Genre-dependent effects of 3D film on presence, motion sickness, and protagonist perception ☆

A.M. Baranowski *, K. Keller, J. Neumann, H. Hecht

Department of Psychology, Johannes Gutenberg-University Mainz, D-55099 Mainz, Germany

ABSTRACT

Do the increasingly popular 3D movies change how we perceive the content of the movie? We presented short (3.21 min) film sequences to observers equipped with shutter glasses. Three genres (horror, action, and documentary) were crossed with three between-subjects viewing conditions (director's 3D, artificial 3D, and 2D). Observers had to rate how the film impressed them in terms of arousal, motion sickness, presence, and immersion. They also judged the personality, attractiveness, and intelligence of the protagonist in all viewing conditions. Not surprisingly, horror films produced more arousal and presence than action films. Documentaries scored lowest on presence. Action movies produced the highest immersion ratings. 2D viewing tended to produce less presence than 3D viewing. Surprisingly, artificial 3D was indistinguishable in terms of presence from the director's 3D. The same was true for motion sickness: 3D viewing, regardless whether intended by the director or introduced artificially, was more nauseating than 2D viewing. We also found a genre effect regarding the impression of the protagonist, the latter was more agreeable in documentaries presented in 2D. The same protagonist was judged to be less extroverted and weighing more when viewed in director's 3D. We conclude that 3D film has complex effects that interact with the film genre. Directors should consider these interactions when planning to produce a 3D movie.

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1. Introduction

With the rise of 3D movies and 3D TV, several questions arise. Supporters of this technology argue that 3D viewing produces a whole new level of immersion while critics are concerned with the health-related issues this technology might cause. Both, advantages and disadvantages have been studied in recent years (see e.g. [25]). Two issues have been largely ignored in the scientific literature, the interaction of genre with 3D technology and the perceptual difference between director's 3D (movies that are shot with two cameras and merged to one film) and artificial 3D (movies that are shot with one camera and later converted into 3D in post-production). We first spell out how these two issues might affect the viewer directly, for instance producing more visual discomfort or presence, and then outline how they might affect the viewers' evaluation of the movie, making it more likeable or more annoying. We then report an extensive experiment that shows how film genre and viewing mode interact with regard to effects on the viewer and the viewer's perception of movie content.

1.1. Effects on the viewer

One of the biggest problems associated with 3D movies is that prolonged viewing may cause visual discomfort. Carrier et al. [6] found that 3D movie viewers were almost three times more likely to experience headaches and over four times more likely to experience eyestrain than did 2D movie viewers, when watching a feature length movie in a theater. The most common complaints related to 3D movies have been nausea, visually induced motion sickness (VIMS), headaches, and eyestrain [18,25,28,29,35]. Lambooij et al. [21] identified three factors that may cause visual discomfort: (1) changing demands on accommodation-vergence linkage over time, which might be caused by fast movement; (2) three-dimensional artifacts resulting from inadequate depth information, which produce spatial and temporal inconsistencies, for instance conflicts between depth cues and geometrical distortions; and (3) an unnatural amount of blur, leading to ambiguous depth percepts. Particularly the last factor points toward a problem with automated 2D-to-3D conversion, which might result in a surplus of blur. In another study, Kooi and Toet [20] found that visual

discomfort increases with errors in stereo presentation. Both studies indicate that artificial 3D might increase visual discomfort, which is already higher in director's 3D than in 2D [28].

While 3D movies have been associated with visual discomfort, they have also been linked to a heightened feeling of presence in some studies [13,25,35]. Presence itself is a very heterogeneous concept. In the context of movies it is usually used to describe a feeling of how much the consumer is "lost" in the movie or experiences a sense of "being there". For further discussion of the concept see Lombard and Ditton [23]. Other factors like memory, attention, or elicited emotions seem not to be affected by 3D-presentations [2,5,7,16].

