction; the colorist no longer has to switch to another software to accomplish the same task. I1 believes that software updates and better algorithms for automatically creating different HDR-versions will make up time for the extra work needed to create multiple versions, which will eventually even out.

I1 says that it's the cinematographers who will be affected the most by HDR; because the lighting and shooting has to be made differently from today, "it's not just about exposing the camera differently, it is about how to construct the image in front of the camera". I1 explains that this means that before cinematographers have acquired the adequate experience, the colorist will have to "rescue what wasn't understood to be a problem at location", and gives an example of where Hollywood employs people who are experts in HDR to advise at location while shooting. I1 says that this also was the case with 3D in the beginning; "where a 3D-specialist said 'that's no good, do it like this instead'". I1 brings up an example of another colorist who has done three big budget Hollywood movies in HDR, all with the same cinematographer, and where the colorist claims that it is just now (after the third movie) that it's starting to feel like they understand what they are doing.

One thing I1 brings up which speaks against HDR is an EU-legislation regarding power consumption, "where a TV is only allowed to draw a specific amount of power per inch". I1 says that "now when we face a change where a TV all of a sudden is supposed to be 10 times brighter, this will mean that it has to draw more power". I1 relates this to when plasma technology was a thing, and where a plasma went from being a very good TV to all of a sudden after the next version become like "okay, what has happened now, it can't even be calibrated". I1 explains that this was due to similar legislations in California, where a plasma could draw too much power during bright scenes, which meant that the display had to be automatically dimmed to solve this. I1 explains that in the world of HDR, this is called *ABL* (Auto Brightness Limiting). Light Illusion<sup>158</sup> address ABL on their website as one of the "often overlooked potential issues with HDR [that] has to do with the (legal) need to limit the power requirement of the display [...] in an attempt to overcome extreme power requirements, just about all HDR displays use one form or another of ABL"<sup>159</sup>. I1 sees a risk that this will constrain the development of HDR.

Finally, I1 touches upon the subject of color management, and says:

One thing that will affect the colorist is that... I believe that, in HDR, it's better to work in ACES<sup>160</sup> or similar [...] I think it will be of big help to work in a color managed pipeline, when doing HDR.

-Informant 1

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<sup>158</sup> LightIllusion. (n.d.)

<sup>159</sup> Ibid.

<sup>160</sup> *ACES is short for 'Academy Color Encoding System'.*

## 6.2 Informant 2

There's actually not an awful lot to [learn] in terms of... I mean grading is grading, [...] it's actually much more about, I would say less about the grading and then more about understanding pipelines actually... and color spaces.

-Informant 2

I2 has experience from working with one (currently ongoing) HDR-project. I2 has no HDR compatible TV-set at home and explains that most of the experience of seeing HDR-video comes from working on that project. I2 thinks that HDR is “the most exciting thing to happen in a TV in a very long time, much more so than 3D or any of the other things that has kind of come and gone”.

I2 explains that “we've never had a standard for brightness before”, where the only standard has been regarding the Rec.709 color gamut, which is based on the limitations of old CRT TVs. I2 explains that there are industry ‘norms’ though, relating to brightness, which colorists follow when they grade in SDR.<sup>161</sup> I2 says that in a way; HDR is about “standards catching up with technology, because television sets have been capable of being much brighter than 100 nits for a very long time, and they've been capable of colors that are much wider than Rec.709 for a very long time”. I2 says that HDR takes advantage of these aspects, “which makes for a much more immersive image”.

I2 gives an example of how HDR can be used for dramatic purposes:

The bad guy goes into the room with a flashlight, the flashlight shines into the camera, when you do that at 100 nits it would just be a white screen. When you do it in HDR, it's almost impossible to look at full white from HDR, it's very uncomfortable when you fill the screen with it, which is the sensation you might want to give people for half a second.

-Informant 2

I2 mentions that HDR also has the ability to display “very high luminance, highly saturated things like neon lights” which would “never look very real in SDR”. This is because of the combination of higher brightness levels and a wider color gamut; which means that it's “in some cases the combination of those two things together that give you something that you didn't have in SDR before”.

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<sup>161</sup> I2 defines these ‘norms’ relating to brightness as 100 nits with a gamma curve of 2.2 to 2.4.

Another difference to SDR, where a lot of time is spent rescuing and “faking back in detail that would have been blown-out” because of the very limited dynamic range,<sup>162</sup> is that in HDR “almost nothing needs to be rescued and everything just looks good”. I2 explains that this can give the colorist a little bit more time to spend on the creative side; “building looks and trying different things”. But in HDR, it can also be the other way round, problems can occur when footage wasn’t shot for HDR, or monitored in HDR on set. I2 says that “what you always want to do as a colorist off course is to draw peoples attention to the part of the frame they should be looking at”. This can become a problem when objects in an image are much brighter than the actors; where in SDR the latitude is very limited and for example a light will clip before becoming overpowering. I2 mentions a scene with a Christmas tree, which was shot for SDR and when later turned into HDR “you just end up looking at the Christmas tree” with “enormously bright lights”, not the actress sitting beside it. I2 explains that in a situation where the colorist is “mastering older material for HDR you would now need to deliberately clip the lights on the tree, so you’re kind of going the other way, you’re not rescuing detail, you’re deliberately getting rid of it because it’s overpowering”. To avoid these situations in an HDR-production, I2 says that “a consideration that apply maybe a little bit more to cinematographers, but obviously, [...] you should – and you need to monitor in HDR on set when you’re shooting”. Contrary to what I1 said, I2 doesn’t think HDR will require specialized personnel on set, as when recording in 3D, “HDR, again, is just an extension of something that we do already, 3D is a totally new art, HDR is just extending the existing... [...] shooting and grading”.

