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ESCUELA POLITECNICA SUPERIOR DE GANDIA

Grado en Comunicación Audiovisual

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POLITECNICA  
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**“La técnica del etalonaje.  
Caso: diferencias entre los archivos  
ProRes y RAW de la Black Magic  
Cinema Camera 2.5K”**

**TRABAJO FINAL DE GRADO**

Autor/a:

**Ferrer Cebrià, Emilio José**

Tutor/a:

**Beatriz Herraiz  
Heikki Timonen**

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## ABSTRACT

Universitat Politècnica de València  
Visual Designer

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Author(s): Emilio José Ferrer Cberia

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The idea of this thesis arises from my interest in new technologies applied to film. Specifically for my personal interest in the evolution of colour grading with the arrival of digital cinema.

The main objective of this work is to observe the behaviour offered by RAW and Apple Prores recording formats of the Black Magic Cinema Camera during the colour grading.

This thesis defines the concept of colour grading and the process from preproduction of an audiovisual project to the completion during postproduction. Some key concepts relevant to colour and digital image will also be defined for a perfect understanding for the practical part of the project. Later I will study through a series of analyses the response of RAW and Apple ProRes files when they are subjected to the colour grading processes. During this stage I will obtain a series of results with which I can make a number of conclusions. I can define the response during grading colour for each of the two signals.

The results obtained after having done all this process have been totally unexpected. We might have thought that the ProRes files, under strong signal compression, would provide a worse outcome compared to RAW files. However, they have shown to withstand a professional quality comparable to the result obtained by RAW signals.

If we think with the technical limitations that arise depending on whether we are using one or the other format, we must ask us if we should use RAW files Black magic cinema camera regarding Apple ProRes files.

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Keywords:

Colour Grading, Colour Correction, Blackmagic Cinema Camera, RAW, Apple ProRes 422

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# 1 WHAT IS COLOUR GRADING

“Color is life, for a world without colors appears to us as dead. Colors are primordial ideas, children of the aboriginal colorless light and its counterpart, colorless darkness. As flame begets light, so light engenders colors. Colors are the children of light, and light is their mother. Light, that first phenomenon of the world, reveals to us the spirit and living soul of the world through colors.” —Johannes Itten (1888–1967)

The colour conveys meaning, is a fundamental element from which we endow our narrative of a unique and personal meaning. It is used as a narrative element of the image, defines and expresses emotions, describes objects and adds richness sensitive to each of the images. It is descriptive beyond what we see. Therefore, the grading has an important role in audiovisual productions.

Since the beginning, the grading has been a laboratory process in which different photochemical processes are involved. Throughout this process, a match on the colour, brightness and contrast is achieved for each of the different drafts of a movie theatre.

Nowadays, with the arrival of digital cinema, the concept of colour grading means all post-production processes referred to the colour grading. During this process, we will get the right look for each of the sequences in function of the narrative of a particular cinematic movie.

The digital colour grading is quite different from the traditional way of working done in photo labs. Through computers and through sophisticated colour editing software, we carry out all our work based on the digital grading. This whole process has become a must to ensure the quality of the final result of a film task.

According to Cutanda, the digital revolution has changed habits and ways of working that had been done for decades in the film industry. Today we find a variety of colour editing software available for all. Not so long time ago, the digital grading was reserved for very specialized platforms and very advanced processing systems aimed at a very specific audience. (Cutanda 2010, 27 - 34).

## **1.1 Colour correction and colour grading**

Through colour grading and colour correction can be obtained a perfect final result of colour and look of the images. These two terms are used interchangeably and tend to merge together but the truth is, they have a different meaning:

- Colour correction:

According to Hernandez Ruiz, it is the process by which each of the clips of the same film is gradually modified to obtain a colour balance between them. This way can be achieved a coherent overall appearance between different parts of the film, with a temperature of real and homogeneous colour. This is to balance the colours, correcting white to really look white and black totally black, obtaining a pleasant, natural and uniform image.

