Binocular Disparity and Emotional Evaluation of Horror in S3D Content
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Abstract
The effects of moods and emotions on correlations with direction methods for stereoscopic 3D (S3D) content are the focus of this study. Specifically, we investigated the sense of horror in different 2D and S3D conditions as well as the different directing methods involved. Directional techniques were sorted into three categories according to the dynamic characteristics of the focus object in S3D space along the Z-Axis, XY-Axis, and Fixed-Axis directions. The emotional value of horror was characterized in terms of two values, valence and arousal, which were measured using the Self-Assessment Manikin (SAM). The results indicated considerable differences in terms of viewing condition, directing method, and gender. SAM measurements indicated low valence and high arousal scores in S3D viewing conditions. Furthermore, the effects of directing methods depended on the center and range of S3D space. Depth representation was a more important factor for female than male subjects.

Keywords: Stereoscopic 3D, Emotion, Horror, Disgust, Fear, Depth Representation, Emotional Evaluation

1. Introduction
The amount of S3D content available today, such as movies and broadcast programs, has increased due to the development of display and camera technologies. Until recently, S3D images had been limited to professional productions, but recent technological developments have made it easier for anyone to produce and submit such productions for publication.

Binocular disparity is quantified as the parallax angle for measurement of adjusted display position and directional space for S3D movie content, which in turn is calculated by subtracting the congestion angle (shift amount) from the angular distances to the left and right images when observing 2D image congestion. The parallax angle of the 2D image was considered to have zero disparity when the visual target was recognized on the viewer’s side of the screen by a negative parallax angle (i.e., crossed disparity). On the other hand, if the visual target is presented further away on the screen, it has a positive parallax angle (i.e., uncrossed disparity). The parallax distribution of the screen and maximum parallax angle are also considered as important factors in the creation of safe and comfortable S3D content. The parallax distribution is represented with a histogram and color map of the shift amount between the left and right image sources. The characteristics of the disparity parallax, parallax angle, and parallax distribution can generate S3D effects, such as reality and immersion, in observers.

S3D effects can also affect the observer’s emotional state. In S3D movies, the spatial design and placement of S3D figures can affect the user’s experience. Therefore, the creator must implement appropriate parallax conditions and establish directing methods to facilitate the observer’s safe and comfortable viewing of S3D content.

This purpose of this paper is to provide research evidence related to effective directing methods for S3D images. The authors have examined the effects of different direction methods on moods and emotions. The sense of horror (a basic emotion) was the focus of this study; it was analyzed in order to provide information on the relation between viewing conditions and directing methods in S3D horror movies.

2. Horror and depth representation
Ekman stated the basic facial expressions of emotion are anger, disgust, happiness, fear, sadness, and surprise. The authors analyzed the binocular disparity parallax included in S3D images from the perspective of producing a sensation of depth. One hundred nine emotional scenes that generate characteristically different depth sensations were extracted from well-known S3D movies for analysis. The maximum possible changes of the center and range of the S3D space from the first to the last frame of a scene were used for quantitative analysis of the parallax angle. The observer could perceive spatial expansion or contraction as the range of the S3D space was altered. In addition, when the center of the S3D space is moved, the observers feel
nearer or further from the target on the screen. In this way, the observer can experience the distance and spread of the target by changing the center and range of the S3D space.

An analysis of variance employing these two factors (emotions and S3D space) showed a significant main effect of changing S3D space ($p < 0.05$). The results of analysis of emotional scenes showed that the range of the S3D space varied by basic emotion; however, the degree depended on the type of emotion. The type of emotion depended on the type of direction method used for the center of the S3D space. The senses of disgust, fear, and surprise have often been used when trying to arouse feelings of horror in a series of S3D movies.

The results indicated that scenes categorized as eliciting disgust, fear, or surprise had more expanded ranges of S3D space than the other emotions had. The senses of disgust and surprise changed as the S3D space was changed to appear nearer to the viewer. In contrast, in scenes categorized as eliciting fear, the results changed when the S3D space was altered to appear farther away from the viewer. Based on this result, the authors conducted subjective evaluation experiments to quantify the effects of depth presentation that produce the intended emotional expressions in S3D horror movies (Figure 1).

3. Experiment

The purpose of this genre of movies is to evoke the feeling of horror in the viewer. Visual images were extracted from S3D Blu-ray discs, which were screened as S3D movies at the theater. The observers’ emotional changes were compared between the 2D and S3D viewing conditions. Emotional change was evaluated by the Self-Assessment Manikin (SAM) after viewing visual images. The SAM is a nonverbal pictorial assessment technique that directly measures valence and arousal. Valence was ranked in nine steps (from pleasure to unhappiness). Arousal was also ranked in nine steps (from upset to calm). The SAM directly evaluates a person’s reaction using a diagram of a mannequin. In order to classify the directional characteristics of the scenes, visual image cuts were extracted from five horror movies; these were included in directing cuts that aroused fear via adjustment of binocular disparity.