I2 says that “the necessity of doing versioning is... it’s not a new thing”, and explains that in Sweden “they don’t want to, usually, pay for separate versions” for TV and cinema; where the colorist instead “applies a basic transform”. I2 says that “if you really want to do it properly, you should do a theatrical version and a TV-version, you should have an extra day of grade to actually go through the TV-version, after doing the theatrical version”. I2 states that “with HDR you can’t get around it”, and explains that there are automatic transformations to go from HDR to SDR, “but it rarely looks as good, compared to when someone takes the time to do a separate Rec.709 pass”. This is where color management becomes important, or as I2 puts it; “working in *scene referred* color spaces”:

So basically you have a very wide color space that all the cameras can be transferred into, which you can transfer out to – into any color space like SDR, like Rec.709 or P3 or Rec.2020 or whatever, and that is one of

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<sup>162</sup> I2 explains that 14 stops of captured dynamic range has to be squeezed into 6-7 stops in SDR.

the things that makes it very easy to do versioning. [...] In many ways it's no different from when you do a theatrical pass [...] so you can do you DCI-P3 theatrical version [...] and then you'll do a TV, you know Rec. 709 trim pass from that.

-Informant 2

I2 says that HDR probably “will be the thing that creates the gap again, between... facilities or setups that have bigger investment levels, and smaller sort of freelancers”. I2 draws a parallel from color grading in general and DaVinci Resolve in particular to what happened to sound 20 years ago “when software became very cheap and everyone could have a go at it”. I2 thinks that HDR will bring back a little more of a divide “simply in terms of equipment and support”, at least for the time being.

### **6.3 Informant 3**

I3 has no experience in consuming HDR, and has no HDR compatible TV-set at home, but has seen HDR content at trade shows, and has also read up on the subject to keep up to date as a colorist, but hasn't yet got any requests of doing HDR. I3 thinks that HDR is a really good thing but at the same time fears that the image won't look as intended by the filmmakers once it reaches the consumer. This is because of how people tend to have the wrong settings in their TVs, which I3 says is a problem today, even with only one standard, and explains that it will be even more problematic with several standards and different brightness levels. I3 doesn't think that the average consumer will join “the HDR-train” anytime soon, but says that HDR will “become something” in the long term, more so than 3D, “which was more of a ploy”.

I3 sees an opportunity to finally not have to force all the dynamic range captured by the camera into the more limited dynamic range of SDR, which I3 hopes will result in less compromises. I3 explains that “a very big part of it has to do with what the cinematographer does”, and states that a lot has to do with collaboration, and that it becomes “more and more important to start collaborating earlier”. Instead of the colorist becoming involved just at the end of a production, I3 would like the colorist to be “someone who's important during the entire [production] chain”.

I3 mentions that there needs to be larger budgets to make several versions, both HDR and SDR:

I mean, if one gets between five and ten days for a full length movie, which is the most common here [in Sweden], and they complain because they think it's expensive, then it's going to be very difficult to say 'okay, but we need two or three days extra to also make a regular SDR version'.

-Informant 3

I3 expresses a pessimism in that colorists won't get extra time to do multiple versions, and will have to complete them in the same time as before, because "it will simply lack the funds to do so". As I2 also stated, I3 explains that even though movies are delivered in multiple versions today, DCI-P3 for cinema and Rec.709 for TV, "in most cases the full length movies I have done have been done with one grade". I3 explains that the single grade is later transformed into both versions, which "often times works really well". I3 is worried that colorists will have to do both an HDR and SDR-version in the same amount of time as before.

Another thing I3 thinks will take up extra time in the grading suite when starting to work in HDR is that "it's not only a learning curve for me as a colorist, but also the cinematographer will have to learn and know what can be done with their images". I3 explains that one thing which talks against HDR in Swedish movies is the fact that these often have both low brightness and low saturation. I3 says that "many cinematographers doesn't tend to like highlights", and explains that "several movies I worked on never reach over 60-70% in brightness". I3 thinks that the cinematographers has to get educated, and that "they need to find this interesting and want to learn it".

I3 also mentions a workflow problem where "people become so very used to watching *log*-footage while editing because they don't utilize any real color management, they don't apply any LUTs". This affects decisions during grading which results in a "flat and boring" looking image. I3 says that even if the photographer would like some more contrast, the director is so used to watching *log*-footage in the editing suite for two months, and therefore says no, which can result in a boring look.

I3 thinks HDR is good from a competitive standpoint, where those who are ready to invest will have an advantage. This will also have the effect of creating a more distinguished segmentation of the market:

15-20 years ago, there were post-houses with expensive gear, and then there were the hobby-fixers. Today, this [divide] has become much more narrow and the difference between the hobby-fixers and us... we use more or less the same gear [...] if one has HDR-equipment then it will all of a sudden be a competitive advantage.

-Informant 3

## 6.4 Informant 4

People say that it's at 3000 nits it [HDR] becomes a thing. At 1000 nits it's a bit, well, it's a bit fun, but when it becomes... when it's a lot brighter then that it can really make for an experience.

-Informant 4

I4 has borrowed a 1000 nits monitor and done some tests with grading HDR on it, but points out that “these were just small tests, not hired jobs”. I4 has a HDR compatible TV-set at home and has consumed some HDR content on it through Netflix. I4 says that when watching the series *Mindhunter* it looked better in SDR, because “the highlights were clipped” when watching the HDR-version on that particular TV.

