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Calm Digital Art Installation for Alleviating Sedentary Anxiety: A Case Study

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Abstract. With the prevalence of sedentary behavior in modern office environment, anxiety symptoms among office workers have been on the rise. This study aims to explore a camera-based system for monitoring sedentary behavior in office crowds and a novel device utilizing dynamic digital art to alleviate anxiety. By analyzing captured images from the camera, we can detect and record the sedentary time of office crowds in real-time, effectively identifying potential anxiety symptoms. Subsequently, we design a series of dynamic digital art pieces that stimulate and guide viewers' sensory experiences through variations in colors and forms to alleviate anxiety. Using a co-constructing story approach, we conducted a user study involving 30 participants to stimulate their imaginations and visions. The results indicate that capturing sedentary behavior in office crowds through cameras and combining it with dynamic digital art as a means to alleviate anxiety significantly reduces anxiety levels among office workers. This research provides an innovative solution to improve the mental well-being of office workers, with potential implications for other related fields of study.

Keywords. Anxiety, dynamic digital art, calm technology, sedentary

1. Introduction

In modern society, sedentary behavior (SB) is becoming increasingly common among office workers. This sedentary behavior is associated with many health issues, including obesity, cardiovascular disease, and musculoskeletal disorders [1]. In addition, recent studies have shown a significant increase in anxiety symptoms among office workers. The characteristic of anxiety is persistent unease, worry, and fear, which can have a profound impact on a person's mental health and overall happiness [2]. Long sitting behavior has been found to lead to the development and deterioration of anxiety symptoms, which may lead to a decrease in productivity, an increase in absenteeism, and a decrease in the quality of life of affected individuals [3]. Understanding the factors that contribute to the prevalence of sedentary behavior and

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increased anxiety symptoms among office workers is crucial for developing effective intervention strategies and promoting healthy workplace practices.

Visual therapy is a non-pharmacological method that utilizes various visual stimuli to evoke positive emotions and promote relaxation. This therapy aims to divert attention from anxious thoughts and produce a calming effect. Some studies have demonstrated the effectiveness of visual therapy as a complementary method in reducing anxiety levels in patients with anxiety disorders [4]. Fractals are complex geometric patterns that exhibit similarity and are repeated at different scales. These charming patterns can be seen everywhere in nature, such as the formation of snowflakes, shells, and clouds. Research has shown that exposure to fractal patterns can significantly reduce anxiety levels due to their inherent aesthetic and mathematical characteristics [5]. A study found that fractal images reduce stress in the workplace and living environment [6]. In addition, a meta-analysis concluded that visual therapy interventions, including exposure to the natural environment and visual stimuli, consistently showed a reduction in anxiety [7].

This article explores the potential of visual therapy, particularly through the utilization of fractals, in alleviating anxiety and promoting mental well-being. It discusses a unique approach to addressing the issue of prolonged sitting in office workers by utilizing surveillance technology to monitor their sitting time and then sending a signal to a digital art installation that plays dynamic fractal images in order to alleviate anxiety.

2. Related Work

Sedentary behavior has been linked to negative mental health outcomes. To address this issue, interventions like incorporating regular physical activity breaks or exercise into daily routines have been proposed. Physical activity has shown positive effects on mood and can reduce symptoms of depression and anxiety. Another intervention is the use of standing desks or adjustable workstations, allowing individuals to alternate between sitting and standing positions [8](Garland et al. 2018). Taking frequent breaks to engage in light physical activity, such as stretching or walking, can also be beneficial [9]. However, these interventions may have limitations such as requiring time and effort or being unavailable or unaffordable in certain settings. Therefore, while interventions targeting sedentary behavior can have potential benefits for mental health, individual circumstances should be considered, and a holistic approach should be implemented.

