

PRESENCE AND AVERAGE DURATION OF FIXATIONS IN STEREOSCOPIC FILM COMPARED TO PLANAR FILM

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Abstract: A preliminary study with the eye-tracker and a presence questionnaire made on the same stimulus, the S3D film *My Life Rehearsed in One Leg* (Bogdan Mustață, 2018), allowed me to observe and propose a link between the concept of presence and the average duration of fixations. Often found in theatrical art, presence is related to the corporeality and physicality of the actor. From this perspective, presence refers to a physical quality that the performer can train. From the spectator's perspective, however, presence refers to the subjective perception of the media object. The object of perception is most of the time the actor's body, but the concept of presence is multi-faceted. Given this relationship between the viewer and the actor's body (or the media object in general) I propose in this article that the longer average fixation duration of one condition relative to another be a sign of a higher degree of presence for that condition. Traditionally, the degree of presence is assigned to a media object using the presence questionnaire. Average fixation duration can be an objective tool with which to check the presence questionnaire. This conclusion needs to be studied further, beyond this preliminary study, on a sample with more subjects.

Keywords: presence, average fixation duration, eye tracker, film, stereoscopy.

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Introduction

A much-discussed concept in relation to stereoscopic film (but also to new media in general), the concept of presence is to some extent equivalent to what a viewer would define by such expressions: "as if you were there", "it feels real" or "you are absorbed in what is on the screen". There are many definitions of presence in the research literature. Two articles that summarize these definitions are those of Soyoung Bae (2012, pp. 560-2) and Simone Grassini (2020, pp. 1-2). S. Bae summarises the definitions found in the articles by saying that presence has multiple dimensions, these including 'realism, transportability and immersion' (Bae, 2012, p. 561). Realism refers to the ability of a media object to reproduce events and objects that seem real; transportability refers to the perceived distance between the viewer and the virtual environment - the viewer's perception of being in the virtual environment or, conversely, of objects in the virtual environment being in the viewer's world; immersion refers to the ability of information coming from the virtual environment to flood and dominate a viewer's sensory system.

None of these definitions found in articles on stereoscopy, virtual reality, augmented reality, etc., however, address the other component of the relationship, the way we encounter presence in the literature on theatre and acting. The two concepts are not homonyms, but refer to the two extremes of the relationship that is built between the media object and the spectator. Compared to the great variety of definitions in the literature on stereoscopy, those on acting also suffer from ambiguity. For Julia Varley (2011, p. 20) for example presence is 'the capacity of physical and vocal actions to persuade', and for Eugenio Barba (1995, p. 9) it is the quality of the actor's body to be 'decisive, alive, believable'. However, the importance of presence for theatre and the performing arts can in

no way be overestimated. Hans-Thies Lehmann (2009, p. 196) says in his book *Teatrul Postdramatic/Postdramatic Theatre* that at the heart of a performance lies the 'production of presence'.

The great variety of definitions or their ambiguity is also reflected in the difficulty of studying the degree of presence. Simone Grassini (2020, pp. 3-5) reviews the methods of measuring the degree of presence and identifies four categories of instruments: presence questionnaires, physiological measurements, behavioural assessments, interviews. Presence questionnaires are clearly the most commonly used, but depend on the definition and dimensions given to the concept of presence. When referring to physiological measurements, Grassini (2020, pp. 4-5) talks about research done with EEG, MRI, cardiac measurement systems, GSR and other electrodermal signals. Behavioural assessments are usually done with the help of tasks drawn to the subjects but these tasks can interfere with the actual sensation of presence, which calls the results into question. Interviews¹ are similar to questionnaires and for the purpose of this article, they can be assimilated to them.

As it can be seen, the eye-tracker was not mentioned at all in this review (Grassini, 2020, p. 6), so it has not been considered so far as a tool for measuring presence in any of the almost 900 articles identified by Grassini. Yet, the eye-tracker is a relatively common piece of equipment and easier to use than instruments such as MRI or even EEG. For the field of cinema, the eye-tracker is all the more relevant² because it provides important information about the direction of the viewer's gaze towards the items on the screen, and can thus correlate the degree of presence with exactly those, clearly defined, elements that cause this presence.

Compared to subjective assessments in a questionnaire, data from instruments such as EEG, MRI and eye-tracker can also provide information about those reactions that may not have reached a conscious level for the subject. In addition, subjects' expectations can influence the results of questionnaires (bias). It is well known, including by subjects, that a stereoscopic film "should" have a higher presence than a 2D one and their responses will be directed in such a way as to confirm these expectations.

