Is 3D Cinema Necessarily Spectacular?

Jeanne Guillot

Translated from the original French by University of Richmond interns

Kim Burns, Kathryn Einerson,

Leander Sinanan and Rebecca Stewart

September, 2009

La Fémis

Dissertation

Visual Department, 20th graduating class

Mentor: Laurent Verduci (stéréographe)

Under the direction of: Pierre-William Glenn and Jean-Jacques Bouhon

Acknowledgments

I would first like to sincerely thank my adviser (who also acted as the stereographer for my film), Laurent Verduci, for his time and generosity in sharing his expertise.

I would also like to thank those who helped further my research with their advice and ideas: Sylvain Grain, Claude Baiblé, Laurent Dondey, and especially Alain Derobe, who most graciously lent me his 3D module, as well as Céline Tricart, who served as co-stereographer and an invaluable advisor during the production of my film.

Thanks to Marc Nicolas, Carole Desbarats and Laurence Berreur for all their support this year.

I extend all my gratitude to the directors of the Image department, Pierre-Willian Glenn and Jean-Jacques Bouhon, who were always there for me during my time at La Fémis. I truly appreciate the value of what they imparted to me. I thank them for their patience and the interest they took in my work – and even if “Being kind is not a profession,” for their kindness towards me.

Finally I would like to thank my close family and friends for their continued support throughout the duration of this project. I am pleased to be able to share with you today the pleasure of having overcome, with their help, the highs and lows of this three-dimensional adventure.

Table of Contents

Stereoscopy: *n.* The process that creates an impression of 3D.

Stereography: *n.* The representation of solid objects by projection onto a planar surface.

Stereographer: *n.* A person familiar with the art of stereography. The stereographer oversees the creation of a film in 3D, from planning to postproduction.

Introduction

While promoting the film *Monsters vs. Aliens* this winter, Jeffery Katzenberg, cofounder of DreamWorks Studios, spoke in numerous interviews about what he sees as the importance of three-dimensional cinema: “To me, when I look at the history of film, there have been, to date, two great revolutionary changes... sound and color. It is in the process of realizing its third major development: 3D.” Like Katzenberg, some view 3D as a significant technological advancement that will most likely become largely standardized in the years to come. Others, more skeptical, see it only as an anecdotal process that will never establish itself as a new form of credible cinematography.

In fact, 3D is not a recent invention. It came about at the same time as film itself and has already failed several times to establish itself lastingly in theatres. But these relative setbacks can be explained in part by certain technical complications, to which the digital revolution offers compelling solutions. However, feasibility of filming and projection equipment aside, stereoscopy remains a medium that if poorly used, can be very tedious, even unpleasant, to watch. Therefore, it is important that when we launch into a 3D film project, we understand the questions of visual fatigue that could come into play and their potential implications on the *mise en scène*.

But even more importantly than these technical questions, which will be mastered in time, it seems to me that the possibility of 3D cinema becoming widespread depends largely on its ability or inability to succeed across a broad range of genres. In fact, until now, 3D has primarily been associated with horror or action films of epic proportions. This medium lends itself particularly well to the spectacular and striking special effects of these film genres. But even so, should stereoscopy remain indefinitely restricted to such a limited sphere of cinema?

Does 3D necessarily imply a spectacle, or can we envision it in more meditative or intimate films? These are the seemingly paradoxical questions I have explored this year in my capstone film and this dissertation.

I/ History and techniques of stereoscopy

1. A brief history of the study of stereoscopy and 3D cinema

It is difficult to say with certainty when reflections on the nature of 3D first originated. Some cite the writings of Euclid during the 3rd century BCE, others the research of the physician Claudius Galenus during the 2nd century. In the 15th century we find evidence of Leonardo Da Vinci's experiments on the mechanics of vision among the large amount of research he conducted related to the human body. He was the first to suggest that the distance between two eyes might be of importance. He pointed out the fact that each eye perceives an image from a slightly different perspective and that it is this gap that permits a visual reconstruction in 3D. Finally, Francois d'Aiguilon's optical treatise *Opticum libri sex philosophis iuxta mahematicis utiles,* which appeared in 1613, cited stereoscopic projection for the first time.

It was during the 19th century that the first attempts to create instruments permitting the reproduction of 3D vision took place. In 1833, the English physician Sir Charles Wheatstone perfected a reflective stereoscope. This optical instrument was based on the principle of binocular vision that permitted one to see two slightly different images simultaneously. This system which consisted of two mirrors at 90° to each other, reflecting the two images placed on two tablets for the right and left eye, respectively, allowed a spectator to experience a sensation of depth and 3D.

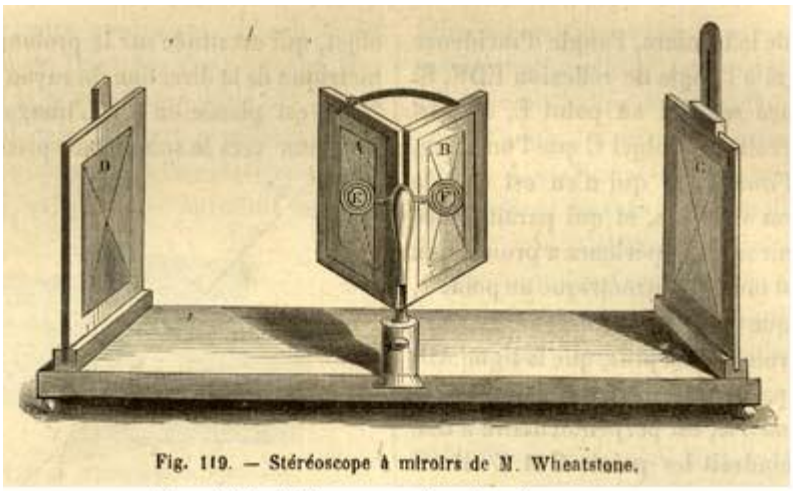
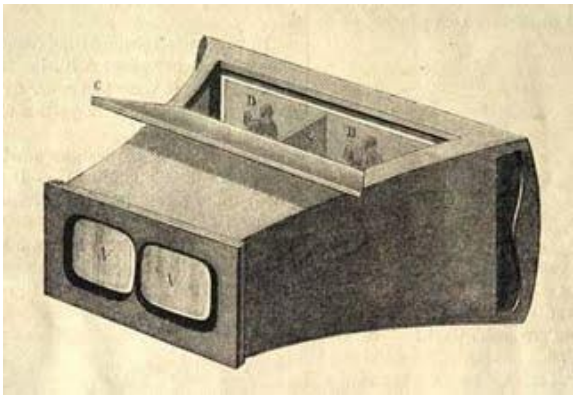


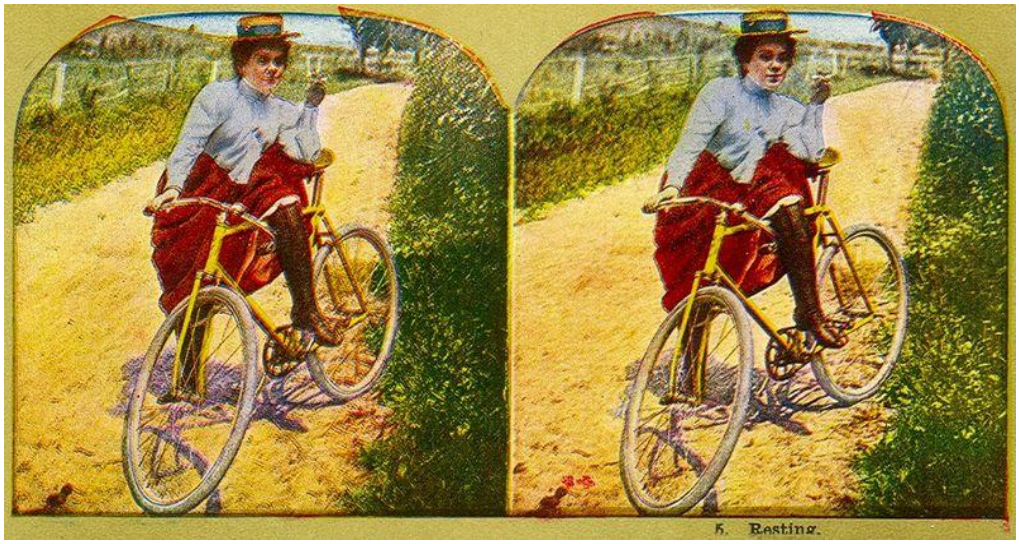
Fig. 119. — Stéréoscope à miroirs de M. Wheatstone.

Fig. 119- Wheatstone's reflective stereoscope

In 1849, Sir David Brewster perfected this system with the refractive stereoscope (or prismatic stereoscope). He replaced the mirrors with lenses, which improved the image quality and emphasized the practical aspect of the object. This instrument allowed the viewer to observe drawings as well as daguerreotypes made for that purpose. A link was thus first established between objects and photography.



With the help of French opticians Soleil and Duboscq, Brewster developed a camera with two lenses. The 1850's were the golden age of the stereoscope, which was no longer merely a scientific curiosity, but an item highly sought-after by many individuals in Europe and the United States. Although print photography did not yet exist, stereoscopic cards became a popular leisure and educational item found in many private homes. These cards covered a wide range of topics: historical events, famous people, dramatic scenes and even erotic images.



3D images became a public spectacle when a projection system was invented by Joseph d'Almeida in 1858. This system was based on the principle of two superimposed images. Each stereoscopic proof was projected onto the same screen. Colored lenses were placed in front of the rays of light so that one image became red, and the other green. When the spectator's eyes are covered by two such lenses, the eye covered by the red lens only perceives the green image and vice versa. The result is a 3D image in black and white. The images produced by such a process are called anaglyphs.

It was Etienne Jules Marey who first experimented with the possibility of linking 3D vision with moving images in movement. In 1885, he adapted his process of chronophotography for stereoscopic images. Thus, his famous chronophotography of the walking man also exists in 3D.

The emergence of 3D cinema dates back to 1903 with *L'Arrivée du train*, a short film by the Lumière brothers, which was screened at the World Fair in Paris. They then created several more short films using the same techniques. The Lobster Society, which specializes in the restoration of old films, recently made a surprising discovery while working on a film by Georges Méliès. The study of two incomplete copies shows the existence of two versions of the

film, corresponding with two different points of view, which would make the creation of 3D possible. We do not know if Méliès really had the intention of creating a 3D version of all of his films or if this discovery is only the result of a happy coincidence. Indeed, to prevent the fraudulent exploitation of his films, Méliès could have filmed his scenes with two cameras so he would have two negatives that he himself could use in France and in the United States. Whatever the case, the prospect of potentially seeing other films by Méliès in 3D is delightful.

The first profitable public screening using the anaglyph process took place in New York in 1915 with *Jim the Penman* by the Paramount Picture Corporation. Seven years later, *The Power of Love* became the first 3D feature film. The 1920s also saw the emergence of animated films in 3D, such as *Plastigrams* by Frederic Ives and Jacob Leventhal. In spite of these attempts, 3D cinema during these years more closely resembled small-budget experiments than big cinematographic productions. The arrival of film with sound, which monopolized the entire industry's attention, marked the beginning of one of the many periods of dormancy for stereoscopy.

The 1950s are considered the golden age of 3D cinema. While big American studios worried about dwindling audiences, due in part to the competition created by television, improved stereography appeared on the scene as a potential means of bringing the public back to theaters. During these dormant years, some isolated inventors developed a new projection technique using light polarization[1]. Although this technique still required audiences to wear glasses, it brought about a significant improvement: the ability to project 3D films in color.

[1] See chapter on screening (Chapter I, Section 5).

The independent film *Bwana Devil*, screened in 1952, was met with surprisingly large success. One year later, Warner Brothers produced the horror film, *House of Wax*, which was another blockbuster. These successes then launched a grand trend of 3D film among the major studios. Between 1952 and 1954, around fifty films were shot using the two-camera technique. This wave distinguished itself in several genres: westerns, action movies, horror movies, and even science fiction. Alfred Hitchcock also tried his hand at filming in 3D with *Dial M for Murder* in 1954. It seems that the idea of using stereoscopy was not his, but rather Warner Brothers'. Surprisingly, the master of suspense used only a few of the more spectacular effects permitted by 3D. Certain critics say that he is only greater for it.

In spite of the enthusiasm that these films aroused and the large sums invested by the major studios, 3D cinema was again confronted with a decline in audience numbers. This seems to be largely due to two factors. For one thing, even if the technique of projection by polarization was viable, it required particular technical capabilities. Stereoscopy had to be well calculated during shooting but also during screening. If the two projectors were not well stabilized, the 3D remained visible but it became a lot more tiring to watch, easily provoking

headaches. Thus, after one or two bad experiences, the spectators would give up seeing 3D films, even if they were impressed by the show. In addition, another advanced technology came once again to compete with and to preempt 3D. The different systems of projection in large format, such as the Cinemascope of 20th Century Fox (1954), the Vista Vision of Paramount (1954) or the Super Panavision (1959) elicited a greater and more lasting interest.

In the 1980's, certain studios once again risked bringing 3D cinema to the forefront. Up until that point, stereoscopy had only been shown in the 1:33 format; the films of this era could be filmed in 1:85. The film *Comin at Ya!* launched this new wave in 1981. The success of this film was so sudden that the production of glasses was not quick enough to keep up with the number of box office tickets demanded. Therefore, the film was not as profitable as it could have been. Films of variable quality followed, such as *Friday the 13th 3D* and *Jaws 3D*. Unfortunately this resurgence of interest was very short-lived and stereoscopy again disappeared from cinema screens.

Since then, 3D has been instead reserved for use in theme parks. The Canadian society Multi-Screen Corporation invented the IMAX system, then IMAX 3D. Big-budget projects thus broke onto the scene in IMAX theaters where movie-goers sought after intense visual sensations. The film *Captain Eo*, which was directed by Francis Ford Coppola, produced by

George Lucas and starred Michael Jackson, among other actors, was used in several Disney parks for ten years. The screening also features smoke and laser games. This marked the beginning of 3D cinema in theme parks. In France we can cite, in addition to the Disney park, the Futuroscope park or even the *Cité des Sciences* with the Geode.

Nevertheless, can we really say that these films belong to cinema? In any case, it is interesting to note that in the history of 3D, theme parks have provided a truly lasting place for films using stereoscopy. In fact, 3D cinema has captured production companies' interest and attracted spectators due to its spectacular dimension many times, but it could also be this aspect that has each time proven a disadvantage. As we have shown, the complexity of techniques put into play has sometimes been a restraint. In addition, there is the question of whether this medium, which is very favorable for spectacular effects, has not paradoxically limited the creativity of filmmakers by constraining them to particular genres. It is as if the possibility of playing with the spectacular dimension had been considered as an obligation, as seen as the means to implement it. Breaking away from this pressure could be the issue confronting the growth of stereoscopy today.

