

Does 3D Increase the Enjoyment Experience? A Comparative Experiment on the Psychological Effects of 3D

Qihao Ji • Jessica Tanca • Sophie Janicke

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1. Introduction

For years, filmmakers, movie studios, and corporations have sought to develop technology that can provide moviegoers with an enhanced and unforgettable experience, whether in the theater or at home. Stereoscopic 3D is one method that has been developed to increase enjoyment. The easiest way of understanding 3D is that it adds an extra dimension of depth perception, which presumably helps viewers to immerse themselves into the media product. Current 3D cameras consist of two side-by-side lenses with each capturing a two dimensional image. Through the two 2D images displayed slightly offset from each other, the brain can yield the visual perception of depth¹.

Generating over \$2.8 billion gross box office, *Avatar* was one of several high-grossing 3D blockbusters to hit theaters in recent years, indicating a strong demand for 3D content. In 2012, the fifteen-year-old James Cameron film *Titanic* was rereleased in 3D, grossing over 2.1 billion around the world. As a matter of fact, nine of the top 15 highest-grossing movies in 2012 were shot in 3D², and the top 3 most profitable movies of all time were 3D movies.

3D technology is not limited to theaters. The adoption of 3D television, or 3DTV, seems to be another promising 3D advancement. In a pilot study, Raney, Ellis and Janicke³ examined the advantages and disadvantages of live sports televised in 3D versus 2D. Although the study included limitations such as ecological validity and a small sample

size, the researchers concluded that “on nearly every measure, viewers and players in the 3D conditions rated their experience as more favorable than their counterparts in the 2D conditions³.” At present, there are several specialized 3D channels available in Europe, United States, Japan and China. It is predicted that 21% of households will have proper equipment for 3D TV content by 2015⁴.

3D technology has also been the subject of criticism. Due to technical limitations, one of the most often criticized drawbacks of 3D is the screen brightness⁵. From human brain’s functional perspective, film critic Roger Ebert⁶ suggested that the current screen 3D requires people’s brains to work unnaturally, which is the reason why many viewers complain 3D causing eyestrain and headache. Furthermore, Ebert⁷ wrote that 3D “adds nothing essential to the movie-going experience” and called it “unsuitable for grown-up films of any seriousness.” Others have argued that 3D is pointless, distracting, and a gimmick⁶⁻⁹. Beyond such aesthetic criticisms is the high cost of the technology used to produce 3D films and display them in theaters. However, a notable point here is that currently there are plenty of “phony 3D movies” (movies that were made in 2D but then converted to 3D in post-production) in the market, which is different from what James Cameron defined as “quality 3D images,” and these converted 3D products are potentially harming people’s confidence in genuine 3D⁵.

Despite the aforementioned drawbacks and shortcomings, investors have poured millions of dollars into the production of 3D movies without a clear understanding of whether the technology can provide better enjoyment experiences when compared with traditional 2D films. Unfortunately, there has been little empirical research done to address this issue. Existing studies have paid more attention to the physical discomfort that audiences experience when consuming 3D films¹⁰⁻¹³ rather than the psychological impacts on viewers. The other train of scholars^{14, 15} who approached the cinematic use of 3D

Qihao Ji¹ (✉) • Jessica Tanca¹ • Sophie Janicke¹

¹ University Center C 3100, School of Communication, Florida

State University, Tallahassee, FL 32306.

E-mail: qji@fsu.edu

technology from the psychological perspective examined the effects of 3D on variables such as presence, arousal, and visual recognition as well as visual and spatial cognition. However, despite their results may pointed to the effect of 3D on viewers' enjoyment experience implicitly, no known empirical studies directly examined the entertainment effect of 3D, which is one of the central bases for the film industry making movies in 3D. Therefore, the current study serves as one of the early efforts that tried to address this issue. Specifically, our goal is to ascertain whether movies produced with 3D technology can provide a better enjoyment experience than those produced with 2D technology. Built upon myriad studies of television, this study also intends to investigate whether structural features of motion pictures (3D/2D) can result in different impacts on individual viewers' attention, memory and emotion. Understanding the impact of 3D on these variables will help to explain why people's entertainment experience differ in 2D and 3D movie viewing, if any. In addition, we proposed the concept of emotional fatigue (EF) to examine a particular emotional experience in the process of consuming 3D media products, we argue such a new concept will not only provide a theoretically fruitful, but also practically useful contribution.

