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A Study of the Effect of Multi-Page Display on Search Efficiency in VDT Control Systems

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Abstract

To explore a more reasonable way of displaying information on the page of the VDT control system, the way of displaying information on the page is the object of study, and it is divided into three types of pages according to different types of information display, which are: complete page, information-graded page, and block-separated page. This paper adopts a combination of subjective evaluation (scale data: NASA TLX scale) and objective evaluation (behavioral data, physiological data: EEG, eye movement) to compare the reaction time, correct rate, cognitive load, and cerebral load of the subjects when they perform target search on the three types of pages, and concludes that the use of information-graded pages is the most effective, followed by complete pages, and the effect of the page with separate blocks of diagrams is less effective. The results of the study suggest that either the full page or the information-graded page can be used when designing the page, both of which can ensure high search efficiency and at the same time enable the manipulator to maintain relatively low cognitive and mental load and reduce human errors. The results of the study can provide a certain reference basis for the optimization of information presentation in VDT control systems.

Keywords
Multiple pages; search efficiency; human-computer interaction; eye movement experiments; EEG experiments

1. Introduction
At present, with the rapid and extensive use of digital technology in large-scale control systems, the main control room information interface with the emergence of a "huge amount of information and limited display" contradiction(Li Z 2020). This problem require the optimization of the system page information display mode and

the rational design of page information display mode, and improve the use of information resources, thereby improving work efficiency and reducing human error.

The VDT control system is now widely used in heavy industries such as coal, chemical industry, iron and steel, machinery, electronics, and other fields. At present, Liu Kunxiu proposed that the VDT control system in master control room environment equipment achieves a high degree of automation and intelligence, and operational activities are also mainly concentrated in the master control room(Liu 2015).With the application of VDT control technology in the master control room, the working environment of manipulators has changed dramatically. As a result, scholars have begun to use VDT control systems as a basis to try to further optimize the design of the human-machine interface in the system. For example, some scholars argued that the factor that has the greatest impact on the manipulator's information acquisition performance is the information display rate; the larger the information display rate is, the greater is the degree of interference of irrelevant information of the interface on the subjects, and the worse is the manipulator's information acquisition performance; while the information provision rate is in the smaller case, the manipulator's cognitive task is smaller and the better the performance is (Li Z et al 2016).Some scholars analyzed the human-caused errors in the main control room of a nuclear power plant and proposed new design requirements for the deep optimization of the human-machine interface, including the rational layout of functional areas and the display update of important information (Jiang et al 2020).

Search efficiency has always been the focus of scholars. To improve search efficiency in in-depth research,some researchers proposed that since the complexity and presentation density of the image will affect the search efficiency, they divided the image information into two categories: simple information and complex information and set up a different image density for the study. They found that the interface for the image is simple and the density of a small time can reduce the cognitive processing of a individual when they search for the target difficulty which is more conducive to improving the search efficiency (Wang et al 2018). Researchers conducted an eye-tracking study on the display of interface parameter names in the gas monitoring system with single and multiple search targets and concluded that interface information should avoid complex information as much as possible to improve the reliability of the task(Sun et al 2020).

In recent years, many studies have analyzed the relationship between differences in information presentation and information search behavior through eye movement experiments. Some academics investigated the relationship between search duration and multi-target visual search during multi-target visual search (Tang et al 2017). Some academics analyzed the behavioral characteristics and influencing factors of users in browsing by first look time, gaze duration, and gaze points, and compared the differences in user behavior between browsing and query contexts(Ji et al 2021). Brain load research in the early days mainly focused on the use of behavioral and subjective evaluation methods for evaluation, as the physiological signal detection technology is becoming more mature, more and more scientists hope to use physiological signal detection methods to establish an objective and reliable real-time brain load detection model.

Therefore, optimizing the display of the VDT control system page to improve the manipulator's work efficiency is particularly important. This paper compares three types of page displays and analyzes their effects on search efficiency, cognitive load, and cerebral load of the subjects through data analysis. The aim is to provide references for the design of VDT control system pages.