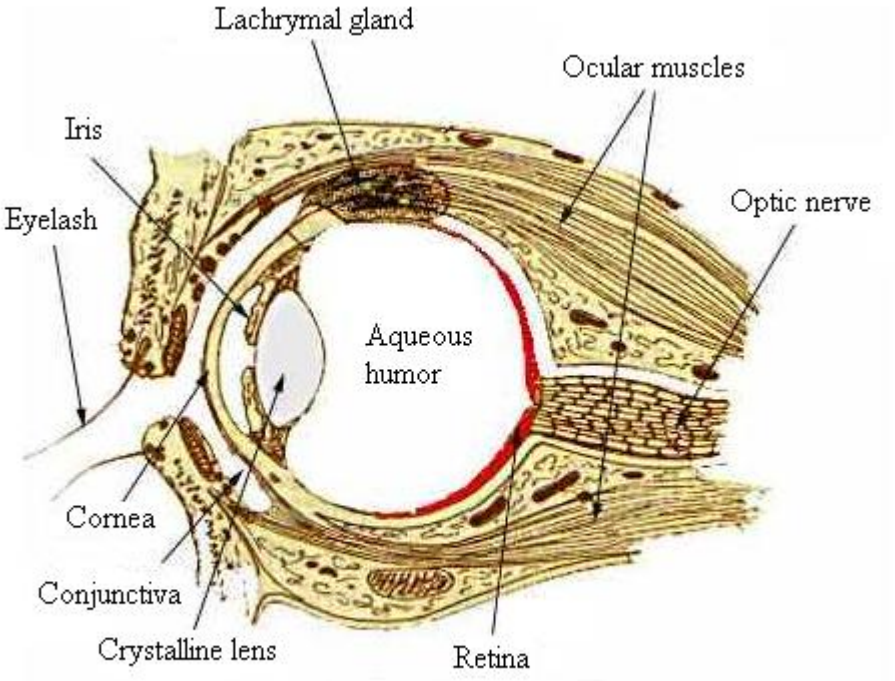
In the beginning of the 21st century again, we saw an increase of stereoscopy emerge in the cinemas. In 2005, Disney studios released *Chicken Little* in a 3D version, followed in 2006 by DreamWorks with *Meet the Robinsons*. Since then, such releases have become more frequent; this year in animation- *Fly Me to the Moon, Volt, Monsters vs. Aliens* and *Coraline*, but also in the area of traditional fiction with *Beowulf, Journey to the Center of the Earth, Friday the 13th*, and the much anticipated *Avatar* by James Cameron. Numerous releases are already anticipated for the years to come.

Once again, a major technical advance was introduced to support this phenomenon. In fact, the digital technology's prevalence in cinematographic production significantly changed 3D film's chance of success. Ever since, the entire series of 3D films has been feasible due to the system of screening from a single projector. The system of glasses with electronic shutters renders stereoscopy controllable from shooting to screening. The digital tools likewise greatly facilitate the image postproduction and permit certain readjustments of the stereography, which aides in visual comfort.

Will this revival of 3D cinema stabilize and endure, or will we wait once again, after a moment of euphoria, for a rapid decline? Certain individuals such as John Lasseter predict that 3D will undoubtedly establish itself as the new dominant form of cinematography, while others (many of whom I crossed paths with this year) see it only as a technological exploit that will never become widespread.

2. Principles of Human Vision

Our perception of 3D is possible due to a set of factors. True stereoscopic vision requires the conjunction of information sent simultaneously from the two eyes. Nevertheless, monocular vision allows the brain to form an idea of depth with the help of several parameters, such as accommodation, monocular parallax, and geometric perspectives.



Transverse section of a normal eye

The phenomenon of *accommodation* consists of different adaptive ocular modifications, which provide sharp vision for different distances. Deformation of the crystalline lens causes the rays of light coming from an object to converge so that a distinct and inverted image forms on the retina. For distant objects (more than five meters away) the rays of light are almost parallel; they are only slightly diverged to be formed on the fovea[2]. For closer objects, the

[2] Zone situated in the center of the retina, where vision is the clearest.

crystalline lens is further curved by the ciliary muscles and thus acts as a convex lens. The brain can already estimate the distance of the object at the time of accommodation.

Monocular parallax, a slightly more complicated system than accommodation, also plays an important role in the impression of 3D as perceived by a single eye. When a three-dimensional object travels past the eyes in a translation motion (or conversely if the observer's eye or head moves) all of the points therefore have the same linear velocity, but their angular velocity in relation to the eye depends on their distance from the eye. This angular velocity is proportional to the difference in depth between two neighboring points on the object. The observer therefore sees the objects traveling at different speeds in relation to their distance. Closer objects seem to fly by very quickly in the opposite direction. The further away the object, the slower it appears to move. For example, for a passenger in a train, nearby objects are hardly visible as they fly by quickly while the faraway objects seem almost immobile in comparison.

The last factors to take into consideration concerning 3D sensation in monocular vision are no longer on the psychological level, but on the cultural level (they call upon knowledge acquired by the visual system). From a planar image, the brain can reconstitute certain distances, or the impression of depth out of habit.

We can distinguish six parameters:

- *Masking* or *interposition*: when objects are partially covered, we can place them in perspective, to determine which ones are in front.

- *The size of an object*: we speak of relative size when we do not know the exact size of two objects but we know that they are identical. That which projects the smallest image on the retina is then interpreted as being placed further away. In the case of a familiar object whose size is well known, we use this reference to evaluate its distance knowing that its size appears diminished with distance.

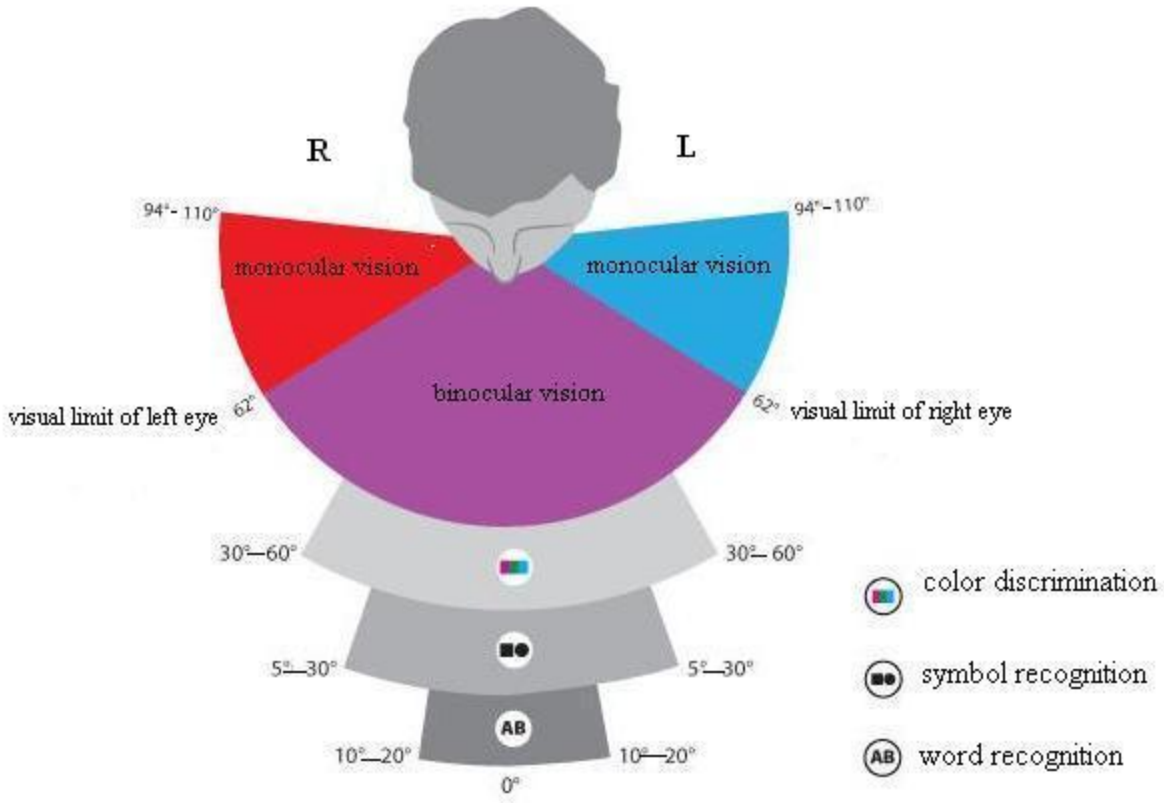
- *Surface perspective*: this is caused by particles of dust and humidity suspended in the air. The farther away an object, the dimmer and more diffuse it appears.

- *Linear perspective*: this occurs when parallel lines appear to converge and meet near the horizon. For example, think of the sides of a road that seem to come together in the distance.

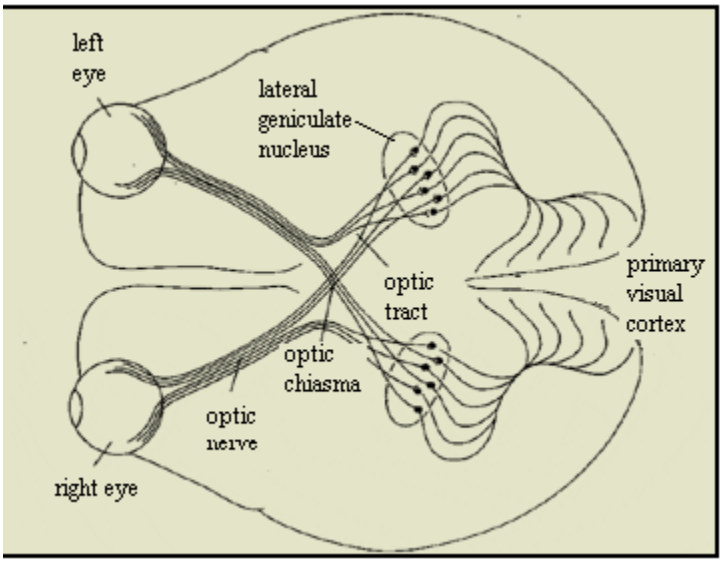
- *Texture perspective*: when we look at an object, the longer we believe the distance to be, the denser and less detailed the texture appears.

- *Shading*: areas of shadow and light allow us to situate objects in relation to a light source and to one another.

In summary, simple monocular vision can give us the same sensation of 3D, because when looking at a two dimensional image we do not experience any difficulty in locating these objects in relation to others. But this three dimensional vision based on monocular factors gives us only a crude knowledge of three dimensionality because the information furnished by these monocular factors is a complete view of the distance. In order to obtain a detailed perception of three dimensions, the ability to perceive local geometry is essential; however, this would not be possible without joint and simultaneous action of both eyes, that is to say, stereoscopy.



Stereoscopic vision is possible in the zone where the monocular fields of vision overlap with one another. Each one of them extends 150° and their common zone is 120°. Each of the retinas receives the light information and transmits it to the brain via the optic nerve. Certain neurons of the brain then carry out a comparison of the two images which are slightly different. It is from these binocular disparities that depth is inferred and three-dimensionality is reconstructed. We will later see that a stereoscopic vision functions on the same principle: it consists of giving the brain two images whose fields overlap but which present slight horizontal disparities. Besides these binocular disparities, in order to estimate distance and depth, the brain also makes use of the simultaneous movement by both eyes to settle on a single point. This is what one calls *binocular convergence*. Even the eyes' position in relation to each other informs the brain about the distance of the object we are looking at.



Another important concept to bring up is *diplopia* from which the properties of *horopter* follow. The phenomenon is easy to experience. If we fix our finger and we intercalate a pencil between our eyes and our finger then the pencil is seen in double vision. This is double vision. Here we have a crossed diplopia. The lines of vision rejoin behind the focus point; the convergence of the ocular pair is insufficient. In the same starting situation, if we place the pencil behind our finger, the pencil is also seen in double vision. The pencil in this case demonstrates homonymous diplopia. In the reverse situation, the lines of vision cross before the focus point, therefore the convergence is too important. The horopter is a line placed between the thresholds of crossed diplopia and homonymous diplopia which links all the points that are not seen in double when we look at a given point. In other words, all the points on this line are merged by the brain. We are not generally aware that outside of this line, except during certain exercises, we see in double because our attention is linked to our eyes' convergence point. This issue of the horopter, and therefore the capacity of the brain to combine different points, is very important for the stereographers who must take it into account in their adjustments of 3D. Beyond a certain distance between two points, the fusion and reconstitution of 3D first becomes taxing, and then eventually impossible.

3. Shooting in 3D

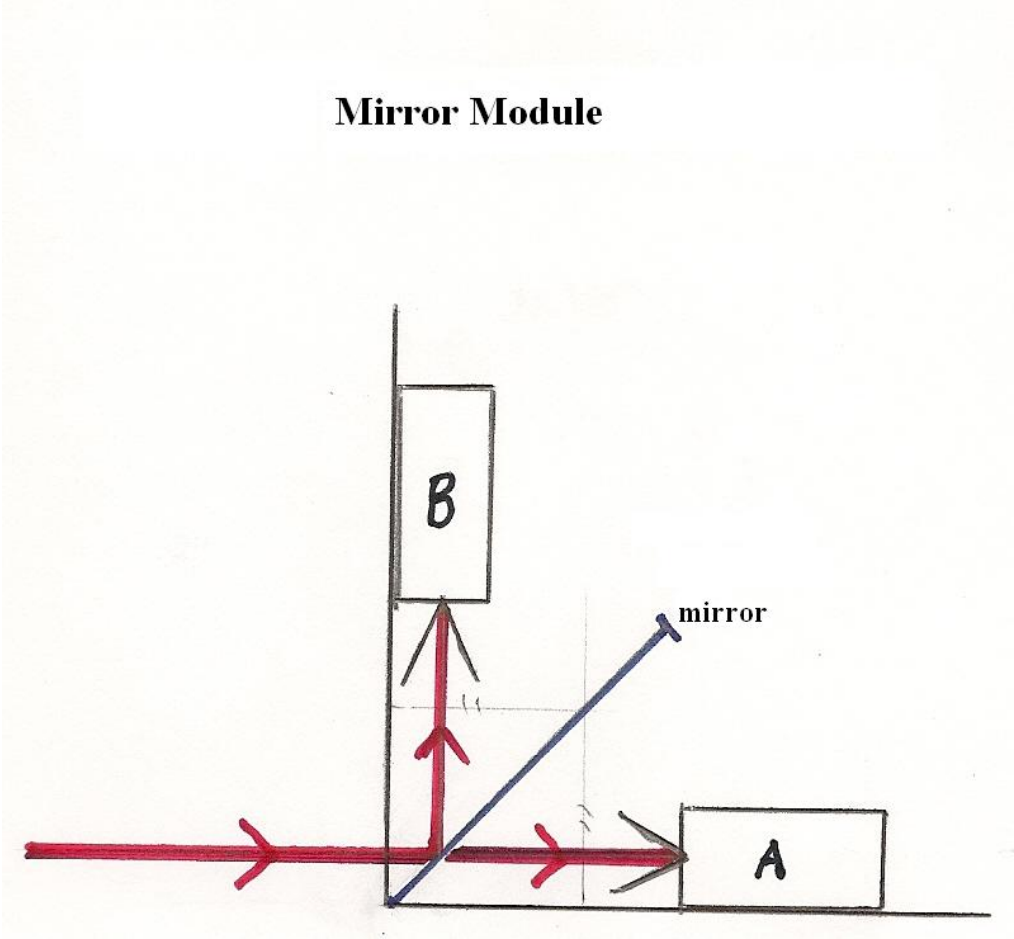
The study of binocular vision is interesting because the base of all systems in the chain of 3D cinema. To begin, these studies laid the groundwork for shooting techniques.