2. Theoretical Considerations

Academic studies exploring media effects initially focused on media content^{16, 17}, as scholars generally believed that content features of media had the most powerful impact on audience's perception and behavior¹⁸. That changed with the introduction of medium theory, introduced by McLuhan¹⁹ in his work *Understanding Media*. Medium theory posited that the form of medium used to transmit a message can influence how information is processed and perceived by audiences. Following the introduction of medium theory, scholars began to look at non-content features of media and the effects of those features. From the television studies perspective, Geiger and Reeves²⁰ suggested that non-content features refer to audio and visual structure of mediums, such as cuts, edits, pacing, camera angles and image size. Several studies have indicated that these structural features do influence people's cognitive processing and emotional responses toward media²¹⁻²³.

Innovations in media technology, notably the introduction of 3D, have changed movie and television production. Traditional structural features such as color, motion, pacing, camera angle, and screen size of media contexts have been modified due to the emergence of 3D technology. We argue that the most important change brought by 3D lies in the motion aspect. Motion is a very basic attribute of objects. According to Gibson²⁴, people can obtain perception about objects' size, distance, speed, and relative positions based on motion. Zettl²⁵ proposed three types of motion in movies: primary, secondary and tertiary, which refers to movement of objects in front of the camera, movement of the camera itself and movement caused by image editing respectively. What the stereoscopic 3D motion image does, is adding a *quartus* type of motion: the movement of image depth. Since visual structural features have been a primary focus for studies about cognitive processing of media content, it is reasonable to hypothesize

that the *quartus* motion would pose certain cognitive effects on the viewers.

An extensive body of research has used the Limited Capacity Model, or more precisely the LC4MP (Limited Capacity for Media Processing Model²⁶) to understand the effects of structural factors on media processing. The core assumptions underlying the limited capacity approach is that people's information processing is limited by the amount of the information they can process at one time²⁶. In order to process information, an individual must be able to encode, store, and retrieve a given message. Each of these sub-processes is affected by the viewers' cognitive resource availability to process the message. Previous research has indicated that the structural features of television messages, such as cuts, edits and graphics, elicit an orienting response (that is, an automatic physiological response²⁷) resulting in resources being allocated to processing²⁶. Studies have found that related and unrelated cuts in content elicited orienting responses in attentive viewers²². Reeves and his colleagues²⁸ found that participants pay greater attention to messages on larger screen sizes than on small-or-medium sized screens. Another study about rates of edits suggested that the number of edits in a message is positively correlated to the audiences' attention²⁷. These existing studies led to the thinking that structural factors of television typically result in the change of attention level. Thus, it is reasonable to assume that a 3D movie will lead to a higher attention level than a 2D movie:

H1: Compared to 2D condition, viewers in 3D condition will report higher level of attention.

Structural features such as camera movement²⁹, pace³⁰, and audio complexity²³ have also been shown to increase self-reported emotional arousal. Studies have indicated that emotional arousal increases as mediated information enhances attention^{31, 32}. Therefore, we predicted, if watching a stereoscopic movie leads to higher attention, participants in the 3D group are likely to be more aroused. It is noteworthy that a recent experimental study by Bae, Eller, and Lang¹⁵ compared the psychological arousal (measured by skin conductance) of viewers who exposed to 3D clips to those exposed to 2D clips, and no significant difference was obtained. However, since the study used repeated measure with very limited sample size, and the stimulus were mostly short, we thought the result may not be generalizable.

H2a: Attention will be positively correlated to emotional arousal.

H2b: Audiences in the 3D condition will be more aroused than audiences in the 2D condition.

The processing of messages has various degrees, ranging from complete processing — the message is encoded, stored and can be easily retrieved — to more partial processing, in which the message “may be encoded but be less well stored”³³. To measure memory in relation to these three sub-processes, measures such as recognition, cued recall, and free recall can be used. According to the LCM, how a message can be retrieved is dependent on how it is stored. Studies have found that an increase in arousal will result in more capability allocated to storage level³⁴, which consequently should lead to better free recall. Additionally, studies that looked at information processing during watching TV programs support the positive correlation between emotional arousal and memory^{26, 35, 36}. As this study predicts difference between 2D and 3D movie

viewing in terms of emotional arousal and attention, the following hypothesis is proposed:

H3: Audiences in the 3D condition will recall more than audiences in the 2D condition.

