Effects of Dynamic Digital Art with Audio-visual Emotional Congruence on Relieving Stress

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ABSTRACT

The fast-paced life of contemporary society increases people's psychological stress, and a piece of creative digital art may help relieve the stress. The interactivity and dynamics of digital art bring different experiences to us. This article sought to determine if the dynamic digital art image transfer process with different music would influence the stress state. The stimuli were the 4 pieces of congruent audio-visual material to test which type of video has a stress-relieving effect. 100 participants were invited and divided into 5 groups for the experiment. The Trier Social Stress Test experiment was used to stimulate the stress state of the participants, and then 4 groups were shown videos of four emotional types: joy, anger, sadness and fear. The fifth group was the control group. The changes in stress state before and after the test were measured by the State-Trait Anxiety Inventory Questionnaire. The study found that happy and sad videos were more effective in relieving stress. The insights from this work could provide input to the design of digital art in emotion intervention and stress management.

CCS CONCEPTS

• **Applied Computing**; • **Arts and Humanities**; • **Media Arts**;

KEYWORDS

Dynamic Digital Art, Music, Emotional Congruence, Interactivity, Stress

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1 INTRODUCTION

The sudden outbreak of "COVID-19" novel coronavirus pneumonia not only threatened people's physical health but also affected people's mental health. Research showed stress is part of everyday life (at home, at work, in personal relations), as well as a psychological condition that is part of a crisis (trauma, wartime, illness, etc.) [1]. In psychology and biology, the term "stress" is applied to describe a response or reaction to an external event or interference that disturbs and jeopardizes the functioning of an organism. People used tranquillizing medications to cope with stress, which had many negative contraindications and side effects [2]. Therefore, many researchers examined the effects of non-pharmacological therapeutic interventions on the prevention and management of stress [3].

While humans are born with creativity in their most active minds, art can nourish the spirit of humans by its abundant spiritual nourishment in return, which enriches the human experience [4]. The wide variety of art does not only give various inspiring philosophies but also gives people leisure and satisfaction. Art therapy [5] has become a communication bridge between art and the psychology field, which can help people to deal with stress and anxiety. In a broad sense, art therapy refers to a treatment method that includes all kinds of art forms, including painting, dance, music, etc. It regulates the stress and anxiety of life through various art activities [6].

The phenomenon of judging the emotional state of oneself and others by integrating multi-channel emotional information is called multi-sensory integration (MSI) [7]. This phenomenon is also common in daily life and is an important topic of emotional research. When the emotional information between channels is incongruent, it will interfere with individual emotional processing, that is, emotional conflict effect [8]. When the emotional information from different sensory channels is congruent, the efficiency of emotional processing can be improved, and the individual emotional response can be faster, more accurate and stronger. That is the advantage of multi-channel integration, also known as the mood-congruity effect [9] (i.e., emotional congruence effect). The work presented in this article was to combine audio and visual channels in digital art as stimuli to see which kind of emotion video could have the effects of stress on people.

2 RELATED WORK

People's visual perception pays attention to the changes in colors and graphics. The dots, lines and surfaces consist of the pictures, the differences between geometric graphics, the colors, the size of space, and the textures. These factors, whether alone or in combination, will produce different psychological effects of visual feedback and have a guiding role in positive emotions. In paintings, the color gives people the most direct and effective intuitive feelings. The effect of color on emotional perception has been found in internet web page design [10] and physical space [11]. Space, where its dominant color was red, would be more possibly described as "stimulus induction", which was identical to Birren's viewpoint [12].

Music is an abstract symbolic language with no specific references or associations. Nevertheless, its intrinsic pattern and structure convey meaning to our brain [13]. It can act as a powerful sensory stimulus, engaging the brain in retraining neural and behavioral functions that can be applied to non-musical contexts in everyday life. Music played in shopping establishments affects customer behavior, improves spatial abilities, increases mood and arousal levels, engenders a compliant attitude towards any message mediated by music, influences pacing and timing of movement [14] and conveys emotional meaning.