Before considering the systems which allow us to link the two cameras (which one calls modules or *rigs*), it is important to emphasize that the two sets of lenses must be chosen with care. They must be as close as possible- obviously in their quality, but also in their actual field of view angles. This year, I have learned with surprise that a 25mm, for example, is not necessarily exactly a 25mm. It is therefore advisable to verify the compatibility of the lenses during trials. For this reason, working with zoom lenses is rather discouraged.

The simplest modules are the "side by side" modules. They reproduce the configuration of the eyes exactly: the two cameras are placed side by side on a framework. This structure allows us to easily adjust the distance between the two cameras and the angle formed by their two optical axes (the interaxis and the convergence, which, as we will see later on, are the two most important parameters on which the stereographer intervenes to adjust the impression of 3D[3]) to be easily adjusted. This type of module is not viable in all cases because the minimum gap depends on the bulkiness of the cameras. And yet, we know that the average gap is 65mm, which corresponds to the distance between our two eyes. We easily understand, therefore, that with the exception of very small cameras, it is not possible to reproduce this gap. This type of module is often used for very large shots that have greater distances between centers. In hyper-stereoscopy, the distance between cameras can be up to several meters.

Mirror modules have been developed to solve the problem of bulky cameras.

[3] Refer to the definitions of these concepts in Chapter II, Section 1.



The first camera is placed traditionally, with its optical axis parallel to the ground. The second is positioned perpendicularly, above the first camera. The two optical axes are at 90° to each other. A semi-transparent mirror is placed between them at an incline of 45°.

The cameras must be precisely the same distance from the mirror. In preparation, it is very important to measure the attenuation of light of the first camera which is “filtered” by the mirror so that it can be passed onto the diaphragm. The image of the second camera (which films the mirror) is doubly inversed (high-low and right-left). Therefore, we must set aside a long time to process the rushes in order to reverse the double inversed images. In these mirror modules, the lower camera allows adjustments in center to center distances and in convergence to be carried out; it can translate and pivot. The higher camera remains fixed.

In macro-stereoscopy, one must necessarily use a mirror module (the distance between the cameras being only a few millimeters apart). The module created by Laurent Verduci (who served in the macro shooting of my film) is consists of two Canon HV20s to which he had added supplementary lenses of three diopters.

In the same way that it is common to check for all mirror modules that each lens does not come into contact with the sun shade, here we make sure that none of the focals exceeds the range covered by the mirror. In regards to the cameras, it is preferable that they have the *Glenlock* function (synchronization signal generator) because the synchronization with the clapperboard is much slower and riskier.

In addition to the module, filming in stereoscopy requires an immediate feedback return on the set. In fact, as we will see later on, the stereographer needs to see the two images superimposed in order to carry out his adjustments. There are several solutions. We can install a polarized projection indoors (see the chapter on projection[4]) by connecting the two cameras to the two projectors. A less costly and yet less precise solution consists of creating a device with two monitors and two mirrors with a 45^{o} angle between the two. By placing them at the intersection of the mirrors, each eye sees an image and the brain can piece together the three dimensions. Finally the Transvideo Company has recently created a series of monitors that, by linking two cameras, allows an instant feedback in anaglyphs.

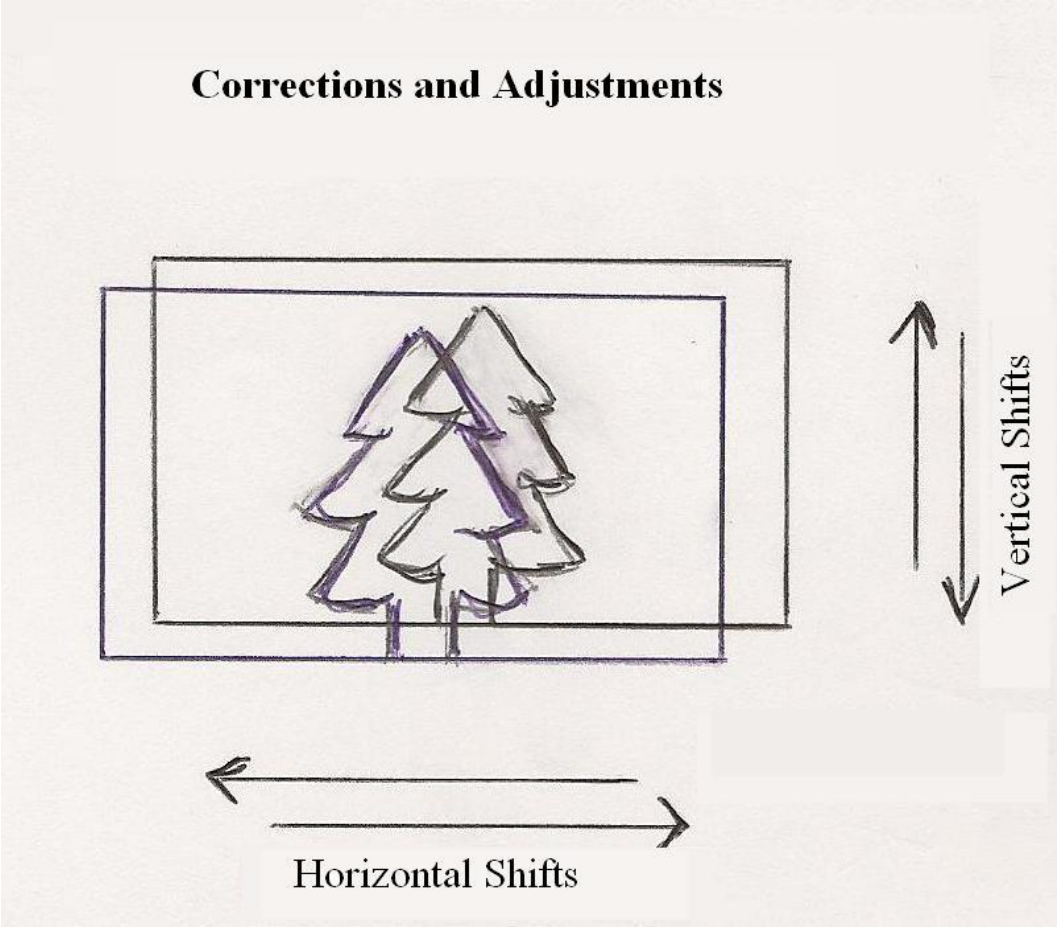
[4] Chapter II Section 1.

4. Postproduction

3D film editing can be done on classical software, principally in two dimensions. The two “eyes” are synchronized within a single image and are located on two superimposed video tracks. Generally, we do not watch with only one eye, but we can still use the calculations of the version in anaglyphs to get an idea of the result. Nevertheless, it is important to have an almost exact idea of the construction of the shots in the depth and amplitude of their three-dimensionality in order to avoid creating link shots that are too harsh for the eye. As we will see later on, the way in which the first of two matching images in 2D are combined with the second can lead to very different outcomes in 3D.

Once the film is edited and before it is timed, we must verify the 3D versions of all the shots and eventually make several corrections. These corrections relate to the way in which two images are positioned in relation to each other, specifically vertically and horizontally. We call these adjustments “shifts.” These "shifts" can also be done on classical editing software, with image alignment tools or on more specialized consoles such as Pablo developed by Quantel. As we will see, horizontal shifts have an impact on the effect of depth and its allocation in comparison to the screen shot. The vertical shifts do not have a real impact on the perception of 3D but they are very important for visual comfort. If the two images are not

aligned on that shot, the brain may still merge the two shots and create the stereoscopy but this requires a much greater effort and can cause headaches.



Finally, the timing, in addition to its usual function, also has an important impact on visual comfort. Two images are never actually exactly identical. Therefore, even though they are filmed at the same place, in same lighting conditions, the two images have slight colorimetric differences due to color sensors and other factors in shooting a film. (It is therefore advised that correction filters or effects not be used to avoid augmenting the differences). Otherwise, when shooting with a mirror module, and even if the diaphragm is offset, oftentimes there will be a slight discrepancy in luminosity. Here too, the differences between the two images do not prevent the brain from reconstructing the 3D, but they make the exercise more tiring.

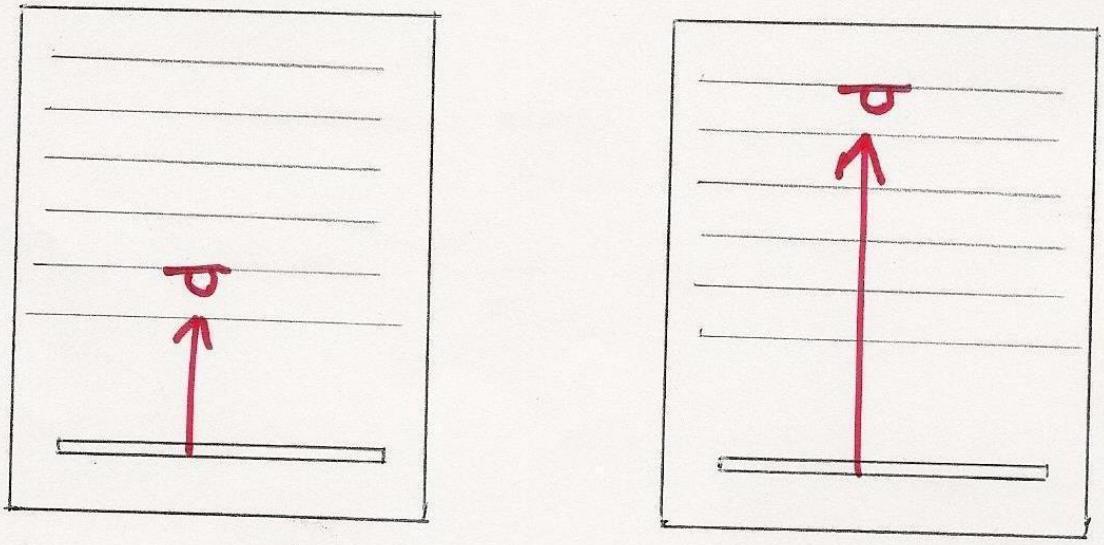
In his article published in the *American Cinematographer* in April 2008, Rob Hummel emphasizes an important fact: one of the great difficulties in the postproduction of 3D films rests in the fact that we become more and more used to the exercise of convergence and reconstitution of 3D. In distancing ourselves in this way from the perception of an ordinary spectator, we become less attentive to the problems that he or she can encounter.

5. Screening in 3D

Several systems for the reconstitution of 3D on the screen have been developed over the course of the history of stereoscopy and which coexist today. The fundamental principle is simple; we must reproduce the conditions of binocular vision of which we have spoken above: presenting a slightly different image to each eye in order for the brain to fuse them together and give us the sensation of 3D. It is easy to understand that this process is complex. Paradoxically, it seems to me that because the brain is powerful and adaptable, it is more difficult to put the process into play. In fact, even with mediocre screening, the brain can reconstruct a coherent 3D image because it is capable of generating a great number of corrections. This adaptability only made 3D worse off in the 1950s and again in the 1980s. Inaccurate projection conditions have created much discomfort among viewers (such as headaches) and that has contributed to the rejection of this medium several times. It is for this reason that the arrival of digital cinema is so important for 3D. It is possible, today, to project a film in stereoscopy with one single projector, which eliminates the possibilities of double projection timing errors.

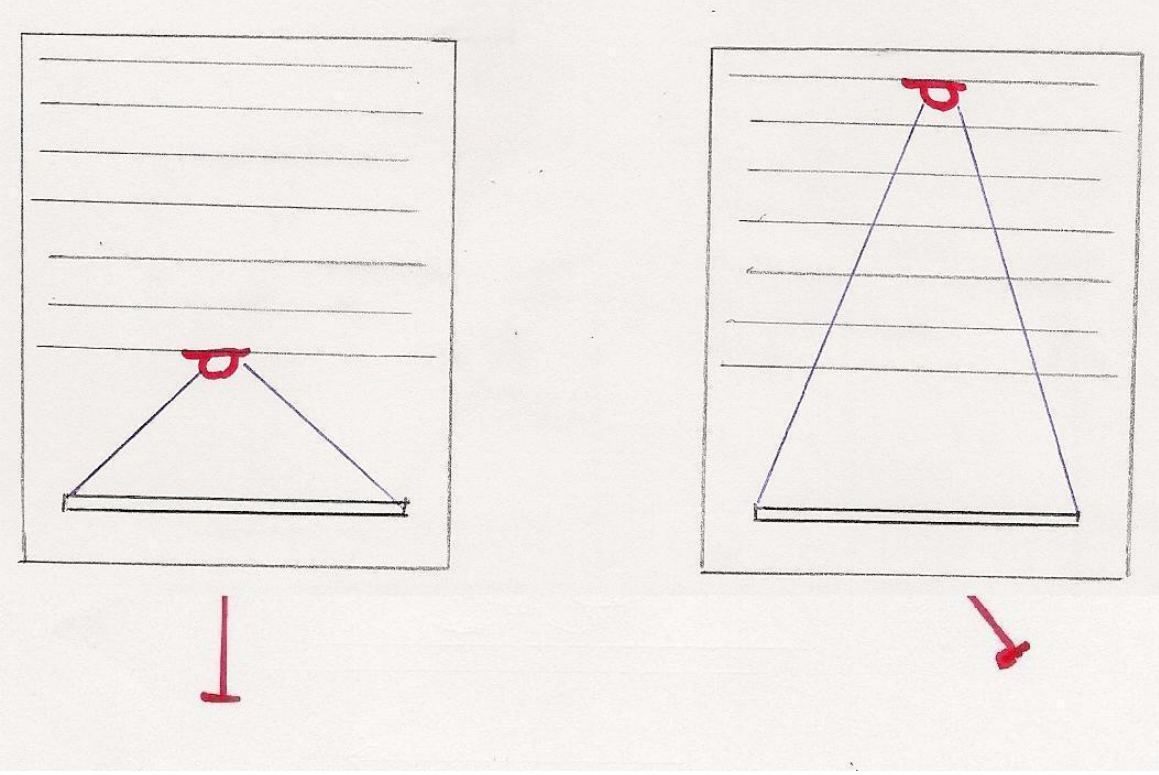
Before describing the different projection systems, it is interesting to point out two characteristics of stereoscopic projection. The first is that the reconstitution of 3D depends on the position of the audience in the room in relation to the screen. The position of the spectator determines the depth or the strength of the 3D sensation and as well as its direction.