2. Method

2.1 Subjects

The experiment recruited 20 current college students from H. The subjects were between the ages of 22 and 25. Abnormal data were excluded, and finally, data from 16 valid subjects were obtained.

2.2 Experimental materials

2.2.1 Subjective Scale

The NASA-TLX scale was selected as the subjective cognitive load scale for this experiment, and the scale data were obtained through questionnaire form. This experiment used a 20-equivalent scale, and after completing each task, the subjects were asked to fill out the scale.

2.2.2 Targeted search materials

In this experiment, the operation page in a digital coal mine control system is selected as the stimulus material for the experiment, and three experiments are set up in E-prime, which are Experiment 1 complete page, Experiment 2 information grading page, and Experiment 3 block separation page, and the specific experimental pages are shown in Figures 1 to 3.

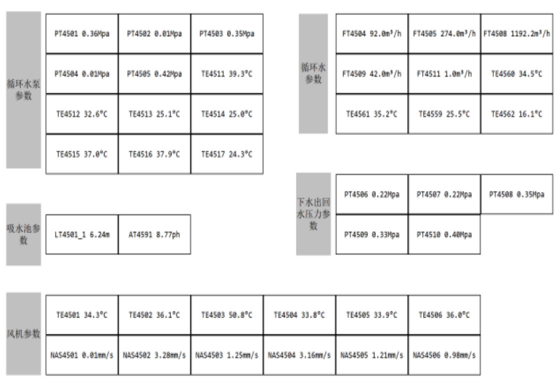

Figure1. Experiment 1 complete page

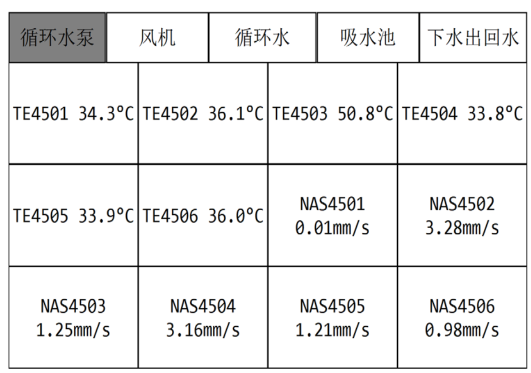

Figure 2. Experiment 2 Information-graded page

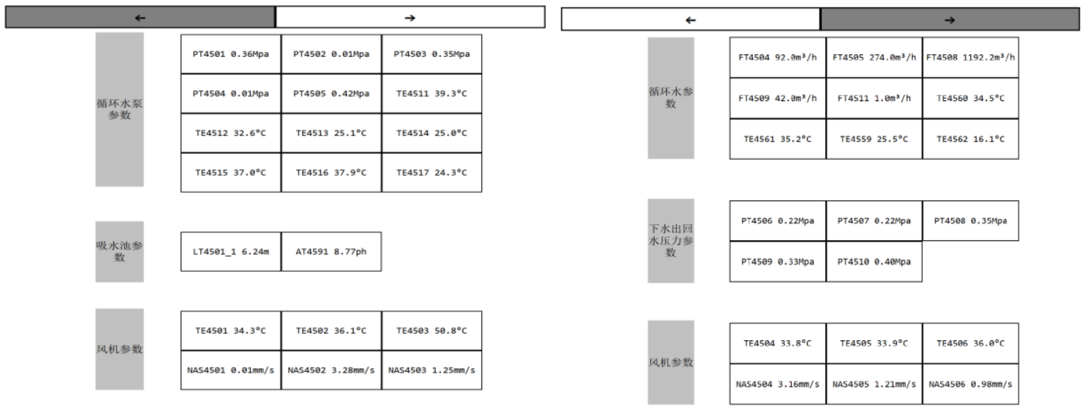

Figure 3. Experiment 3 block-separated page

2.2.3 Experimental process

First, the experimental procedure and requirements were explained to the subjects, the EEG cap was put on the subjects, and the laptop computer connected to the EEG device was opened to check whether the electrode points changed from white to green. Then, the subjects were given an eye-tracking device and asked to adjust their sitting posture, sit in a relatively comfortable position about 60-80 cm from the computer screen, and calibrate the subjects' gaze points. After the preparatory work, the practice experiment was started, and after the subjects understood the experimental task and mastered the experimental operation, the formal experiment was started. The steps of the formal experiment are as follows:

(1) Welcome to the experiment, click the space bar to start the experiment after preparation;

(2) The target task to be searched for this time is displayed on the screen, the page is switched after 4000ms to show the attention point "+", and it is automatically switched to the task search page after 2000ms. The subject searched on the task page, and after finding the task goal, the subject had to click on the task goal with the mouse to complete this search and enter the next target task release page;

(3) Repeat the above steps and complete ten search tasks for each experiment to complete the one-page display mode experiment. At the end of each experiment, subjects took an appropriate rest to reduce fatigue and stress, and then proceeded to the next experiment until all experimental tasks were completed;

(4)After subjects completed the three experiments, the NASA-TLX scale was filled out.

3. Results and analysis

In this experiment, there were 4 subjects with abnormal data, so only data from 16 subjects were analyzed, and a total of 480 trials (10x3x16) were obtained from the three experiments. Data from the behavioral experiments were organized and analyzed using Excel and IBM SPSS Statistics 23. Eye-movement experiments were analyzed and completed using BeGaze analysis software and IBM SPSS Statistics 23. EEG experiments were analyzed using ASA analysis software and IBM SPSS Statistics 23.

3.1 Behavioural data

This study analyzed two objective evaluation indexes, reaction time and correct rate, for behavioral data analysis. The experimental data is presented in Table 1.

Table 1. E-prime data

Subject No.	reaction time（ms）			correct rate（%）		
	Experiment 1	Experiment 2	Experiment 3	Experiment 1	Experiment 2	Experiment 3
1	3023	3081	3795	0.9	1	0.9
2	3747	3220	3777	0.9	1	0.9
3	2965	2723	3145	1	0.9	1
4	4190	3512	4684	0.7	0.7	0.6
5	6399	4590	6430	0.8	1	0.9
6	4227	3979	5865	1	1	0.9
7	5436	2766	7474	0.7	0.7	0.7
8	5528	3619	5881	0.8	1	0.9
9	5158	4247	6264	1	1	1
10	5182	2542	4054	1	0.8	0.9
11	8706	4337	6283	0.8	1	0.4
12	3563	3123	5026	0.9	1	1
13	5036	6742	5974	0.8	0.6	0.9
14	4914	3822	5245	0.8	0.8	0.9
15	5343	2974	4915	0.9	1	0.9
16	4648	4281	5286	0.9	1	1

Paired-sample t-tests were conducted on the page information display methods, and the results are presented in Table 2. A significant difference in the subjects' reaction time during the experiment was found when comparing the data from Experiment 2 and Experiment 1 ($t=3.248$, $P=0.005<0.05$). There was a significant difference in the subjects' response time during the experiment when comparing Experiment 2 and Experiment 3 ($t= -5.298$, $P= 0.000<0.05$). Furthermore, there was a significant difference in the target search time for the three-page information display methods. The average correctness rate of the subjects was 86.9% in Experiment 1, 90.6% in Experiment 2, and 86.3% in Experiment 3. This suggests that the subjects performed better in Experiment 2 than in Experiment 1 and Experiment 3.

Table 2. E-prime data Paired-sample t-test results

	Experimental group	standard error	T-value	P-value	95% confidence level	
					Upper bound	Lower bound
reaction time	Experiment1	348.64737	3.248	0.005	397.716	1915.659
	Experiment2	257.03792				
	Experiment2	257.03792	-5.298	0.000	-2150.782	-916.718
	Experiment3	291.30522				
	Experiment1	348.64737	-1.391	0.185	-955.034	200.909
	Experiment3	291.30522				

3.2 Eye-movement data

This paper utilizes the physiological measurement method of eye tracking to measure the cognitive load of the subjects, referring to related studies. Objective indexes such as gaze time, pupil diameter, blinking time, and blinking frequency were selected from the eye-movement experimental data, and the results are presented in Table 3.