In comparison with traditional art, the strength of digital art is apparent. The emergence of dynamic media, e.g., animation, audio, video etc., has broken the monotonous traditional painting art, further enriched the visual sensation, and increased interactivity and entertainment. In our work, we combined music and the abstract image transfer process as video stimuli. There were videos of 4 types of emotional congruence. We would like to see which emotion could relieve stress.

3 STUDY DESIGN

3.1 Experiment Design

3.1.1 Participants. We recruited 100 participants from Zhejiang University for the experiments, aged between 19 and 24 years old, with an equal number of male and female participants to avoid gender bias. They were at the education level of college or above and with computer literacy. All participants reported good vision and hearing abilities and could react corresponding emotions to different types of videos.

3.1.2 Experiment Design. In this experiment, videos featuring 4 types of emotions were used as independent variables. The level of stress was the dependent variable to explore the relationship between the emotional congruence of dual-channel audio-visual integration and stress relief. The emotional types of the videos were joy, anger, sadness, and fear. We used the Trier Social Stress Test (TSST) [15] to induce stress in participants. The changes of stress before and after watching the videos were examined. The participants were divided into 5 groups in this experiment: Joy Group, Anger Group, Sadness Group, Fear Group and Control Group. The Control Group measures the change in pressure when not disturbed by conditions other than the time.

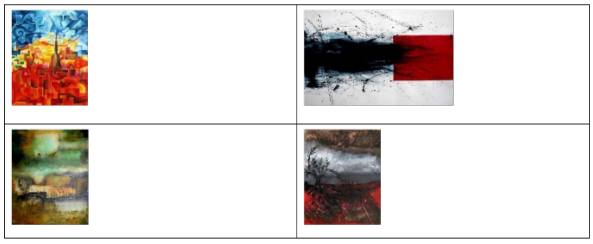

Figure 1: Abstract images with 4 types of emotions.

3.2 Stimuli

3.2.1 Music stimuli. We chose 4 pieces of music which could evoke the 4 types of emotions (see Table 1) respectively and produced a 1-minute clip for each piece of music. Before the formal experiment, 15 participants were randomly selected to evaluate the edited 1-minute clips. The subjective self-rating questionnaire scaled four emotions, namely joy, anger, sadness and fear, with a 6-point score rating. The higher the score, the stronger the feeling of the emotion. The results showed that the mean emotion valence score of each clip was greater than 5.

3.2.2 Picture stimuli. The experiment applied the open data set of abstract artworks established in 2010 by Machajdik [16] and others, including 228 pieces of abstract artworks that contain only color and texture, with no identified objects to evoke emotions without simulating any specific objects. 280 images were rated by approximately 230 people, where each image was rated about 14 times. For each image the category with the most votes were selected as the ground truth. In this article, 4 images were chosen from the data set to represent emotions (joy, anger, sadness and fear). See Table 2 for votes of emotions.

Below were the 4 abstract images, please see Figure 1.

3.2.3 Video stimuli. The production process was captured in 4 clips. The style transfer processes were visually recorded and edited so that each image creation lasted for 1 minute in motion. ALab and SmartPainting were adopted. These 2 software tools were developed by the Engineering Research Center of Computer Aided Product Innovation Design, the Ministry of Education, China. They were used to carry out algorithm techniques to realize image style transfer methods meanwhile showcase the process of image manipulation with brushwork. At the same time, we would add congruent music into the image transfer process. Each clip was 1-minute long.

3.2.4 TSST.. TSST is a validated protocol used to induce stress in a study that has been widely used in psychology research. Experiments were carried out following the 3 main phases of stress described in the original TSST protocol: a relaxation period (20 minutes), stress-inducing tasks (speech and arithmetic), and post-stress recovery. We chose speech as our task to induce stress.

3.2.5 STAI.. Spielberger and colleagues asked participants to self-report their anxiety levels using the State-Trait Anxiety Inventory (STAI) [17] to identify the occurrence of stress in their experiment. In our study, we collected self-report data using by STAI Questionnaire to validate that we were indeed inducing stress on our participants throughout the experiment.