3D depth is relative to the distance from the screen.



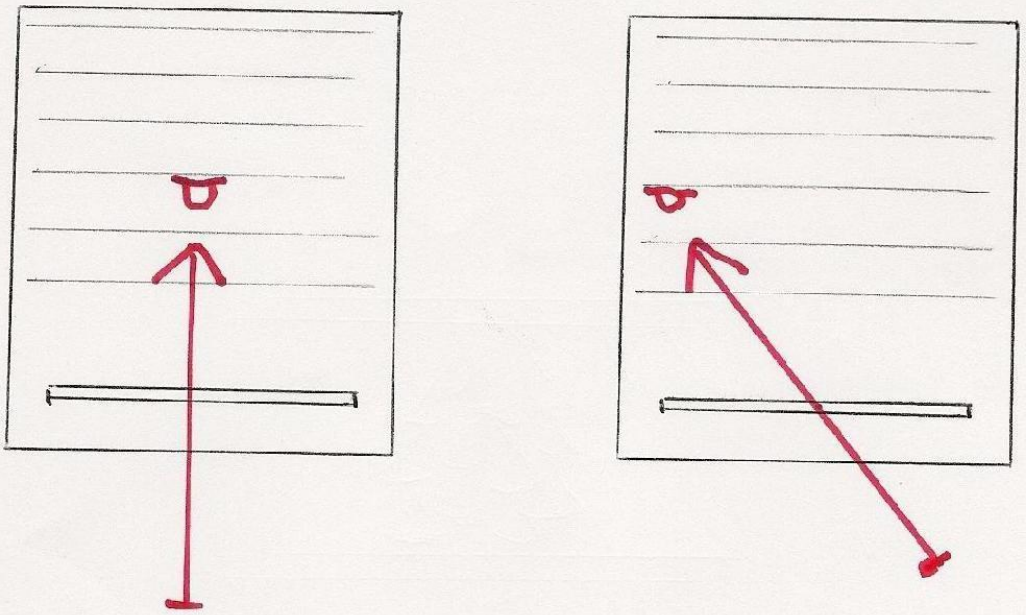
The closer we sit to the screen, the weaker the 3D becomes. As we get further away, the 3D becomes deeper behind the screen and greater the "jumping out." This phenomenon is unfortunately contradictory to another parameter: the larger or smaller range covered, by the field of vision. Because on the contrary, the closer we are to the screen, the more our field of view is covered and, consequently, the more powerful the immersive ability of 3D becomes.

Coverage of the field of vision is relative to the distance from the screen.



This is why the IMAX 3D system is so interesting. It combines both advantages and allows for the sensation of being “in the screen.” In a traditional room, the best position is to be at a distance equivalent to the width of the screen. The lateral position in relation to the screen has an equivalent impact. When seated in the middle of the room, the 3D is centered. On the other hand, when on the side of the room, the 3D “follows” us.

The direction of 3D is determined by the position of the spectator.



Let's imagine a scene with the head of a dragon coming out of the screen with a magnificent setting sun far behind him. For the spectator seated in the middle, the head comes out right in front and the sun seems to be in the middle of the depth. For a spectator seated to the right of the screen, the head comes out at the right and the sun sets in the left of the background. (You will not be able to find a place in the room to completely escape from the dragon…) This poses the question of the diffusion of sound in the room. How, in this phenomenon of the relativity of the image in relation to the spectator, can one conserve a coherent sound track for everyone? One possibility would be to ask each spectator to use headphones corresponding to their placement in the projection room (which is not likely since images in stereoscopy are already costly and the idea of wearing headphones and glasses surely would become a deterrent...)

The second important characteristic of 3D projection is that it is equally relative to the size of the screen. During the shooting phase, stereoscopy is calculated in relation to the

projection screen. A film calculated to be projected on a screen of 15 meters can be projected on a screen of 9 meters, but the impression of 3D will then be lessened (one can therefore eventually think of reinforcing the 3D in postproduction in order to obtain a more adapted copy). On the other hand, this same film should not be projected on a bigger screen. Stereoscopy would be excessive and would become uncomfortable for the eyes. The question is whether we should produce different versions of the same film or carry out the correction by means of the digital server at the time of projection.

There are three major types of projection in 3D. The different procedures make it possible for each eye to only see the images intended for it to see. Therefore, there is a tradeoff: to exclude a part of what is projected (the second eye) or conserving the best quality for the image that must be seen (specifically, the best possible rendition of color).

The first system is that of colorimetric selection, or *anaglyph*. It was the first to be invented and is the system that is most widely known by the general public. The principle is simple: to color each luminous flux with two complementary colors (red and cyan or red and green or blue and yellow) and have spectators wear glasses with filters of the same color, but inversed. This system, which has been used for a long time in cinemas, has two advantages: the glasses are not very costly and the screen used is classical. The main problem concerns the rendition of colors, which are obviously altered. Another problem is that this system is easily subject to the "*ghost*" phenomenon, which is a minor effect of doubling of the image. It creates a slight effect of a double image, which gives an impression of irisation of contours and which reveals the presence of two distinct images. This procedure is no longer used in cinema but it is still useful in many cases. It is a quick and easy method to visualize 3D in several stages of the creation of a 3D film, even if this film is intended for another format of projection. For example, while filming, this principle can be used to create a feedback video to facilitate stereoscopy adjustments. The Transvideo Company developed a feedback system that is very practical, specifically when filming outdoors. For editing (which is done in 2D on classical software), anaglyphs allows us to get a general idea of the 3D aspects of certain shots, to check

if a particular transition works. The operation is very simple, it only consists of superimposing the two images while reducing their opacity by half and applying an effect filter to them.

A current projection process that uses the colorimetric principle is the “Dolby 3D” system. A wheel is placed in front of the projector. By turning, it colorizes the luminous flux 144 times per second. (The make-up of the filters is still kept a secret.) Adapted glasses allow for the restitution of 3D with a greatly improved rendition of color.

The second procedure functions due to the *polarization* of light. This system requires two projectors that each can diffuse a video track. A filter that polarizes the light in inverse ways is placed in front of each of the projectors. The glasses worn by the spectator are also equipped with polarizing filters that correspond respectively to those of the projectors and thus allow each eye to see only one of the two images. (This system is based on the fact that two identical polarizing filters placed at right angles block light). This system has the advantage of being much more respectful of colors, but on the other hand it is more unwieldy to put in place. In addition to the two projectors, a metallic screen that conserves the polarization of light is required. For this process of projection, we favor circularly polarized filters because in the case of linear polarization, the system is corrupted as soon as the spectator tilts his or her head. There is now a mono projector polarizing system developed by RealD. A polarized slab is placed in front of the projector and polarizes the light 144 times per second, that is, 72 times per eye.

The last method of projection, which is the most widely used in France, is *active glasses*. The size is advantageous because if a room is equipped with an HD projector it can project 3D: the classic screens are compatible with this procedure. As the name indicates, the glasses are active; they produce shutter closings that are synchronized with the projector due to an infrared case. These glasses allow a very good reconstitution of colors and little of the ghost effect, but their major disadvantage is that they are more cumbersome than the others and are also much more expensive to manufacture. The owners of the cinemas that use this

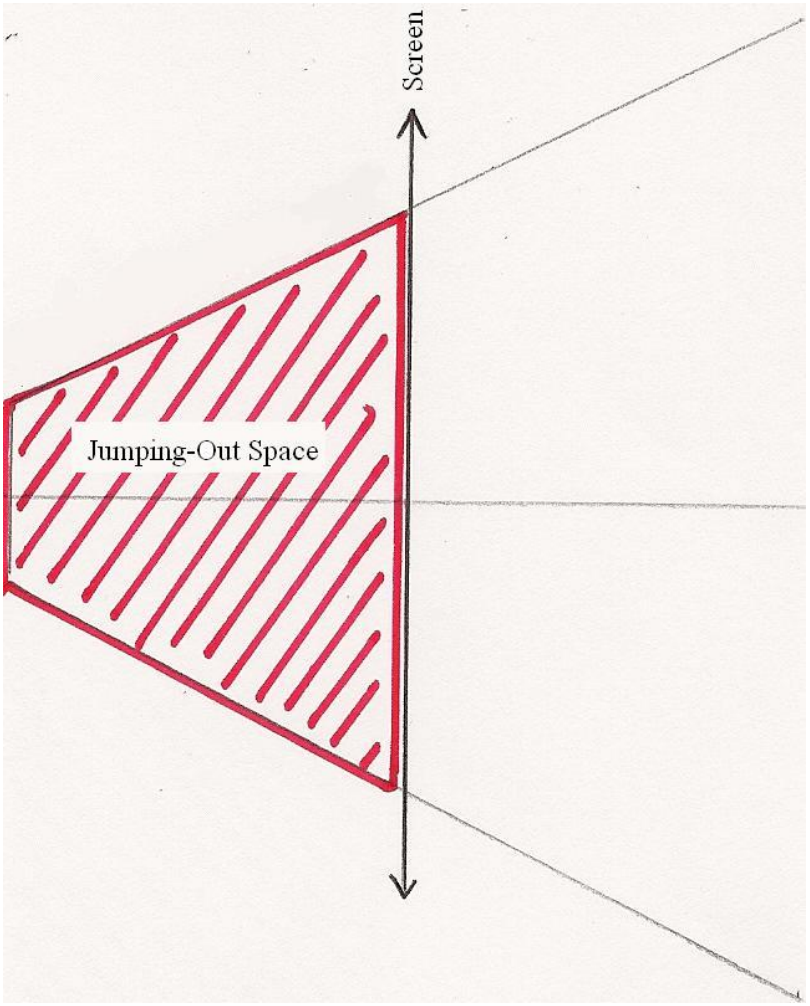
system are therefore forced to organize a system for the collection of glasses at the end of every session. In addition, in France, the cinema ticket is surcharged because these glasses are considered rented (the session costs between 12 and 15 Euros, which can be a bit of a deterrent…).

II/ Stereoscopy and its consequences on *mise en scène*

1. Specifics of 3D *mise en scène*

When anticipating the production of a film in 3D, it is important to keep in mind that as a medium it is close to traditional cinema, but that it involves a certain number of new idiosyncrasies and constraints. In some ways this method of filming implies a new cinematic grammar. This is explainable simply by the fact that the cinematic space and *mise en scène* are different. It is no longer a question of the flat surface of a screen but of a sort of cinematic box. When we bring up cinematic depth or 3D around those who have had little to no experience with it, the most common reaction is "Oh yes, it's when you feel as if you could catch the objects on-screen" or "it's when the scene breaks away from the screen and enters the theater…" This is a very reductive vision of 3D cinema; the cinematic space is much more complex and interesting. The cinematic box can be divided into three components.

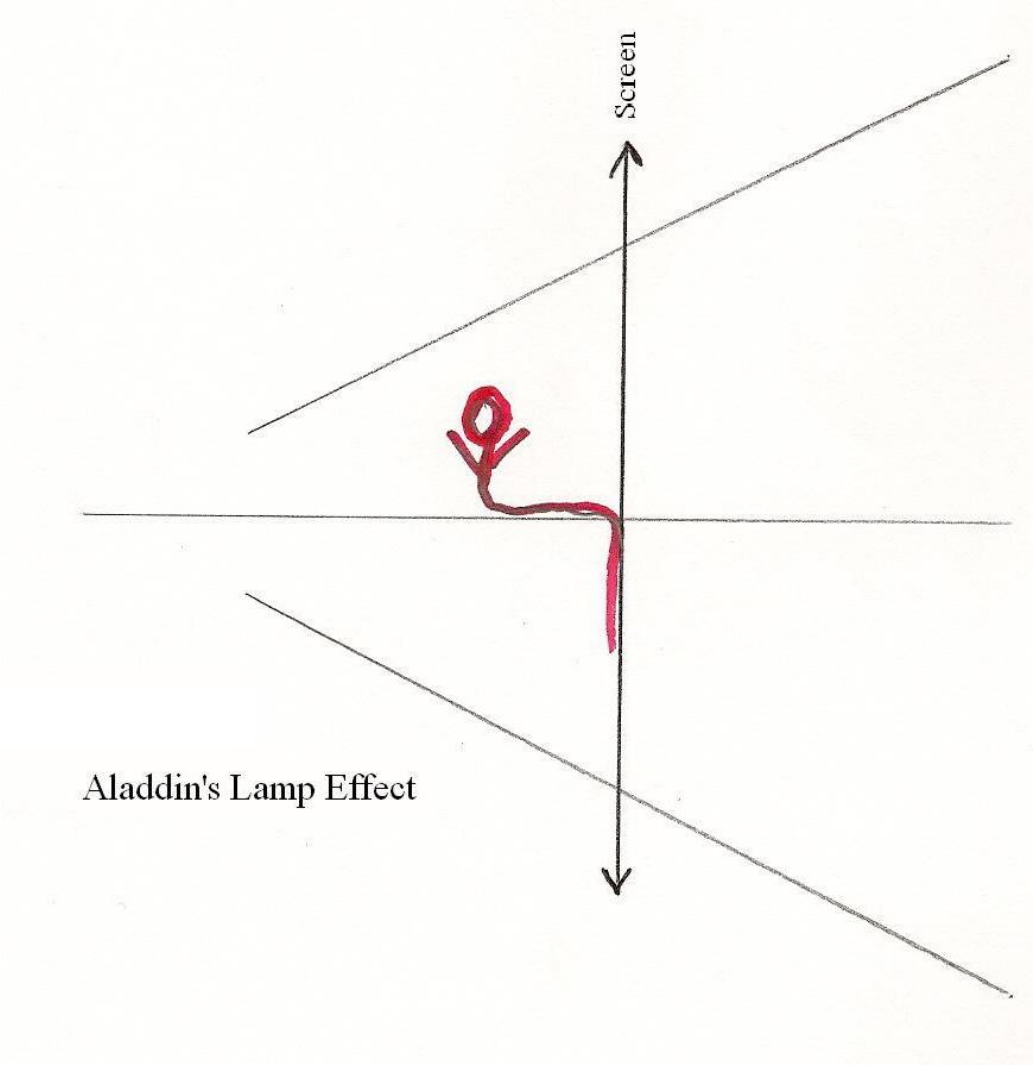
The first is the “jumping-out space” or the “forward space."



