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Emotional arousal with 3D images and effects on time perception

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Abstract

In this research, the effect on time perception of enhancing the emotional arousal of 2D images is examined experimentally. Images are converted to 3D and, additionally, disparity modification is carried out. The experimental results show that estimates of time are longer when 3D and disparity modified stimuli are presented for longer durations, and the tendency is significant in the case of images classified as evoking high arousal.

1. Background

Recently there have been attempts made by stereoscopic (3D) image creators to systematize and share their creation techniques [1-2], as well as attempts by researchers to analyze the binocular disparity in 3D images [3]. The authors have continued analyzing the disparity of 3D images from the point of view of emotional expression and binocular disparity. Specifically, prominent 3D movies were analyzed for disparity and the parallactic angle of emotional scenes was extracted. Then the change in parallactic angle over time in each scene was analyzed, taking as indexes the center of the represented 3D image space and its range. From the results, trends in parallactic angle variation associated with basic emotions such as happiness, surprise, sadness, and fear were found [4].

The authors define this characteristic change in parallactic angle as "disparity modification" and focus on it as a unique technique for expressing emotions in 3D images. Figure 1 shows the basic patterns of disparity modification.

The authors have also examined the psychological effects of adding binocular disparity to 2D images (2D to 3D conversion) intended to evoke specific emotions (emotional images), comparing the results with and without disparity modification applied.

In this paper, the investigations by the authors to date are summarized in section 2, while section 3 introduces a study on time perception related to emotional arousal. The present experiment on the effect of disparity modification on time perception is described from section 4 onwards.