- Colour grading:

Once colour correction has been made for the clips it is possible to continue with the colour grading. In this step image is changed by giving it a narrative meaning consistent with the ideas, with aesthetic and communicative purposes. During this process there is the opportunity to improve the history by manipulating the colours and lights, resulting in a new visual tone.

When is talked about colour correction it is referring to one specific step and the whole process is called colour grading. (Jesus hernandez Ruiz 2014).

## **1.2 Process of colour grading**

The process of colour correction can be divided in three big parts: before the recording, during the recording and after the recording. At the same time, during the postproduction the process can be divided in three steps: primary correction, secondary corrections and filters and effects.

### **1.2.1 Before the recording**

To get a perfect score on gradation of colour, work should begin even before recording starts.

During this part it should be clear what kind of look should have the movie and consider a number of goals to achieve at the end result. All this should be shown on the storyboard planning as well as in all documents referring to all elements that appear on the scene. It is very important to have a complete control over the dominant colour depending on the look that is supposed to give our production. It is needed to know if the scenes are marked by a certain tone and contrast or the type of items that appear on the screen.

For instance, it is clear that in a romantic video warm colours should prevail or a horror scene should be marked by very harsh shadows and high contrast. The items shown on image for recordings should be adjusted to that idea and take care of the colour of the costumes of the characters, decorative objects and sets.

### **1.2.2 During the recording**

When recording, one must focus on the parameters of the image and take care that these fit on the needs. Having a well-adjusted white balance every time we go to record a scene is primordial as well.

To perform a good white balance we need a grey card. That is very simple, just have to show it on camera for a few seconds at the beginning of each scene and then remove it to continue recording. While luminance conditions are not affected, it is not necessary to re-display the card to the screen.

The way these grey cards are built serves us to make a perfect white balance in postproduction. Its exact shades serve as a reference for quick and accurate balance on the tones of our scene.

In post-production, during colour correction it is important to use only the eyedropper tool to record the tones of the card and make necessary changes to correct any deviation. This way can always ensured to have a well-balanced images.

Another important and directly related aspect is to maintain a proper colour temperature in the camera. This measure help to make the same film set a good white balance, eliminating possible predominant colour due to luminance features of our set. Later it is explained more detail about white balance and its direct relationship with the predominant colour.

### **1.2.3 After the recording**

At this point starts one of the most important moments (STEPS) of all colourist, the stage of post-production. This is when work is done on computer with digital colour grading software.

Once imported all the material to the computer and software, the colourist organized his job in three main steps: primary corrections, secondary corrections and filters and effects to achieve the final look to the images.

#### **- Primary corrections**

It is common to find a wrong exposure in recorded images (darker or lighter images than they should be) and/or a dominant colour, i.e. a tone that contaminate the entire image giving it a yellow appearance, green, blue, etc. The primary correction is responsible for compensating these basic flaws and adjust the images so that is as close as possible to neutrality.

This step is essential so the expert can manipulate the image to continue with the subsequent manipulations of the colour. It means it is needed to make the image to look as close as it should have looked at the time when it was recorded, without any kind of dominant colour and a good colour balance. If not neutralized potential dominant first, then it will be very difficult to manipulate the video to achieve precisely the desired end tone.

Colour correction is a very dynamic process and any changes in a range of colours inevitably affect the others. Therefore it is easy to have a sense of lack of control and feel very lost if one does not have a good initial correction. (Cutanda 2010, 5 – 7).

### **- Secondary corrections**

Secondary corrections affect only certain areas of the image. Several examples should be highlighted such as achieving more light on the faces of the characters, get a more intense blue on the sky, adjust skin tones, accentuate or lightening shadows, etc. For this type of work best allies are the masks, colour selection tools and trackers.