Table 3. Eye-movement data

	gaze time（ms）			pupil diameter（mm）			blinking time（ms）			blinking frequency（times/sec）		
	E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3
1	79844	73732	79059	4.003	3.950	4.087	13939	13895	13043	0.5	0.6	0.5
2	63651	59577	76259	4.065	3.858	4.551	20235	10727	8435	0.5	0.4	0.3
3	77793	65393	79766	3.811	3.789	3.680	11929	11859	11447	0.7	0.7	0.7
4	79387	68364	71768	3.286	3.188	3.308	18614	18989	14551	0.9	0.9	0.7
5	116728	90541	109950	3.901	3.79	4.023	4800	6721	3783	0.2	0.4	0.2
6	93433	79224	97711	3.313	3.237	3.341	8881	10032	8074	0.4	0.4	0.3
7	90746	60425	95531	3.610	3.390	3.594	16105	19044	16443	0.5	0.5	0.4
8	107458	84620	93555	4.036	3.744	4.098	33123	2359	2590	0.1	0.1	0.1
9	90732	78613	86023	3.770	3.622	3.785	14252	12664	11042	0.4	0.5	0.4
10	102247	70585	83084	3.808	3.666	3.690	5861	4554	6050	0.3	0.4	0.4
11	101339	61627	72544	3.123	3.019	3.201	24822	24946	22008	0.4	0.4	0.4
12	84359	68428	80009	4.047	4.229	4.477	10063	10977	9312	0.4	0.5	0.4
13	84174	97505	77429	3.931	4.140	3.956	7168	4652	8674	0.2	0.2	0.3
14	78825	71477	75830	2.834	2.964	2.962	21974	1253	12083	0.6	0.5	0.5
15	95342	66085	79872	3.490	3.309	3.857	13560	15436	9608	0.6	0.8	0.6
16	86483	78463	78891	4.136	4.150	4.324	13681	13416	10131	0.7	0.7	0.6

Paired-sample t-tests were performed on the metrics for each experiment, as presented in Table 4.

Table 4. Eye-movement data Paired-sample t-test results

	Experimental group	X±S	T-value	P-value	95% confidence level	
					Upper bound	Lower bound
pupil diameter	T2	3.62781±0.403003	-3.292	0.005	-0.297	-0.064
	T3	3.80838±0.456598				
blinking frequency	T2	0.500±0.2066	3.503	0.003	0.0294	0.1206
	T3	0.425±0.1693				

gaze time	T1	89533.81±13159.891	4.866	0.000	9057.034	23178.216
	T2	73416.19±10847.250				
	T2	73416.19±10847.250	-3.539	0.003	-16285.075	-4042.675
	T3	83580.06±10455.902				

A significant difference was found in the subjects' gaze time during Experiment 1 and Experiment 2 (t=4.866, P=0.000<0.05). The mean gaze time in Experiment 1 was 89533.81ms, while in Experiment 2 it was 73416.19ms, indicating that Experiment 2 required less time to complete the task. There was a significant difference in subjects' gaze time between Experiment 2 and Experiment 3 (t=-3.539, P=0.003<0.05). In Experiment 3, the gaze time was 83580.06ms, indicating that subjects spent less time searching for the target and extracted information faster than in Experiment 2.

A significant difference was found between the subjects' pupil diameters during Experiment 2 and Experiment 3 (t=-3.292, P=0.005<0.05). The mean pupil diameter was 3.62781 mm in Experiment 2 and 3.80838 mm in Experiment 3, indicating that the subjects' cognitive load changed during the experiment.