Table 1: 4 pieces of music with 4 types of emotions

Emotion	Joy	Anger	Sadness	Fear
Music	Beautiful Sunday	The Yellow River	Zigeunerweisen	The Planets

Table 2: Ground truth of 4 chosen abstract images

Code	Emotion	Amusement	Anger	Awe	Content	Disgust	Excitement	Fear	Sad
abstract_0020.jpg	Joy	9	1	6	2	0	3	2	1
abstract_0081.jpg	Anger	0	7	0	1	1	1	2	1
abstract_0007.jpg	Sadness	0	0	1	0	5	0	4	9
abstract_0027.jpg	Fear	0	4	2	0	1	2	12	3

3.2.6 Experiment Environment. We experimented at Zhejiang University's lab, with an experimental setup consisting of 2 adjacent rooms. One room was a desensitization room for the participants to rest and relax, while the other was used for the stress-inducing tasks. We welcomed our participants upon arrival in the desensitization room.

3.3 Experiment Procedure

3.3.1 Participants. The participants were divided evenly into 5 groups, 20 people in each group, 10 males and 10 females in each group, one of which was the control group, and the other 4 groups were the experimental groups. Each experimental group took 1 type of music as the experiment material.

3.3.2 Experiment Procedure. The experiment included 4 steps and lasted 35 minutes for each participant. We took 5 days to complete the whole experiment.

Step1: Rest and fill out the STAI Questionnaire. Participants were left alone for 20 minutes to rest and stabilize their emotions. After that, the participants completed the STAI questionnaire to measure their perceived anxiety state.

Step2: Induce stress and fill out STAI Questionnaire. We guided our participants to the experimental room. Participants were given 5 minutes to prepare a 5-minute speech for their dream job. To make them more nervous, they were told their performance was video-recorded and reviewed by judges. And they were then followed by completing the STAI Questionnaire again.

Step3: Watch videos and fill out the STAI Questionnaire. We played the 4 types of videos for the 4 experimental groups and asked the participants to fill out the STAI Questionnaire. The control group did not watch the videos but was asked to fill out the STAI Questionnaire 1 minute after their speech which was recorded.

Step4: Recovery. After the experiment, we performed breathing relaxation training for the participants to eliminate the negative emotions brought about by the experiment.

3.4 Data Analysis

3.4.1 Stress Inducing. We examined participants' self-reported anxiety values as measured by the STAI Questionnaire collected when they completed Step1 and Step2. A one-way repeated measures ANOVA yielded a statistically significant effect of stress on self-reported anxiety values ($p<0.01$). Post-hoc comparisons using the Tukey HSD test (with Bonferroni corrections) indicated that participants were significantly more anxious ($p<0.01$) during the Stress Induction period ($M = 37.08$, $SD = 11.77$) of the experiment compared to the baseline values ($M = 30.71$, $SD = 6.37$). The results showed that the speech test of TSST in the experiment could effectively induce stress in the participants. See Figure 2.

3.4.2 Stress Relieving. The Joy Group and Sadness Group participants reported that they felt significantly less anxious ($p<0.01$) after watching the related videos compared to the Stress Induction period. The Anger Group and Fear Group reported no significant change in stress relief. See Figure 2 for the anxiety mean values.

We selected an equal number of men and women for the Joy Group and Sadness Group to experiment on effective pressure relief. It was analyzed that gender differences existed in anxiety relief with the changes in anxiety values of the selected participants before and after watching the videos. It showed that the Sadness Group had a gender difference in relieving the stress ($p<0.01$), and the effect on women was greater than that on men.

4 DISCUSSION AND FUTURE WORK

4.1 The Effects of Relieving Stress by Videos of Different Emotions

Regardless of appreciating art or creating art, it can bring experiences of happiness and resonance. Although this experience is short, it profoundly touches the soul. So, we use digital art as stimuli to see if it could relieve stress by combining audio and visual channels. That might be a new way to cope with daily stress by exploring psychology and the medical field.

The video of this study was composed of visual and auditory information with congruent emotion, which enhanced the transmission of emotion and made the participants better interact and empathize. Joyful music and image made people feel positive, and this kind of emotion could effectively relieve anxiety. Some studies have shown that concerts with joyful emotions lead to increased dopamine secretion in the body, and dopamine is an essential neurotransmitter in the reward system in the brain [18]. Therefore, they will produce happy emotions, thus alleviating the current anxiety state.