The masks allow to select certain areas of the image and apply the changes only in those areas. They can be simple geometric masks, rectangles or ellipses or complex products with the way the masks are wanted. By the idiosyncrasies of the video should animate masks using keyframes to apply to the interesting area of the video.

### **- Filters and effects: the look**

Primary and secondary corrections are usually quite imperceptible. This step only serves to correct errors and clarify subtly the pictures to obtain a natural and balanced outcome. Very often can be only observed the changes made in the image when compared with the before and after. However, at this point, an image similar to reality has been achieved, so it is possible to continue the work without any kind of unwanted interferences to create looks.

To make the video remarkable, has to apply one aspect called "look" that differentiates our images of any domestic camcorder. Like the soundtracks, the same thing happens with colour grading, they are to assist the viewer to get inside the story. The viewer should note that images trap him, he is comfortable, but he should not really know why. The work of colourist must go as unnoticed as possible except, in cases, justified discretion is the best weapon. (Cutanda 2010, 18, 19).



## 1.3 Basic concepts: colour in digital image

### 1.3.1 Colour depth

Colour depth is the number of bits used to describe the colour of each pixel of the image. The higher the colour depth of an image is, the higher its paletter colour will be and therefore, the representation of reality can be performed with a greater number of colours. For example, if there is only 1 bit to describe the colour of each pixel, can only choose between two colours: one colour if the bit is set to 0 (usually black) and another colour if the bit is 1 (usually white).

If there is 8 bits to describe the colour of each pixel, can be chosen from 256 colours. With 8 bits each pixel can adopt a tone between 256 possible grey values between absolute black (00000000) and pure white (11111111).

Also can be used a colour depth of 8 bits to form a colour image. In this way a panel is used with the 256 most common colours, including black, white and various shades of grey to compose the image. Each of the 256 possible combinations of ones and zeros of the 8 bits is an index that allows access to the panel. This type of images are called indexed colour images. (Sarmiento Benítez, 19 - 21).

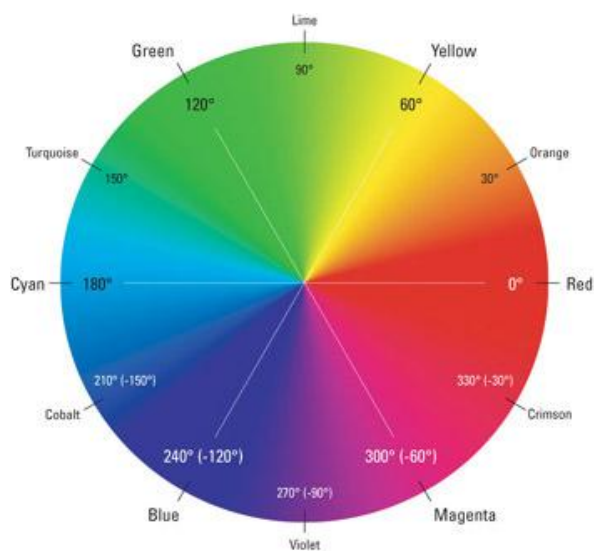
The greater the depth of colour, the greater the number of colours that describe the image. These differences can be seen in the next pictures:



Picture 1. The Digital Still Image. JISC Digital Media.

### 1.3.2 Hue

As stated by Sarmiento Benítez, hue refers to the dominant wavelength in the emitted or reflected light from an object. To assign a value to the tone a colour wheel is used a standard, in which the three primary colours (red, green and blue) and three secondary colours (cyan, magenta and yellow) alternate along the circumference. In the next picture can be seen all the colours in the colour wheel.



Picture 2. Hue Shifting and Colorizing by McClelland D. & Fuller R. C.

Each colour is located at the opposite end to its complement, i.e. the magenta is at the opposite to green, yellow and cyan are opposite to blue and red. The tone is measured in degrees, from 0 to 360, according to their position on the periphery of the colour wheel.

When an image editing program works in this mode, to add the proportion of a colour in an image, the program reduce the amount of its complement. (Sarmiento Benítez, 2005, 4).