There are several existing approaches to monitor sedentary behavior in office environment. Activity trackers and smartwatches, which use accelerometers to detect body movement, are commonly used to monitor sedentary behavior in office environment [10]. Pressure sensing mats or chairs are equipped with sensors that detect pressure changes when someone sits or stands up. By analyzing these pressure patterns, sedentary behavior can be monitored and tracked [11]. Some studies have also explored the use of computer-based systems that track mouse and keyboard activity, as well as the duration and frequency of computer use [12]. A few studies have utilized video-based monitoring techniques to assess sedentary behavior. These methods involve using cameras to record office activities and then manually analyzing the footage to determine levels of sedentary behavior [13]. These approaches have been used to gain

insights into sedentary behavior in office environment, further research is needed to develop more accurate and user-friendly monitoring methods.

In the workplace, public surveillance systems that incorporate the ability to recognize sedentary office workers can be enhanced with Calm technology [14] to make the system unobtrusive and seamless. This innovative approach focuses on using technology in a subtle and non-intrusive manner, aiming to improve the overall well-being of employees. The use of Calm technology in public surveillance systems helps to prioritize employee health and wellness without creating a sense of constant monitoring or intrusion. Art offers a visually appealing and immersive experience that helps individuals relax and alleviate stress [15]. The use of vibrant colors and mesmerizing visuals in digital art has been shown to have a calming effect on the mind. It allows employees to maintain their focus and productivity while providing valuable feedback on their sedentary behavior.

3. Design Concept

The concept presented in this article involves utilizing surveillance technology in public areas to monitor the sitting time of office workers. Once the system detects that an individual has been sitting for more than an hour, it sends a signal to a digital art installation. When people observe fractal images, they will feel a charming beauty and harmonious geometric structure. This installation called "ArtZen" combines digital photo frames with dynamic fractal images to create a peaceful and relaxed atmosphere. Its purpose is to help users alleviate anxiety, achieve inner peace, and achieve a state of physical and mental balance by contemplating these fractal forms.

As shown in **Figure 1**, human behavior recognition based on video analysis mainly uses cameras to obtain motion images, and identifies different behaviors through four steps: image preprocessing, foreground target extraction, feature parameter selection, and behavior posture classification. Human behavior recognition based on video analysis has been a research hotspot in recent years, and this method has higher recognition accuracy. Therefore, this article chooses video analysis method to identify sedentary office populations.

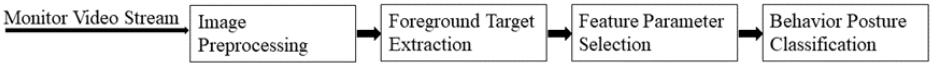

Figure 1. Behavior Recognition Algorithm Steps.

The system designed in this article (as shown in **Figure 2**) mainly alleviates the anxiety caused by office workers' prolonged sitting. When office workers experience prolonged sitting for more than an hour or more, the system will make a timely judgment and transmit the signal to the intelligent photo frame. The overall workflow is to obtain video image information through surveillance cameras in the public area of the office, transmit the video image information to the backend through the network, and the backend server uses video analysis algorithms to identify the behavior and posture of office workers. Then, based on the information of sedentary hours, the

sedentary level is divided. When the sedentary time exceeds the normal value, the signal is transmitted to the intelligent photo frame, which plays the corresponding dynamic digital art in real-time based on the sedentary level, allowing sedentary personnel to receive corresponding anxiety relief.

Fractal animation combines graphic design and digital media art, resulting in more flexible and diverse visual effects that provide a full and rich visual experience. The dynamic rhythm of fractal animation makes it easier to create psychological suggestions for viewers, prompting them to follow the rhythm of the changing graphics and engage in deep breathing exercises. This helps viewers emerge from negative emotions and focus on the present moment, leading to a calm and relaxed state of mind. To create fractal animations, the software Chaotica Lite 2 is used. In order to achieve a soothing mood, the graphics are set to change slowly and at a constant speed, with smooth color transitions. The rotation angles of each keyframe coordinate do not exceed 180°, and the scaling factor does not exceed 0.5. In the palette, the number of colors is adjusted to 3, with adjustments made to the brightness, saturation, and highlight luminosity of each color. Colors with lower brightness and saturation are chosen, and the highlight luminosity is reduced. Finally, the animation is previewed and rendered.