I4 is enthusiastic about HDR and sees that a lot of current problems colorists encounters when working in SDR regarding both saturation and contrast won't be problems anymore. I4 explains that the color red is a big problem in SDR and Rec.709 because “it clips quite fast”, and explains that it will be possible to “work more with what the camera has captured”, also in that the whole dynamic range of the camera can be displayed on a TV, without having to be compressed to a very narrow dynamic range, as with SDR. Another benefit of HDR I4 mentions is the ability to make “bright and super-saturated” images. I4 explains that to make an image very saturated in SDR it has to be dark, and finds HDR fun because of less limitations.

I4 says that there will be a lot more time spent on doing different versions, both in different brightness levels for HDR, and also an SDR-version, but that the budget won't be bigger, “not in Sweden anyways”. The solution for this, according to I4, is to work faster; “doing less details [...] and fewer feedback-rounds”. I4 mentions that another solution which the color grading software BaseLight is starting to implement more of are target-specific primary tools; which doesn't affect the whole image as much as regular primary tools, without the need to use keys or shapes:

What's bothersome and takes time is to key things, or make windows, so tools which can affect something specific which you want to change, I don't know how to explain it... [...] that you can be more... working on the whole image but still be precise, you know, because then you can work much faster. [...] Some projects will surely have more time and have thought it [the versioning] through, but I believe that most [projects] will result in more to do in the same amount of time.

-Informant 4

I4 thinks that working in a color managed workflow can make it easier when making different versions; “you can watch it in 100 nits and 1000 nits, you can change your output and it will do all the calculations for you”. But I4 doesn’t like how it is to grade in a color managed workflow; where the software performs the ‘normalizing’-process, and the starting point becomes an already expanded image, instead of the original flat looking *log*-image:

With *log*, or when I work as usual I try to bring out the contrast and color, while in color managed you already have a whole bunch of color and contrast which has to be brought down, so the whole way of working becomes reversed.

-Informant 4

I4 thinks that clients will be disappointed with SDR-grades, and that it will be difficult to get them approved “after a whole day, or maybe two weeks” of grading and seeing the HDR-version:

I think that people have huge problems with getting [SDR-versions] approved by clients after having done a HDR-version, when everybody is really happy and ‘okay, now it’s time to work the last day in SDR’ and they become really disappointed because it lacks the color and brightness.

-Informant 4

A solution to this which I4 talks about is to treat the SDR and HDR-versions as completely separate looks. This was also discussed at a panel at the trade show NAB recently where Van Hurkman<sup>163</sup> stated that “I feel like Dolby Vision is fantastic for managing multiple nit-levels in the HDR-range, going all the way down to SDR, everyone I’ve talked to has had the same experience I have where it’s... you know, it’s a big ask”. Medellín<sup>164</sup> agrees on this and also says that this is a budget related question, and that it’s not always possible to treat the SDR-version as a completely separate grade.

Lastly, I4 wishes for HDR to be one standard, with one nit value “and that’s it”, and thinks it’s “very vague and pretty annoying”, and says that “you won’t know what people sees, you will never have a chance to know exactly what people look at... a bit like now but three times worse [...] the feeling will be the same and it will be pretty much the same thing, but now the variables are bigger”. I4 ends with saying that HDR will become a norm, and that the idea is super-good, “but the dream for me would be one standard, like HDR 1000 nits, and then it’s decided, but that will never happen”.

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<sup>163</sup> Van Hurkman, Alexis, et al. [CineTechGeek]. (2019, April 29). *What are the Best Ways to Manage Color for HDR and Multiple Deliverables - NAB2019* [video]. Retrieved from <https://www.youtube.com/watch?v=Ws5fopAIH5U>

<sup>164</sup> Ibid.



# 7. Analysis

This chapter will use the research questions as an outset to relate back to the data presented in chapter 5 and 6. The first section will utilize a more general approach, and can be seen as an introduction to this chapter, while the three remaining sections will proceed from the theoretical framework presented in chapter 3.

## 7.1 General evaluation

This section will address the research question of ‘How can color grading in HDR be approached?’ and also discuss common themes discovered during both the production, and from the performed interviews.

One of the early findings of this study was that to do professional work in HDR, it requires investing in expensive equipment; specifically a HDR reference monitor. For this study, this was solved by instead utilizing a consumer TV-set with HDR capabilities. All four informants mentioned that a HDR reference monitor would be a big investment for them, or the companies they work at. Both I2 (informant 2) and I3 said that because of this, the market will become more segmented between those who can make this expensive investment, and those who can't. On the contrary, colorist Dado Valentic<sup>165</sup> makes the case for grading on a HDR-compliant TV (though it seems to be a more expensive model he refers to). It should be mentioned that he also has a \$30,000 HDR reference monitor on the side for critical viewing. Regarding color grading on a consumer TV-set I3 said that “sure, it can be done, but how do you know that it's calibrated, and that it can hold the calibration over time?”. Valentic<sup>166</sup> explains that the reason for working primarily on the TV (with the reference monitor on the side) is because of its size; since the reference monitor is smaller<sup>167</sup> it becomes “a little bit crowded” around the colorist with a lot of people watching the monitor.

