Affective and Pleasurable Design, Vol. 123, 2024, 46–54
https://doi.org/10.54941/ahfe1004675

Effects of Dual Tasking With Visual Display Terminal Work and Advertisement Presentation on Workers' Interest and Emotions

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ABSTRACT

Advertisements invoke emotions and interests that could degrade or enhance worker concentration. This study focuses on the impact of advertisements on workers' emotions and interests while performing visual display terminal (VDT) tasks. To investigate how these factors affect workers' concentration and task efficiency, we designed a cognitive memory task and placed simulated advertisements on a monitor during task execution. An impression survey of the simulated advertisements was conducted to explore the impact on workers' emotions and interests. The effects on concentration were assessed based on task outcomes, subjective evaluations of concentration, and eye-tracking data. It was found that colors and backgrounds that are highly visible and eye-catching, as well as a mismatch between words, can evoke negative emotions associated with annoyance. Furthermore, negative emotions towards advertisements directly hinder concentration, and if concentration is maintained, the comprehension of advertisements is unlikely.

Keywords: Concentration, Interest, Emotion, Advertisement, Peripheral vision, Gaze

INTRODUCTION

In recent years, the proliferation of visual display terminal (VDT) devices such as computers and mobile phones has led to an increase in VDT-related tasks. To efficiently conduct VDT tasks, immersing oneself and concentrating on the work are crucial factors. However, because many VDT tasks are performed online, concentration can be inadvertently hindered by various factors. A prime example is internet advertisements displayed during tasks. Although the advertising market is rapidly expanding, and advertisements exist as a beneficial medium for providing information and encouraging consumer behavior, they are often considered disruptive and have been socially problematized for unintentionally impeding concentration. Therefore, it is necessary to explore advertisements that can be recognized by workers as

beneficial in maintaining or enhancing their concentration on the task, benefiting both advertisers and workers. For workers, task and advertisement recognition are considered dual tasks, and exceeding the brain's processing capacity with dual tasks can lead to a decline in performance. Furthermore, previous research (Kamata et al., 2021) reported that visual distractions presented in the peripheral vision can decrease concentration on tasks performed using the central vision, suggesting that interest in visual stimuli can affect concentration levels. When considering advertisements as visual stimuli, positive emotions towards advertisements may motivate information processing or enhance task performance if the content is engaging, whereas a lack of interest in advertisements can diminish concentration. Therefore, the emotions and interests evoked by advertisements are believed to be closely related to worker concentration, potentially maintaining or enhancing it. This study focuses on the impact of advertisements displayed during VDT tasks on workers' emotions and interests and investigates how these factors affect workers' concentration and task efficiency. This study makes a significant contribution to the literature because a better understanding of the effect of advertisement during dual tasking is likely to lead to more effective advertising design.

EXPERIMENT ON THE EFFECTS OF ADVERTISEMENTS DURING (VDT) TASKS

Cognitive Memory Task

This task was developed using a serial memory task used in earlier studies (Kamata et al., 2021), (Ohno and Nakamura, 2018) to evaluate the ability to concentrate when a visual disturbance stimulus was shown in the peripheral view. As shown in Figure 1, one of the nine square buttons placed on the monitor was randomly turned on for one second and then turned off. This was repeated seven times. The participants were instructed to memorize the position and order of the lit buttons. This phase is known as the "memory phase." After the buttons were turned on seven times, participants were asked to answer the questions by pressing them according to the memorized sequence. This phase was called the "answer phase." A trial was considered successful when all seven answers matched.

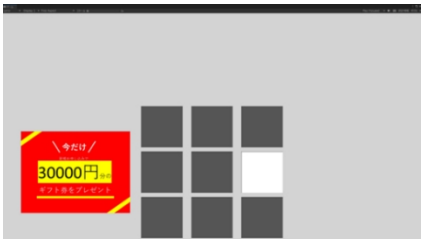

Figure 1: Memory phase (A3).

Experimental Method

This study was approved by the Ethics Committee on Research Involving Human Subjects of Saitama University (R4-E-21). Informed consent was obtained from all the participants.

The experiment was conducted on nine healthy male subjects (22.7 ± 0.5 y old). The experimental setup is shown in Figure 2. An eye-tracking device (Tobii Pro Spectrum) was used to measure the gaze information during the experiment. The participants were seated in a chair at a 0.75 m from the center of the monitor, with their gaze horizontal, and their heads fixed using a chin rest. During this process, simulated advertisements were displayed on

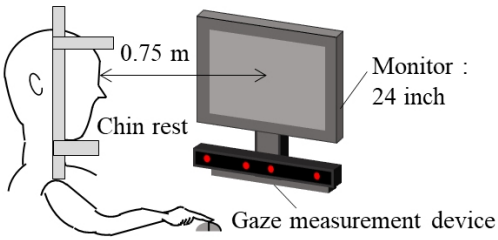

Figure 2: Experimental environment.