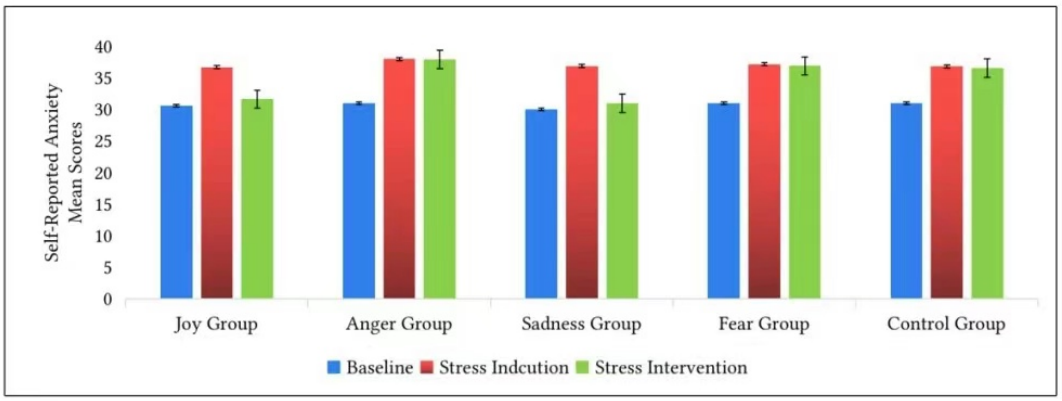

Figure 2: Self-reported Anxiety Mean Scores.

Watching sad emotional videos is generally believed to be more stressful under tense emotional conditions. However, some studies have found that sad emotional videos could induce happiness. When participants were watching sad emotional videos, they would go through a series of complex emotions, including sadness, romance, happiness, and other emotional experiences. Mori and Iwanaga believed that a happy experience induced by listening to sad music might be related to the secretion of prolactin in the individual [19]. Prolactin is a peptide hormone that could trigger feelings of calm and relaxation. So, when an individual was in a sad mood, prolactin might be able to bring a happy experience, which that might be part of the reasons to alleviate the current anxiety state.

Watching videos of fear and anger could not effectively relieve the participants' anxiety. The brain perceives music signals through the auditory pathway. For a familiar piece of music, it will involve the brain's memory system, while for an unknown melody, it will activate the right area of the hippocampus [20]. Music can evoke memories. We could infer that when individuals watch fearful emotion videos, they would recall their memories of personal sadness, resulting in the feeling of sadness, but have no effect on alleviating anxiety.

4.2 The Gender Difference

There was a significant difference between men and women in relieving stress when they were watching the videos of the same emotion, which indicated that the subjective perceptions of men and women in watching videos were dissimilar. Some studies [21] have found that women have more intense and frequent fluctuations in emotion than men have, and even when they have the same sentiment, men and women might have different feelings.

4.3 Limitations and Future work

The current study has some limitations that need to be mentioned. Firstly, we need to recruit more participants of different ages and occupations and add more music and images as stimuli to enlarge the validity and reliability of the experiment. Secondly, future research should focus on the specific characteristics of the interventions on stress reduction, for example, the music tempo, music genre, the use of live music or prerecorded music, music selection, or the frequency of the music intervention sessions. What's more, we should consider make comparative experiment of incongruent emotions of audio-visual information and to see what will happen to impact the anxiety relief. Last but not least, we will add physiological data collection in future research, e.g., skin conductance measurement, HRV, EEG etc., to coordinate with the STAI Questionnaire for comprehensive observation of the anxiety data.

5 CONCLUSION

This study showed that watching videos with congruent emotions of joy and sadness could significantly relieve acute anxiety, and videos with anger and fear emotions have no significant effect. Despite the limitations, this study has important implications for future research and the practical use of interventions in relieving stress. Many people suffer from stress-related symptoms in their daily lives and some settings (e.g., medical settings, mental health care settings, work-related settings). Since digital art interventions are accessible and affordable to be incorporated into daily lives and medical treatments, it is essential to recognize their effects.

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