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<sup>165</sup> Valentic, Dado. [FlatpanelsHD]. (2019, February 22). *How Hollywood movies are color graded for HDR & SDR (w/ Dado Valentic)* [video]. Retrieved May 11th 2019 from <https://www.youtube.com/watch?v=jDtnmvkNW3I>

<sup>166</sup> Ibid.

<sup>167</sup> *The reference monitor measure 30" whereas the TV measure 65" in diameter.*

One thing several of the informants mentioned, which I also experienced when color grading in HDR, was that the wide dynamic range captured no longer had to be forced into the narrow confinements of SDR. Van Hurkman<sup>168</sup> also acknowledge this by saying that “grading SDR, when you get, you know, high latitude media, has always been a process of manually tone-mapping HDR to SDR”. This is something I2 said colorists “spend a lot of time doing”. My experience from grading the short film in HDR is that rather than trying to bring down the highlights and prevent them from clipping, I instead used basically the same tools but the other way around; to boost the highlights further into the realm above 100 nits. I3 said that colorists will have to learn “how much one should have over 100 nits”. I3 also mentioned the fact that ‘muted’ grades are common (at least in Swedish tv-series and movies), where brightness levels might not exceed 60-70%. This was something I also experienced as a challenge when starting out with grading in HDR. I’m used to keeping the overall brightness levels down when grading in SDR, which also contributes to a certain mood, and to brighten up the image felt instinctively wrong.

Another reason for keeping down the overall brightness in SDR is to be able to bring up the overall saturation, or object specific saturation (for example the sky). It has become evident during this study that HDR holds less limitations in this regard, something both I2 and I4 also brought up during the interviews.

A difference of view between the informants was regarding how much they thought HDR will affect the work of cinematographers. I1 said that cinematographers will be very much affected by HDR, and will have to adjust how they “construct the image in front of the camera”. I2 said that it will be very important to monitor in HDR on set to make sure that the brightness levels works in HDR, but other than that, there isn’t much more to it. I4 mentioned that “10-year old movies can be re-mastered in HDR, it doesn’t matter”.

During the process of color grading the short film I had no problem with the footage except on a few occasions where the brightest point in the image had been clipped, even though the movie was shot for SDR. This might be something which differs on a case by case basis, depending on the footage. With my (although limited) experience, it seems that an overall well-exposed image with good highlight detail is a sufficient starting point for color grading in HDR.

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<sup>168</sup> Van Hurkman, Alexis, et al. [CineTechGeek]. (2019, April 29)

## 7.2 HDR in relation to Modality

This section will address the research question ‘What effect can HDR have on visual modality?’ by discussing HDR in relation to the eight modality markers for *visual modality*<sup>169</sup> presented in section 3.1. While decisions on set, and later in postproduction, dictates the outcome of the final image; the focus here lies with the specific possibilities of HDR, and its relation to visual modality.

1. The first modality marker *color saturation* relates to HDR in specific scenarios. A useful way to approach an answer to how *saturation* can affect modality is to ask ‘in what cases can saturation in SDR fall short?’. As discussed in chapter 2.3.1, which also has become evident in chapter 5 and 6; HDR has a great advantage over SDR in the case of allowing saturation in elements with high brightness. The two main scenarios which have been put forward as examples in this study are the case with a bright blue sky, and also yellow fire. In this regard; HDR offers a wider range of modality expressions than SDR, with the possibility for higher naturalistic modality.

2. The second modality marker, *color differentiation*, concerns the available range of colors; from monochrome to a maximally diversified range of colors. This relates not to HDR in general, but to its combination with a wide color gamut, for example P3-D65; which encompass richer hues than Rec.709. In this regard, HDR has a wider range of modality expressions than SDR.

3. The third modality marker, also relating to color, is *color modulation*. This marker is about the extent of nuances from flat unmodulated color to fine nuances, of a given color. Quantization (or bit-depth) is the deciding factor when it comes to nuances; as it dictates how fine the digital steps are. Bit-depth also has an indirect relationship to HDR, where (as presented in the ‘Appendix’) the PQ curve needs a bit-depth of 10-bits at minimum, which is higher than the common 8-bit quantization of SDR. It’s important to point out that SDR also can be delivered with a higher bit-depth. Since half of the bits in HDR<sup>170</sup> sits in the 100 nits range (and the other half between 100 and 10’000 nits) it means that a 10-bit signal will have a twice as fine gradation in SDR than in HDR. Informant 3 said that in HDR “I think it would be good to have 12-bits”, and pointed out that while the PQ-curve is more adapted to human vision than regular gamma curves, in 10-bit; it’s still half as many steps (in the 100 nit range), compared to SDR in 10-bit. To conclude; images with higher bit-

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<sup>169</sup> Kress, G. & van Leeuwen, T. (2006)

<sup>170</sup> HDR with a PQ-curve, see the Appendix for more information.

depth sits higher on the naturalistic *color differentiation* modality scale; compared to those with the same EOTF<sup>171</sup>. Comparing the same bit-depth value between HDR and SDR has proven to be more problematic; where SDR has twice as many steps in the 100 nit range, but those steps are utilized differently than those in HDR. It should also be noted that Dolby Vision utilize a 12-bit signal.

4. *Contextualization* relates to the context, or background, visible in an image. This scale goes from a white or black background – to out-of-focus – to a background with maximum sharpness and detail. It's difficult to see how this relates to HDR, and should mostly relate to artistic decisions made primarily on set. Though, technologies, and HDR, can influence filmmakers in their decision-making. One example could be that the cinematographer potentially would want to preserve more highlight detail in HDR, and by doing so, not clipping windows. This would mean that instead of white windows, the viewer will see an out-of-focus background or background with sharpness and detail, within the confines of that particular window. Again, this is an artistic decision, where the technology of HDR might prove be influential; resulting in a different *contextualization* modality.