Figure 3: Mock advertisements.

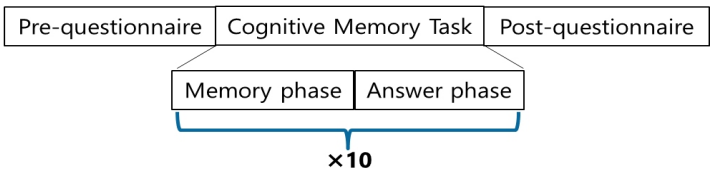

Figure 4: Experiment flow of one condition.

the monitor as external stimuli, as shown in Figure 1. Six simulated advertisements were created based on actual Internet advertisements: three with text precedence (A1, A2, and A3), and three with image precedence (A4, A5, and A6), as shown in Figure 3. The advertisements were randomized to appear at the top, left, or right of the task to prevent habituation. For example, the appearance of the monitor during the memory phase when the A3 simulated advertisement was presented is shown in Figure 1. The experiment was conducted under seven conditions, one without simulated advertisements. The procedure for each trial is shown in Figure 4. Participants were first asked to complete a pre-experiment questionnaire regarding their level of concentration. They then performed a cognitive memory task under one of seven random conditions. This sequence from the memory phase to the answer phase was repeated ten times consecutively. After the task, participants were asked to complete a post-experiment questionnaire regarding their concentration level and impressions of the simulated advertisements during the task. This procedure was repeated for all seven conditions with sufficient time allowed between each condition to conduct the experiment.

VALUATION INDEX

The correct task response rate, response time, and pre- and post-questionnaire scores were used as evaluation indices. In addition, the pupil diameter during the task was measured. The measured pupil diameter data required correction for missing pupil data owing to blinking and altered pupil data before and after blinking. Hershman et al., (2018) proposed that the eyelid signal and fluctuations before and after missing the pupil diameter data can be used to distinguish between the blink range and eyelid signal. Therefore, the blink range was established using this blink detection method., then pupil diameter data in the blink range were extracted and linearly interpolated.

The Z-score was calculated by standardizing the correct task response rate, response time, and evaluation based on the questionnaire results, using the following equation:

$$X(t)_{z-score} = \frac{X(t)_{Raw} - \mu_{All}}{\sigma_{All}} \tag{1}$$

where μ_{All} is the mean of each collaborator, σ_{All} is the standard deviation of each collaborator, and $X(t)_{Raw}$ is the raw data of each collaborator.

RESULTS

Factor analysis was conducted based on the subjects' impressions of the simulated advertisements during the task. Table 1 lists the eigenvalues and contribution rates of each factor. Since the sum of the contribution rates was between 0.7 and 0.9, indicating that the original information could be explained, and eigenvalues greater than 1 were considered effective factors, the number of factors was set to five. Table 2 lists the adjectives with high factor scores for the first factor, and Figure 5 shows a graph of the factor

scores for each simulated advertisement. The first factor was characterized by high scores for "cluttered," "ugly," "oppressive," and "resented," hence it was identified as the nuisance factor. Table 3 lists the adjectives with high factor scores for the second factor, and Figure 6 is a graph of the factor scores for each simulated advertisement. The second factor, with high scores for "plain," "dark," etc., was identified as the negativity factor. Table 4 lists the adjectives with high factor scores for the third factor, and Figure 7 shows a graph of the factor scores for each simulated advertisement. The third factor was characterized by high scores for "felt intrusive," "commonplace," "easy to understand," and "presence was noticeable," indicating that it was perceived as typical advertising and found to be intrusive, hence labeled as the advertising universality factor. Table 5 lists the adjectives with high factor scores for the fourth factor, and Figure 8 shows a graph of the factor scores for each simulated advertisement. The fourth factor, with high scores for "presence was noticeable," "interested," "unique," was identified as the curiosity factor. Table 6 lists the adjectives with high factor scores for the fifth factor, and Figure 9 shows a graph of the factor scores for each simulated advertisement. The fifth factor, characterized by high scores for "light," "bright," "open," was identified as the openness factor.

Figure 10 shows the accuracy of the tasks across all conditions in a box-and-whisker plot. Using the condition without simulated advertisements as a control and conducting Dunnett's test, the average values for conditions A2 and A5 were found to have statistically significant differences at the 5% level. Therefore, concentration was inhibited by simulated advertisements A2 and A5.

Table 1. Eigenvalues and cumulative contribution rates for each factor.

	Eigenvalues	Cumulative contribution rates [%]
First Factor (nuisance)	7.6	32.7
Second Factor (negativity)	4.8	53.2
Third Factor (advertising universality)	2	61.7
Fourth Factor (curiosity)	1.4	67.5
Fifth Factor (openness)	1.1	72.4
Sixth Factor	0.9	76.9
Seventh Factor	0.7	80.1

Table 2. Factor scores for adjectives related to nuisance.