The eye-tracker is a device that monitors and records the eye movements of the subject. The most important data analysed are fixations and saccades. Fixations are slow eye movements that direct the fovea to a small part of the image

1 in fact Grassini (2020, p. 5) identifies only one study that uses the interview

2 see David Bordwell's articles on this topic: <http://www.davidbordwell.net/blog/2011/02/06/the-eyes-mind/> or <http://www.davidbordwell.net/blog/2011/02/14/watching-you-watch-there-will-be-blood/>

for careful analysis of that spot. Saccades are rapid eye movements that cause the gaze to move from one place in the image to another. Generally, during saccades no information is received from the object being viewed but only during fixations (Zdziarski, 2015, p. 3). In other words, fixation and attention occur at the same time.

With this preliminary study, I sought to link the higher degree of presence of the 3D condition, confirmed by the presence questionnaire, to the quantitative data measured with the eye-tracker. Thus, starting from two articles that I will present below, I want to propose that the results of a presence questionnaire can be confirmed by the average duration of fixations.

Theoretical background

This study is mainly based on the definition of presence developed in the Temple University presence questionnaire (Lombard, 2011) and on two articles, one from 1993 by J. Stauer and another from 1981 by Friedman and Liebelt. I will now very briefly present ideas from these articles that are relevant to my study.

As I said, there are several attempts to define presence and its dimensions, the Temple questionnaire being one of them. It is built on 8 chapters³ (Lombard, 2011, p. 2), and the data can be analysed on each chapter separately thus determining the degree of presence for each dimension. The eight chapters refer to six dimensions of presence: Transportation (Spatial Presence chapter - the subject shares space with the media object); Realism (Social Realism and Perceptual Realism chapters - accurate representation of objects, people, events); Immersion (Engagement and Social Presence chapters, Passive Interpersonal chapters - engagement, extension of the subject's senses in the virtual environment); social complexity (Social Richness chapter - the virtual environment is perceived as warm, intimate, sociable); social actor in the environment (Social Presence, Actor w/i medium chapter - the interaction that subjects have with characters encountered in the environment); media object (Social Presence, Active Interpersonal chapter - anthropomorphism of the media object, the subject interacts directly with the technology).

For J. Stauer (1993, p. 6), the information received on all sensory channels as well as the mental processes that assimilate this information contribute to a subject's sense of *being* in an environment. He defines (Stauer, 1993, p. 11) two variables that determine stimulus properties: *vividness* and *interactivity*. *Vividness* refers to the information richness of the environment as it is presented to the sense organs. Variation in *vividness* is presented by Stauer in two directions, horizontal

3 The questionnaire can also be found at: http://matthewlombard.com/research/p2_ab.html

and vertical. The horizontal dimension refers to the number of sensory stimuli that are presented *simultaneously* by an environment. The large number of stimuli, says Stauer (1993, p. 12), leads to redundant information due to the simultaneous activation of sensory organs. This informational redundancy in turn leads to the reinforcement of the perception of a particular context. In other words, presence is greater if the context carries more (redundant) information that is perceived simultaneously on more than one sensory channel. The vertical dimension refers to the quality of the sensory information of a presented context. For example, in terms of an image, the better its resolution, the stronger the presence. The other variable Stauer presents, *interactivity* (1993, pp. 14-7), refers to the ability of subjects to alter the form or content of a context presented in an environment. As *interactivity* is low in stereoscopic films, I will not insist on this variable.

In their article, Friedman and Liebelt (1981, pp. 137-8) start from the observation that what attracts our gaze, in the absence of a task, are generally objects that seem to be out of context, strange, difficult to understand. Subjects make an automatic classification, the researchers say, looking for objects that *do not belong*. Friedman and Liebelt (1981, pp. 149-53) note that information obtained from these objects influences the duration of subjects' fixations. Interestingly, following their research, the two also calculate the distribution of fixations to objects and observe that fixations are directed most of the time to ordinary objects (which *belong* to the context) but that the *average fixation duration* has an opposite trend as compared to the distribution of fixation position. Thus, objects that do not *belong* attracted fixations with an average duration of 562 msec compared to 324 msec that was the average fixation duration for objects that *belong*.

Methodology

For this study we used as a stimulus the stereoscopic film directed by me, *My life rehearsed in one leg* (Bogdan Mustață, 2018), projected in two versions, 2D and 3D. The film tells the story of two ex-lovers who reunite after several months spent in different hospitals following an accident whose details seem to fade more and more in their minds. The film is 62 minutes long (at a framerate of 24 frames/second) and was projected on a 2m high and 3.5m wide screen (16:9 format). The screen was positioned as close to the floor as possible (about 10 cm) so that the virtual space looked like a continuation of the viewing space. Subjects were positioned at a distance of about 3.5m from the screen. The film was projected from a Projection Design projector capable of projecting 3D. These conditions were chosen in order to replicate as closely as possible the audience projection conditions of the film.