### **1.3.3 Saturation**

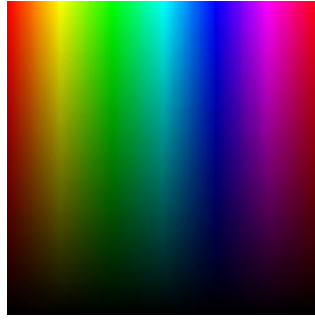
Saturation is the property that describes the vividness of colour. A highly saturated colour is a colour with an intense and pure tone. On the other hand, a little saturated colour has a hue off.

The saturation of a colour is expressed in percent and ranges between 100%, which corresponds to the maximum saturated pure colours and 0%, corresponding to the muted colours. (Netdisseny Diseño Industrial, 6).

### **1.3.4 Brightness**

According to Atienza Vanacloig, the brightness amount describes the amount of light reflected. It is therefore a relative magnitude. It is also expressed as a percentage from 100% (full brightness) to 0% (total darkness).

In this picture (Picture 3) it is possible to see how the colours evolve with the light, from the little bright colours at the bottom of the image, to the bright colours on top. In the picture also is seen the colour range from the highly saturated colours on top to the little saturated colours at the bottom. (Vicente Atienza Vanacloig, 3 - 4).



*Picture 3. Color name & hue by Colblindor.*

### **1.3.5 Dynamic range**

Dynamic range measures the set of tones from dark to light what a camera is able to take in the same picture. In other words, determines the ability of the camera to capture detail in light and dark in the same picture.

Normally the dynamic range of a digital camera is 5 steps (f), this means that the camera is impossible to capture a scene with more than 5 steps difference between light and shadow and it should choose if is want to preserve shadow detail or highlights. (Anne R. Kenney & Oya Y. Rieger 2003, 14).

### **1.3.6 Posterization**

Normally the adjacent colours in an image are mixed gradually making our eye impossible to distinguish where one colour begins and ends. However, sometimes can be seen that transition in areas with little detail, for example, in the sky. As a result appears stripes that cross the image resulting in posterization and can be perfectly distinguished the different shades of blue for the sky example.

The use of images 16 bits of colour depth can greatly reduce the risk of pasteurization since it provides 65536 colour levels compared to 256 featuring the images to a colour depth of 8 bits. (Aranda, discussion 31-10-2010).



*Picture 4. By Ian Watt. Nov 03, 2010.*

### **1.3.7 Colour temperature**

Colour temperature is the dominance of one of the colours of the light spectrum over others. Depending on the colour temperature radiated by objects (measured in degrees Kelvin) can be differentiated between cold and warm tones.

Warm colours are the colour range between the Yellow and Red-Violet (red, yellow and orange), are associated to sunlight, fire, etc. On the other hand, cold colours are palette ranging from yellow-green to violet through blue. Those colours are associated with water, ice, moonlight, etc.

The light emitted from the Sun varies in colour temperature depending on time of day and atmospheric conditions. The perfect light of the day has theoretically 5,500 degrees kelvin. For cloudy days the colour temperature rises (one blue dominance occurs) to 12,000 K. In the case of the interior of a house that has temperature of 2500 K which provides a common artificial lighting. (Sarmiento Benítez, 2005, 5).