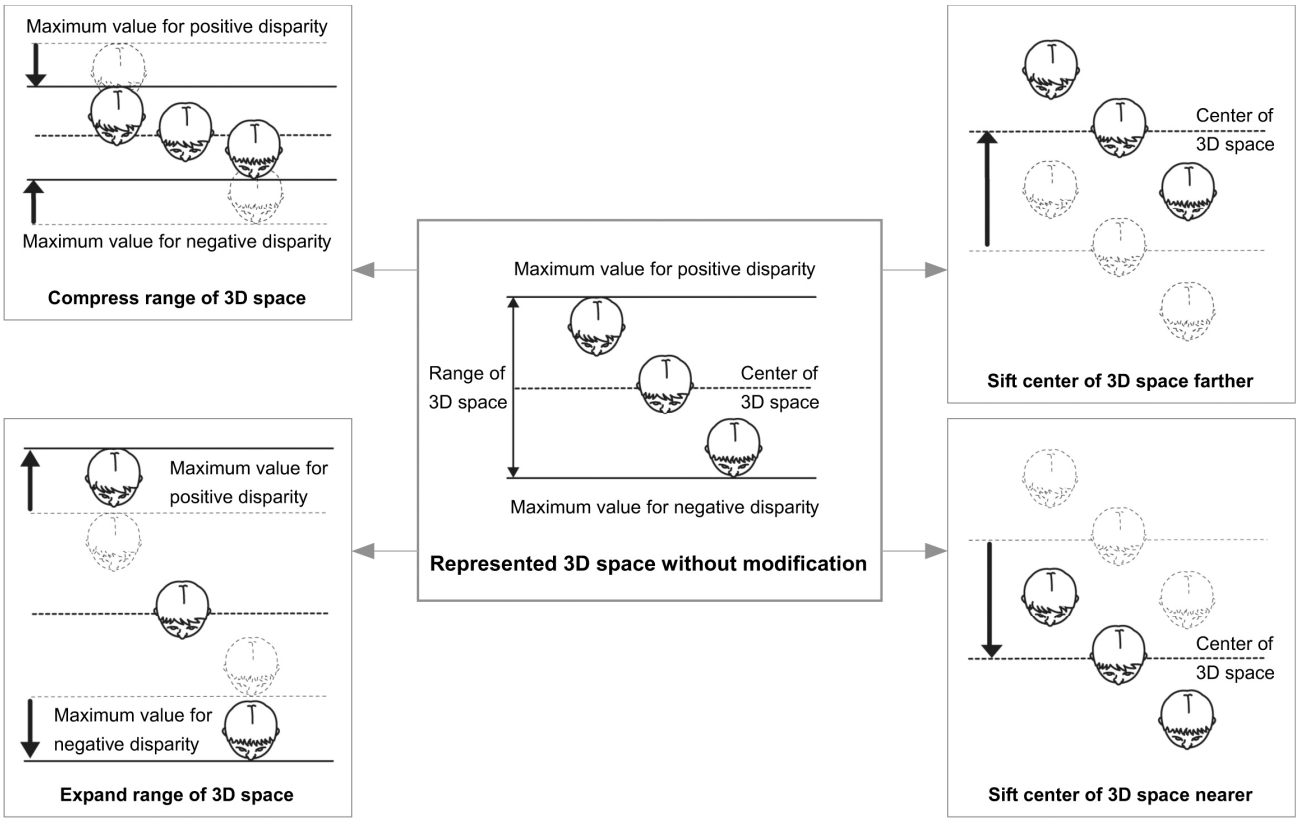

Figure 1. Basic patterns of disparity modification

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2. Disparity Modification and Emotional Arousal [5]

The authors carried out an experimental investigation to examine the psychological effects of images to which the results of the disparity analysis are applied as coefficients of disparity modification. The coefficients act as magnification ratios for the maximum value of crossed and uncrossed disparity in the 3D space. Figure 2 shows the concept of applying disparity modification to the depth map of a 2D to 3D conversion.

The International Affective Picture System (IAPS) [6], a large scale set of images with normative emotional ratings, was selected as the experimental stimuli. Each IAPS image was evaluated in two dimensions for pleasure and arousal, and the values were compared with Russell's circumplex model of emotion [7]. A total of 12 images were selected, three each of images considered to evoke a basic emotion from happiness, surprise, sadness and fear. The IAPS is a set of 2D images, so 3D stimuli were prepared by performing 2D to 3D conversion of the 12 images. Modified 3D (M3D) stimuli were then prepared by applying disparity modification to the converted images. Using these stimuli, a comparison was carried out for pleasure and arousal.

Figure 2. Concept of applying disparity modification

2D image (left), depth map based on monocular cues (center), magnified depth map (right)

Participants in the experiment were 20 university students having normal binocular vision. The purpose and methodology of the experiment were explained in advance and all participants gave their consent. A 24-inch 3D display and polarized filter glasses were used to present the stimuli. The stimuli were presented to participants at random for five seconds each, with 10 seconds between for responses. After each stimulus, pleasure and arousal were evaluated using the Self-Assessment Manikin (SAM) [8]. In the experiment, one trial consists of a presentation of one image and an answer to the SAM. A total of 36 trials constituted 1 set (12 images * 3 stimulus types), and 3 sets were carried out for each participant.

A two-way analysis of variance (ANOVA) test against the factors type of emotion and stimulus condition (2D, 3D, or M3D), a significant variance was found for the main effect of the pleasure emotion (Figure 3). On the other hand, for arousal, a significant variance was found for both main effects (Figure 4). In the case of arousal, it was found that the evaluations tended to increase in the order 2D, 3D, and M3D. This suggests a possibility that disparity modification affects emotional arousal.

The authors then carried out an additional experiment and found that the range of 3D space affected by disparity modification is important in evoking emotional arousal, and the effect varies depending on the magnification ratio [9].