Negative-scoring Adjective	Positive-scoring Adjective	Factor Scores
Orderly	Cluttered	0.824
Ugly	Beautiful	−0.809
Open	Oppressive	0.776
Empathized	Resented	0.709
Kind	Terrifying	0.698
Stable	Unstable	0.695
Dislike	Like	−0.672

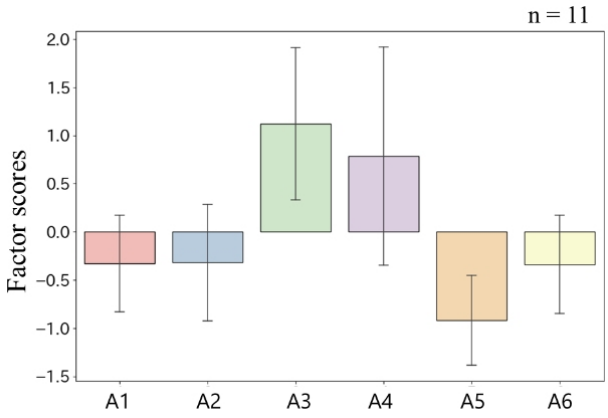

Figure 5: Factor scores for nuisance.

Table 3. Factor scores for adjectives related to negativity.

Negative-scoring Adjective	Positive-scoring Adjective	Factor Scores
Flashy	Plain	0.761
Dark	Bright	−0.738
Fun	Boring	0.714
Interested	Indifferent	0.57
Strong	Weak	0.57
Quiet	Lively	−0.57

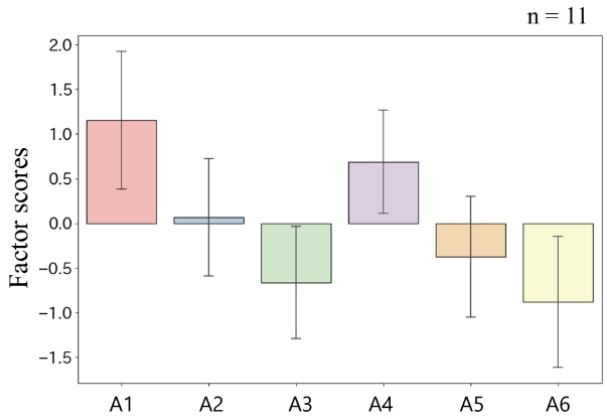

Figure 6: Factor scores for negativity.

Table 4. Factor scores for adjectives related to advertising universality.

Negative-scoring Adjective	Positive-scoring Adjective	Factor Scores
Felt intrusive	Necessary	−0.487
Unique	Commonplace	0.465
Difficult to understand	Easy to understand	0.433
Presence was unnoticeable	Presence was noticeable	0.424

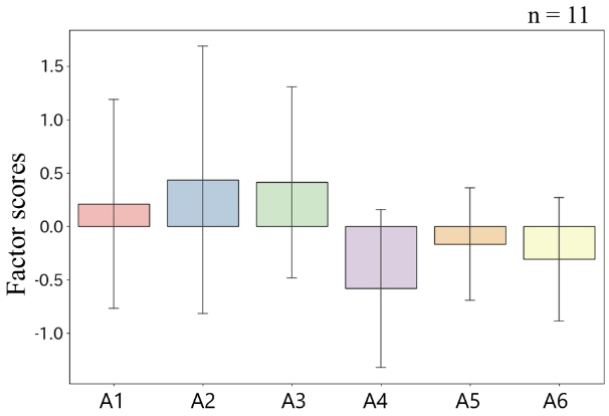

Figure 7: Factor scores for advertising universality.

Table 5. Factor scores for adjectives related to curiosity.

Negative-scoring Adjective	Positive-scoring Adjective	Factor Scores
Presence was unnoticeable	Presence was noticeable	0.49
Interested	Indifferent	−0.457
Unique	Commonplace	−0.371
Dark	Bright	−0.305

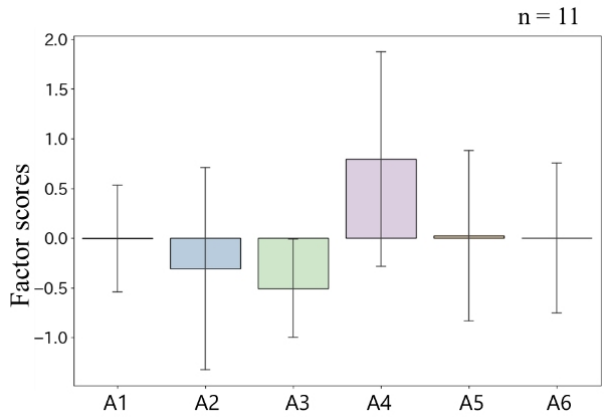

Figure 8: Factor scores for curiosity.