Emotional change has been a central concept for scholars of entertainment studies when examining individuals' perceived media enjoyment³⁷. Emotional change is a complex psychophysiological experience of external stimuli³³, and many scholars alluded that emotion and its effects are essential factors for people perceiving enjoyment³⁸⁻⁴¹. For instance, theories such as affective disposition theory^{40, 42} suggest that enjoyment is related to viewers' emotional change which is related to the expectations of different characters. Conceptually, two primary approaches have been adopted in the study of emotion: the categorical and the dimensional⁴³. The categorical approach deals with specific emotions such as sadness, happiness and anger, while the dimensional approach conceptualizes emotion as consisting of direction (valence) and intensity (arousal). For the purpose of our study, only the extent of emotional arousal — an indication of the intensity of activation — is examined. A study by Tamborini and his colleagues⁴⁴ have found that arousal contributed a big proportion to the enjoyment experience. Thus, we expect that:

H4: The more aroused people feel while watching a movie, the higher their enjoyment will be.

In addition, since we hypothesized that there will be different level of emotional arousal between 3D and 2D movie watching (H2b), consequently, it is likely that the enjoyment level will differ as well.

H5: Audiences in the 3D condition will have a higher level of enjoyment than audiences in the 2D condition.

Thus far our discussion has been primarily focusing on 2D and 3D as a structure feature of movie. However, no researcher would deny that the narration of a story plays a critical role in terms of perceiving enjoyment as well. In fact, a large body of research has found that different facets of narrative involvement are associated with enjoyment^{45, 46}. Particularly, by developing a specific set of scales in the film/television context, Busselle and Bilandzic⁴⁵ found that narrative engagement predicts audiences' enjoyment level in a substantial way. From a theoretical perspective, in order to enjoy a movie/TV drama, one has to experience an emotional response, which is derived from the characters and other information the narrative provides⁴⁰. Since we hypothesized that viewers' in the 3D condition will have higher enjoyment and emotional arousal, accordingly, we would expect:

H6a: Audiences' narrative engagement will be positively correlated to emotional arousal.

H6b: Audiences in the 3D condition will have a higher level of narrative engagement than audiences in the 2D condition.

Finally, we were also interested to explore a new emotional state of media. During the past decades, psychologists observed a phenomenon that commonly existed inside the work place: burnout. According to Maslach and Jackson⁴⁷, burnout is an exhaustion of physical and emotional strength which can be caused by job stress. It is a compound syndrome featured by emotional exhaustion (EE), depersonalization, and decreased personal performance. Essentially, EE is the core concept among

these three components of burnout as it directly reflects the depleting process of emotion⁴⁸. This unique but universally existing phenomenon of emotional exhaustion⁴⁸ leads to our thinking that there might be a similar emotional experience resulting from media exposure. Based on the concept of emotional exhaustion, we propose the notion of Emotional Fatigue (EF) and define it as a state of emotional tiredness resulting from excessive activation of an individual's emotion during the course of consuming media content. However, EF has to be differentiated from compassion fatigue, which is a specific emotional exhaustion caused by over exposure to tragic news content⁴⁹.

EF cannot be simply situated in either categorical approach or dimensional approach of emotion, because EF is not a specific emotion, but a result of excessive arousal. Lang and Ewoldsen⁵⁰ noted that "emotion [are] action tendencies stored in memory and retrieved in specific stimulus contexts, all of which involve the processing of information (p. 277)". Based on LCM, if there are not enough cognitive resources available for processing a message, overload will cause fatigue as a result of emotion change.

Previous studies have found that both 2D and 3D motion pictures may lead to different levels of "visual fatigue" which includes eye strain, general discomfort, nausea, focusing difficulty and headache¹². Through a comparative experimental study, Yano and his colleagues¹³ found that 3D HDTV cause visual fatigue more easily compared to 2D HDTV. Based on these studies, our research takes an information processing perspective and studies whether watching 3D movies will cause higher emotional fatigue, as compared to visual fatigue, which was studied before. Since myriad studies have already been conducted in the field of visual fatigue, we posed a research question to investigate the relevance of emotional fatigue in the context of 3D movies:

RQ1: Do 3D audiences differ from 2D audiences with respect to the level of emotional fatigue they perceived during the movie viewing?

If 3D technology leads to the symptom of visual fatigue, then it may potentially lead to the loss of attention¹². From the standpoint of LCM, conceptually, since emotional arousal is a reflection of information processing, it is plausible to assume that when emotional and/or visual fatigue happens, people would pay less attention towards the media content. In other words, emotional fatigue may become negatively associated with attention level because our brain automatically refuses to, or is incapable of processing more information.

It has to be noted, in most emotion related studies, that attention is typically measured by real-time physiological measures such as heart rate change, while in this study attention was evaluated by self-report immediately after the exposure. However, with EF assessed also, shortly after the exposure, we expected to see:

H7: EF will be negatively correlated with attention.