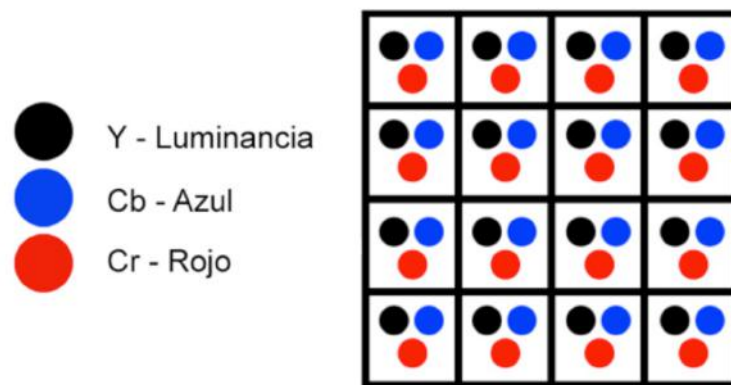
### **1.3.8 White balance**

Adjustment is made on the image to get pure white regardless of the colour temperature of ambient light. If not done a proper adjustment, the picture presents some white coloration or pervasive that depends on the type of lighting used during filming, whether artificial or natural. (Sarmiento Benítez, 2005, 6).

### 1.3.9 Colour subsampling

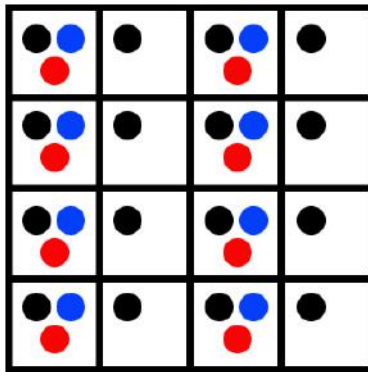
Colour subsampling is a technique for reducing colour resolution without affecting the brightness. This technique allows the image requires less bandwidth without the appearance of a degraded image. The colour subsampling is measured in ratios that can be 4: 4: 4, 4: 2: 2, 4: 2: 0 or 4: 1: 1. For purposes of video compression, video engineers realized they could eliminate color information without it being visible to the viewer. (Blog Cine Digital, 2012)

The information of a pixel in an image has a value Y (luminance), one Cb (blue) and Cr (red) value, the combination of these so-called YUV values allows us to see the colour that corresponds to that pixel. For the purposes of color subsampling, we take as reference an array of 4 by 4 pixels:



Picture 5. ¿Qué es el color subsampling? By Cinedigital.

This first example shows us that each pixel has a value and a Cb and Cr. To analyze the image, can be seen that there are 4 values in a line Y, 4 Cb and 4 Cr, this is a 4: 4: 4. It is the standard for color excellence, however, most high-end devices recorded on what is called 4: 2: 2. This standard, using the same example, looks like this:



Picture 6. ¿Qué es el color subsampling? by Cinedigital

## 2 COLOUR GRADING TEST WITH RAW AND PRORES FILES

During this part, It is showed how compressed files like Apple ProRes 422 and files without compression like RAW are working during the colour grading process. To do all the tests are made with a Blackmagic Cinema Camera EF 2,5K using Apple Prores 422 and RAW recording format for each one of the shoots. Software used to grade the images is DaVinci Resolve. Colour grading tests are divided in four parts:

1. An analysis about Posterization effect.
2. A test about dynamic range in Apple Prores 422 and RAW files.
3. One case to see how colour balance can be fixed from one shoot with a huge colour pre-dominant.
4. A general colour correction with one file and with the other to see if there are some important differences.

This is the link to see the video of the final result of this test:

<https://www.youtube.com/watch?v=AatdvBM8O5M>

### 2.1 Apple Prores 422 and RAW files

Each video codec can be characterized by three aspects: compression, quality and complexity. The compression means the data reduction or how many bits are required in comparison with the original image. The quality describes the level of similarity in the compressed image with the original. "Fidelity" would be therefore a better term, but widespread term for this is "quality". The complexity refers to how many arithmetic operations should be calculated to compress or decompress a frame or sequence of images. The design of each video codec must find the balance between these three properties.

In the case of Apple ProRes 422 codec there is a high image quality even they have a high compression. Pictures taken in RAW, however, contain all the image data as they have been captured by the digital sensor of the Black Magic Cinema Camera. (Book Apple ProRes, 2014, 7)



The main differences between Apple ProRes 422 and RAW files of the BMCC are in the resolution of each of these two recording formats. The resolution of RAW files is 2400x1350 pixels while recorded in Apple ProRes 422 format files maintain a resolution of 1920x1080 pixels.