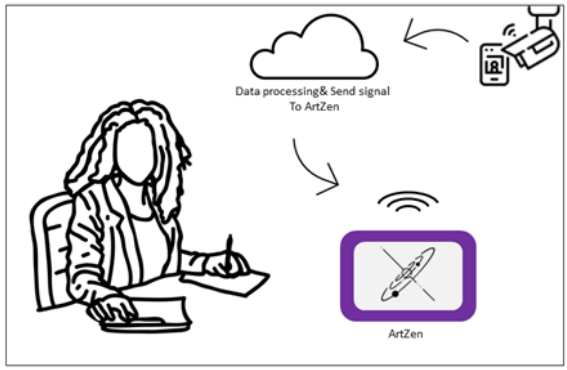

Figure 2. Design Concept of ArtZen.

4. Methodology

The co-constructing story [16] is a participatory design technique to elicit users' in-depth feedback and suggestions about the design concept. ArtZen is a system which aims to alleviate users by means of dynamic digital fractal image. In this study, ArtZen was presented as a probe to evoke users' contextualized visions based on their experiences. We have created a storyboard that presents ArtZen as an open design concept, rather than a completed prototype, to stimulate users' imagination and vision.

4.1. Participants

30 work staff (mean age = 40.23± 6.04, 58% females) were recruited as participants from China. Eligible participants were recruited if they met the following inclusion

criteria: office-based workers ≥21 years old, working day ≥4 days per week, not physically disabled or handicapped, and not pregnant. Screen-based sedentary time, which was self-reported. Anxiety symptom was evaluated using the Self-Rating Anxiety Scale (SAS). The participants were asked to voluntarily participate in the study, and their informed consent was obtained prior to their involvement. The study protocol and the data collection procedure were approved by the relevant ethical committee.

4.2. Co-constructing Stories

Sensitization Phase. "Samantha, an administrative staff member at a food company, is responsible for handling administrative tasks for a company of hundreds of people on a daily basis. Due to her prolonged sedentary work and constant exposure to computer screens, she has experienced some negative health symptoms such as obesity and anxiety. In an effort to overcome this situation, she has attempted to change her work routine and incorporate some physical activities after work. However, she has found it difficult to maintain consistency, resulting in unsatisfactory outcomes."

Figure 3. Sensation Phase.

In the sensitization phase, we started with a fictional story through sketch(see **Figure 3)** to introduce a couple of scenarios in order to evoke participant's past experiences. As a result of this dialogue, stories revealing past experiences were elicited that enriched our understanding of the current context of sedentary anxiety. After that, the participants filled out the Self-Rating Anxiety Scale.

Elaboration Phase. In the elaboration phase, we introduced ArtZen in a visioned context and illustrated the concept. Then we explained how the ArtZen system worked. Then we will play the recorded dynamic fractal image for 1 minute to test the efficacy of the ArtZen by iPad, which is similar size of the digital photo frame. The participants were asked to fill out the Self-Rating Anxiety Scale again. At last, we asked the participants to illustrate suggestions about the ArtZen design to elicit their positive and negative feedback. The whole session lasted about forty minutes and was audio recorded.

We transcribed the interview recordings that covered the whole storytelling session. In total, there were 415-minute of data from all the participants. We conducted the thematic analysis method to identify user's contexts, expectations, as well as attitudes on the usage of visualization design. Using Statistical Package for the Social Science (SPSS) 28.0, descriptive analyses were conducted on individual-level data including frequencies and medians (IQR) to describe SB among the sample participants.