In addition, we also intended to see if EF is associated with people's perceived enjoyment in addition to emotional arousal:

RQ2: Does EF predict enjoyment in both viewing conditions?

3. Method

3.1. Participants

All together 130 undergraduate students who were enrolled in communication courses agreed to participate in the study in exchange for extra credit. The majority of participants were female (75.4%), and White (73.1%), with a mean age of 20 years old ($SD = 1.2$). Due to the capacity of the research lab, only 13 seats were offered each time, therefore, we random assigned the 130 students into 10 research sessions. Meanwhile, ANOVA and chi-square test were ran to check the group differences, overall, the result rendered non-significant difference among sessions in terms of viewers' age, race and gender.

Sessions were randomly assigned to present the movie in 3D or 2D. Participants were not told what version of the film they would see prior to the session. In total, 65 participants viewed the 2D version, and 65 participants viewed the 3D version. All sessions were conducted in an audio-visual room, which equipped a 55 inch SAMGSUNG™ LED series 3D television set with a resolution of 1920×1080 pixels. The TV was placed on a wall, 1 meter above the ground, and the viewing distance was 2.5 to 3 meters depending on the rows students chose to sit in.

3.2. Stimuli

Participants in this study viewed the feature film *Dolphin Tale*. The movie itself was originally shot in stereoscopic 3D. It differs from any high-end stereographic conversions such as *The Clash of the Titans* which is considered 2.4D in the view of James Cameron⁵¹. The stimuli were also in the resolution of 1920×1080 pixel with widescreen aspect ratio of 16:9, and Dolby Digital.

Categorized as drama or family, the film tells a true story about a group of people who endeavored to save a dolphin which lost its tail because of an accident. The story line was not complicated, yet involves various conflicts among multiple characters. In order to enhance external validity, the movie was shown in full-length (113 minutes) instead of partially.

3.3. Procedure

Upon entering the research room, participants were given an IRB-approved consent form and a pre-movie questionnaire. On the questionnaire, participants listed demographic information (sex, race, college major, and age) and indicated their general attitude towards 3D movies (ranging from 0 "I hate them" to 7 "I love them"). Participants were instructed to fill out both the consent form and the questionnaire, returning the former to one of the two researchers and keeping the latter until the end of the film.

Once the consent forms were collected, participants were informed of the procedure of the study. In the 2D sessions, the participants then proceeded to view the film. In the 3D sessions, they were given a pair of Samsung™ SSG-5100GB 3D Active Glasses and instructed to watch a brief 3D montage for 1 minute to make sure the glasses were

working properly. Small talk was not inhibited for each session during the experiment in order to create a quasi-theater experience, however, viewers remained quiet in general among all sessions. After the montage, participants watched the film in 3D. At the conclusion of the film, participants were given a post-movie questionnaire. The first part of the questionnaire was a free recall measure, in which participants were instructed to write down as many names as they could remember from the movie in three minutes. One of the two researchers leading the session timed this portion and instructed participants to move on to the remainder of the questionnaire when time expired. Participants then proceed to the remainder of the post-test, which consisted of measures of overall enjoyment, emotional arousal, emotional fatigue, narrative engagement as well as attention. Once the post-test was completed, participants turned in both the pre-movie questionnaire and the post-test, signed out on an Excel spreadsheet, and were thanked and dismissed.

3.4 Measures

Emotional Arousal. Emotional arousal was measured by using the Self Assessment Manikin (SAM), articulated by Hodes and his colleagues⁵². The SAM is a 9-point, pictorial scale assessing people's emotional response on three dimensions: valence, arousal and dominance. We used the 6 items related to measure the arousal dimension that include semantic differential items such as relaxed vs. stimulated, calm vs. excited. This subscale yielded a high reliability of Cronbach's $\alpha = .857$.

Attention. The outcome variable attention was measured by four items that had been previously used by Potter and Choi²³. Three of them ("How much did you pay attention to the messages in the movie you just watched? How interesting did you find the movie you just watched? How much did you concentrate on the movie you just watched?") used a 7-point scales anchored by "not at all" and "very much." The final one ("How much thought did you put into evaluating the movie you just watched?") was anchored by "none" and "a lot," and assessed again on a 7-point likert type scale. Reliability was sufficient ($\alpha = .736$).

Memory. In this study, memory was conceptualized mainly as the retrieval level of information which was operationalized through free recall. Similarly to Potter and Choi²³, we asked our subjects immediately after the film to list as many character names from the film as they could in three minutes, with memory quantified by how many names they recalled.