Directions were classified into three categories according to the depth map of the S3D image: the Z-Axis, XY-Axis, and Fixed-Axis directions. The depth map created a 2D image that represented the depth cue as a 256-level grayscale image. The depth information of each pixel in the content was described as a grayscale value, whereby brighter and darker areas have crossed and uncrossed parallax, respectively.

Analysis of depth maps can be quantified in terms of center and range of S3D space. On the basis of the viewers, the Z-Axis direction was defined to direct the object of focus between the front and back of the screen. The center position of the S3D space was decided by shifting the value of binocular disparity along the Z-Axis. The object of focus along the XY-Axis was
directed to move between the horizontal and vertical direction planes on the screen. The object of focus along the Fixed-Axis was directed to stay fixed on the screen. The center position of the S3D space was directed to move along the XY-axis or be fixed without producing any change in binocular disparity.

The experimental stimuli were arranged by type of directing method. Thirty cuts were randomly selected and combined as 2D and S3D images. The same cuts of both 2D and S3D images were not arranged consecutively. Each cut was shown for 5 seconds. The subjects were asked to fill out the SAM after one visual stimulus presentation while viewing a black screen for 10 seconds. The SAM test was repeated three times, including a 5-minute break between measurement blocks. The subjects viewed the visual stimuli on a S3D display (Hyundai IT, E465S) while wearing polarized glasses. The experiment was performed in a dark room at a viewing distance of 171.9 cm (3H). In the post-experimental interviews, the subjects were asked about their viewing experience. The subjects were thirty student volunteers (fifteen male, fifteen female) between the ages of 23 and 30 years who were emmetropic and had normal binocular stereoscopic vision.

4. Results

Symptoms related to horror were evaluated to analyze the average values of emotional valence and arousal after each stimulus presentation. Because there has been no previous research on the relation between horror and SAM scores, the authors have assumed that horror relates to low valence and high arousal scores. Subjects were expected to feel emotions of unpleasantness and excitement. Each subject’s experiences of valence and arousal were evaluated according to a nine-point self-rating method in the SAM, which was required in order to define the five points of the previous stimulus presentation. Differences in SAM scores were also analyzed using a mixed-model ANOVA with viewing condition (2D and S3D) and direction method (Z-Axis, XY-Axis, and Fixed-Axis) as repeated measures and gender as a between-subjects factor.

According to the analysis of valence on the SAM, there were significant main effects of gender (F(1, 448) = 16.711, p < 0.01), viewing condition (F(1, 448) = 23.067, p < 0.01), and direction method (F(2, 896) = 33.411, p < 0.01) and a significant three-way viewing condition × direction × gender interaction (F(2, 896) = 3.277, p < 0.05). The valence values along the Z-Axis for both genders had significantly lower values than the other two direction methods had in the S3D conditions. Differences along the XY-Axis and Fixed-Axis produced significant results in S3D viewing conditions. Changes along the Z-Axis aroused emotions of horror regardless of viewing condition. On the other hand, changes along the XY-Axis and Fixed-Axis directions produced different results depending on viewing condition and gender (Figure 2).

According to the analysis of arousal on the SAM, significant results were seen in relation to the effect of viewing conditions (F(1, 448)=90.75, p < 0.01), and direction methods (F(2, 896) =53.13, p < 0.01). S3D
viewing conditions and Z-Axis direction had significantly higher values than in 2D conditions and using the other two direction methods. The results produced by XY-Axis direction were higher than Fixed-Axis direction regardless of viewing condition and gender (Figure 3).

5. Conclusion

In this study, the authors examined the effects of fear and analyzed the relations between viewing conditions and directing method of S3D effects. The results indicated that for the Z-Axis, complicated factors affect the relationships between valence and arousal values on the one hand and disgust, surprise, and fear on the other.

The characteristics of the S3D space (i.e., that the center was nearer and farther from the viewer with negative and positive parallax, respectively) evoked a sense of horror during change along the Z-Axis. In 2D viewing conditions, manipulation along the Z-Axis affected the sense of horror via monocular disparity. The XY-Axis– and Fixed-Axis–direction methods obtained effects of arousing horror by spatial production when the center and the range of the S3D space were expanded to positive parallax values. It could be problematic to represent the same effects in a 2D space.

Furthermore, since the varied Fixed-Axis direction presented less effective results than those along the Z-Axis and XY-Axis, the pictures’ movement may be the most important element in the arousal of horror by S3D content. The results of these evaluations indicated that the following three points:

1. S3D viewing conditions were more effective than 2D to arouse a particular emotional state: horror.
2. Direction methods produced different emotional states depending on the center and range of the S3D space.
3. The results of S3D effects, direction methods, and viewing conditions differ depending on the viewer’s gender.

Further study is needed to clarify the complex interactions between various types of depth information and emotions while viewing S3D images.

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References