The eye tracker used was an SMI Eye Tracking glasses 2w (SMI ETG). It has the option of viewing 3D with the help of a special additional Volfoni active device that is placed in front of the main device.

This methodology also led to limitations. Some were technical: colour changes during projection, occasionally loss of 3D sync signal, darker image in 3D version. The novelty of using the eye-tracker system in the CINETic centre led to additional preparation time for establishing practical details due to the need to replicate the conditions of the projections with viewers and to identify elements that were not part of the standard package during the stereoscopic presentation of the stimulus. More importantly, another limitation was the very large amount of data collected and thus the difficulty of processing it. Research with stereoscopic movie stimuli encountered by me has typically used short extracts of a few seconds or minutes. The longest studied stimulus I encountered in J. Hakkinen's research, *What do people look at when they watch stereoscopic movies* (2010), where the 3D movie projected as a stimulus was a short film of 6 minutes and 20 seconds. Choosing to project the whole film meant that each subject watched the 62 minutes of the film twice, for each condition.

This meant it was impossible to work with a large number of subjects at this stage, of the preliminary study.

Thus, the novelty of the research and the quantity of data collected forced me to test my hypotheses and check the quality of the data on a small number of subjects. In the research literature on stereoscopic stimuli analysed with the eye-tracker device, I came across research conducted on relatively small samples of subjects. For example, Magy El-Nasr and Su Yan's 2006 study is based on data collected from six subjects, and the study coordinated by Wismeijer in 2010 is also based on six subjects. From a statistical point of view, they are thus almost irrelevant, but for me they were extremely important in order to know the limits and possibilities of stereoscopy.

Five subjects participated in my testing, all with directing/editing/production experience. The small number of subjects participating in the test makes it necessary to explore further to see if the conclusions I reached from the test are confirmed.

In order to minimize the influence of memory on the data I chose to have all subjects have already seen the film several weeks prior to the research. All subjects watched both the 2D and 3D versions of the film in random order. Thus 3 subjects watched the 3D version first and 2 subjects watched the 2D version first.

For the analysis of the data collected with the Eye Tracker, we used the SMI BeGaze analysis software (SensoMotoric Instruments, 2015).

After each of the two screenings each subject filled in the Temple Presence

Questionnaire, with the scale for responses being 1 to 7. The questionnaire was presented in its original English version. All subjects were fluent in English.

To determine whether the data differed significantly we used the paired samples t-test and noted whether the threshold for rejecting the null hypothesis was below 1% or, if not stated, below 5% ($p < 0.01$ or $p < 0.05$).

Results

From the results of the questionnaire (see Table 1) it can be clearly concluded that subjects assigned a higher prevalence to the 3D condition of the movie compared to the 2D condition ($p = 2.3 \times 10^{-14}$). Although the 2D condition had a high score (mean of 4.25), the 3D condition had a mean score almost one point higher (5.17). Analysing each presence chapter, it can be seen that the differences are statistically representative for all chapters ($p < 0.05$), but that the probabilities vary. The statistically largest differences occur in the Spatial Presence chapter, the one corresponding to the transportation dimension ($p = 2.3 \times 10^{-14}$). Interestingly, however, the means are not large, just below the overall mean across the questionnaire: 4.8 for the 3D condition and 3.2 for the 2D condition.

	SPATIAL PRESENCE		SOCIAL PRESENCE - ACTOR W/I MEDIUM (PARASOCIAL)		SOCIAL PRESENCE - PASSIVE INTERPERSONAL		SOCIAL PRESENCE - ACTIVE INTERPERSONAL		ENGAGEMENT (MENTAL IMMERSION)		SOCIAL RICHNESS		SOCIAL REALISM		PERCEPTUAL REALISM	
	2D	3D	2D	3D	2D	3D	2D	3D	2D	3D	2D	3D	2D	3D	2D	3D
Avg	3.286	4.8	3.7	4.1	5.7	6.1	3	3.9	5.1	6	5.3	5.6	4.7	5.3	3.4	4.7

Table 1. Averages on each chapter of the Temple questionnaire for the two conditions.