Emotional Fatigue (EF) Though EF is a newly proposed concept as a result of viewing media content, it shares much in common with emotional exhaustion (EE) in terms of the emotional depletion process as used in studies of burnout. Therefore, we adopted and revised items from the EE scale from the Maslach Burnout Inventory-General Survey⁵³, a 16-item self-report measure used to assess the extent of one's burnout. We adopted 5 items from the original EE scale by framing them to be related to the movie experience. For example, the original EE item "I feel emotionally drained," was reworded to "I feel emotionally drained by the movie" (The other four items were: "I feel emotionally used up at the end of watching the movie," "I felt tired before I came to the movie today," "Watching this movie

was really a strain for me,” and “I feel burned out from this movie.”) In a pilot study with 46 participants, reliability analysis indicated that the reliability of the scale could increase from .76 to .80 after excluding the item “I felt tired before I came to the movie today.” Considering the fact that EF is a specific reaction resulting from an entertainment (film/television watching) content which conceptually can help to differentiate physical tiredness from emotional exhaustion, we then decided to drop this item for the study at hand. The final EF scale consisted of 4 items with acceptable reliability (Cronbach’s $\alpha = .806$)

Narrative Engagement (NE) Traditionally, researchers have developed many concepts such as transportation, identification, and flow to catch audiences’ level of engagement in certain types of narratives. However, Busselle and Bilandzic⁴⁵ argued that these existing concepts only grasp part of narrative engagement in the film/television context. In congruence with their argument, we adopted their narrative engagement scale, which consists of 4 dimensions (narrative understanding, attention focus, emotional engagement, and narrative presence) Each dimension contains 3 scale items that are answered on a scale from 1 to 7 (strongly disagree to strongly agree) Example items are: “At points, I had a hard time making sense of what was going on” for the narrative understanding scale ($\alpha = .729$); “I found my mind wandering while watching the movie” for the attention focus scale ($\alpha = .873$); “I felt sorry for some of the characters in the movie” for the emotional engagement scale ($\alpha = .622$); “During the movie, my body was in the room, but my mind

was inside the world created by the story” for the narrative presence subscale ($\alpha = .733$) Busselle and Bilandzic⁴⁵ suggest a comprehensive scale including all subscales, comprising 12 items, yielding a Cronbach’s $\alpha = .81$ after correcting for reverse coded items. In order to avoid order effects, scale items for NE and EF were mixed randomly in the questionnaire.

Enjoyment. Enjoyment of watching the movie was assessed by using six items adopted from a study by Raney⁵⁴. Various enjoyment related aspects were included in these items. A sample item is: “How exciting was the movie?” The reliability of the scale was strong ($\alpha = .930$)

4. Result

This research aimed to examine whether there is a difference between the stereotypic movie structure and traditional 2D structure in relation to enjoyment. Due to violation of normality, a series of Mann-Whitney tests were conducted to compare the differences in attention, enjoyment, memory, emotional arousal and emotional fatigue (EF) between the 2D and 3D samples. Correlation analysis using Spearmans rho was adopted to test the possible relationship between emotional arousal and enjoyment, narrative engagement and emotional arousal. Multiple regressions were used to examine whether the EF has predictive power for enjoyment. Table 1 shows the means and standard deviations for all dependent variables.

Table 1 Means and Standard Deviations for all Dependent Variables

	Attention	Enjoyment	Emotional Arousal	Emotional Fatigue	Memory
Condition	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
2D	5.30 (1.00)	7.02 (1.76)	4.07 (1.33)	2.21 (1.14)	12.07 (3.26)
3D	5.31 (1.13)	6.83 (1.68)	4.28 (1.47)	2.33 (1.21)	11.89 (3.36)

Note. Memory was assessed with free recalling of character names present in the narrative and thus reflect the average of recalled names per condition. Attention, Enjoyment and Emotional Fatigue were assessed on 7 point likert-type scales ranging from 0 (*strongly disagree/not at all*) to 7 (*strongly agree/extremely*) Emotional arousal was assessed using a 9 point semantic differential scale, employing the arousal dimension of the SAM.

Table 2 Bivariate correlations

Measures	Enjoyment	Arousal	EF	NE	Memory	Attention
Enjoyment		.632**	-.076	.669**	.132	.723**
Arousal			.238**	.581**	.092	.494**
EF				-.040	-.126	-.159
NE					.088	.683**
Memory						.220*
Attention						

Note. * $p < .05$, ** $p < .001$.