A significant difference in the subjects' blink frequency during the experiment was observed when comparing Experiment 2 and Experiment 3 (t=3.503, p=0.003<0.05). The average blink frequency was 0.500 blinks/sec in Experiment 2 and 0.425 blinks/sec in Experiment 3. This decrease in blink frequency suggests that the page in Experiment 3 increased the cognitive load of the subjects. The mean blink frequency of Experiment 1 was 0.4625 blinks/sec, which was not significantly different from Experiment 3.
There were no significant differences in blink times across the three sets of experiments. The average blink time was 14938ms in experiment 1, 11345ms in experiment 2, and 10455ms in experiment 3.

3.3 EEG data

EEG is a weak signal that is highly susceptible to interference from various noise sources. The EEG signals collected in this study were analyzed offline using ASA software, using bilateral mastoid electrodes for re-referencing and 1-30 Hz band-pass filtering. Outliers were detected and subsequently replaced or removed. The EEG data were subsequently fast Fourier transformed and divided into five different frequency divisions: delta (1-4 Hz), theta (4 - 8 Hz), alpha (8-18 Hz), beta (18-30 Hz), and gamma (above 35 Hz). After data preprocessing the three experiments were grouped two by two and paired-sample t-tests were performed on the data of 32 channels in the five bands of Delta, Theta, Alpha, Beta, and Gamma as shown in Table 5 below, and brain maps were generated as shown in Figures 5 and 6.

Table 5. EEG data Paired-sample t-test results.

	Experimental group	X±S	T-value	P-value	95% confidence level	
					Upper bound	Lower bound
Delta	E1	6.148748973±2.6904599256	4.245	0.001	0.413	0.872

	E2	4.396751912±1.9548179177				
	E1	6.148748973±2.6904599256	4.258	0.001	0.389	0.827
	E3	4.492972933±1.7247497254				
Beta	E1	-18.567718166±2.1997491636	-3.091	0.007	0.773	-4.035
	E2	-16.179920574±4.1308999487				
	E1	-18.567718166±2.1997491636	-5.559	0.000	0.715	-5.497
	E3	-14.594418061±3.1787186713				
Gamma	E1	-37.359810794±1.9644276462	-2.985	0.009	1.663	-8.509
	E2	-32.395351547±6.9719217219				
	E1	-37.359810794±1.9644276462	-5.612	0.000	1.451	-11.233
	E3	-29.218494867±5.6515112388				

The results of Experiment 1 and Experiment 2 indicate that the use of the Experiment 1 full page and the Experiment 2 information-graded page led to higher activation in prefrontal and bilateral temporal regions in Delta band (t=4.245, P=0.001<0.05), prefrontal and parietal regions in Beta band (t=-3.091, P=0.007<0.05), and all brain regions in Gamma band (t=-2.985, P=0.009<0.05), as depicted in Figure 4.

Experiments 1 and 3 revealed higher activation in prefrontal and temporal lobe regions in the Delta band (t=4.258, P=0.001<0.05) when subjects used the Experiment 1 full page and the Experiment 3 block separated page. In the Beta band, higher activation was observed in both whole brain regions (t=-5.559, P=0.000<0.05), and in the Gamma band, activation was higher in all brain regions (t=-5.612, P=0.000<0.05), as depicted in Figure 5.