This designates everything that takes place between the screen and the spectator (There is obviously a limit to how close the eye may come to the screen, past which the images will no longer converge). This zone is the most familiar because it is the most spectacular at first sight. We might see it as the space that engages the spectator the most because it gives him the illusion that he is physically participating in the action. During fast action scenes, we might feel as if we are actually being hit in the head with rocks or attacked by a monster.

The first problem with this space is that even though it has a rich capacity for creating sensations, it also imposes the most limitations on the *mise en scène.* This heavy constraint is linked to a visual principle: the “breaking frame.” This principle prohibits an actor or an object in this “jumping-forward” space from touching the edges of the frame. If this occurs, the visual

coherence is lost; the brain recognizes the illusion. A visual expression used by certain stereographers helps us imagine the effect this produces: “the Aladdin’s lamp effect.” If we take, for example, the case of a figure set within a medium close shot in the “jumping-out space,” whereas in 2D our brain would simply imagine that the bottom of the body extended past the edges of the frame, here this would produce a strange effect. Our brain would register the bottom of the body as seemingly sucked into the flat part of the screen.



Certain solutions, such as the application of a "floating window", are sometimes used in post-production. This involves applying a mask blurred edges to the image in order abstract the borders of the frame and thus diminish the problem. It is also possible to attempt a similar effect during the filming process by adjusting the lighting so as to darken the edges of the

frame. (But we can easily imagine the complexity of such a process, and all for a hardly reliable outcome.) In the end, we can always hope or wager that the spectator will not look at that part of the image. This is the theory that Rob Hummel promotes in his article entitled "3D Cinematography[5]," published in the April 2008 issue of *American Cinematographer*. He uses the example of a shot where a figure would begin walking forward out of the depth until he reached the "jumping-out" space with his torso framed in a medium-close shot. Rob Hummel says that in such a progression, the spectator's attention is necessarily attracted by the actor's face and is thus unbothered by the breaking frame. This theory is likely viable in certain cases, but seems risky and must not be taken as a general rule.

This restriction leads 3D film directors to develop a fair number of "strategies." We understand, for example, why they decide to "throw" objects towards the audience so frequently: for one it is spectacular, but above all, it is a possibility (there are not so many of these as we might expect). In terms of fixed objects, we quickly get used to thinking of the type of objects we might call *"objets en console,*" which have protruding parts that are liable to be isolated. The perverse consequence of this principle is that it sometimes causes directorial choices to function in reverse. The more familiar we become with 3D filming techniques and the more films we see, the more we pick up on these instances where it is not the film that dictates the use of 3D, but the use of 3D that dictates certain directorial choices. We may look to Eric Brevig's *Journey to the Center of the Earth,* released in 2008, as an example. In the first part of the film, while we are still in the real world, one scene shows the hero arguing with an arrogant man who wants to throw him out of his scientific laboratory in order to reclaim the space for himself. The man casually takes a measuring tape out to take down the dimensions of the room. As expected, the measuring tape suddenly begins to unroll uncontrollably toward the audience. It is obvious that the playful use of this accessory was thought of specifically to incorporate the jumping-out effect and not because it had any stylistic or narrative purpose. This scene is thus unfortunately hampered by this desire to integrate out-of-place effects at

[5] Cf. p. 22.

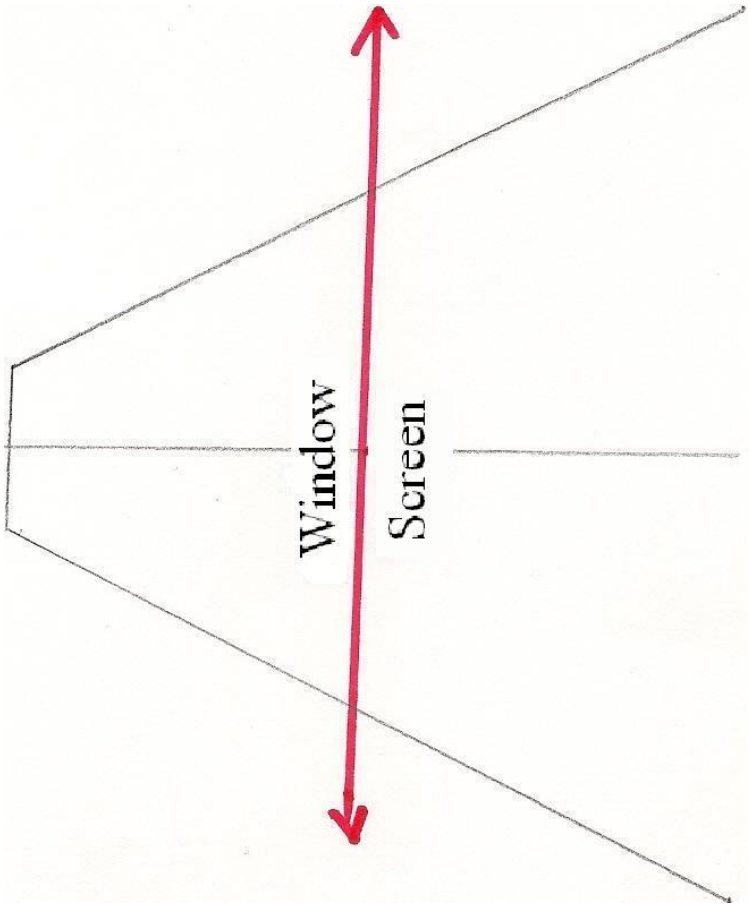
every turn. In the second part of the film, when we are in the marvelous world of in the center of the Earth, the 3D effects, while still a little forced, blend in much better.

These “jumping-out” effects, even if commonly used and seemingly awaited by the public, are in fact often criticized by 3D theorists and technicians.

In Ray Zone’s book *3D Filmmakers* (a collection of interviews by stereographers and directors), stereographer Lenny Lipton comments on a promotional video where his clients demanded the maximum number of “jumping-out” effects possible: “It's like having a musician and always making him play loud. It's crazy.” In an interview given to *Studio Ciné Live* at the time of the opening night screening of *Up* at the Cannes Film Festival in May 2009, John Lasseter, a Pixar producer, said that “all special effects are gratuitous gimmicks and distract the audience from the storyline.” This question often comes up around film critics as well. In the special edition of *Repérages* on the subject of *“*The 3D Craze,” a review of the film *Coraline* speaks very highly of director Henry Selik who “does not fall into technical traps” in this film “that never jumps out at you.”

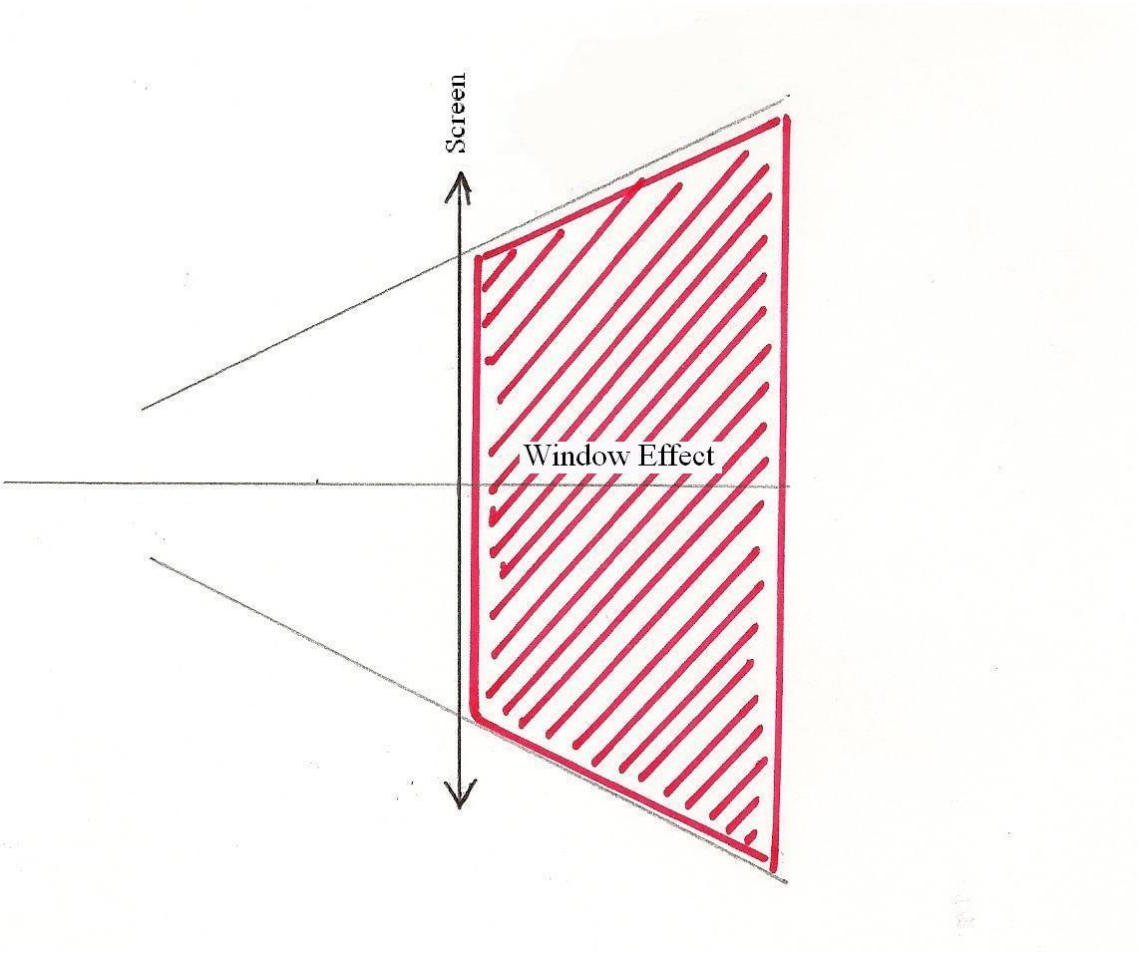
Thus, this first space is rich, restrictive, very tempting, and risky!

The second space is very simply the “screen-level.” This is the central space the other two spaces define themselves against.



Here it is important to highlight an idiosyncrasy regarding the function of our visual perception while viewing a film in 3D: if the convergence of our eyes follows the points of interest in the shot (and can thus go before and behind the screen), accommodation is always made at the screen-level, as this is the physical base on which we must constantly focus. This represents an important difference between our perception of the real world and our perception of a 3D film. In reality, accommodation and convergence are linked, whereas in the case of 3D images, they are isolated. This fact is equally important to the depth limitations for the two other 3D spaces (the jumping-out and the rear space): if the point of eye convergence is brought too far away from the screen and thus from the point of accommodation, this produces a visual fatigue that, as we have already said, often results in a headache.

The last space, less familiar than the others, is found behind the screen. We might call this the “rear space” or the “window effect.”



This space poses few directorial constraints as it does not bring the jumping-out space's "breaking frame" problem with it. It offers an infinite space where the figures and objects may move about in the depth. This depth is further enhanced when split up into multiple planes by objects or parts of the set that allow the viewer to recognize the different dimensional layers.

We might consider one constraint related to this space, which seems questionable to me. Many stereographers believe that the 3D depth space must necessarily benefit from a total depth of field (which implies, as we know, using a great deal of light in order to work with

very small apertures, a process that makes filming in 3D all the more cumbersome). The reasoning behind this is, first of all, that the purpose of 3D is to allow us to see and to "feel" depth, and that it would be contradictory to reduce this possibility in leaving the background unfocused. The other argument is that the lack of focus could itself produce visual discomfort for the spectator: this spectator, led to scan the image, would be bothered by the inability to focus on certain blurry objects. Even if this principle is often considered one of the fundamental rules of filming in 3D, it may be called into question. In practice, this has been the case for many of the full-length animated films released this year that include many shots with reduced depth of field (and yet we know that in animation this is obviously not due to a technical impossibility during filming…). We can take the case of *Up* as an example. In an interview given to *Studio Ciné Live* in June of 2009, John Lasseter says that "at the beginning of the film, when Karl becomes a widower, the depth of field was purposefully reduced to highlight his state of depression, whereas the moment he leaves on an adventure, much of the depth of field is brought back. This type of subtlety, completely subliminal to the public, allows us to better engage with the story emotionally and relate better to the character. In my own experience viewing 3D images with a reduced depth of field, the unfocused field paradoxically reinforces the effect of the 3 dimensions. Certainly, it diminishes the depth, but on the other hand, it sharply dissociates spatial planes in the shot which consequently increases the perceived volume of each clear object. Indeed, when we speak of 3D, we think above all of a medium that offers a new sensation of depth, but it also allows us to render the volume of a simple object in an unsettling way. With this in mind, the rule regarding depth of field is one to reconsider.

2. The Different 3D Settings

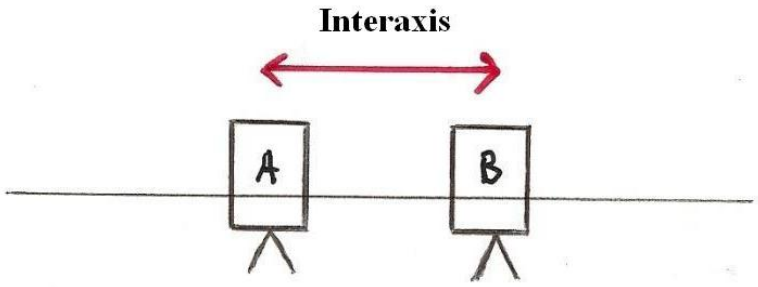
While filming in 3D, the stereographer adjusts the module for each shot. These adjustments are based on the components of the shot and their distance to the camera as well as the director's preference. The two important elements of the image the stereographer

determines are the placement of the converging shot (or the window) and the intensity of the 3D effect.