Few studies have investigated the effect of genre on 3D movies. Je and Lee [15], for example, discovered that 3D documentaries produced higher levels of narrative engagement and 3D action movies engendered more enjoyment and presence, compared to their 2D counterparts. A further study by Janicke and Ellis [14] found that sports content in 3D led to higher enjoyment, but this was not so in a movie trailer. In contrast, Rooney and Hennessy [27] found higher levels of perceived apparent reality related to 3D but observed no significant group differences in attention, emotional arousal or satisfaction for the fantasy movie *Thor* (2011). However, data where obtained by questioning movie goers after they had left the cinema and not in a laboratory setting. These findings indicate that 3D movies produce genre specific effects on the subjective experience of movie goers. These were movies originally produced with 3D technology involving two cameras (or a stereo camera with two lenses). We refer to this technology as director's 3D.

1.2. Protagonist perception

In this study, we focused on the perception of the protagonist in three particular genres: action movies, horror movies, and documentaries. This choice was, in part, motivated by a pre-study in which we tested 175 subjects who saw a documentary, a dance film, and two short stories either in 2D or in director's 3D [32]. We found that 3D produced higher presence ratings except for the documentary. We also found that subjects liked the documentary in the 2D version just as well as in the 3D version. In contrast, subjects preferred the 3D over the 2D versions of the short stories. One problem we encountered was that we used custom-made movies (in co-operation with a local film school (Rhein-Main Hochschule; Zeitabsierte Medien), some of which received only moderate presence ratings. To minimize such potential floor effects, we have decided to use mainstream movies made with the intent to please large audiences.

One factor that might contribute to a feeling of general discomfort when watching 3D movies is perceptual impact of binocular disparity. The differences between the two retinal images contribute decisively to depth perception at close range in so-called personal space (see e.g. [9,11,12]). With the introduction of sizable disparity, observers are likely to experience objects as closer than in 2D viewing, where such disparity is absent. This feeling of proximity to the events on screen may in turn generate more presence. For instance, Wilcox et al. [33] asked subjects to rate their level of comfort in response to objects and people in a stereoscopic projection and in real life. They found that observers showed the same strong negative reactions to violations of their personal space in 3D as in the natural environment. This effect translates to movies and is amplified when movie protagonists are filmed at close range [4].

Almost no studies exist that compare the impressions made by protagonists as a function of 2D vs. 3D viewing. This is surprising given how important it is to evaluate such potential 3D effects. Not only movies but also teleconferences or even private telephone conversations of the future are very likely to be held in stereoscopic projection. One reason could be that most experts to not expect significant differences here because such differences have not been found in direct communication settings. One study that supports this suspicion is by Hauber et al. [10]. The authors compared conferences either transmitted in 2D, 3D, or in real life. They found that real life conferences were preferred to video conferences but did not find significant differences between 2D and 3D videos except for social presence. Conference calls in 2D were just as warm, personal, sensitive, sociable, pleasant, formal, and positive as in 3D. 3D may play a very different role when watching movies, and we thus investigated if stereoscopic viewing makes a difference in this domain.

1.3. The current study

We conducted a 3×3 mixed design with the within factor genre (action, horror, documentation) and the between factor viewing condition (director's 3D, artificial 3D, 2D). We expected the artificial 3D condition, which merely doubled each frame with a slight offset between the eyes, to produce the highest amount of visual discomfort, operationalized as visually induced motion sickness, followed by director's 3D and 2D. We also assumed that horror movies would produce the highest amount of visual discomfort, because of the disgust and arousal they should produce. We further expected artificial and director's 3D to produce a higher amount of presence and immersion, compared to 2D presentations.

Concerning the protagonist perception, we were concerned that ratings might involve deliberations about viewing modalities and introduced a task in which subjects had to assume a comfortable distance to the picture of the protagonist. They should prefer a larger distance in the director's 3D, compared to the 2D condition if 3D moves the protagonist perceptually closer. Based on our preliminary findings, we also expected the subjects to prefer a larger distance in documentaries, compared to action and horror movies. We thought that a higher presence in the 3D version would also lead to a higher identification with the protagonists, which in turn should result in more favorable personality ratings. The stereo presentation should further result in a more intense experience which in turn might let the protagonist appear more intense, as operationalized with ratings of body height, weight, and attractiveness.

2. Methods

2.1. Participants

One hundred and eight (84 female and 24 male) psychology students participated in the experiment in exchange for partial course credit. Mean age was 25.11 years (SD = 8.08 years). We only used subjects with self-reported normal or corrected-to-normal vision.