5. *Representation* goes from maximum abstraction to maximum pictorial detail and runs from the simplest line drawing to the sharpest and most finely grained photograph, which relates to spatial resolution. It could be argued that HDR and 4K goes together in some sense, for example; HDR movies sold on Blu-Ray discs implement a UHD/4K-resolution. The HDR standards discussed in this master thesis works in other spatial resolutions as well, and 4K still exists without HDR technologies. Another variable in digital video which can be influential here is video compression, which is outside the scope of this thesis. If an image becomes 'too detailed' it can enter the realm of sensory modality; which depends on the dominant imaging technology for representing naturalism.

6. The modality marker *depth* goes from the absence of any representation of depth to a maximally deep perspective. When discussing depth in terms of technology, 3D is what first comes to mind. Even so, there have been a couple examples of where the added brightness of HDR in combination with deep black creates a contrast which also can make the viewer perceive more depth. These examples are presented in chapter 2.3.2 and 5.1.2. Therefore, HDR could potentially affect this marker to be of higher naturalistic and sensory modality. Even if this doesn't hold true, it's hard to see that it would go the other way; resulting in a lower range of modality expressions than SDR.

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<sup>171</sup> See the Appendix for more information.

7. The scale *illumination* goes from the absence of the play of light and shadow to its fullest representation. This modality marker relates directly to HDR; meaning that with higher brightness and contrast; the higher up on a naturalistic *illumination* scale it will be. This is a modality marker where HDR clearly differentiate itself from SDR; by extending beyond the realm 100 nits.

8. Lastly, *brightness* goes from two brightness values to the maximum number of different brightness values. In relation to technology, this is basically the same modality marker as *color modulation*, which also relates to quantization (bit-depth), but in a desaturated representation. The same argument is therefore also valid here; bit-depth has an indirect relationship to HDR, where (as presented in the Appendix) the PQ curve needs a bit-depth of 10-bits at minimum, which is higher than the common 8-bit quantization of SDR. Imagery with higher bit-depth has a higher naturalistic *brightness* modality. See modality marker 3 for a more extensive discussion about bit-depth.

Modality marker	Explanation
<i>color saturation</i>	Relates to color volume, and the ability to maintain saturation in bright objects
<i>color differentiation</i>	Relates to color gamut, and the reach and richness of its hues
<i>color modulation</i>	Relates to the quantization (bit-depth) in a saturated representation
<i>contextualization</i>	Relates to the ability to see the background, or surroundings of an image
<i>representation</i>	Relates to spatial resolution, for example HD and UHD/4K
<i>depth</i>	Relates to perspective, but can also be related to technology, for example 3D
<i>illumination</i>	Relates to the brightness and contrast of an image, directly linked to HDR
<i>brightness</i>	Relates to the quantization (bit-depth) in a desaturated representation
<i>temporality</i>	Relates to temporal resolution, or FPS (frames per second)

Table 2: Visual modality markers and how they relate to digital video technology.

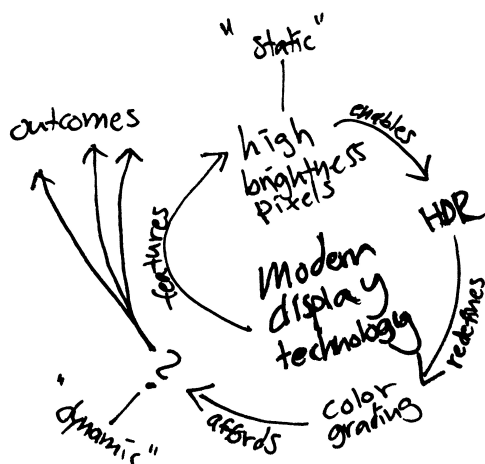
Table 2 summarizes the relationship between visual modality and digital video technology. In relation to moving pictures, the modality markers presented by Kress and van Leeuwen isn't really complete. Temporal resolution is the foundation for moving images, therefore, the modality marker *temporality* was added to the table, even though it isn't linked to HDR. This marker goes from a very low frame rate, like a picture slide show, to a fast frame rate; which in contemporary cinema could be for example 48fps. Because 24fps is the current norm in movies, once that frame rate is exceeded *temporality* starts to move from naturalism to sensory modality.

## 7.3 The Affordances of HDR

Before presenting what specific affordances HDR can offer the colorist, the theory of affordance will first be revisited briefly. Figure 16 is an attempt to illustrate the conditions for the relationship between the technology and the colorist, which results in certain affordances and outcomes.<sup>172</sup> Starting in the middle of the figure; the *object* of modern display technologies - which *features* high brightness pixels - enables the *function* of HDR, that (to a certain extent) redefines the act of color grading. The specific *affordances* and *outcomes* of color grading in HDR is the result of the colorist's interaction with the technology. Relating back to chapter 3.2; the feature of an object was defined by it being static,<sup>173</sup> which in this case means that even if display technology develops and pixel brightness change, it's static at the time of color grading on a particular monitor, whereas the affordances can vary (the colorist being the variable) and therefore being dynamic. Keeping this in mind is important when specifying the affordances; to make sure that these really are inherently dynamic, and emerging from the interaction between the technology and the user.