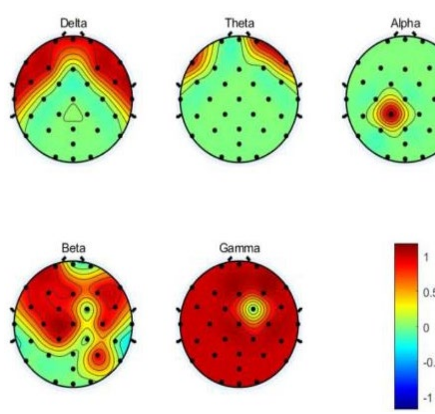

Figure 4. Experiment 1 2 Brain Map Comparison

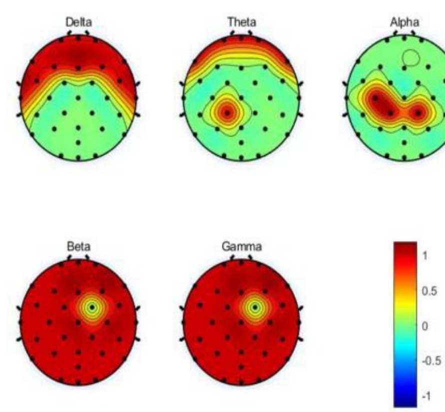

Figure 5. Experiment 1 3 Brain Map Comparison

3.4 NASA-TLX Scale data

The NASA-TLX scale is widely used to measure cognitive load. It is known for its high acceptance and low inter-subject variability(Yang et al 2010). The results of the paired-samples t-test on the NASA-TLX scale data are shown in Table 6.

Table 6. NASA-TLX data Paired-sample t-test results

	X±S	T-value	P-value	95% confidence level	
				Upper bound	Lower bound
E1	9.87375±2.469584	6.820	0.000	0.528455	1.008920
E2	9.10506±2.358729				
E2	9.10506±2.358729	-7.654	0.000	-0.835572	-0.471553
E3	9.75863±2.528081				
PhD	5.19±3.146	-5.361	0.000	-6.549535	-2.822965
E1	9.87375±2.469584				
Per	14.25±4.435	2.725	0.016	2.201350	6.551150
E1	9.87375±2.469584				
FL	5.06±3.021	-7.289	0.000	-6.218166	-3.404334
E1	9.87375±2.469584				
PhD	5.19±3.146	-4.781	0.000	-5.664094	-2.171031
E2	9.10506±2.358729				
TD	11.81±4.446	3.330	0.005	0.974369	4.440506
E2	9.10506±2.358729				
Per	14.25±4.435	4.899	0.000	2.906330	7.383545
E2	9.10506±2.358729				
FL	5.06±3.021	-6.773	0.000	-5.314752	-2.770373
E2	9.10506±2.358729				
PhD	5.19±3.146	-5.152	0.000	-6.462294	-2.679956
E3	9.75863±2.528081				
TD	11.81±4.446	2.621	0.019	0.383645	3.724105
E3	9.75863±2.528081				
Per	14.25±4.435	4.215	0.001	2.220260	6.762490
E3	9.75863±2.528081				
FL	5.06±3.021	-7.433	0.000	-6.042828	-3.349422
E3	9.75863±2.528081				

Upon comparing the six dimension scores with the total scores of the three experiments, it was discovered that the significant dimensions in Experiment 1 were physical demand ($t=-5.361$, $P=0.000<0.05$), performance level ($t=2.725$, $P=0.016<0.05$), and frustration level ($t=-7.289$, $P=0.000<0.05$). In Experiment 1, the subjects experienced a higher cognitive load due to physical demands, performance level, and frustration level. The subjects were particularly affected by the frustration level.

The significant dimensions in Experiment 2 were physical demands ($t=-4.781$, $P=0.000<0.05$), time demands ($t=3.330$, $P=0.005<0.05$), performance level ($t=4.899$, $P=0.000<0.05$), and frustration level ($t=-6.773$, $P=0.000<0.05$). This indicates that in Experiment 2, subjects perceived cognitive load to be dominated by physical demands, time demands, performance levels, and frustration levels. Experiment 1 did not reflect the difference in time demands, indicating that switching pages after adding multiple pages increased the subjects' maneuvers and affected their time demands. The significant dimensions in Experiment 3 were: physical demands ($t=-5.152$, $P=0.000<0.05$), time demands ($t=2.621$, $P=0.019<0.05$), performance level ($t=4.215$, $P=0.001<0.05$), and frustration level ($t=-7.433$, $P=0.000<0.05$), which showed essentially the same results as in Experiment 2.