2.2. Film selection

We selected 6 popular movie clips that were all shot in director's 3D based on their genre. We used two action movies (Gravity, 2013; The Amazing Spiderman, 2012), two horror movies with splatter elements (Final Destination 5, 2011; One Way Trip, 2011), and two documentaries (Pina, 2011; Die Huberbuam, 2012). Of each movie a 3.21 min. scene was chosen, which was representative for the genre (see Appendix A for a detailed description of each scene we used). We deliberately chose short scenes in order to present several movie clips representing different genres within subjects in one session. We know that 3-min sequences are sufficient to induce a representative level of visual discomfort [18].

Moreover, the same study has shown that longer exposure to 3D movies raises the visual discomfort, thus increasing the risk of participant drop-out. Any effects of 3D on visual fatigue found with short exposure times would therefore potentially underestimate the effects, making them more likely in full length movies. The 2D and 3D versions of the films were readily available. The artificial 3D version was produced by duplicating the 2D image and moving both seven pixels (horizontal visual angle 0.34°) apart. We used the commercial software Leawo Video Converter, which uses similar algorithms for 2D to 3D converting like those found in modern 3D TV.

2.3. Effect on the viewer

To assess the severity of VIMS in each condition, we used the Fast Motion Sickness Scale (FMS; [17]). The FMS consists of verbal ratings ranging from zero (no sickness at all) to 20 (frank sickness). FMS scores were acquired 3 times during each trial; once each before stimulus exposure, during the exposure at 1.40 min., and right after the testing. Then, we asked subjects to rate presence (0 = no presence, 20 = complete presence), immersion (0 = not realistic, 20 = extremely realistic), and vection (0 = no traction, 20 = clear feeling of traction) on a comparable scale. Note that we explained presence in terms of the feeling of being there, whereas immersion was taken to refer to the technical sophistication of the 3D impressions and effects. We did not use further behavioral measures, such as posturography, because they are too unspecific to differentiate between VIMS (e.g. [26] and presence (e.g. [30]). To assess arousal, we used the Self-Assessment Manikin scale (SAM; [3]). After each movie scene subjects filled out the SAM on a scale from 1 (calm) to 9 (aroused).

2.4. Protagonist perception

To assess personality aspects of the main character, the short Big-Five-Inventory-10 [24] was used. The BFI-10 consists of 10 questions, two for each personality factor (extraversion, neuroticism, openness, conscientiousness, and agreeableness). After each film clip, subjects filled out the BFI-10, judging the personality of the protagonist. They further rated his/her sympathy and attractiveness on a scale from 1 (not at all) to 5 (very high). Subjects were also asked to estimate the protagonists' size, weight, and IQ (IQ = 100 being average). After filling out the questionnaire, we instructed the subjects to imagine they were to meet the protagonist of the movie on the street and would ask him/her for directions. They then approached as closely toward a DinA4 picture of the main actors' head, as they would do in real life. The picture was always hung at the eye level of the subject. This measure of interpersonal distance was taken from the picture to the center of the subject's head.

2.5. Procedure

Each subject saw all genres (6 movies) in different orders, but only one viewing condition. The average rating for the two films per condition was then used for further analysis. Each viewing condition was seen by 36 subjects.

Upon arrival in the laboratory, subjects were seated 1.75 m (horizontal viewing angle 60°) from the screen (1.06 m tall and 1.90 m wide) (see Fig. 1). The distance (and therewith the viewing angle) was chosen, because previous studies indicated that smaller (e.g. [34]) and larger viewing angles (e.g. [1]) lead to a lower level of presence, which in turn might have distorted our results. We always tested three subjects together. We recorded the position of each subject and later controlled for position effects by testing position as independent variable against the dependent variables.
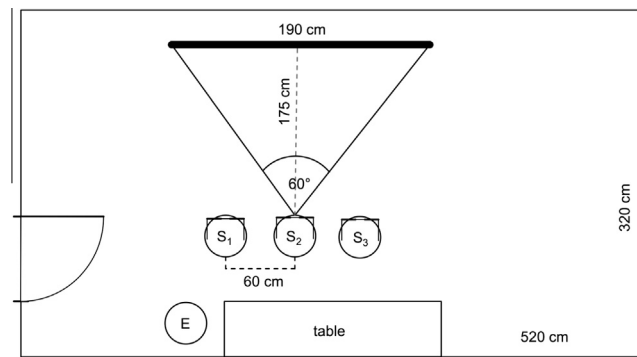
Fig. 1. Set-up of the experiment. Three subjects were testes simultaneously. Note that subjects wore shutter glasses during all conditions, including 2D presentation. E = experimenter, S = subject.