HDR is a function of high brightness pixels, a feature which can support several functions. Take modern mobile phones for example; the main function of high brightness pixels in a phone is high brightness output. When a human interacts with the phone it affords *high visibility*, even in bright surroundings; when the brightness is increased by the user or the device itself. The same device could also potentially support HDR, since it has the basic feature required for it.

Another feature of modern display technology is that the pixels can display rich hues. The function of this is support of a wide color gamut; for example DCI-P3, and its specified hues. For



the colorist this relates to the affordance of *color expandability* in a two-dimensional sense. Going back to the feature of high brightness pixels, the function of HDR then builds upon this and affords *color expandability* in a volumetric sense; attaining brighter colors than before. This can for example result in a bright blue sky or bright yellow fire as outcomes. Table 3 provides a list of the HDR-related affordances which has been observed through this study.

Figure 16: Conditions for the relationship between technology and the colorist.

<sup>172</sup> Evans, S. K., Pearce, K. E., Vitak, J. & Treem, J. W. (2017)

<sup>173</sup> Ibid.

Affordance	Explanation
<i>Color expandability</i>	The ability to display bright colors (and/or richer hues)
<i>Highlight differentiability</i>	The ability to distinguish between different areas of highlights
<i>Tonal rangeability</i>	The ability to set different brightness ranges of individual scenes
<i>Brightness disturbability</i>	The ability to make an image so bright that it disturbs the viewer

Table 3: The affordances HDR offers the colorist, presented in this thesis.

These affordances (which HDR offers the colorist) are relevant to discuss in the context of a colorist’s creative space.

## 7.4 HDR and Creative Space

This section will relate to how HDR can influence a professional workflow, and how HDR can affect the colorist’s ability to perform creative work. The concept ‘creative space’ is made up by three dimensions.<sup>174</sup> The dimension *digital information available for processing* relates primarily to video compression and codecs, which is outside the scope of this study. Therefore, this dimension won’t be discussed any further.

The dimension *expressive potential* is limited by *tool capacity* and *user skill*. According to Shaw<sup>175</sup>, HDR “is a new toolkit”, which, as presented in chapter 7.3; provides a different set of affordances for the colorist than SDR, “extending the existing” as I2 put it. HDR therefore grows the *expressive potential* and creative space of the colorist. To realize the greater *expressive potential* provided by the capacity of a new tool; the colorist must have the required *user skill*. The colorist must also have time to spend on creative work, which was a concern made explicit by the informants.

*Time to spend on creative work* is in a professional context directly related to the budget of a production. The relationship between budget and this dimension is exemplified by I1’s statement; “I won’t get more money for it, which means that I won’t be able to put in more time”. This statement was made in the context of the need to deliver multiple versions because of HDR. I3 said that “moreover, I sit at the end of the chain, which means that the money is always spent when it’s time for post[production]”. I3 explained that this makes it difficult to acquire extra time.

<sup>174</sup> Swenberg, T. & Eriksson, P.E. (2012)

<sup>175</sup> Petok, J. & Shaw, K. [Colorist Podcast]. (2016, July 11)

The need to create multiple versions is something all four informant talked about, which can regard both multiple HDR-versions with different brightness levels, and also the creation of a separate SDR-version. I2 and I3 explained that even today, they deliver different versions for cinema and television, but most of the time these are derived from one grade; where the different versions are generated by an automatic transform function. I3 said that this automatic transform “often times works really well”, and according to I2 “most people seem to be happy enough” with the results. With HDR, the supposition is different in that “you can’t get around it”, as I2 put it. I1 expressed a belief that there will be future algorithms which can automatically generate different versions better than today, “which should not need manual processing”. A solution to handle this situation today, where time needs to be spent on creating multiple versions, according to I4, is “to work faster”, which means “doing less details [...] and fewer feedback-rounds”. Both I1 and I4 has a belief in that future tools will help to make up time, in that they speed up the grading process.

Something all informants mentioned is that when working in SDR, colorists spend a lot of time “faking back in detail that would have been blown-out”, as I2 explained. With less limitations in HDR, I4 anticipate that there will be less time spent on such problem solving and less time making the image *broadcast safe*. At the same time, new problems might arise if the cinematographer doesn’t light for HDR on set, as I3 said “things might show up in HDR which hasn’t been visible in SDR, that hasn’t been noticed and could have been hidden easier”. I2 gave the example where a Christmas tree became too bright in HDR (compared to the actress sitting beside it), which wasn’t a problem in SDR, and that the colorist would have to “deliberately getting rid of [detail] because it’s overpowering”. I3 also pointed out that it might take longer in the grading suite when working in HDR in the beginning, since “it’s not only a learning curve for me as a colorist, but the cinematographer will have to learn and know what can be done with their images”.

To summarize, the need to (more or less) manually create multiple versions in the same amount of time as today will mean that colorists will have less time to work on creative details. New tools and better automatic processing might help in this manner. HDR imposes less technical constraints on the colorist, which might also free up time that previously was spent on forcing wide-latitude media into the more narrow confinements of SDR. At the same time, new problems might arise that will need the colorist’s attention.



## 8. Discussion and conclusion

The ambition with this master thesis is to contribute knowledge about the technology of HDR, and how it might affect colorists working in the motion picture industry. This study confirms that the knowledge about HDR still is in an early state, at least amongst colorists in Sweden. This probably holds true for other countries with similar markets as well.