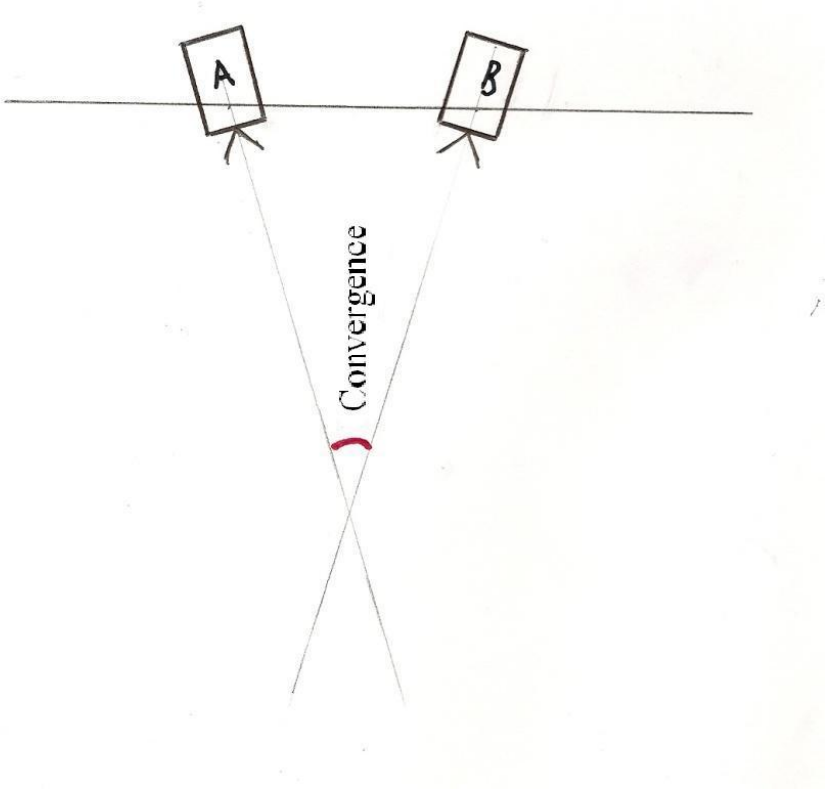
Before describing these parameters and how to adjust them, it is important to specify that there exist two schools of stereography: some directors work in parallel, while others use convergence in their image adjustment as well.

The two variables we can work with are the interaxis and the convergence.

The *interaxis* is the distance that separates the optical axes of the two cameras.



The *convergence* is the angle formed by the two optical axes.



Working in *parallel* creates a sense of dimension by simply shifting the interaxis. Working in *convergence* brings both parameters into play. Each of these methods offers certain advantages and raises technical problems.

Working in parallel leaves much more latitude in post-production work. The location of the window can be modified to a large extent after filming. The main advantage of this is the ease with which the window may be adapted to different sized projection screens. The large margin for maneuvers in postproduction allows 3D calculation for a screen with a fifteen-meter base length just as easily as for a television monitor. However, these postproduction manipulations are detrimental to the image quality. Indeed, what take place here are a series of horizontal shifts that serve to “resize” the image and thus result in a more or less sizeable loss

of pixels. The use of this method therefore depends on the quality of original image capture, which either allows for or prevents the degradation of the image.

Working in convergence creates images where the 3D is less easily reworked in post-production. The window and the quality of the 3D are more firmly determined at the time of filming (which can be an advantage or an inconvenience according to points of view). The resulting main advantage this presents is that the image is much less susceptible to damage. However, the act of converging the cameras entails trapezoidal deformations which are less simple to correct than horizontal and vertical disparities.

As we have seen, the size of the screen on which the film will be displayed is a determining factor for 3D film settings. Therefore, during preparation the stereographer performs a simple calculation to determine the relationship between the size of the screen and the size of the print track. The video allows this calculation to be made according to the number of pixels per line. This calculation allows us to determine the maximum distance between two points in the infinite space that must not be exceeded. The formula is as follows:

(Number of pixels per line / Screen size) x 0.065 m

The value 0.065, which is multiplied by the ratio between the number of pixels per line and the screen width, corresponds with the 6.5 cm mentioned above, which is the distance between the eyes of an average adult.

To use an example: imagine that a film shot with an HD camera capable of capturing 1920 pixels per line is to be shown on a 12-meter screen. We have:

(1920 / 12) x 0.065 = 10.4

The result, rounded to the nearest 10th, tells us that in the distance, two similar points belonging to the images on the right and left, respectively, must not be separated by more than 10 pixels. The adjustment of each shot must respect this maximum value.

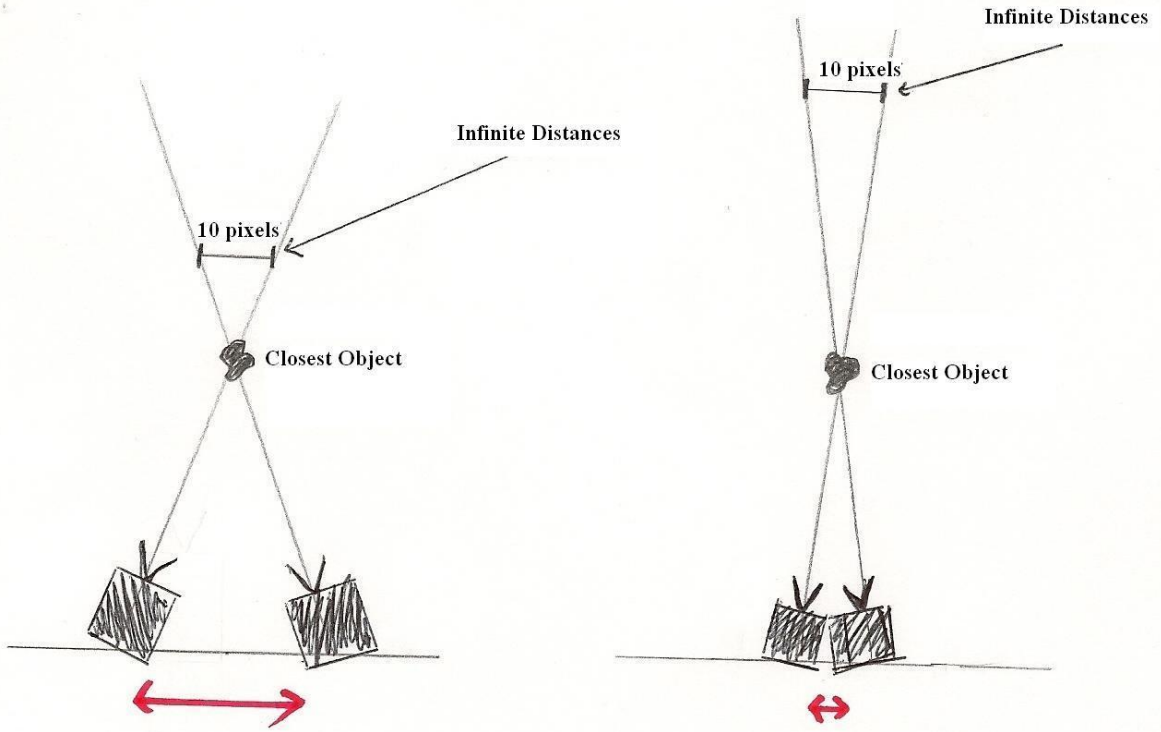
When a shot is set up, the stereographer begins by adjusting the plane of convergence. In general, we place the window very delicately in front of the main object within the shot (the point where accommodation and convergence will naturally take place for the spectator). To determine the interaxis, we can make use of the rule of the thirtieth:

Distance from the main object (in cm) / 30

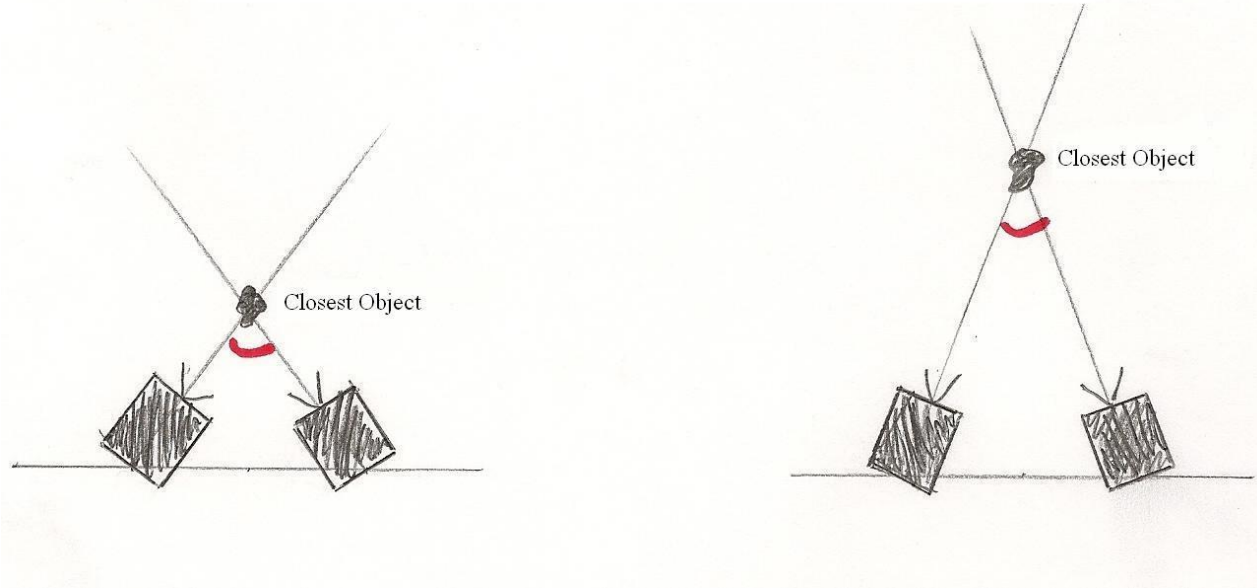
The window can also be adjusted to the eye thanks to the indispensible 3D video feedback. Once the convergence is set, the stereographer can modify the interaxis to ensure that the infinite distances are less than or equal to 10 pixels in our example.

These parameter settings fix the window's position and distance from the infinite distances but also determine the quality or the amplitude of the 3D. The larger the interaxis, the more pronounced the 3D will be. Thus, the composition of the shot can be a determining factor in the quality of 3D the stereographer can suggest. If we take the example of a figure standing at the bottom of a mountain, the window is focused on this figure and the infinite distances are set at 10 pixels in order to have the richest sense of depth possible (still according to our example). But if a tree branch is raised in front of the figure as a lead, the stereographer must adjust his settings so as not to create a "breaking frame." He thereby shifts the plane of convergence to rest in front of the branch. The amplitude of the 3D will have therefore changed: since the interaxis will have been diminished (because we will no longer register the camera's distance relative to the figure but to the branch), the amplitude of the third dimension itself will have been diminished. But paradoxically, the sensation of 3D will be perhaps greater because the addition of an object in the foreground will give the image more depth and additional levels of detail. If we now imagine that the figure is placed a few meters in front of a wall, the three-dimensional settings change as well. In this situation where what is in the distance is not in infinite space, the stereographer has the choice of applying a space of 10 or fewer pixels to the wall. Indeed, choosing 10 pixels will give the strongest sense of three-dimensionality but will not necessarily be consistent with the 3D quality of the entire film. In order to achieve a continuous sensation of dimension, it would be more coherent not to set the interaxis at its maximum value.

Distance From the Infinite Distances and the Interaxis



Distance From the Closest Object and Convergence



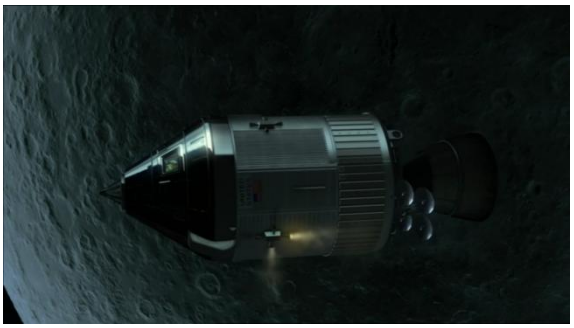
The global consistency of 3D is indeed important. Also, the 3-dimensional settings of a shot are often equally linked to the settings of the shots that precede and follow it. Let's take the example of a shot reverse shot with no leads where the conversing characters are not at the same distance from the camera. Since we know that during editing it will be possible to go from one shot to the other several times, the stereographer's interest here is to minimize possible 3-dimensional jumps. Thus, he will be able to decide to place the window at the same distance for the two shots (in this case he will have to lean heavily on the closer of the two characters).

It is obvious that once visual comfort is assured by the rules that have just been explained, choices in the adjustment of 3D are aesthetic choices that, as with other visual elements, must go along with the development of the story.

3. Shot Analysis: *Fly Me to The Moon*

Along with my research on the technical aspects of stereography, I spent a good deal of time trying to understand its implications on the *mise en scène.* I therefore watched and re-watched as many 3D films as possible and noted my impressions of each shot, analyzing how these shots were constructed, the impact of 3D on the narration, and the effect it produced on the viewer's reception. I chose to mention some shots from *Fly Me to the Moon* here because this film presents very rich 3D, often rather spectacular, and it gave me a large amount of material to reflect upon.

EXTERIOR. NIGHT. OUTERSPACE...



This first shot of the film subtly invites the spectator to discover the entire scenic space the film intends to occupy. With the moon as a background, the small shuttle first appears in the jumping-out space, coming out of the screen completely. Then, in continuing its movement around the moon, it touches the surface of the screen and travels farther into the depth of the shot toward Earth, which has appeared in the distance. The viewer's attention is carried along by the space ship. The eyes are invited to explore the entire depth of the shot and appreciate its scope.

EXTERIOR. DAY. A JUNKYARD.



The scene starts with a large view of the junkyard, and then a traveling shot begins and slowly moves closer to the wire fencing. The virtual camera passes through a hole in the linked iron fence and then makes its way into the brush.

One might feel a sense of discomfort while passing through the fence, which goes off-screen at the edges of the frame. The natural movement of the eyes in a shot such as this should be, on one hand, to look at the center of the image, and on the other, toward the destination. But here, the third dimension gives the wire fencing a good deal of importance, and the spectator's gaze might stay "hooked" there. If this is the case, one experiences the rather unpleasant feeling of having to focus first on a very close object on the edge of the frame, and then, when this object leaves the frame, of being in a daze for a short moment as we take the time to refocus on the infinite. This creates a jump of gaze in a shot that is intended to be slow and fluid.