Hypotheses 1, 2b, 3, 5 and RQ1 dealt with the differences of attention (H1), emotional arousal (H2a), memory (H3), enjoyment (H5), and emotional fatigue (RQ1) between the 2D and 3D conditions. Surprisingly, the t test (for arousal) and Mann-Whitney tests revealed no significant differences for either of these variables, as apparent from the means in Table 1. Although there was a slight mean difference observable descriptively in emotional arousal, as well as emotional fatigue between 2D and 3D in the expected direction, the differences did not become significant ($U_{\text{arousal}} = 1883.0$, $z = -.929$, $p > .05$, $U_{\text{EF}} = 2009.0$, $z = -.485$, $p > .05$) Therefore, Hypotheses 1, 2a, 3, 5 and RQ1 were not supported.

Hypothesis 2b predicted a positive relationship between

attention and emotional arousal. A Spearman’s correlation analysis showed a significant relationship between these variables for ($r_s = .494$, $p < .001$, see table 2), supporting Hypothesis 2b and thus previous research findings. H4 examined the correlation between emotional arousal and enjoyment. As expected, correlation analyses suggested that a strong, positive correlation exists between viewers’ emotional arousal and their perceived enjoyment ($r_s = .632$, $p < .001$) Hypothesis 4 was therewith supported. The same statistical technique was applied on H6a which focused on the relationship between narrative engagement (NE) and emotional arousal. The correlation analysis supported our hypothesis indicating that NE and emotional arousal are highly associated for each group ($r_s = .581$, $p < .001$) H6b

predicted a mean difference between the groups in narrative engagement. As already indicated by the means (table 1) there was no significant difference between groups ($U = 1573.5$, $z = -.639$, $p > .05$) H6b was not supported.

H7 predicted that emotional fatigue and level of attention will be negatively associated. Our data did not support the hypothesis ($r_s = -.159$, $p > .05$) However, after we split the

data and ran the same test, a moderate negative correlation was observed in the 2D condition ($r_s = -.324$, $p < .05$), but no significant correlation was found in the 3D condition ($r_s = .001$, $p > .05$) Thus H7 was only partially supported. Several reasons for this finding will be explained in the discussion section.

Table 3 Multiple Regression: Emotional Fatigue within 2D group and 3D group

Variable	2D		3D	
	β	SE	β	SE
Emotional Fatigue	-.356**	.145	-.143	.128
Emotional Arousal	.793*	.155	.781*	.108

Note. ** $p < 0.001$. * $p < 0.01$.

Table 4 Results of Hypotheses and Research Questions

	Hypothesis/Research Question	Result
H1	Compared to 2D condition, viewers in 3D condition will report higher level of attention.	Not supported
H2a	Attention will be positively correlated to emotional arousal.	Supported
H2b	Audiences in the 3D condition will be more aroused than audiences in the 2D condition.	Not supported
H3	Audiences in the 3D condition will recall more than audiences in the 2D condition.	Not supported
H4	The more aroused people feel while watching a movie, the higher their enjoyment will be.	Supported
H5	Audiences in the 3D condition will have a higher level of enjoyment than audiences in the 2D condition.	Not supported
H6a	Audiences' narrative engagement will be positively correlated to emotional arousal.	Supported
H6b	Audiences in the 3D condition will have a higher level of narrative engagement than audiences in the 2D condition	Not supported
RQ1	Do 3D audiences differ from 2D audiences with respect to the level of emotional fatigue they perceived during the movie viewing?	No
H7	EF will be negatively correlated with attention.	Partially supported
RQ2	Does EF predict enjoyment in both viewing conditions?	Only in 3D condition

Finally, our RQ 2 intended to assess the relative explanatory power of EF in addition to emotional arousal for enjoyment for each condition. As discussed before, emotional arousal was the central variable that is conceptually associated with memory and attention. Prior to analyzing the regression results, multicollinearity diagnostic statistics was conducted. The Tolerance for the two predictors were larger than .85, indicating no multicollinearity issue to be worried. The multiple regression model was significant for both conditions (2D: $F(2, 58) = 19.35$, $p < .001$; 3D: $F(2, 61) = 37.07$, $p < .001$) As indicated in Table 3, the multiple regression revealed that EF had predictive power in 2D condition ($\beta = -.356$, $p < .001$, $R^2 = .400$), but not in the 3D condition ($\beta = -.143$, $p > .05$, $R^2 = .549$) Therefore, we can only claim that EF has predictive power in 2D movie viewing with respect to the enjoyment level.