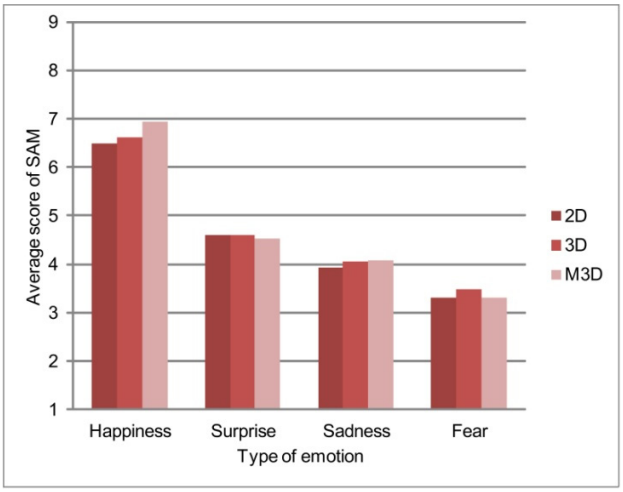

Figure 3. Average values for pleasure

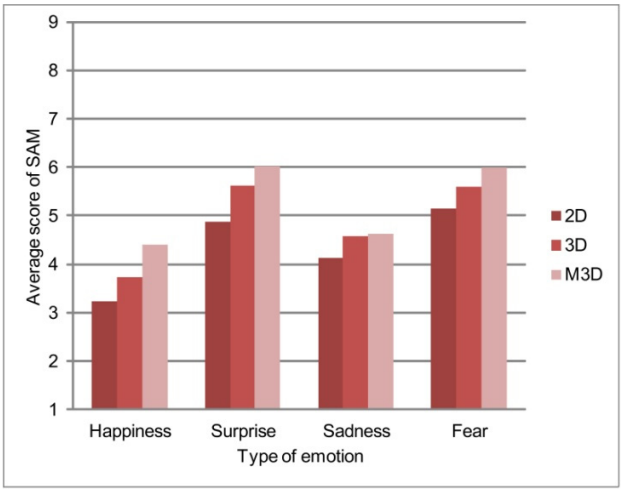

Figure 4. Average values for arousal

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3. Emotional Arousal and Time Perception

The findings reported above point to a technique that creators might use to increase emotional arousal using 2D to 3D conversion and disparity modification. On the other hand, recent research on emotion and cognition has drawn attention to the effects of arousal on time perception. For example, Gil and Droit-Volet have reported an arousal-based lengthening effect on the perception of the duration for which emotional images are presented [10]. Specifically, a tendency was found for the level of arousal to affect the verbally expressed estimated duration of a stimulus in experiments using IAPS. If such effects could be enhanced by the presentation of 3D images, innovative applications can be expected.

Against this background, the authors have carried an experiment to examine the basic characteristics of time perception when normative emotional images are converted from 2D to 3D and disparity modification is applied.

4. Methods

4.1 Participant

The participants consisted of a total of 20 male and female university students whose binocular vision was confirmed by the Stereo Fry Test. The purpose and methodology of the experiment were explained to participants in advance, and all gave their consent.

4.2 Equipment

The experiment was carried out with each participant individually in a dark room. The stimuli were presented using a 27-inch polarizing filter 3D display (D2743, LG) with appropriate glasses. The viewing distance was three times the height (3H) of the display, and a chin support was used for viewing.

4.3 Stimuli and Conditions

Six images were extracted from IAPS (No. 2091, 2810, 6313, 6510, 7004 and 7009) as the 2D stimuli and the level of arousal each evoked was measured by the participants using SAM. From the results of cluster analysis, each three images were classified into two arousal levels (high and low).

Next, 3D stimuli were prepared by 2D to 3D conversion based on the monocular cues in the 2D images. The modified 3D (M3D) stimuli were then prepared by applying disparity modification to the converted images based on the authors' previous work [9]. Table 1 shows the maximum values of positive and negative (or nearest) disparity (parallactic angle; degrees) for each of the 3D and M3D images.

These images were presented for four different durations (600, 1000, 1400, 1800 ms) and participants responded with their estimates of the duration using a numeric keypad. This type of verbal estimation task is commonly used in time studies [10]. One experimental set consisted of 72 trials (6 images * 3 stimulus types * 4 durations). Each participant performed five experimental sets with two minutes rest in between sets.