EXTERIOR. DAY. MEMORY OF GRANDFATHER.

We are in a black and white scene where the grandfather fly recalls his journey across the Atlantic in a plane. In a subjective shot from the window, we see the cabin of an airplane, the propeller, and the ocean in the background. This image composition should naturally lead us to look at the moving propeller in the center of the shot. But here, the composition in 3D places the plane's cabin in the jumping-out space, which causes it to take on a considerably greater importance. The gaze is held as if caught in a contradiction between the geometry and the volume of the image. It seems that this would not be the case if the proportions were different and if the cabin would take up more space in the image, or again, if the choice of 3D techniques had been different and the shot had been worked upon to accentuate depth and invited our gaze to look into the distance.

EXTERIOR. NIGHT. THE JUNKYARD.

This is one of the first shot reverse shots in the film. The hero attempts to convince his two friends to go with him to the moon and invites them into the human space shuttle. Here 3D allows for interesting effect. The shot reverse shot is emphasized by characters jumping in

and out of the screen. The hero, arguing, is in the room, while the two others are “in the screen.” This 3D construction reinforces the empathy we might have for this situation. When the hero is on screen in front of us, it is as if we are caught in the same position as those he is speaking with in the story. In simplest terms, it is as if we were in the conversation. The character who appears thus in front of the screen has a singular, more authoritative presence. This is particularly interesting in this sequence because here form corresponds precisely to meaning. The character invades our own space and imposes a physical pressure on us (all relative, of course; this is only a fly…) as well as on his friends. Singular

OUTDOORS. DAY. THE JUNKYARD.


This is an establishing shot which announces a new day. It is a static shot that relies on a change of focal point. We begin on a small spider spinning its web, and then the focal point moves beyond it and rests on a car in the junkyard, where we find our hero. The interest in this shot is that it emphasizes the setting’s different layers of depth. But strangely enough, the shot does this in a contradictory fashion with the use of 3D *mise en scène.* The use of 3D specifically allows the coexistence of the different elements in the field of depth without dissociating them. In addition, the amount of light is obviously not a problem, as this is animation… Perhaps this is what is of interest: on one hand the animator is alluding to classical cinematic grammar, which is an interesting tendency to observe in animated films. But on the other hand, emphasizing two “flat” shots is perhaps a way of strengthening the sensation of 3D in the coming scenes.

EXTERIOR. DAY. A MEADOW.

As the three small flies leave on an adventure they head toward the space center. Here we have a wide-angle shot with an entrance into the frame from the back of the camera. The frame is empty at first, and then the arrival of the three flies captures our attention. This effect, although very classic and dynamic in 2D, is rather taxing for the eyes in 3D even though there is no jumping-out space. Indeed, our eyes are subjected to the strain of a quick and sizeable convergence. In the beginning of the shot, we focus on the infinite background because nothing is happening in the foreground. When the flies enter the frame, we must focus on them and therefore converge them. We have to transition from focusing on the far distance to the screen-level suddenly, without anything to guide our gaze gradually to another element in the shot. This transition is very straining for the eyes (to get an idea of the effort involved, shift your focus successively between a finger placed in front of you and an object far away.)

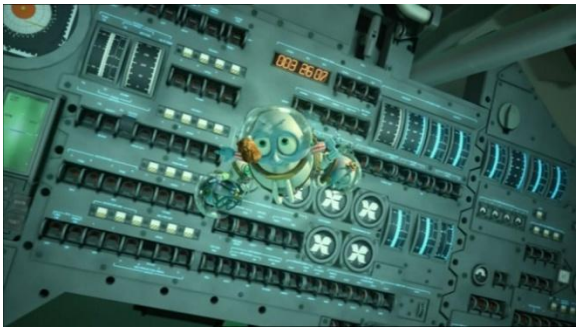
EXTERIOR. DAY. A STREET.

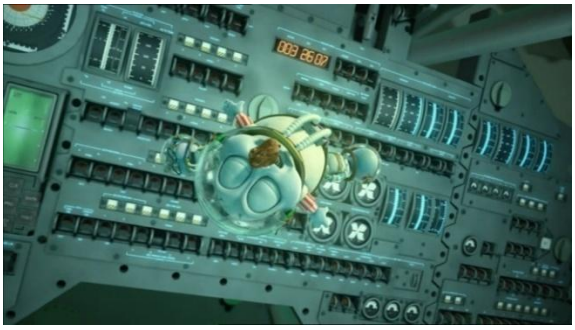
This effort involved in converging can easily arise during certain link shots as well. This is the case for this transition between two sequences. In the first shot, we see a pick-up truck driving away in a relatively wide shot. Our gaze stays focused on this moving car and we are therefore gradually led to focus on the background. The following shot cuts to the next scene. We arrive in the flies' house where two small larvae brothers are fighting over a piece of bacon. They are placed on the screen-level, and therefore much closer than where the car ended up in the previous shot. This connection makes us converge rapidly near a closer distance, which is again rather uncomfortable for the eyes.

EXTERIOR. DAY. FLIES' HOUSE.

Certain camera movements can pose the same problem. We are now in the hero's house while his mother learns that he has left with the intention of going to the moon. The depth is relatively limited; there is no jumping-out space. We start on a medium shot of the mother, who then faints on hearing the news and therefore disappears from the frame. We pan very quickly on the grandfather, who is next to her. There are two problems here. On one hand, the shot implies a back and forth convergence of our eyes which goes from the foreground on the mother to the background in the far end when she exits the frame, only to be brought back suddenly to the foreground when the grandfather appears. The second problem comes from the movement itself. It is so quick that it is difficult to rest your gaze and find a focal point to accommodate. The gaze is therefore dazed for a few seconds and is all the more difficult to converge later on.

INTERIOR. DAY. THE SPACE SHUTTLE.





There is a visual gag in this sequence that we might consider a "3D gag." It functions even better when seen with its composition in depth. The three small flies succeeded in

climbing aboard the space shuttle with the astronauts. First, we have a weightless waltz scene that is particularly enticing because it allows the jumping out to happen slowly and comically. The sequence leads to a game between one of the small flies (the greedy fly) and a piece of weightless floating cookie. The shot is constructed in such a way that the piece of cookie slowly gushes out into the theater, while the greedy fly appears far behind in the background and attempts to capture it. This shot works particularly well because as it is very slow, it allows us to adjust our gaze several times from the cookie to the fly. The 3D gives us a good perception of the distance between the fly and the coveted object. The superhuman effort the fly must make in order to reach it is therefore all the more tangible. The slowness also allows us to enjoy all of the character's desperate facial expressions as he fails to pull himself out of the screen-level to catch his cookie. This is where 3D is interesting. It allows for a dividing of the shot that does not exist in 2D. The screen acts as a barrier that separates us from the character and puts the coveted object on our side.

INTERIOR. DAY. THE SPACE SHUTTLE.


The little flies continue to explore the spacecraft. One of them lands on a control button. Suddenly, one of the pilots gets ready to push this button. The tension reaches its max: will the little fly be crushed before even having seen the moon? This moment of intense suspense is highlighted by a subjective cutting. We find ourselves in the fly's field of vision, who sees the pilot's large finger coming toward him. This oppressive effect is reinforced by 3D: the finger is jumping out and comes toward us, the spectators… Again, 3D augments our empathy

for the character in giving us the illusion of sharing the same physical sensations. Fortunately, we do not end up crushed by the pilot's index finger, and neither does the little fly!

INTERIOR. DAY. A MEETING ROOM IN RUSSIA.

A Russian fly general holds a discussion with one of his subordinates. He is furious at having learned that the three American flies will be the first to go to the moon and begins to devise a plan to prevent them from accomplishing this feat. At first the two flies are side by side, then the general flies off and keeps a little distance from the other. The shot is a rather sharp high-angle shot. The general is in the foreground and the jumping out space, while his right arm is in the background and behind the screen. Again, the 3D composition here reinforces a separation in the shot. Not only is the general higher than his subordinate, which is highlighted by the low angle shot, but he is also clearly in front of his subordinate, who is in the depths of the field. The balance of power is clearly established. In addition, this composition allows us to consider two readings of the shot. On one hand we have what is said in the dialogue, and on the other we have the expressions on the general's face, which is close to us. A fairly similar effect is possible in 2D. If a character turns his or her back on a second character but faces us, we are the only ones to see that character's expressions. In 3D, this effect is stronger because the character is closer to us. The character is physically on our side of the screen, which heightens our attention to the slightest of his expressions.

INTERIOR. NIGHT. CABIN OF THE SHUTTLE.

The three astronauts are seated side-by-side in the cabin. The shot shows their profiles in a row. This composition creates a perspective toward the depth of the image that should lead our eyes to seep across the shot toward its deepest part, from the first astronaut to the third. But 3D does not work this way. The first astronaut is jumping out and therefore takes on greater importance. The equilibrium, then, that exists in the 2D shot no longer exists in 3D. It is as if the gaze were cut short by the foreground, which is not even more important to the narrative than the others.

INTERIOR. DAY. SPACE SHUTTLE.

The three flies have been put to sleep and then locked up by the astronauts. We find them unconscious in a test tube. The shot is constructed totally in depth; the virtual camera is placed on one of the ends of the tube. This shot is relatively unspectacular as it is static and without

jumping-out effects. The first of the little flies regains consciousness and tries to rouse his two friends. To do so he makes his way toward them, farther into the depth of the tube. This shot works particularly well in 3D because it allows us to benefit fully from the feeling of traveling freely through space. This is primarily due to the fact that the shot is static, which lets our eyes travel freely through the shot without being led. This is also due to the rather complex composition of glass reflections, which form a multitude of luminous points from which the gaze bounces back and forth. The eyes are therefore subtly invited to navigate the depths and benefit from all the shot's textural effects.

INTERIOR. DAY. SPACE SHUTTLE.

The greedy little fly gives into temptation once again. A carton of orange juice is opened and pours out like rain drops. With the weightlessness, the drops glide slowly in the cockpit. It is a low-angle, very slow traveling shot. The little fly glides between drops, gulping them down one by one. The drops seem to fall on top of us, the first ones jumping out. This shot is visually pleasing because it is very slow, and it also allows us to scan the space in the background at our own pace. In the beginning, we are naturally guided by the fly, but the shot lasts long enough to allow us to focus our attention on other parts of the shot and converge on the different drops at our leisure. Having the option of going back and forth in the background of the shot is particularly enjoyable. This seems to me to be one of the most interesting aspects of 3D.

INTERIOR. DAY. CONTROL CENTER.

An evil Russian fly has been sent by the general to sabotage the space shuttle's landing. The little hero's grandfather, warned of his intentions, decides to go to the control center as well to challenge him. So begins a long fighting scene. The evil fly arms himself first with lit matches, then a knife. In each case, certain shots are from the grandfather's point of view. We are therefore facing the evil fly and receive his blows that are lightly jumping out. This is a classic 3D effect as it is very effective: it gives the spectator the impression that he is going to receive a blow by making the danger jump out toward him, into the theater. This effect works well in two ways. On the one hand, the jumping out is very effective and does not pose any breaking-frame problems. It also directs the aggressive intent toward the spectator, which is very appropriate for a fighting scene. On the other hand, this again allows us to empathize with the grandfather because we identify with the delicate situation in which he finds himself amplified.

4. The Role of the Stereographer

Filming in 3D allows for the creation of new sensations. This medium opens up a very wide and fascinating field of experimentation. Nevertheless, as we have seen in Chapter I, even if the tools have evolved and today 3D is technically viable in all stages of production and post-production, the issue concerning visual comfort and the tiring nature of this art form remain very important. The study of 3D films such as *Fly Me to the Moon* shows that we cannot

content ourselves with simply transposing the cinematic grammar of 2D cinema. New methods of creating shots are possible; but on the other hand, certain effects must be used with caution. Even if the established rules must constantly be called into question, it is important, at all stages of the film, to consider how the image will be perceived and what effort it will demand of the spectator. This question concerns each isolated image (in the way the shot is composed, the rhythm of movement, the distribution of jumping-out effects and depth…) but also the way the images are juxtaposed. It may be bothersome to show two images together which have:

- Planes of convergence very far apart from one another.
- Very different 3D qualities.
- Points of interest placed on levels of depth that are very far apart.

The importance of rhythm and length of shots also intervene in the question of editing. We know that the brain takes an average of three seconds to read 3D. This implies that 3D editing must therefore be slower. Moreover, 3D is naturally more tiring to watch and slowing down the editing rhythm will also improve visual comfort.

The role of the stereographer, then, is first of all to assure visual comfort, as emphasized by Laurent Verduci (stereopgrapher) in an interview given to *Repérages* in June 2009. To the question, “The role of the stereographer would be, therefore, to think essentially of the spectator and their visual comfort?” he responds “If we do not take this into account, 3D will never develop”.

But beyond these technical questions, the stereographer certainly contributes to the narrative and creative aspects of 3D. The way a film is put into 3D, just as much as other visual elements, plays a very important role in the construction of the film's universe. The creators of *Coraline*, in an interview given to *The American Cinematographer* in June 2009, commenting on the choices they made, said, “We realized that a set that remains behind the screen evokes an impression of space and freedom […] Sometimes we did the opposite in order to give the impression of claustrophobia and discomfort.” For cinema, unlike amusement park films, 3D does not have to be an end in itself, a technical demonstration, with the sole goal of impressing

the spectator. It is more a vector for the expression of, sometimes tenuous, meanings and emotions.

Therefore, when directing a film in 3D, we can choose to make use of very pronounced effects (if this is consistent with the film), or on the contrary we can use stereoscopy in a much softer, less present and spectacular way. This medium does not necessarily forbid a usage more contemplative than sensational. It is this seemingly paradoxical approach of using 3D with discretion, of sculpting the image in what I might call bas-relief, that I personally adopted for my capstone project: my short film *Le train où ça va…*.

III/ *Le train où ça va…* Creating a Film in 3D.

1. The Project: An Intimist Film in 3D

One year ago, when I became interested in 3D, I had never really seen a feature-length film in 3D. I was only familiar with stereoscopic photos, which I had had the opportunity to see in different expositions and films screened in Futuroscope. This subject interested me greatly because I knew nothing about the history of stereoscopy and even less about shooting techniques. I had everything to learn.