5. Discussion

The current research study examined whether movies produced in 3D result in greater enjoyment experience than the same movie in 2D, as anticipated by moviemakers. Through a comparative experimental study, we manipulated the exposure to a family movie (*Dolphin Tale*) and either presented it in its originally filmed 3D version, or a simple 2D version, while identifying its effects on attention, memory, emotional arousal, emotional fatigue as well as enjoyment.

Despite the fact that most participants reported neutral

interest toward 3D movies ($M = 3.88$, $SD = 1.60$), but high interest toward 2D movies ($M = 6.22$, $SD = .90$), the absolute values of the measures suggested that audiences are equally captured by the movies regardless of their structure feature. To a certain extent, the result suggests that audiences appear to tolerate the defects of 3D visual production (e.g. darkness, dizziness) and are able to perceive enjoyment from 3D movies just like watching 2D movies. Combining with the fact that the market of 3D movie has been growing in the past 3 years, the result seems support Teo and Noyes⁵⁵ argument that when it comes to the technology acceptance, what matters is the level of enjoyment that a new technology can bring rather than the general public attitude toward the new technology per se.

Our data surprisingly suggested that 3D movie had a non-significant impact compared to 2D in terms of all the variables (attention, memory, emotional arousal, narrative engagement and enjoyment) tested in the study, which made our hypotheses all rejected (see table 4 for a quick review) A possible explanation for our result is the genre of our stimulus material. Dolphin tale is a family movie, so naturally, the level of emotional arousal from a content level is rather moderate (as indicated by our mean values $M = 4.28$ $SD = 1.47$, assessed on a scale ranging from 0-7) Thus, the 3D's ability to enhance this content arousal with its additional structural features could not be fully exploited, as compared to an action movie for example (i.e., "Transformers"), where 3D just lends itself more to enhance the emotional arousal that is already provided by the storyline. It has been stated that 3D, as a viewer experience enhancing feature, might be highly genre dependent. Janicke and Ellis⁵⁶ found that 3D greatly enhanced the

enjoyment of a sports clip, but not for a narrative clip. Our results strongly indicate that for family movies, the 3D effect simply does not add enough to the viewing experience that consequently, would make it worthwhile to adopt for the family living room. Nevertheless, our results corroborate Bae, Eller, and Lang's¹⁵ finding that cinematic use of 3D does not lead to higher level of emotional arousal compared with traditional 2D.

Furthermore, based on research that showed a relationship between emotional arousal, attention, and memory⁵⁷, it was also expected that the 3D movie would not only increase the viewers experienced arousal and attention level based on its enhanced structural features, but also increase memory performance. However, our finding that 3D did not elicit higher attention resonates with Boobeke, Looy, Szmallee, and Duyck's¹⁴ result. Test through a visual research task, they found that people exposed to 3D movie content did not show significantly higher visual attention than those who exposed to 2D content. Therefore, we conclude that current cinematic use of 3D does not differ from 2D in terms of eliciting viewer's attention. In terms of memory, the recall performance was the same for both conditions, with about 12 names remembered on average. Although our hypothesis was not supported, it was also not refuted. That is, based on the LCM it could also be the case that an excessive level of arousal leads to a cognitive overload, inhibiting any further information processing, which would be detrimental for storage of new information. However, our data shows that for the content tested, no overload seemed to be indicated by the 3D movie. This implies that the information was likely similarly processed (to the extent that it does not trigger cognitive overload) as in the 2D version of the movie. This becomes especially important for the application of 3D narratives in the learning environment.

As a fairly new application in this study, the concept of emotional fatigue (EF), as an indicator of cognitive overload due to heightened emotional arousal resulting from 3D content, has been proposed. Our study revealed interesting results regarding the relationship between EF and the structural feature of 3D. First of all, despite the fact that 3D has been criticized for its technological side effects (visual fatigue, and dizziness), it does not increase the level of emotional fatigue significantly. In other words, 3D as a new structural feature in the movie does not create an extra emotional burden for audiences. Combining the facts that the level of narrative engagement, attention and emotional arousal are almost the same in both groups, we might reach the thinking that our mind simply refuse to process 3D as a "perceptual salience"⁵⁸, because it does not help or hinder audiences understanding of the narrative. However, current study also found that audiences' EF associates with attention and has negative predictive power on enjoyment in the 2D context. Conceptually, it makes sense, as the LCM contends, emotional change reflects information processing, which requires certain level of attention. If a viewer perceives emotional fatigue immediately after the exposure, his/her evaluation of enjoyment level might be affected. Since EF had no predictive power in the 3D group, and no correlation was found between EF and attention level in the 3D setting, we tend to argue that the structural feature of 3D activates slightly different mechanism of information processing rather than simply being ignored by our brain.