5. Results

5.1. Sociodemographic Data

Table 1 presents the sociodemographic characteristics of the sampled participants: mean age was 40.23 ± 6.04 years, with 42% males and 58% females. Marital status was 33% single, 60% married, and 7% divorced. Waist circumference mean ± SD was 91.2 ± 10.3 cm for males and 77.9 ± 11.1 cm for females. Education level was < university degree for 10% and ≥ university degree for 90%.

Table 1. Sociodemographic of sampled participants.

	n(%)
Mean ± SD age in years	40.23 ± 6.04
Gender	
Male	13(42)
Female	17(58)
Marital Status	
Single	10(33)
Married	18(60)
Divorced	2(7)
Waist Circumference mean ± SD in cm:	
Male	91.2 ± 10.3
Female	77.9 ± 11.1
Highest education	
< University degree	3(10)
≥ University degree	27(90)

The typical work week consisted of five working days for about 9.5(0.5) hours per day. Median sitting time at work was 419(170) minutes with 21 participants (70 %) reporting ≥360 min of occupational sitting time. The majority of participants (n = 17, 57.5 %) reported only taking 0-1 breaks per hour. Self-reported SB at work accounted for 51.0 % of all SB on a typical workday **(Table 2)**. By domains, work-related SB was highest on workdays while leisure-related SB is highest on non- workdays.

Table 2. Self-reported sedentary behavior(SB) of sampled participants (n=30).

	Workdays		**Non-workdays**		**p-value**
Minutes of SB by domains	**Median(IQR)**	**%**	**Median(IQR)**	**%**	
Work	419.0(170.0)	51.0	-	-	-
Transport	73.5(61.0)	10.3	59.5(89.0)	11.0	0.47
Total leisure	325.0(310.0)	38.7	585.5(354.0)	89.0	<0.01*
Minutes of total SB	870.0(342.8)	100	650(365.0)	100	<0.01*

Upon analyzing the collected data of SB time and SAS, it was found that there is no significant correlation between sedentary time and anxiety levels. This suggests that having a longer sedentary time does not necessarily imply a more pronounced state of anxiety.

5.2. Effectiveness of Dynamic Digital Art Installations in Alleviating Anxiety

The 30 participants were divided into three groups, namely Group A with 3 participants who scored less than 50 and were not anxious, Group B with 15 participants who scored between 50 and 59 and had mild anxiety, and Group C with 2 participants who scored more than 60 had moderate anxiety. To facilitate statistical analysis and obtain macro-level conclusions, the scores were averaged within each group. The mean standardized score for Group A was 45.7, for Group B it was 54.38, and for Group C it was 64.67. After the experiment, the mean standardized score for Group A decreased to 44, for Group B it decreased to 47, and for Group C it decreased to 55.83. The record table is shown below **(Table 3)**.

Table 3. Mean standard score of pre- and post- experiment of participants.

Group	**Mean pre-standardized score**	**Mean post-standardized score**
Group A	45.7	44
Group B	54.38	47
Group C	64.67	55.83

A paired t-test was conducted to compare the average standardized scores before and after the experiment. The results showed that the average score before the experiment was 45.7 and after the experiment, it decreased to 44. The p-value was 0.432. Since the p-value is greater than the significance level (0.05), we fail to reject the null hypothesis, indicating that there is no significant difference in the average scores before and after the experiment in Group A. For Group B, the p-value was 0.013. For Group C, The p-value was 0.017. There is a significant difference in the average scores before and after the experiment in Group B and Group C. There are significant differences were observed in the average scores before and after the experiment in both Group B and Group C.

The results indicated that ArtZen had a moderate alleviating effect on sedentary individuals with mild and moderate anxiety. However, it demonstrated no significant effect on individuals without anxiety symptoms.