None of the four colorists interviewed for this study had any extensive experience of consuming HDR content, whereas I have seen several tv-series and movies in HDR. One of the colorists was currently working on its first HDR-production, while two had done some tests on borrowed equipment, and one had none of this experience. These actualities have, with great certainty, affected the results of this study. The outcomes from the interviews are directly related to both the researchers experience and understanding of the subject; which is reflected both in the interview topics and follow-up questions. The informants themselves have also affected the focus of the interviews to some extent; by influencing the direction of the conversations.

Mann<sup>176</sup> writes that reflexivity in qualitative interviewing “is a crucial element of ensuring quality”. As a researcher, I have limited experience in the craft of performing semistructured interviews; which I also did with four subjects during my bachelors degree. I would argue that my insights and understanding of the colorist profession and color grading affects this study in a positive manner; contributing to a higher empirical quality, which might even out my limited experience as a interviewer. The risk for personal bias in that I’m personally enthusiastic about HDR was dealt with by asking open questions<sup>177</sup> with no standardized response options.

Something which has become evident from this fact is the different outsets between me as a researcher, and the professionals. While I have a personal interest mostly in the experience of HDR, and also creative side of it, the colorists seemed more interested to primarily discuss implications to workflow, and how HDR might affect their professional life. This difference in outset has been very beneficial to this study. Doing my own production combined with insights from professionals contributes to a wide perspective, and provides a rich and deep understanding of the subject, more so than any of those two sets of data would be able to accomplish on their own.

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<sup>176</sup> Mann, Steve. (2016:x)

<sup>177</sup> Trost, Jan. (2010:40). *Kvalitativa intervjuer*. Lund: Studentlitteratur.

While this study was limited to working with one production and performing four interviews, it contributes with a fundamental understanding of the subject which future research can use to further build on. Hopefully, this master thesis might inspire to future research on the subject of HDR.

## **8.1 Future work**

Since HDR is a fairly new technology, further case-specific observations and interviews are needed to gain knowledge about how this technology affects production processes, as well as artistic decisions. Research into viewing experience is another area where future researchers can contribute with academic knowledge about the social implications of HDR.

Informant 1 mentioned that legislation regarding power consumption might constrain the progress of HDR. Can the imposed legislation have a limiting effect on TV-sets being produced and sold, or is it mainly the technology itself which limits the progress of the HDR experience at the consumer side? This subject will need further research to be better understood.

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# Appendix

This section contains information about HDR formats and corresponding specifications.

## HDR formats

This section will address two of the current main formats used for the delivery and playback of HDR video; Dolby Vision and HDR10/HDR10+. There are other formats available, for example; HLG (Hybrid Log-Gamma), which was “specifically developed for television by the BBC and Japanese broadcaster NHK”<sup>178</sup>. Since the focus of this master thesis is on HDR in relation to the colorist working in motion picture (and not live broadcast), HLG won’t be discussed any further. Technicolor also has three different HDR formats, but these have so far seen limited implementation and is not yet supported by DaVinci Resolve (the software utilized in this study); which currently supports Dolby Vision, HDR10/HDR10+ and HLG.<sup>179</sup>

## SMPTE ST.2084

Before diving into the two formats of Dolby Vision and HDR10/HDR10+ it’s important to get familiar with the ST.2084 standard published by SMPTE (Society of Motion Picture & Television Engineers). This standard ratifies the PQ (perceptual quantizer) EOTF (electro-optical transfer function) developed by Dolby; which allows for a peak luminance of up to 10,000 nits, and requires a signal with a bit depth of at least 10-bits.<sup>180</sup> This transfer function is developed in relation to how the human visual system interprets the world, which occur in a non-linear fashion.<sup>181</sup> As an example; this means that in a room lit by 50 candles we perceive the change of doubling the amount of candles to 100 as equally large of a step as removing half the candles to 25 (an adjustment usually referred to as the measure *stops*), and therefore, being more sensitive to low light.<sup>182</sup>

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<sup>178</sup> BBC. (n.d). *High Dynamic Range Television and Hybrid Log-Gamma*. Retrieved March 7th 2019 from <https://www.bbc.co.uk/rd/projects/high-dynamic-range>

<sup>179</sup> Blackmagic Design. (2018:186)

<sup>180</sup> Ibid. (2018:195)

<sup>181</sup> Eilertsen, Gabriel. (2018:7). *The high dynamic range imaging pipeline: Tone-mapping, distribution, and single-exposure reconstruction*. Diss. Institutionen för teknik och naturvetenskap, Linköpings universitet, Tekniska fakulteten, & Medie- och Informationsteknik. Linköping: LiU-Tryck.

<sup>182</sup> Siragusano, Daniele. [FilmLight]. (2018, October 31). *International Cinematography Days 2018, Stuttgart: Colour Management* [video]. Retrieved from <https://vimeo.com/298129056>

“When conventional EOTFs are stretched beyond a few hundred nits, even with a 10-bit signal, they start to produce image contouring, due to the inefficient way they use bits relative to the human visual system. [...] Since SMPTE ST2084 corresponds closely to the human perceptual model, it makes the most efficient use of signal bits throughout the entire luminance range. [...] Half of the HDR codes are in the SDR range, meaning that 10-bit HDR doubles the number of code values in the SDR range, compared to traditional 8-bit video.”<sup>183</sup>

An EOTF can be described as “a function that determines the transition of [a] video signal from black to white”.<sup>184</sup> In the SDR world this function is referred to as gamma; “which performs a non-linear correction of the linear luminance  $L$  in order to generate the final *luma* value  $l$  that should be encoded and sent to the display.”<sup>185</sup> Different transfer functions also impacts the colorist:

I feel like when I take that R3D or that Arri raw or that Sony raw file or whatever and I place it into PQ, I'm just like; oh yeah this is easy, and I know this sounds kind of funny, but grading actually becomes way easier, it literary does, you just look at this and go; ah yeah thats good [...] We have been forcing contrast and perceived contrast and color into things for so long, right, thats really the basis of what we use windows and keys and all that kind of stuff for, is that we're trying to fake stuff that's not really there, it's always been a compromise [...] We got this huge wide dynamic range thing that a camera shoots and putting it down a small pipe. When you start grading in PQ you realize, like, no it's actually all there; I'm not clipping anything, I'm not making any sacrifices, or a very few sacrifices.<sup>186</sup>

-Robbie Carman

## HDR Metadata

A difference (also mentioned in chapter 5.2) between SDR and HDR EOTF's are their relative vs absolute nature. The actual output brightness of a bit value in SDR will vary depending on the display and its settings, while in HDR (PQ) a bit value refers to a specific brightness level output. The problem with the absolute approach is the different specifications between the consumer TVs and professional grading monitors regarding color gamut coverage and especially peak brightness, this is where the metadata comes in.<sup>187</sup> Metadata “conveys the color volume of the mastering display and the luminance of the content [...] described by the chromaticity of the red, green, and blue display primaries and white point of the mastering display, plus its black level and peak

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<sup>183</sup> Schulte, T. & Barsotti, J. (2016:4)

<sup>184</sup> CalMAN Resource Center. (2019, April 2). *BT.1886 - 10 Questions, 10 Answers*. Retrieved April 8th 2019 from <https://calmankb.groovehq.com/help/bt-1886-10-questions-10-answers>

<sup>185</sup> Eilertsen, Gabriel. (2018:7)

<sup>186</sup> Carman, R., Inhofer, P. & Moran, D. [MixingLight]. (2018, January 14). *MailBag Ep:41 Talking About Dolby Vision* [podcast]. Retrieved March 5th 2019 from <https://mixinglight.com/color-tutorial/talking-about-dolby-vision/>

<sup>187</sup> LightIllusion. (n.d.)

luminance level”<sup>188</sup>. The metadata also includes information about the Maximum Content Light Level (MaxCLL); which defines the luminance of the brightest pixel, and the Maximum Frame-Average Light Level (MaxFALL); which is the highest frame average brightness of all frames in the content.<sup>189</sup> Static metadata uses the same values for the entire duration of a given program, while dynamic metadata changes as often as needed.<sup>190</sup>

## **Dolby Vision**

Dolby Vision is a technology created by Dolby Laboratories, and was introduced in January 2014 as “the natural next step after 4K”; delivering the experience to streaming, UHD Blu-ray, gaming and broadcast.<sup>191</sup> Dolby Vision use the PQ EOTF<sup>192</sup> and a 12-bit signal with dynamic metadata to deliver HDR-video up to 10’000 nits.<sup>193</sup> Dolby Laboratories<sup>194</sup> has recently released a tutorial series for content creators which explains the essentials of Dolby Vision postproduction and delivery.

## **HDR10/HDR10+**

HDR10 is a open standard that use the Dolby Laboratories PQ EOTF<sup>195</sup> and supports a brightness level up to 1000 nits, which is delivered by a 10-bit signal accompanied by static metadata.<sup>196</sup> According to Hoffman<sup>197</sup> “this is the most popular HDR standard with the most HDR content”. Founded by 20th Century Fox, Panasonic Corporation and Samsung Electronics<sup>198</sup> HDR10+ is an advancement to the earlier standard and supports a maximum brightness of 4000 nits, as well the incorporation of dynamic metadata.

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<sup>188</sup> Schulte, T. & Barsotti, J. (2016:5)

<sup>189</sup> Ibid.

<sup>190</sup> LightIllusion. (n.d.)

<sup>191</sup> Dolby Laboratories. (n.d). *An Introduction to Dolby Vision*. Retrieved January 29th 2019 from <https://www.dolby.com/us/en/technologies/dolby-vision/dolby-vision-whitepaper-an-introduction-to-dolby-vision.pdf>

<sup>192</sup> Ibid.

<sup>193</sup> Schulte, T. & Barsotti, J. (2016:12)

<sup>194</sup> Dolby Laboratories. (n.d.). *Creating in Dolby Vision*. Retrieved May 1st 2019 from <https://www.dolby.com/us/en/professional/content-creation/tutorial-series.html>

<sup>195</sup> Schulte, T. & Barsotti, J. (2016:9)

<sup>196</sup> Hoffman, Chris. (2018, September 4). What is the HDR10+ Standard?. In *How-To Geek*. Retrieved May 1st 2019 from <https://www.howtogeek.com/364609/what-is-hdr10/>

<sup>197</sup> Ibid.

<sup>198</sup> HDR10+. (2018, August 28). *HDR10+ Technologies, LLC, Founded by 20th Century Fox, Panasonic and Samsung, Welcomes First Adopters of HDR10+ Technology*. Retrieved May 1st 2019 from <https://hdr10plus.org/press-releases/>

*Each new medium is justified because it fills a lack or repairs a fault in its predecessor, because it fulfills the unkept promise of an older medium. (Typically, of course, users did not realize that the older medium had failed in its promise until the new one appeared.)<sup>199</sup>*

*-Bolter & Grusin*

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<sup>199</sup> Bolter, J. D., & Grusin, R. (1999:60). *Remediation: understanding new media*. Cambridge, Mass: MIT Press.