Another parameter that is affected is the dynamic range of the camera. For the specific case of the RAW files we have 12 stops (f) while in the case of Apple ProRes 422 format does not use the full dynamic range of the sensor BMCC.

If compared the colour depth between the two types of archive, the difference is greater. While Apple ProRes 422 has a colour depth of 8 bits, raw files keep a colour depth of 16 bits.

Finally, also the difference between the two files stands out when talked about subsampling colour. In RAW files we found a colour subsampling of 4: 4: 4, but Apple ProRes 422 files reduce the number of colour samples to 4: 2: 2. (Book Apple ProRes, 2014, 4 – 6).

## **2.2 Case 1: Posterization effect**

The bit depth of an image determines the smoothness of subtle color gradient that can be represented in a sky at sunset, no visible artifacts or striping. The images with 10 bits may contain finer gradations of colour, preventing the artifacts found in 8-bit images. However, is there a difference between Apple ProRes 422 images with 10 bits of colour depth compared to RAW images with 12 bits?

Frame shot of the video can be observed for each of the cases. Under are the ones corresponding to the image recorded in RAW format, and beneath the image recorded in Apple ProRes format.



*Picture 7. RAW file.*



*Picture 8. ProRes file.*

Having performed a simple colour correction of the images, can be seen that they practically do not differ from each other. Neither see the posterization effect on any of the two images. However, if tested each of the two formats on the extreme levels, which of them are presented in first place the posterization effect? For the next test is increased the contrast of their signals by 80% over the original.

There can be seen a clear difference amongst the two signals when carry them to their extremes. No doubt the RAW video hold better than the Apple ProRes video. The sky in the Apple ProRes images ends completely broken and posterized, but in RAW images they are getting better degraded thanks to its 12-bit colour depth.



*Picture 9. RAW file.*



*Picture 10. ProRes file.*

### **2.3 Case 2: Dynamic range**

As mentioned, the Blackmagic Cinema Camera offers the ability to record video in RAW format with a resolution of 2,5K (2432 x 1366 pixels), colour depth of 12 bits and 13 steps of dynamic range. In the case of Apple ProRes format we lose some points of dynamic range and the colour depth is reduced to 10 bits.

With the next test is showed if there is any difference between the images in relation with the dynamic range. Here can be seen two images recorded from inside a barbecue. The images

have been exposed considering the outside lighting. Because of this type of exposure, shadow areas inside of the barbecue have been underexposed:

RAW files with a dynamic range of 13 stops should show greater balance between highlights and lowlights than ProRes files. This difference is almost imperceptible to the human eye.



*Picture 11. RAW file.*



*Picture 12. ProRes file.*

Next step is a colour grading for both images. Focus in dark areas, namely tried to balance the exposure inside of the barbecue for greater light balance between the exterior and interior.



Picture 13. RAW file.



Picture 14. ProRes file.

Again both files respond successfully when increased the lighting in postproduction and it is not possible to observe major differences between them. RAW and Apple ProRes files have perfectly withstood a light increment of two stops on the part of the shadows.

## 2.4 Case 3: Colour balance

The next test is to conduct by recording the same scene in each of the two formats with an exaggerated predominant colour. Images are recorded with a temperature colour of 2500 Kelvins on a clear day with a natural light around 5500 Kelvin degrees. The images obtained resulted on a cold predominancy, where the whole palette has acquired a bluish tint.



*Picture 15. RAW file.*



*Picture 16. ProRes file.*

Purpose of this test is to get the images back to their natural colour through the colour grading process. There is made a wrong white balance in the same filming location to determine whether, as a function of either format recording, there is a greater or lesser possibility of recovering the natural colours of the image. The result was as follows:



*Picture 17. RAW file.*



*Picture 18. ProRes file.*

The capacity offered by the files of the BMCC during the grading processes in postproduction impresses. In both cases is possible to correct the predominant colour and obtain a natural looking image. Again, is not observed relevant differences between the two signals. For the RAW and Apple ProRes case the signal has been performed satisfactorily without major differences.