No effect for position was found. Subjects first received a written description of the experiment and then gave informed consent. They were told that they could close their eyes and stop the experiment at any time without giving a reason, but no subject exercised this option. The film clips were shown in random order and the light was switched off during the movie presentation. Five seconds after each movie scene had finished, ambient light was switched on and subjects filled in the rating scales and were tested for interpersonal distance. Subjects had to wear 3D shutter glasses (Crystal Eyes 3 Stereo 3DTM Eyewear, Stereo Graphics®) during all conditions, including the 2D condition, to control for potential effects produced by the glasses. All movie clips were shown in 16:9 with a resolution of 1280 × 720 pixels. The entire experiment lasted about 75 min.

3. Results

We performed a 3 × 3 mixed design MANOVA, with the between-subjects variable **viewing condition** (2D, artificial 3D, director's 3D) and the within-subjects variables **genre** (action movie, horror movie, documentary). The dependent variables consisted of scales for VIMS and the perception of the protagonists, and were analyzed separately.

3.1. Effect on the viewer

A Pillai-trace test indicated significant main effects of genre, $F(10, 96) = 48.73$, $p < 0.001$, $\eta p^2 = 0.84$, and viewing condition, $F(10, 204) = 3.17$, $p < 0.001$, $\eta p^2 = 0.13$, as well as an interaction between them, $F(20, 194) = 1.68$, $p = 0.039$, $\eta p^2 = 0.15$. A univariate test of the genre, using Greenhouse-Geisser correction for unequal sphericity, revealed that all dependent variables differed significantly between genres. We further used contrast analysis to see, which conditions exactly differed from each other. When all three conditions differed significantly from each other, we only report the main effect for better readability.

We found that horror movies ($M = 5.18$, $SD = 3.00$) produced significantly more VIMS than action movies ($M = 3.35$ $SD = 2.45$), which in turn produced more VIMS than documentaries ($M = 2.48$, $SD = 2.38$), $F(1.62, 172.99) = 130.51$, $p < 0.001$, $\eta_p^2 = 0.55$. Horror movies ($M = 5.70$, $SD = 1.76$) also lead to the highest arousal, followed by action movies ($M = 4.44$, $SD = 1.62$), and documentaries ($M = 3.48$, $SD = 1.37$), $F(1.81, 195.65) = 117.87$, $p < 0.001$, $\eta_p^2 = 0.53$. Action movies were more immersive ($M = 11.85$, $SD = 3.31$) than horror movies ($M = 8.48$, $SD = 3.48$), which were more immersive than documentaries ($M = 6.47$, $SD = 3.49$), $F(1.92, 202.39) = 85.59$, $p < 0.001$, $\eta_p^2 = 0.45$. Action movies also produced the highest values of vection ($M = 4.47$,

$SD = 3.60$), followed by horror movies ($M = 2.07$, $SD = 2.70$), and documentaries ($M = 1.28$, $SD = 1.99$), $F(1.76, 190.08) = 60.00$, $p < 0.001$, $\eta_p^2 = 0.36$. Horror movies ($M = 10.59$, $SD = 3.95$) and action movies ($M = 10.33$, $SD = 3.68$) did not differ in their presence ratings ($F(1, 107) = 7.52$, $p = 0.488$, $\eta_p^2 = 0.01$), but both were significantly higher those for documentaries ($M = 6.47$, $SD = 3.49$), $F(1.85, 196.51) = 53.21$, $p < 0.001$, $\eta_p^2 = 0.34$ (Fig. 2).