And yet, I could not necessarily see the interest of this medium. It seemed a bit anecdotal, and above all I did not see it as a form of cinematography. I thought of it as little more than a technical feat meant for creating sensational images to entertain spectators at amusement parks. But in the end it was precisely this sensational aspect, and perhaps a bit of a defiant spirit, that pushed me to continue along this path. I simply asked myself why this form should necessarily be tied to such a specific realm. Why did only horror or action films make use of this visual medium? Must we assault the spectator, when producing a film in 3D, by launching meteorites or other projectiles at him, all the while bombarding him with an overblown soundtrack? It seemed to me that there was no reason for form to dictate a specific content.

My project has come out of this simple question: why can't we make an intimist film in 3D? What would be the final result? Would such a filmic universe be compatible with the application of this technique?

The more my research progressed, the more this idea of producing a stereoscopic film moved beyond my simple desire to do the opposite of what was expected. The more I saw of these images, films, and documentaries in 3D, the more I thought to myself that before the sensational aspects of this form there was the fundamental notion of sensation: a film in 3D

produces particular sensations. Now, I wanted my film to make the strongest possible appeal to the spectator's feelings. It seems to me that this is the goal of the operator, to translate screenplays into light and color sensations, to make things perceptible. In *Le train où ça va…* there is not really a story; what plays out here is most importantly the relationships between the characters and their connection with a place. And once I set preconceptions aside, 3D appeared to me an extremely sensual medium, capable of making tangible the tiny details so imperceptible in daily life and redirecting a particular attention toward objects, bodies, and atmospheres. Even more than relief, i. e., the act of freeing objects from the background, it was the possibility of conveying their volume that interested me. I found it fascinating how 3D could impart such presence.

Moreover, I realized that stereoscopy was not necessarily an invasive form. Filming in 3D does not imply attacking the spectator. In fact, it can mean exactly the opposite. It is possible to use this form as an invitation to enter a universe. When we work with stereoscopy in terms of depth or window effect, instead of entering the spectator's space, the theatre, we invite him to become immersed in the depth of an image. It is moreover a medium that makes the spectator a free and active participant. There is always more space for him to discover and more ways for him to read the image.

It is for these reasons that the idea of creating an intimist film in 3D appeared less and less incongruous to me. Because it seems to me that the form itself can imply a certain intimacy with the spectator.

However, during film preparations not a single member of the team or the other people that had read my script asked me, "*But what is the connection with 3D?"* The idea was far from being met with unanimous approval, but fortunately it at least had the advantage of piquing curiosity.

Two other aspects of working in stereoscopy could have put an end to my project. While beginning my research, the first conversation I had about three-dimensional film images was with a friend and director who had had the opportunity to produce a promotional film in 3D. He said he had found it very interesting but equally restrictive to the *mise en scène*. He found that

the stereographer significantly influenced directorial choices by constantly making a priority of what would "work well" in 3D. He cautioned me against the danger of letting this form dictate a certain manner of directing or letting it restrict my artistic freedom. I thus strove from the beginning not to make choices based on what would work best in 3D: that is, not to let a desire to show the most striking elements of 3D guide the *découpage*, and not to make stereoscopy a technical element that dominated all the others.

The other fear concerned the method of filming. I was afraid that this technology would be physically restrictive because it is heavy and difficult to manipulate. I did not want the film to be confined from the preparation phase to a precise and definitive storyboard that would not leave me the option of readjusting during filming along with what the actors were doing. I was afraid that putting this technology into practice would suck all the energy from the set and would monopolize everyone's attention to the detriment of what I consider to be most important, the actors. I took this fear as a challenge, and in preparation I often told the team that we were there just as much for the sound, the decor, the light, and the costumes as we were for the stereoscopy. I made it my goal to ensure that the use of this technique would not make for a rigid filming process.

It seems to me that this was the risk I had to take to prevent my film from becoming a simple exercise in style or a demonstration of technique. In order to convincingly support my original intuition, the idea that 3D can be a suitable form for intimist films, I had to try to preserve as much of the spontaneity and the energy of filming as possible.

2. 3D Directorial Choices

During preparation, as I have said above, I watched and re-watched as many 3D films as possible. And beyond my desire to understand this technique, to analyze how the images were constructed, I also tried to develop my own taste by noting all the shots that caught my interest and the editing styles that I liked. But when the time came to edit my own film, it became obvious I could not content myself with cataloging all that I had liked and trying to reproduce all the ideas that pleased me. *Le train où ça va…* called for simple *découpage*, including many long takes and a general preference for rather soft 3D. We quickly decided, along with Laurent Verduci and Céline Tricart, who carried out the stereography work for the film, that for the most part we would set up 3D with use of the window effect, with the exception of two "jumping-out" shots that I will bring up later on, and the close-up shots which were a bit of a special case.

I was fortunate to film partly in a constructed set and to be able to set up many of the shots along with the changes being made to different parts of the house. With Sophie Bégon, the chief decorator, we often based our decisions on what the decor would allow us to do in terms of *découpage* and 3D.

One of my first priorities was to dedicate the most possible attention to materials and textures. Indeed, in many of the 3D films I had been able to see, I had unfortunately noticed a slight metallic aspect to the image, and rather poor textural effects. Although it might be a bit of an exaggeration, I would say that this type of 3D seems closer to the world of video games than that of cinema. Such an effect is perhaps due to the rather frequent use of synthetic images. With this in mind, we discussed at length all the materials we would use for the set and in particular the treatment of sheets. In the main room, Sophie proposed a work in cowhide (which involves covering the sheets with plaster before painting them), in order to render the potential ruggedness of 3D. In each room, she was very attentive to the finish of the paint and the wallpaper. While we were putting the set together, we also discussed the way that objects

and furniture could play a role in the construction of 3D shots, because as I have said earlier, the type of objects and their location in the shot often condition stereographical choices.

3. Editing

INTERIOR.DAY. BATHROOM

The little boy takes a bath and plays, making bubbles of soapy water with his hands.

The bathroom is a very small room, which is not ideal for 3D in the first place because it provides little depth for us to represent. We set up these proportions intentionally, so 3D would be reduced here. Twice we filmed scenes in this room of the house with characters that are by themselves, as if in a bubble. I wanted to translate this idea of a cocoon using soft 3D and a reduced depth of field.

In this bath scene that opens the film, I imagined that the little boy's bubbles would jump out from the screen. The bubbles did not pose any problem of "breaking frame" and I thought that this effect would give me the opportunity to reassure the spectator from the start: "yes, it really is a 3D film." But in fact, this effect was very complicated to stabilize. It would have been necessary to place the window precisely in front of the little boy's hands and then hope that it would remain perfectly in position. At this moment in filming, I finally came to understand that it is impossible to work with a six year-old child and at the same time

anticipate shots that require such precise markers. I think that in order to carry out my original idea, I would have had to resort to adding a synthetic image.

INTERIOR. DAY. BATHROOM.

The mother dries off the little boy and then takes him in her arms to carry him to his room.

For this shot, I had planned a tracking shot that would have followed the characters as far as the kitchen, to then show them walking up the stairs at the other end of the room. I imagined that this would be the moment to move from the confined space of the bathroom to discover the main room of the house. This shot posed a technical problem, however. In order to carry out this passage through the door, it would have been necessary to change the point of convergence during the shot, because the shot would have presented several configurations of infinite distance versus the closest object. The shot therefore remains fixed while the figures move away from the door frame. The interesting thing about this shot as it was finally filmed is that it permits the expression of great depth, as the characters begin their movement just in front of the window and glide into the distance. The gaze should presumably be directed to the end of the room as the sound of their voices, as if it had a spatial dimension, moves into the background.

EXTERIOR. DAY. TRAIN-TRACKS.

The grandfather and the child walk along the train-tracks.

Passing to exterior spaces allows for 3D work that contrasts greatly with such work carried out in interior spaces, as the former allows us to frame actual infinite distances. We have used the widest possible 3D setting to reinforce the idea that the train tracks represent a special space in the film.

In this shot reverse shot between the grandfather and the little boy, we had to adjust the windows in post production. These two edited shots created a jump, as the window in the frame on the little boy was too close compared to the window of the grandfather's frame. We therefore "moved the grandfather closer" by "shifting" the images horizontally. So, even though the values of the shots are different, we have adjusted the 3D so the characters are at the same distance from the screen-level and the result is smoother.

INTERIOR. DAY. KITCHEN.

The mother is hanging up laundry by the fireplace when the grandfather and the little boy return from their walk.

The kitchen is the largest room in the house. To maximize its size and to permit the widest possible range of perspective we came up with the idea of allowing the spectator to "discover" adjoining rooms as we do here with the entryway. We constructed the shot along the axis of this depth. The clothesline interested me because it helped set up a rather unique shot that I hope reinforces the impression of depth.

INTERIOR. NIGHT. THE LITTLE BOY'S ROOM.

The little boy is jumping on the bed, the mother comes to tuck him in…

This shot is relatively flat, with little perspective. It consists of a figure in front of a wall, framed directly from the front. I made this decision because it seemed interesting to occasionally incorporate shots that were almost "anti-3D" to create points of contrast and

emphasize the depth of following shots. Moreover, I wanted to take full advantage of the graphic effect of the wallpaper.

I was a bit afraid that the little boy's jumping would be too visually tiring, which is not the case. The problem might have presented itself had we filmed the image any closer-up than had designated. In this case, the little boy would have moved in and out of the field through the bottom of the frame, which would have been somewhat disagreeable for the spectator, requiring a back-and-forth process of convergence. In this case it would have certainly been better to shoot in quasi-monoscopy.

INTERIOR. MORNING. KITCHEN.

The grandfather has been up for some time and he calls out for his daughter to wake up. She comes down, slightly displeased to have been roused from bed so early.

Here we have another example of letting the spectator "discover" another part of a series of adjoining rooms: the pantry. We positioned the camera along the axis of this perspective and I asked the actress to come and go in the background throughout the course of the conversation. My idea was to invite the spectator to "look around" the entire space. During editing, we cross-cut this shot with its reverse shot significantly, which diminished the effect.

INTERIOR. DAY. BATHROOM.

The mother sings in the bath and she is interrupted by her son, who comes to pester her.

For this sequence, I had planned an inward traveling shot toward the young woman. And yet we were working with a limited depth of field, as I had wanted for this room (for the same reasons as in the first sequence). Along the trajectory of the traveling shot, we inserted a chair in the foreground that becomes a focal point at the end of the shot. In my experience viewing 3D films, I have noticed time and again that a blurry foreground or blurry objects in the foreground could produce discomfort during camera movement. Indeed, while the camera is moving, these elements attract attention and if they are blurry, our gaze cannot rest on them without discomfort. I therefore insisted that the focus remain on the chair during the traveling movement and then shift to the young woman. It is one of the major mistakes that I made in terms of *découpage*. Perhaps the theory was sound, but there was really no reason to take the focus away from the mother, who is the main point of interest.

The reverse shot of the son behind the door is practically two-dimensional. All that we have inside the frame is the flat translucent surface of the stained-glass windows and the little boy's silhouette moving back and forth behind it. However, I find that we are able to sense the space behind the door quite well, as if our gaze were following the little boy into the background, which is of course not technically possible.

EXTERIOR. DAY. TRAIN TRACKS.

The little boy and the grandfather are on the tracks, the mother arrives and an argument breaks out.

I arranged this shot to make the most of its depth, placing the three figures on different planes so the spectator could pass from one to the other as he pleased. A question was raised during filming: whether or not to remove the shrub that appears in the foreground. Its importance in terms of dimension is that it brings attention to the foreground and as a result accentuates the sensation of depth. But from another point of view, it takes on an importance in the shot that is perhaps excessive.

EXTERIOR. DAY. A ROAD.

The mother is riding a bike on the road.

We filmed this shot with cameras positioned on the back of a truck, in front of the actress. There is a technical risk involved with this, as the moving truck causes the mirror of the

module to vibrate, which could have created unpredictable vertical and horizontal disparities in the image. In this case it would have been necessary to correct the "shifts" frame by frame in postproduction.

EXTERIOR. DAY. THE GARDEN.

The little boy and the mother are in the back of the garden.

The shot is quite large and the figures are deep in the background; however, we are able to clearly make out their conversation. I wanted to film it this way because I noticed that with such a shot, we could create an impression of greater proximity to the characters than was possible in 2D. To me it seems that with a wide shot in 3D, we can feel closer to a specific point in space if the sound attracts our attention there, as if we could choose an area of interest in the image. In this scene, the goal was to thus emphasize the sensation of intimacy shared by the two characters. With 3D, the effect of a wide shot is no longer necessarily that of distancing, but rather of directing a path toward a particular object in the shot.

INTERIOR. NIGHT. THE LITTLE BOY'S ROOM.

The mother tells the child a story and falls asleep next to him. The little boy begins to daydream, playing with the shadows that come from his magic lamp.

This shot is one of the rare ones we set up to "jump out" at the spectator. Because the little boy reaches his hands out toward the light and toward the camera we were able to place the window so that they jump out slightly. From a narrative perspective, I "allowed" myself a jumping-out moment because to me this sequence was somewhat dreamlike, all the more so as it was meant to initiate a dream sequence.

THE DREAM SEQUENCE.

We had planned a succession of close-ups with a voice-over done by the child. These shots were finally edited in as moments of punctuation several times throughout the film.

I discovered the 3D close-up during a visit to my sterography tutor Laurent Verduci at his studio. I was struck by the intensity of such images. And yet, we might think that the close-

up, as it shows only small objects within a very limited field, would not lend itself well to 3D, which to the contrary allows us to emphasize great depth. But it seems to me that the close-up shot highlights another strong potential of 3D: that of making volume seem incredibly tangible.

For me, these shots represent the little boy's special attention to the objects around him. The use of close-up allows us to see the house from his frame of reference, and conveys the idea of a childlike fascination for simple, everyday things.

Conclusion

3D cinema is a fascinating medium to discover. When beginning my research I never imagined I would encounter so many different technical parameters that would allow me to explore and convey such a large range of visual sensations and new emotions. It is a subject all the more interesting as it implies a profound questioning of *mise en scène* and the impact that the construction of images bears on the narration of a film. Finally, conducting this research was so delightful because in 3D cinema, everything seems new, everything remains to be explored. You wait impatiently for the results of each shot and you feel an almost infantile excitement learning how to handle this tool that offers so many new possibilities.

I remember the first test projection that we carried out on the big screen, while still in the editing stages of production; it was in black and white and off-centered (the encoding had partially failed) but it was magic. We couldn't help ourselves from saying to one another, "it's incredible, it works."

This is the reason why I feel rather confident about the future of 3D cinema. I believe it will spark the curiosity and certainly the creativity of a number of directors, who will find ways of bringing this format into new realms. Stereoscopy is too rich a medium to remain confined to a restricted realm. I eagerly look forward to the many full-length films already underway.