Table 1. Maximum values of positive and negative disparity

Arousal level evoked	IAPS No.	3D		M3D	
		Positive max	Negative max	Positive max	Negative max
High-arousal	2810	0.38	0.09	0.71	-0.04
	6313	0.51	0.19	0.91	0.09
	6510	0.36	-0.04	0.73	-0.28
Low-arousal	2091	0.44	0.00	0.91	-0.21
	7004	0.35	0.21	0.59	0.21
	7009	0.38	0.15	0.69	0.06

5. Results

The results of the verbal estimation task showed that estimated durations were longer with the high-arousal 3D and M3D stimuli when the presentation time was longer. With the 1400 ms presentation time, a significant difference between the M3D stimulus and the 2D stimulus was revealed ($p<.05$). In the case of low-arousal images, no difference was found among the 2D, 3D and M3D stimuli (Figure 5-6).

Comparing the high- and low-arousal images, significantly longer estimates were made with 1000 ms ($p<.01$) and 1400 ms ($p<.05$) presentation times for the M3D stimuli. In the case of 2D and 3D stimuli, no significance was found between the high- and low-arousal images (Figure 7-9).

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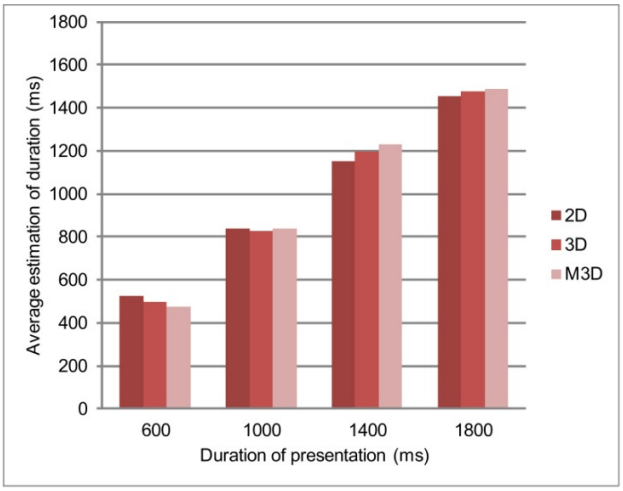