Using a one-way MANOVA with the independent variable viewing condition (2D, artifical 3D, director's 3D) we found a significant differences for the dependent variable VIMS and immersion. Post hoc analyses were performed using the Scheffé tests with p < 0.05 to identify exactly where significant differences exist. We found that overall artifical 3D ($M = 4.81$, $SD = 2.12$) and director's 3D ($M = 3.98$, $SD = 2.44$), produced significantly more VIMS than did the 2D condition ($M = 2.65$, $SD = 1.95$), $F(2, 107) = 9.00$, $p < 0.001$, $\eta_p^2 = 0.15$. The artificial 3D condition also produced higher presence ($M = 9.99$, $SD = 2.28$) than the 2D condition ($M = 8.59$, $SD = 2.50$); the director's 3D condition ($M = 8.79$, $SD = 2.69$) did not differ from either, $F(2, 107) = 3.29$, $p = 0.041$, $\eta_p^2 = 0.06$. We further found an interactive effect on of genre and viewing condition for immersion, $F(4, 105) = 2.90$, $p = 0.025$, $\eta_p^2 = 0.05$ (Fig. 3).

3.2. Perception of the protagonist

A Pillai-trace test found significant main effects of genre, $F(24, 80) = 51.99$, $p < 0.001$, $\eta_p^2 = 0.94$, but not the viewing condition, $F(24, 186) = 1.45$, $p = 0.091$, $\eta_p^2 = 0.16$, or the interaction between the two, $F(48, 162) = 0.97$, $p = 0.524$, $\eta_p^2 = 0.22$. A univariate test of the genre, using Greenhouse-Geisser correction for unequal sphericity, revealed that the dependent variables of the protagonist's neuroticism, openness, conscientiousness, interpersonal distance, sympathy, attractiveness, IQ, height, and weight differed significantly between genres (Table 1).

A contrast analysis of the genre revealed that subjects found the protagonists in horror movies to be more neuroticistic ($M = 3.87$, $SD = 0.74$) than in action movies ($M = 2.68$, $SD = 0.60$), and both more so than in documentaries ($M = 1.96$, $SD = 0.46$), with $F(1, 105) = 220.41$, $p < 0.001$, $\eta_p^2 = 0.67$, and $F(1, 105) = 119.15$, $p < 0.001$, $\eta_p^2 = 0.53$, respectively. Subjects also found the protagonists in action movies the most likeable ($M = 3.81$, $SD = 0.65$), attractive ($M = 3.64$, $SD = 0.78$), and intelligent ($M = 116.22$, $SD = 8.94$), followed by horror movies ($M_{lik} = 3.38$, $SD_{lik} = 0.67$, $M_{att} = 3.27$, $SD_{att} = 0.69$, and $M_{IQ} = 104.09$, $SD_{IQ} = 7.76$), $F(1, 105) = 24.05$, $p < 0.001$, $\eta_p^2 = 0.19$, $F(1, 105) = 17.46$, $p < 0.001$,
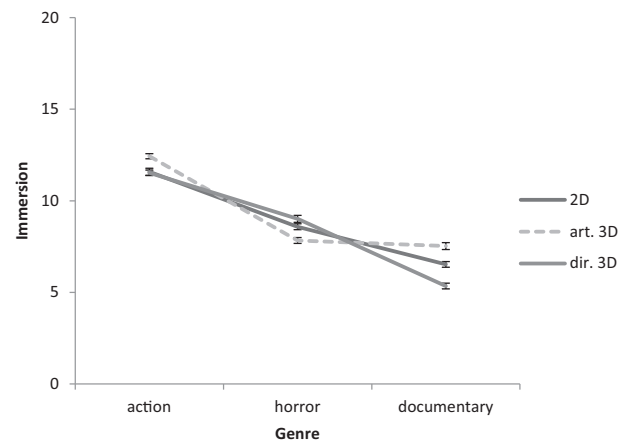
Fig. 3. Interaction between genre and viewing condition for immersion. 2D and artificial 3D worked better for action movies and documentaries while director's 3D worked best for horror movies. Error bars indicate SEM.

Table 1
Effects of genre on the dependent variables. Significant differences between two or more groups are marked with * (p < 0.001); n = 108.