For the data collected with the eye tracker I chose to analyse the differences between the two conditions, 2D and 3D, and also for the first 20 minutes of the film versus the last 20 minutes to see how the average fixation duration evolves over the course of the film. Each of these 20 minutes contains 9 shots. The shots are similar in terms of content and framing: one detail shot, one wide close-up, two medium shots and the rest wide shots. The data collected for each of these shots, in both conditions, for the average duration of the fixations are shown in the table below (Table 2). As it can be seen, at both the beginning and the end of the movie, the average fixation durations for the entire set of 9 shots for the 3D condition were higher than those for the 2D condition (382.9 vs 372.2 for the first 20 minutes and 395.3 vs 314.8 for the last 20 minutes while the coefficient of variation was of 16% vs 16.53% for the first 20 minutes 3D vs 2D and 19%

vs 15.25% for the last 20 minutes 3D vs 2D). But for the first 20 minutes the difference between the averages of the 2 conditions, 2D and 3D, is not statistically significant ($p=0.17$). Moreover, it can be seen that, taken separately, there are three shots in the beginning of the film for which the average fixation duration for the 2D condition is slightly higher than that for the 3D condition. This difference between 2D and 3D becomes highly significant, however, for the last 20 minutes of the film ($p=0.00001$).

The same data show that the average fixation duration decreased for the 2D condition in the last 20 minutes compared to the first 20 minutes. For the 3D condition, however, the average fixation duration increased. It can be seen that the 2D condition showed the greatest evolution, with an average fixation duration decreasing from 372.2 to 314.8. For the 3D condition there was an increase in the average fixation duration, but not very significant – from 382.9 to 395.3.

Average duration of fixations					
Beginning: the first 20 minutes			End: the last 20 minutes		
Shot no.	2D	3D	Shot no.	2D	3D
1	255.1	259.46	21	346.72	397.96
2	421.66	417.1	22	357.28	502.74
3	374.42	378.86	23	388.74	406.48
4	464.74	461.16	24	227.5	247.14
5	403.7	420.08	25	329.4	383.86
6	402.34	424.38	26	293.72	416.16
7	367.84	351.06	27	297.86	416.7
8	322.84	329.1	28	316.58	465.78
9	337.6	405.2	29	275.06	320.74
	372.248889	382.933333		314.762222	395.284444

Table 2. Average fixation duration per each shot for the two conditions

An analysis of the spatial distribution made on 4 shots of *My Life Rehearsed In One Leg* shows that in both 2D and 3D, the focus is mostly on the actors' bodies. The shots were chosen to contain both tight and wide framing, both day and night atmosphere, both inside and outside. The actors' bodies were selected as the areas of interest. For the first shot shown, the time subjects spent looking at the two areas of interest (dwell time) was of 73.1% of the total time for that shot in the 2D condition and of 61.1% in the 3D condition. In the second shot, the three areas of interest drew attention for 71.7% of the time in 2D and 70.6% in 3D. In the third shot, the areas of interest drew attention 73.8% of the time in 2D versus

78.5% in 3D and in the fourth shot 27.5% in 2D and 56.8% in 3D. Differences occur when there are other interesting, strange structures in 3D such as the smoke around the characters in the first shot or the fact that the character is very small in the shot and not very visible in the dark in the last shot. In this last shot, stereoscopy helps to present the actor's body as a special structure that attracts the viewer's attention even if it only occupies a small part of the frame. Some research from 2010 (Jukka Hakkinen et al.) makes the same observation, that eyes are drawn to the actor's body in both 2D and 3D but in 3D there is a tendency for eyes to be drawn to other objects with complex or "fascinating structures" (Jukka Hakkinen et al., 2010, p. 9). In general, films designed to be 3D abound in the use of such objects. The research by Z. Zdziarski (2015, p. 80-91) nuances this result by studying several types of shots: with pronounced three-dimensional structures, fast editing, long shots with few movements. In the absence of three-dimensionally interesting structures, the results are similar between 2D and 3D conditions especially if the shots contain faces of people. Research carried out by Junle Wang et al. (2012, p. 1) shows that in 3D, objects closer to the viewer, namely those with more pronounced volume, attract attention more than those further away. The closest object attracts the most fixations.

As a follow-up to this study, a spatial distribution should be performed on each shot in the first 20 minutes versus the last 20 minutes, not just on a selection of representative shots, and analysed how and whether the average duration of fixations varies according to the spatial distribution.

Discussion

Although the questionnaire reveals a higher presence in the 3D condition, it is possible that they are biased so I propose that they be validated by measuring the average fixation durations. I will argue that, in 3D, the actor's 3D body (and other 3D structures) are both redundant information (1) and objects that do not belong to the context (2). The first part of hypothesis (1) would lead to the conclusion that vividness, the stand-in for presence at Stauer, increases in the 3D version along with the amount of redundant information. According to the second part of this hypothesis (2), from Friedman and Liebelt, the average fixation duration should increase for the 3D condition, which is confirmed by the data obtained.