## **2.5 Case 4: Basic colour grading**

Colour grading is done for specific instances of posterization, dynamic range and white balance. Below, is analysed the behaviour of a RAW and an Apple ProRes file when they submit the complete process of grading colour during the postproduction.

Following in the steps of the process of colour grading in postproduction, the result was as follows (left original file and right the graded file).



*Picture 19. RAW file.*



*Picture 20. ProRes file.*

Again, final analysis obtained a similar result in both cases, without any kind of difference in their colours or look.

By watching the following video answer the question: would you know which sequences were recorded in RAW format and which ones were recorded in Apple ProRes format? Emilio Ferrer has graded all images through the DaVinci Resolve software.

<https://www.youtube.com/watch?v=4l4oRkm1CRw>



### 3 CONCLUSION

Once done all the research process, applying various methods and techniques of grading on the various RAW and Apple ProRes files, I can make a final assessment.

First I will objectively analyse the behaviour of each signal for each of the cases. Then, I will show the pros and cons of using RAW and Apple ProRes recording formats during the colour grading.

#### 3.1 Advantages and disadvantages of RAW and Apple ProRes files

Throughout the process we have seen how Apple ProRes files have never been exceeded markedly by the RAW format. We can summarize with the following statements the results of each analysis:

1. Most colour depth of the RAW files (12 bits) against Apple ProRes 422 files (10 bits) has reduced the posterization effect. In other words, RAW files have shown a greater palette of blues. However, I needed to break the signal to see the differences.
2. The greater dynamic range of the RAW images make easier the colour grading with very high light contrast. On the other hand, with the compression 4:2:2 of the Apple ProRes files is almost impossible to see huge differences between files.
3. In general both files have responded satisfactorily well when I removed the predominant colour during the colour grading . However, with the RAW files is easier in postproduction to do a good white balance. The DaVinci Resolve software exclusively dedicated an entire section to the colour correction for RAW files.
4. When I performed a general colour grading without forcing the signal of the image and/or causing a volunteer wear, I observed that both files respond similarly. In optimal conditions the difference between the two images is almost imperceptible to the human eye.

## 3.2 Critical reflection

The last of the points I have described I think is the key to make a final conclusion about the behaviour of both files during the colour grading process. As it is true that raw files have the power to store videos without any kind of internal processing, Apple ProRes files reach an almost exact quality.

Answering the question posted in the introduction of this work, we can say that the compression of Apple ProRes file is undeniable. While for a 240-gigabyte card you can store 300 minutes of Apple ProRes material, if you decide to record with RAW you will have only the capacity to store 30 minutes. Just watching this great difference in the compression we could also imagine the huge difference between the qualities of both files. However, Apple ProRes files left that difference in practically zero.

Apple ProRes files let less advanced computers to work on the colour grading process with professional results. The relative lightness of these files enables obtaining professional audiovisual finishes without large and expensive technical equipment.

The design of each video format must find the perfect balance between compression, quality and complexity. In my opinion, the recording format Apple ProRes 422 maintains a perfect balance between them, almost equalling its quality with the RAW files when we are performing a colour grading.

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<https://vimeo.com/91620701>

"Canon 5d mk3 - H.264 vs Prores HQ vs Raw Video Magic Lantern, 2014".

<https://www.youtube.com/watch?v=Gqx4sv51L84>

## APPENDICES

Video link "Colour grading test BMCC - RAW vs ProRes 422":

<https://www.youtube.com/watch?v=AatdvBM8O5M>

Video link "Which sequences were recorded in RAW and which ones in Apple ProRes?":

<https://www.youtube.com/watch?v=4l4oRkm1CRw>