Figure 5. Average estimation for high-arousal images

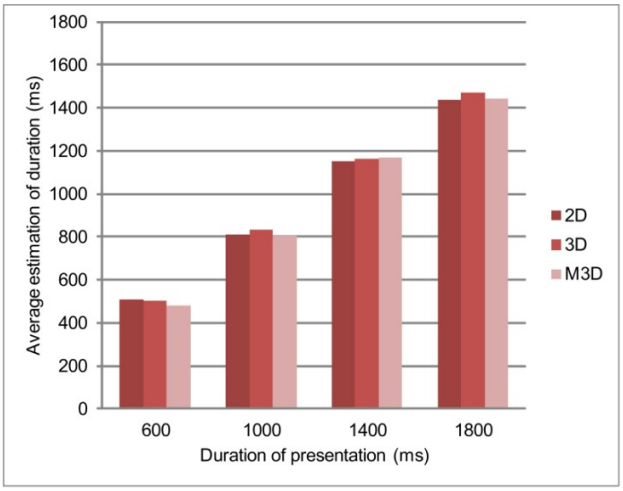

Figure 6. Average estimation for low-arousal images

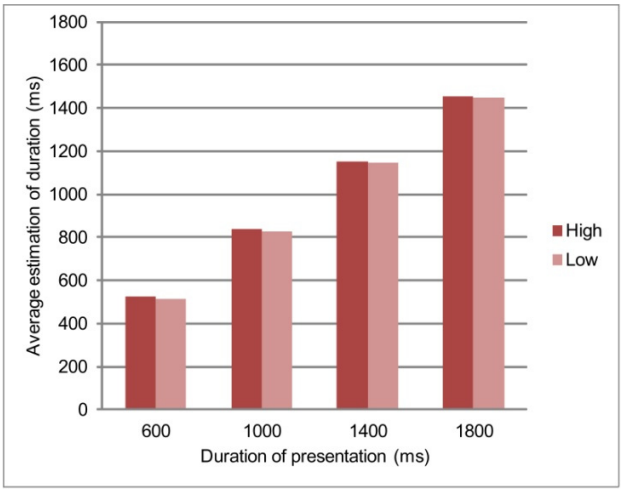

Figure 7. Average estimation for 2D stimuli

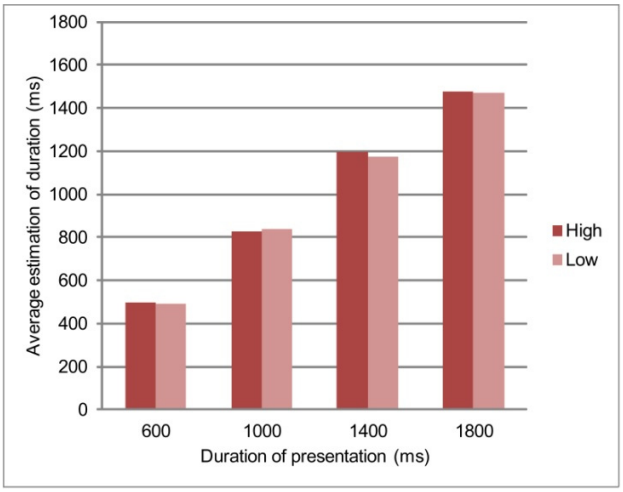

Figure 8. Average estimation for 3D stimuli

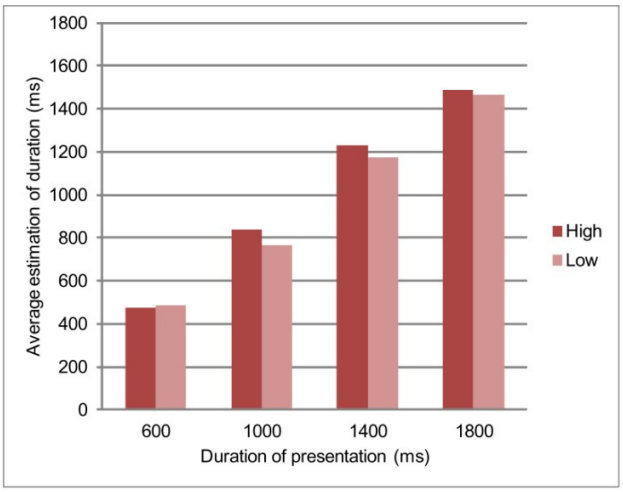

Figure 9. Average estimation for M3D stimuli

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6. Discussion

This research examines the effect on time perception of emotional arousal resulting from enhancing 2D emotional image stimuli through 3D conversion and, additionally, disparity modification. Experiments show that participants tend to give longer estimates of presentation time when 3D and disparity modified stimuli are presented for longer durations. This tendency is particularly significant for images categorized as high arousal. While supporting previous findings, these results also show that the effect is more notable with M3D stimuli, which have previously been shown to increase arousal level.

On the other hand, Gil and Droit-Volet have reported the arousal-based lengthening effect occurred for shorter durations (< 1000 ms) [10]. In this regard, there is a possibility that the greater significance of this tendency when duration of presentation is longer might be related to binocular fusion time for larger disparities with M3D stimuli. However, further examinations are required considering the other factors, such as the type of discrete emotions.

7. Conclusion

In this research, the authors obtained basic findings on emotional arousal with 3D images and effects on time perception. Based on these findings, the authors intend to examine the possibility that other conditions, such as the use of higher definition or a larger screen size, might result in higher arousal in order to further understand the characteristics of interaction between emotional enhancement of 3D images and time perception. In addition, the authors are also considering what kind of content and interface can effectively make use of the increased emotional arousal.

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