Variable	df	Error df	F	p	η_p^2
Neuroticism	1.77	186.08	292.67	<0.001*	0.73
Extraversion	1.73	181.79	1.28	<0.277*	0.01
Openness	1.98	208.08	42.87	<0.001*	0.29
Agreeableness	1.96	205.82	0.87	<0.416*	0.00
Conscientiousness	1.96	205.91	164.16	<0.001*	0.61
Interp. Distance	1.89	198.90	33.90	<0.001*	0.24
Sympathy	1.94	203.93	24.11	<0.001*	0.18
Attractiveness	1.81	190.96	86.23	<0.001*	0.45
IQ	1.74	183.52	88.61	<0.001*	0.45
Height	1.99	209.91	101.61	<0.001*	0.49
Weight	1.95	204.99	45.60	<0.001*	0.30
Length	1.94	204.31	1.12	<0.325*	0.01

$\eta_p^2 = 0.14$, $F(1, 105) = 170.46$, $p < 0.001$, $\eta_p^2 = 0.62$, and documentaries ($M_{lik} = 3.17$, $SD_{lik} = 0.78$, $M_{att} = 2.41$, $SD_{att} = 0.75$ and $M_{IQ} = 108.43$, $SD_{IQ} = 8.63$), $F(1, 105) = 40.20$, $p < 0.001$, $\eta_p^2 = 0.28$, $F(1, 105) = 124.48$, $p < 0.001$, $\eta_p^2 = 0.52$, $F(1, 105) = 53.85$, $p < 0.001$, $\eta_p^2 = 0.34$. Documentaries produced higher openness ratings ($M = 4.00$, $SD = 0.54$) than action movies ($M = 3.53$, $SD = 0.60$), $F(1, 105) = 49.29$, $p < 0.001$, $\eta_p^2 = 0.32$, or horror movies ($M = 3.49$, $SD = 0.51$), $F(1, 105) = 71.02$, $p < 0.001$, $\eta_p^2 = 0.40$. The main characters in the documentaries were rated as more conscientious ($M = 4.49$, $SD = 0.44$) than in action movies ($M = 4.31$, $SD = 0.53$), $F(1, 105) = 9.81$, $p = 0.002$, $\eta_p^2 = 0.09$, who in turn were rated more conscientious than in those in horror movies ($M = 3.49$, $SD = 0.53$), $F(1, 105) = 184.70$, $p < 0.001$, $\eta_p^2 = 0.64$ (Fig. 4).

Also, documentaries produced the highest values for interpersonal distance ($M = 87.81$ cm, $SD = 21.98$ cm), compared to horror movies, ($M = 82.42$ cm, $SD = 20.17$ cm), $F(1, 105) = 23.91$, $p < 0.001$, $\eta_p^2 = 0.19$, which produced higher values than action movies ($M = 78.42$ cm, $SD = 20.72$ cm), $F(1, 105) = 14.50$, $p < 0.001$, $\eta_p^2 = 0.12$. The main actors in documentaries were also estimated to be taller ($M = 178.19$ cm, $SD = 3.83$ cm) and heavier ($M = 70.95$ kg, $SD = 5.58$ kg) than the actors in action movies ($M = 174.67$ cm, $SD = 3.74$ cm, and $M = 67.24$ kg, $SD = 3.85$ kg), with $F(1, 105) = 76.34$, $p < 0.001$, $\eta_p^2 = 0.42$, and $F(1, 105) = 54.19$, $p < 0.001$, $\eta_p^2 = 0.34$, respectively, and horror movies ($M = 172.49$ cm, $SD = 3.10$ cm, and $M = 66.91$ kg, $SD = 4.04$ kg), with $F(1, 105) = 203.02$, $p < 0.001$, $\eta_p^2 = 0.66$, and $F(1, 105) = 77.91$, $p < 0.001$, $\eta_p^2 = 0.43$, respectively.
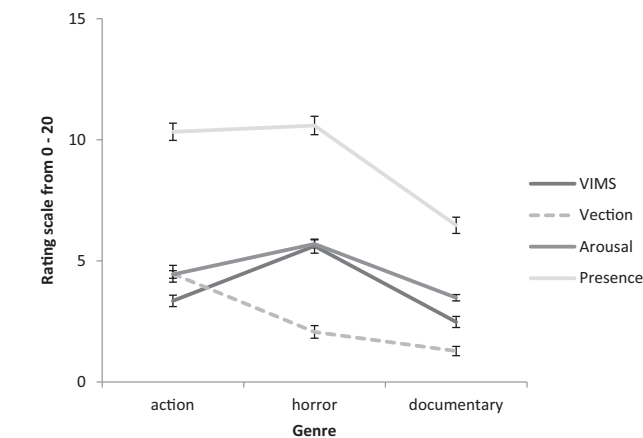