(1) Stereoscopy is an extra element that floods the viewer's sensory system and creates redundant information. If we look only at the actor's body, it is present in the frame with all its features, apart from volume, in both 2D and 3D condition. Volume becomes an extra element in 3D, as binocular depth stimuli overlap with monocular ones becoming redundant information for this condition

leading to increased vividness (hence presence according to Stauer's research) in 3D compared to 2D. The quality of the images, sound etc (the vertical variable of vividness) is similar for the two conditions even if there were small differences in colour saturation or a darker tint to the 3D projection. For the accuracy of the data however it is necessary in further research to eliminate these differences. In terms of interactivity, the 3D movie does not have a high interactivity. Thus, we can consider that the horizontal variable of vividness is the only variable that produces the effects.

(2) The other hypothesis to be further investigated is that certain structures (including the actor's body) become, in the case of 3D projection compared to 2D projection, strange objects that do not belong to the context. I recall you that, in their article, Friedman and Liebelt (1981, pp. 137-8) start from the observation that what attracts our gaze, in the absence of a task, are generally objects that seem not to belong to the context, strange, difficult to understand. For Hakkinen, Zdziarski or Junle Wang, these structures that attract attention in 3D are those closest to the viewer – in the foreground – or those that have a special structure such as water or smoke. The attraction of the viewer's attention by smoke is also confirmed by the shot 11 analysed by me. In the absence of these objects or structures the eye is drawn to the actor's body most of the time. These objects have the quality of standing out, of not literally belonging to the context. Close objects are the ones that attract attention because they have the most pronounced volume, a specific characteristic of stereoscopy. There is a mathematical relationship between the roundness of an object and the interaxial used during the shooting on the one hand and the distance of the object/actor from the camera on the other. Often the body of the actor in the foreground also determines the interaxial/distance combination used in the shot.

Friedman and Liebelt (1981, p. 140) say that 'after the initial assessment of a new situation, ordinary objects should receive only little attention'. It was to be expected, then, if we were to go by what the two say, that at first there would not be much difference between the two conditions in terms of the average duration of fixations: in both a new world is presented to the subject/viewer, which they do not recognise, in which anything can be considered unusual or out of context. The hypothesis is that, in the first 20 minutes, the viewer has to explore and analyse all the information in order to give coherence to this context. The extra dimension in the stereoscopic presentation appears in the higher average of the fixation duration in the 3D condition compared to 2D (the volume of objects including the actors' bodies, in the foreground, literally sticking out of context, attracts attention) but the differences are not statistically significant.

In the last 20 minutes, however, the extra dimension is permanently a

source of rich information, a dimension that creates the feeling of strange, *out-of-context*, special objects, and causes longer average fixation duration.

If hypotheses (1) and (2) above are correct it means that presence and average duration of fixations are linked through the actor's body (and other 3D movie specific structures) and one could measure the degree of presence by quantitative eye tracker measurement of average fixation duration.

No relevant conclusions can be drawn from the absolute average durations because they vary. Friedman and Liebelt's (1981, p. 151) results show mean durations of 562 msec versus 324 msec (*not belonging* versus *belonging*). In my study, for the last 20 minutes the average durations between conditions are 395 msec versus 314 msec (3D versus 2D). The absolute average duration probably depends on viewing duration, depends on content, etc. Quantitative data becomes relevant when making comparisons between conditions or analysing their evolution over time.

Conclusion

I propose that a quantitative way to determine the degree of presence and to check the presence questionnaires is to make a comparative analysis between 2D and 3D conditions of the average duration of fixations taking into account their evolution over time. In the case of this research, the data collected with the eye tracker confirmed the results of the questionnaire.

In order to get a clearer picture, this study needs to be repeated with a larger number of subjects and a spatial distribution of fixations for all shots and all conditions analysed.

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Filmography:

My Life Rehearsed In One Leg (2018). Regia Bogdan Mustață [Film]. București: Axel Film.

Bogdan Mustață is the winner of the Golden Bear, Berlinale 2008, for his short film *O zi bună de plajă/A Good Day at the Beach*. His feature debut *Lupu* premiered in the competition of the Sarajevo Film Festival 2013. The experimental film *My Life Rehearsed In One Leg* is one of the first stereoscopic films shot in Romania. He now lives in Bucharest after several years working as a writer and director in Vietnam and Dubai. He completed his doctoral studies at "I.L. Caragiale" National University of Theatre and Film "I.L. Caragiale" Bucharest with the thesis *The Art of the Actor in S3D Cinema Language* where he is currently Head of Film Directing and Producing Department in the Faculty of Film.