Table 6. Factor scores for adjectives related to openness.

Negative-scoring Adjective	Positive-scoring Adjective	Factor Scores
Light	Heavy	−0.321
Dark	Bright	0.312
Open	Oppressive	−0.266
Empathize	Resent	0.264

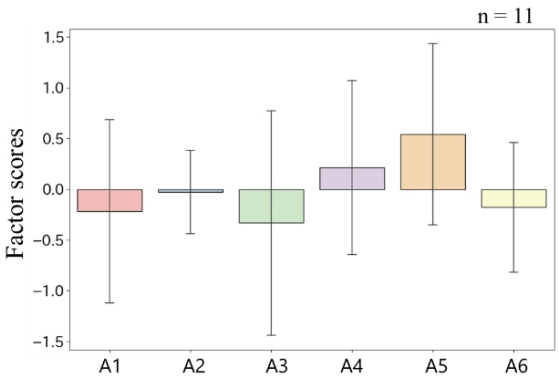

Figure 9: Factor scores for openness.

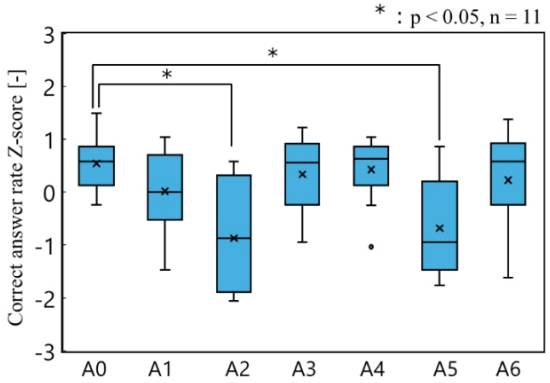

Figure 10: Correct answer rate all conditions.

DISCUSSION

The simulated advertisements impacted the workers' emotions and interests, which then affect concentration. Regarding the nuisance factor, Figure 5 shows that advertisements A3 and A4 scored high on factor 1. Therefore, it can be inferred that colors with high visibility and eye-catching qualities as well as a mismatch between the background and words evoke negative emotions associated with annoyance. For the second factor, Figure 6 indicates that in decreasing order of A1, A2, and A3 for text-predominant advertisements and A4, A5, and A6 for image-predominant advertisements, the negativity factor scores were high. Thus, it appears that the dullness of colors were perceived negatively. Regarding the third factor, advertising universality, Figure 7 shows that the factor scores were high for text-predominant A1, A2, and A3 and low for image-predominant A4, A5, and A6. This suggests that the ease of imagining and high visibility of advertisements led to impressions of being commonplace and intrusive. For the fourth factor, curiosity, Figure 8 shows that A4 had a high score. Mismatches in words and backgrounds in A4's advertisements likely influenced curiosity. Regarding the fifth

factor, the openness factor A5 scored high (Figure 9). Thus, it is believed that the background of A5 conveyed a sense of openness.

Next, we discuss the impact of impressions of simulated advertisements on concentration. Considering Figures 3 and 10, we explored the reason for the decrease in concentration associated with A2. A2, with its high legibility of text and lack of attention-grabbing colors, was recognized as a typical advertisement and deemed annoying. This annoyance, a negative emotion, is believed to have led to a scatter in attention and a subsequent decrease in concentration. Similarly, A5 scored high on the openness factor, giving participants a sense of openness that inadvertently diverted their attention due to the advertisement's background, leading to decreased concentration. On the other hand, advertisement A3, which was found to be the most annoying, did not decrease concentration, which might be because a desire to avoid annoyance prevented a drop in concentration. These results suggest that negative emotions towards advertisements can directly inhibit concentration, or even if concentration is maintained, the comprehension of advertisements is unlikely. Additionally, positive emotions towards advertisements can also lead to a decrease in concentration if too much attention is drawn to them.

CONCLUSION

In this study, we focused on the impact of advertisements displayed VDT tasks on emotions and interests and investigated how these emotions and interests affect workers' concentration. It was found that colors and backgrounds with high visibility and eye-catching qualities, as well as a mismatch between words and backgrounds, evoke negative emotions associated with annoyance. Moreover, negative emotions towards advertisements can directly inhibit concentration, or even if concentration is maintained, the comprehension of advertisements is unlikely. In the future, by incorporating eye-tracking information such as gaze, we plan to analyze the relationship between emotions, concentration levels, and the understanding of advertisements. We will consider the definition of a balance between the understanding of advertisements and concentration levels and explore the conditions for presenting effective advertisements that maintain concentration.

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