Moreover, in cognitive psychology, memory consists of a verbal system and a visual spatial system⁵⁹, and visual spatial memory was found to be associated with visual attention⁶⁰. In our study, we did not make the differentiation in our measures of attention and memory (In fact, what we measured here is more likely to be the memory and attention of narration) Thus, there is the possibility that 3D, as a relatively new technique of making movies, still maintains some level of visual novelty among viewers, and it increases viewers' visual attention as well as visual spatial memory (the relationship between visual attention and emotion change remains unknown in academia thus far) If this is the case, we might take a step further and argue that watching 3D movie is inherently different from watching a 2D movie.

6. Limitation

In our study, all variables were measured by direct self-reported questionnaire data. Indirect psychophysiological measures, for example, the use of heart rate to measure attention, may provide us with a more differentiated picture about the pattern of attention distributed to the film in relation to the technical features of 3D, specifically in relation to motion. In addition, the study was conducted in 3DTV rather than in film screen, which might cause certain consequences. Moreover, several other psychological variables that have been associated with enjoyment in the entertainment literature, such as character involvement³⁹, presence⁶¹, or perceive realism⁶² would further inform us on the potential differences 3D can create for the viewer. Furthermore, with respect to our stimulus selection, a student audience may not have been the best fit. As Raney et al.³ indicated, one of the challenges of entertainment scholars to research the effects of 3D content is the selection of the content. Films such as *Avatar*, *Transformers*, or *Pirates of the Caribbean* may have been more "attractive" for a college aged viewer, however, their familiarity with the content would interfere with the investigation of the outcome variable of enjoyment. Future studies need to address this problem, whereas field studies could be a valuable alternative to investigate the relative advantage of 3D compared to 2D content. On the other hand, choosing a family movie as the stimuli was to comprise our goal of investigating EF among young viewers, which may affect the generalizability of our results, future studies should incorporate other movie genres such as action, documentary or even animation.

In terms of the new concept of EF we proposed in this study, conceptually it is a time bonded variable, but how specifically fatigue changes over times remains uncertain. Future studies have to identify whether there is a liner or curve linear relation between the time and EF. Therefore, we call for more studies to examine the mechanisms of how emotional fatigue works and the effects of it. In addition, as a pioneer study of the concept of EF, we adopted the scales of EE to measure EF. However, the measurement could be problematic because the origin of EE is slightly different from EF as we defined in this study. Thus, future research should examine this concept with other variables that are associated theoretically and test the scale with confirmatory factor analyses. Moreover, like many media effect studies,

we are cautious to reach any definitive conclusions by using a convenience student sample. In fact, we suspect that the convenience sample might be a reason causing the low EF observed in the current study, because students are more exposed in the family atmosphere and they are more likely to have more interest in this specific type of movie than others. Follow-up studies are expected to use samples that are more representative in order to reach more generalizable results. In addition, asking viewers use of 3D content in the pre-movie questionnaire or conducting pretest and posttest (c.f. Boobeke, Looy, Szmalee, and Duyck¹⁴) might help our understanding that whether prior acquaintance with stereoscopic 3D systems or other 3D viewing systems has any effect on the variables we examined here and their pairwise correlations.

7. Conclusion

The current study took respect to the advancements of our technology driven living rooms and investigated the assumed added value 3D content could have for viewers' enjoyment experience. A family drama film, Dolphin Tale, was shown to college students either in 3D or a 2D version. Viewers' responses on the variables of attention, memory, emotional arousal, enjoyment and a new concept, emotional fatigue, were collected. Findings indicate that the 3D features did not enhance any of the viewer experiences substantially, which could explain the slow adaptation rate of 3D technology and 3D content into the living room. However, in line with Janicke and Ellis⁵⁶ and Raney et al.³, we argue that 3D only works content or rather genre specific in the cinematic context, and indeed may not lend itself very much to increase the viewing experience of a relative "unspectacular" family narratives. The new concept of emotional fatigue, as compared to visual fatigue may provide a fruitful variable for film producers as the study implies that 3D movie viewing might trigger an information processing mechanism that is different from traditional 2D movie viewing. Although our study does not further inform us on this issue, the conceptualization of emotional fatigue for specific 3D content creators can be a crucial variable of interest.

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