Fig. 2. Ratings of VIMS, vection, arousal, and presence. All ratings were given from 0 to 20, except for arousal, which was rated on the SAM scale from 1 to 9. Error bars indicate SEM.
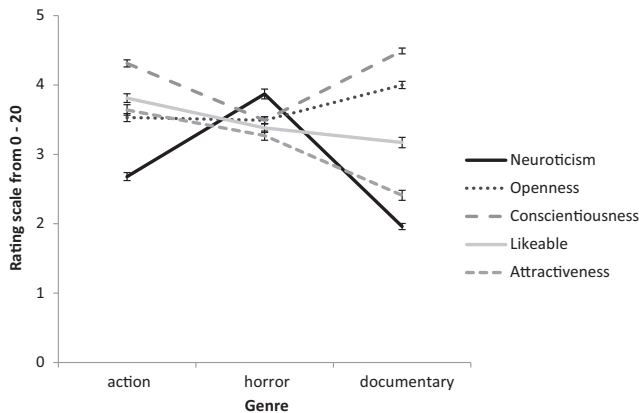
Fig. 4. Ratings of neuroticism, openness, conscientiousness, likeable, and attractiveness. Error bars indicate SEM.

4. Discussion

In accordance with our hypothesis, we found that horror movies produced the highest amount of discomfort (VIMS). We also found that 3D movies produced overall more presence than 2D movies. We did, however, not find a difference between artificial and director's 3D. This is surprising given the amount of sophistication and money that goes into producing 3D movies. The straight-forward algorithm used to transform 2D into 3D images created impossible retinal disparities. Disparity-selective neurons in the V1 and V2, which are tuned for absolute disparity [31], might show roughly comparable firing rates for director's and artificial 3D. However, disparity-selective neurons in V4 and the middle temporal visual area (MT or V5) are tuned to relative disparity. In director's 3D, the relative disparity mimics real life vision with no disparity at the fixation point and strong disparity at locations behind or in front of this point. Additionally, disparity crosses at the fixation point, features not present at artificial 3D. Instead the disparity is the same at any given point in the picture, which should be reflected in neurons in V4 and MT. Nonetheless, the visual system did not complain any more than it did with director's 3D. This may betray the quality of 3D technology or the tolerance of the visual system. Be this as it may, compared to director's 3D, the artificial 3D did not add any visual discomfort in the viewer.

Our data indicate that action movies produced the highest level of immersion and vection while they did not differ from horror movies in their generation of presence. This is easy to explain when looking at the budget spent for each genre. Our action movies had an average production cost of roughly 165 Mio. US-Dollars, the horror movies of roughly 20 Mio. US-Dollars, and the documentaries of roughly 2 Mio. US-Dollars. This is representative for the industry, with most money spent on action movies and least on documentaries. Under these circumstances, action movies should be technologically most advanced, which would be reflected in more immersion and vection. Presence, in contrast, is more dependent on the story than on technology and both, action and horror movies, had an exciting story line that was more captivating than the documentaries.

We also found a significant interaction between genre and viewing condition for the dependent variable immersion. Horror movies produced the highest immersion with director's 3D and the lowest with artificial 3D, but the ratings were reversed for documentaries. This is hard to explain since there was no difference for most measures between artificial and director's 3D. We suspect that this difference can be attributed to the ratings of the climbing documentary. It included shots of mountains with a separation

between the two cameras of up to 10 m. This makes the mountains look like a toy scenery (similar to the tilt shift technique in 2D) and reduces the realism of a scene. The artificial 3D did not include such large discrepancies and made the documentary more immersive. This is speculative, however, and we would need more stimuli to back up such a claim.

Protagonists were perceived as more attractive, likeable, and intelligent in the action movies, compared to the horror movies, which in turn produced higher ratings than documentaries. This is in line with the budget spent making the movies and hiring attractive actors. Attractiveness ratings also correlated with perception of intelligence and likeability [8,19] in previous studies.