6. Discussion

Consistent with other investigations [17] when data from both contexts were merged and analysed together, sedentary time was associated with greater odds of frequent anxiety symptoms. The relationship between sedentary behavior and anxiety is complex and context-dependent. While leisure-time sedentary behavior has been linked to an increased risk of anxiety [18], the relationship between sedentary behavior at work and anxiety is influenced by various factors. Office-based jobs that require prolonged sitting do not necessarily lead to anxiety, as individuals may have a greater sense of control and autonomy, resulting in higher job satisfaction and a sense of accomplishment. One participant shared, "I make sure to incorporate regular exercise into my routine, even if I have to sit for long hours at work. It really helps me keep my anxiety in check." It is important to consider individual differences in how sedentary behavior at work affects anxiety levels. Further research is needed to better understand these mechanisms and develop strategies to mitigate potential negative effects on mental well-being.

Visual cure has been recognized for its beneficial impact on alleviating anxiety [19]. The incorporation of abstract art into this design approach has shown to be particularly effective in promoting emotional care and soul relaxation. One participant in the study remarked, "The integration of abstract art has opened up a whole new world of tranquility for me. It truly helps in alleviating my anxiety and provides a much-needed escape from life's challenges". These findings align with the broader literature on the therapeutic effects of art in anxiety management [20]. Attention Restoration Theory (ART) proposes that exposure to natural environment, including fractal patterns, can restore attentional resources, reduce mental fatigue, and alleviate stress and anxiety [21]. By leveraging the principles of visual stimulation and emotional resonance, abstract art brings about a profound impact on the well-being of individuals seeking relief from anxiety.

ArtZen's integration of calm technology principles sets it apart as an innovative and user-friendly device. Through non-intrusive posture recognition and the display of calming fractal animations, it enhances the work environment, promoting relaxation and ultimately improving the overall productivity and well-being of office workers. One of its standout features is its unobtrusive design, as it does not rely on sensors attached to the user's body. Instead, it leverages the existing office area security

monitoring system to detect and recognize the posture and sedentary behavior of employees. Another notable feature of ArtZen is its implementation of dynamic fractal animation displayed on an digital photo frame. These mesmerizing animations are carefully designed to alleviate anxiety and promote a sense of calmness. They create a soothing visual environment, relieving work-related stress and fostering a more relaxed atmosphere in the office. With its emphasis on unobtrusiveness and calm technology principles, ArtZen discreetly assists users in improving their work habits and well-being. By reminding them to maintain proper posture and take regular breaks, it encourages healthier work practices while also creating a visually pleasant and stress-relieving ambiance.

The small sample size used in user research may limit the generalizability of the findings. It is important to involve a more diverse range of participants to gain a comprehensive understanding of user experience. This study heavily relies on assumed scenarios and participants' perceptions and preferences rather than real-world implementation. The lack of testing and evaluation in real-world settings may lead to unexpected challenges or limitations not discovered in the study. Conducting actual experiments to verify the functionality and effectiveness of the system is crucial. Additionally, this study does not consider the long-term impact or changes in user behavior over time. Further research or longitudinal studies are necessary to assess the sustained impact and effectiveness of the system. Addressing these limitations will strengthen the research findings and improve the system design. Future research should aim to overcome these limitations and explore the feasibility, scalability, and user satisfaction of the system in real-world settings.

7. Conclusion

In conclusion, this study introduces a camera-based system for monitoring sedentary behavior in office crowds and a novel device utilizing dynamic digital art to alleviate anxiety among office workers. By analyzing captured images, sedentary behavior can be detected and recorded in real-time, enabling the identification of potential anxiety symptoms. The incorporation of dynamic fractal animation, guided by calm technology principles, stimulates sensory experiences and promotes relaxation. However, it is important to acknowledge the limitations of this study, such as the small sample size and the need for further research to validate the effectiveness of this approach. Despite these limitations, the findings suggest that this innovative approach, combining sedentary behavior monitoring with dynamic digital art, has the potential to improve the mental well-being of office workers. Further research and application of calm technology principles may lead to broader implications for promoting a more tranquil and stress-free work environment.

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