4. Discussion

4.1 Comparing the findings of Experiment 1 and Experiment 2

This paper examines the objective data from Experiment 1 and Experiment 2 using a paired-sample t-test to investigate the impact of single versus multiple pages on manipulators when the total amount of information is the same. The comparison results indicate that the subjects in Experiment II had a shorter average reaction time and a higher correct rate. Some scholars discovered that reducing the rate of information display can enhance search efficiency (Guo et al 2023). Additionally, dividing a certain amount of information into two pages can effectively improve the efficiency of target search. The results of this paper are consistent with their findings. The three experiments contain the same amount of information. Experiment 2 categorizes and summarizes similar information to reduce the information displayed on a single page. The results indicate that Experiment 2 has the highest search efficiency and significantly lower information display rate than Experiment 1.

The eye-movement data reveals a significant difference in gaze time between the complete page and the information-graded page. Gaze time represents the total time subjects take to analyze and judge the target(Sun et al 2020). It is positively proportional to cognitive load and increases as task complexity, mental effort investment, and subjective task difficulty increase(Tan et al 2021). The results show that subjects' gaze time was significantly lower when using information-graded pages compared with complete page. This suggests that the cognitive load was lower when using information-graded pages. The gaze time reflects the search efficiency of the subjects using the information-graded page. Experiment 2 had a shorter gaze time and higher search efficiency compared with Experiment 1. The eye-movement data were consistent with the behavioral data.

The EEG data reveals a significant contrast in the Delta, Beta, and Gamma bands when comparing Experiment 1 and Experiment 2. The power spectrum of Theta, Alpha, Beta, and Gamma EEG waves is a sensitive physiological signaling index used to study psychological stress. Delta waves are generally released during periods of unconsciousness, deep sleep, and in adults experiencing extreme fatigue and lethargy. Research has demonstrated that when transitioning from increased mental load to mental fatigue, there is an increase in Delta and Alpha bands and a decrease in Beta bands(Reznik 2017).When comparing Experiment 1 with Experiment 2, it was found that Beta band activation was higher and Delta band activation was lower in Experiment 2 than in Experiment 1. This suggests that subjects experienced increased mental load and higher fatigue when using the complete page compared with the information-graded page. The categorization of information on the pages of Experiment 2 may have reduced the mental load of the subjects to some extent, thus reducing their level of fatigue.Activation of prefrontal areas is higher in the Delta and Beta bands. Among the brain area functions, the prefrontal area is responsible for thinking, planning, and central executive functions as well as motor functions. In addition, activation was higher in the parietal area in the Beta band, which is responsible for visual perception and processing. In the present experiment involving the search and completion of a target task, subjects performing the task activated prefrontal areas as well as parietal areas. Some researchers believe that the Gamma wave reflects whether attention is focused or not and acts as a carrier frequency to facilitate data exchange between brain regions. Others have linked Gamma waves to rapid eye movements, which are thought to be integral to sensory processing and information absorption.In Experiment 2, the gamma wave activation was higher than in Experiment 1, indicating that the subjects were able to process all of the information faster and more completely when using the information-graded page. The brain maps show that Experiment 1 brain map activation is higher than Experiment 2 brain map activation, indicating that subjects have a higher brain load when using the full page of Experiment 1 and a lower brain load when using the information-graded page of Experiment 2.

4.2 Comparing the findings of Experiment 3 and Experiment 2

To investigate the impact of varying page breaks on manipulators in a multi-page scenario, we conducted paired-sample t-tests on all subjective and objective data from Experiments 2 and 3. The behavioral data indicates a significant difference in reaction time between subjects in Experiment 2 and Experiment 3. This difference is likely due to the incomplete display of information on a single page in the block-separated pages. Subjects were unable to memorize all the information and were unsure of the page on which the search target was located, resulting in increased reaction time as they switched back and forth between pages.