Our data suggest that protagonists are seen as more conscientious in documentaries than in horror movies, with the action movies lying somewhere in-between. However, the ratings for neuroticism were reversed. The main characters in horror movies were perceived as more neurotic than in action movies or documentaries. This can be probably explained by the different plots. Whereas the protagonists in the documentaries were in control and obviously knew what they were doing, the protagonists in the horror movies were portrayed as poorly prepared and in distress. The main characters in the action movies were shown in scenes were they had to overcome obstacles that were challenging and in part out of their control, making them seems less conscientious and more neurotic.

As expected, we found that subjects preferred larger interpersonal distances in documentaries, compared to action and horror movies. We assume that this is because documentaries are already quite realistic and subjects want to keep some distance to not be overwhelmed by the experience. Additionally, we found that protagonists in documentaries are perceived as least attractive, which also correlates with interpersonal distance [22]. Contrary to our hypotheses, there was no effect of stereopsis on the perception of the protagonists. We only found a non-significant trend for protagonists in 2D movies to be more agreeable than in 3D. Considering that subjects prefer a larger interpersonal distance in documentaries, we recommend avoiding stereopsis when producing person-centered documentations.

We conclude that 3D viewing has minimal effects on the perception of the protagonist, but considerable effects on the viewer's sensations. Also, artificial and director's 3D were practically indistinguishable for our subjects, which goes against the common wisdom that the stereo-disparity of the eyes has to be correctly reproduced. The visual system appears to be surprisingly tolerant when it comes to fusing the information of the left and the right eye into a single stereoscopic image. Finally, there were strong genre effects. 3D technology may be helpful for action and horror movies, but this is not the case for documentaries.

Appendix A

Movie/Genre	Movie data	Summary of the used scenes
Gravity *Action*	County: USA, UK Runtime: 90 min	The two astronauts, Matt Kowalski and Dr. Ryan Stone (played by Sandra Bullock), are working together at the

Appendix A (continued)

Movie/Genre	Movie data	Summary of the used scenes
	Year of release: 2013 Director: Alfonso Cuaron	Hubble Space Telescope. They learn from the NASA command central that a large amount of debris is heading their way. First it seems that they are no endangered, but after satellites are hit, several parts hit the crew. Dr. Ryan Stone is catapulted into space and rotates uncontrolled around her own axis. She is threatened to suffocate and loses contact to Kowalski
The Amazing Spider-Man *Action*	County: USA Runtime: 136 min Year of release: 2012 Regie: Marc Webb	Peter Parker (played by Andrew Garfield) discovers his new abilities and finds out, that he can move like a spider. He uses his Superhuman reflexes and agility and Wall-crawling ability to fight crime. To optimize his mobility and hide his identity, Peter constructs a spandex bodysuit including a mask
Final Destination 5 *Horror*	County: USA Runtime: 92 min Year of release: 2011 Director: Steven Quale	Molly und Sam (played by Nicholas D'Agosto) are on their way to Paris. On board of the plane a passenger has a panic attack and predicts that the plane will crash. Shortly after departure the engines catch fire and damage the plane. Molly is catapulted out of the plane and Sam dies in a firestorm. The last installment shows the plane crashing
One Way Trip 3D *Horror*	County: Austria, Switzerland Runtime: 85 min Year of release: 2011 Director: Markus Welter	After Lilli (played by Tanja Raunig) observed how one of her friends was stabbed in the head, she escapes to the roof of the house. She is followed by an unknown person with a knife. Lilli tries to stay on the roof but slips and falls off. She gets impaled by a fence through the stomach and dies. A friend of Lilli observed the whole scene in distress. Suddenly three of her friends appear and she is relieved
Pina Documentary	County: Germany Runtime: 106 min	The dancers (main dancer in this scene, Regina Advento) are on a stage flooded with water. It is raining from the

Appendix A (continued)

Movie/Genre	Movie data	Summary of the used scenes
	Year of release: 2011 Director: Wim Wenders	stage ceiling. The minimalistic stage design consists of the water and one boulder. The artists have buckets of water as requisite with which they ladle water from the stage and spill it in a flowing movement.
Die Huberbuam *Documentary*	County: Austria Runtime: 42 min Year of release: 2012 Director: Jens Monath	Alexander and Thomas Huber are extreme climber. They report from their last big challenge, project "Karma" at the slab of the Loferer alps. This tour is symbolic for their conflicts in life and their relationship as brothers, who always tried to find exits together from seemingly impassable situations

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