The eye-movement data reveals a significant difference in pupil diameter and blink frequency between the block-separated page and the information-graded page. Studies have shown that pupil diameter is a sensitive indicator of resource allocation and processing load during cognitive processing activities(Hess 1978). Pupil dilation typically indicates that a person is experiencing a greater processing load or mental stress while performing cognitive activities (Verney 2004).When a person experiences fatigue, there are low-frequency, large fluctuations in pupil diameter. These fluctuations are typically preceded by a rapid decrease in pupil diameter in most test subjects(Nishiyama 2007). Pupil diameter is positively proportional to cognitive load. As the difficulty of an experiment increases, subjects need to exert more cognitive effort, which tends to result in a larger pupil diameter (Tan et al 2021).Experiment 2 and Experiment 3 showed a significant difference in pupil diameter, suggesting that block-separated pages increased cognitive load. Compared to the information-graded page, subjects experienced a higher processing load and greater mental stress during the target search. The lower blink frequency observed indicates that subjects needed to pay more attention as the task difficulty increased, resulting in a higher mental load (Pérez-Moreno 2011). Blink frequency is inversely related to cognitive load, and when the task is more difficult, it inhibits the occurrence of blinking, leading to a lower blink frequency . Comparing Experiment 2 and Experiment 3, the results of previous studies suggest that the difference in subjects' blinking frequency may be due to the presence of multiple repeated page-switching operations in Experiment 3. Comparing Experiment 2 and Experiment 3, the results of previous studies suggest that the difference in subjects' blinking frequency may be due to the presence of multiple repeated page-switching operations in Experiment 3. Comparing Experiment 2 and Experiment 3, the results of previous studies suggest that the difference in subjects' blinking frequency may be due to the presence of multiple repeated page-switching operations in Experiment 3. This increased the subjects' thinking, which in turn increased their cognitive load and decreased their blinking frequency.Furthermore, blink time is defined as the average duration of one blink of the operator at a given time, which is a reliable indicator of the operator's fatigue. It has been observed that the blink time increases significantly with the level of fatigue. The absence of a significant difference in blink time suggests that the fatigue levels of the subjects in all three experiments were similar.

From the EEG data, it can be obtained that the brain map activation was higher in Experiment 3 compared to

Experiment 2, indicating that the subjects had a higher brain load when using the block-separated pages in Experiment 3. Since the brain map activation was higher in Experiment I than in Experiment 2, and the activation was higher in Experiment 3 than in Experiment 1, the subjects in Experiment 3 had the highest brain map activation. It shows that the subjects' brain load was the highest in Experiment 3, and the page use in Experiment 3 was less effective compared to the other two pages. Blocks separate pages increase subjects' brain load, which increases fatigue and affects task performance.The experiment focuses on visual search, with the prefrontal, parietal, and occipital regions being the main brain areas involved. The data showed a significant difference in higher activation in temporal lobe areas on both sides. It was initially thought that external noise factors were interfering with the laboratory environment, which may have contributed to this result.

5. Conclusion

This paper presents an exploratory study on page display in VDT control systems. The aim is to investigate the relationship between the manipulator's search efficiency and the way pages are displayed in VDT control systems. The study draws the following conclusions. In a VDT control system, complete information is displayed on a single page when space permits. Although the manipulator is presented with a large amount of information, familiarity with the page increases over time, leading to improved search efficiency and reduced cognitive load. The increase in pages for the information-graded page did not reduce the total amount of information. Categorizing the information on different pages was an improvement in search efficiency based on behavioral data. Based on the eye-movement and EEG data, it can be concluded that compared to the other two display methods, the cognitive and brain load on the manipulator is lower when the information-graded page is used. Therefore, the information-graded page is the most effective display method among the three. Based on the feedback from the subjects, the block separation page is impractical and difficult to use. Based on the information provided on the block separation page, it appears that this page may not be ideal to create informational target search tasks. Instead, it may be better suited to display graphic or icon search tasks. Further investigation is recommended. In summary, when designing the page for a VDT control system, one can either concentrate all the information on a single page or integrate and design information with a large amount of data and regular type of information as a information-graded page. Both of these pages can ensure high search efficiency, enable the user to maintain a low cognitive and brain load, reduce human error and improve work efficiency.

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