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Research Article

Application of Electroencephalogram Physiological Experiment in Interface Design Teaching: A Case Study of Visual Cognitive Errors *

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Abstract

Technology changes accelerated the speed of subject interaction more and more frequency in now days. Take advantage of electroencephalogram (EEG) physiological experiments to analysis the user interface (UI) of software, bring the assessment criteria of quantitative analysis to the design discipline, these methods were accepted by more and more researcher in a university or institute. As a researcher in a university, we show EEG in this paper our experiences and results in teaching students whose major in interface design with five stages, our focus is one of EEG solutions, which offers several UI possibilities. Take EEG physiological experiments to analysis the visualization cognitive errors (VCE) could help designers understand the cognition process of digital interface visual information (DIVI) by different users and improve the overall efficiency of digital interface design. Based on the composition of DIVI, VCE of DIVI were analyzed from color and layout difference. According to the experimental factors of the error trap, this paper designed two EEG physiological experiments to study the behavioral responses and EEG responses of the brain to DIVI. In order to improve the versatility of experimental conclusions in digital interface design, the EEG physiological experiments in this paper was designed under the Oddball experimental paradigm. And the experimental materials include the digital interface of PC terminal and mobile terminal. The statistical analysis results of the experimental data show that the behavioral data and brainwave data of the EEG experiment can be used as the basis for judging the cognitive errors of the digital interface visual information. However, EEG components and EEG topographic maps related to VCE of DIVI may vary significantly due to differences in experimental materials. The experiment also indicates that there are many branches in the EEG experiments to analysis the VCE of DIVI. It is helpful to improve the reliability of digital interface design by perfecting the EEG physiological experiments of these branches. We give an example of the practical problems and adequate sequences for teaching EEG approaches based on our study and experiences.

Keywords

Electroencephalograph (EEG) • Visualization Cognitive Error (VCE) • Digital Interface • Physiological Experiment

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We know that subject interaction more and more frequency in now days, interdisciplinary interactive can be more possible than ever (Chi, 2013). In the education we introduce some interdisciplinary resource beyond the general theoretical subjects (Selmeci, & Orosz, 2014). In the advance of development of interface design, digital interface has gradually replaced the traditional hardware interface and become the main media and carrier of human-computer interaction. As a medium for human interaction with information, users receive information from the digital interface through the visual system. Reasonable visual communication enables users to quickly search, discover, and identify information presented on digital interfaces. How many criteria approach for analysis the user interface? The assessment criteria of quantitative analysis appeared in recent years, for instance, the Likert component table method, eye-movement tracker methods etc. (Berson, 2018; Chen *et al*., 2017). Such assessment criteria approach more and more used in design major education, effectively improve the reliability of design evaluation results (Cowen *et al*., 2002; Roth, Tuch, Mekler, & Bargas-Avila, 2017; Chen *et al*., 2015; Chen, 2017).

The ability to teach and educate students in an efficient way is depending not only on the theory and the availability of equipment, for instance, in experiment physic. The students should be regularly trained, retrained, and brought nearer to the real behavioral experience. In the following sections we go through diversity in education forms, methodologies and techniques, to manage it should be the principle of gradual improvement.

In this paper the progress of teaching EEG in user interface can be divided into these steps: First, give the concept of methodologies contain theories of cognitive neuroscience and the factors of User Interface; second, in the base of methodologies explore the relationship of visual system and interface factors. The color coding corresponding “What” visual pathway and layout factor of dashboards corresponding “Where” visual pathway gave a clearly interpretation for learning mechanism of the experimental in our study. Third, research subject generation and concept gap in the stage, we should give a specific concept of the experimental with more examples interpretation. Forth, EEG physiological experimental for VCE of DIVI, in this section experimental method, experimental design and experimental progress will be given in details. Fifth, analysis of experiment data, analysis of behavior data, analysis of EEG data and discussion of Experiment results setting according to a original experimental routine.

Methodologies

Theories of cognitive neuroscience

As to cognitive psychology, information cognitive processing is considered to be the main process of visual information processing. It is the result of a series of interpreting processing through the brain after the visual system extracts the external stimulus information. The relationship between visual perception of different color perceptions and brain structure is shown in Figure 1.

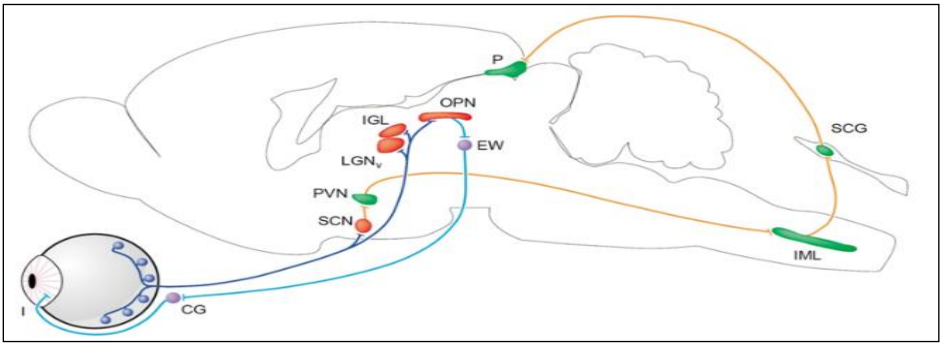


Figure 1. Relationship between visual system and brain structure

Over the recent twenty years, theories of cognitive neuroscience increasingly mature. As an important research method of cognitive neuroscience, the development of EEG physiological experimental technology has gradually enriched and matured (Berson, 2018). Different from the traditional psychological research, EEG physiological experimental is a simple and practical method used to study the cognitive function of brain (Potts, & Tucker, 2001; Kok, 1997; Kutas, Mccarthy, & Donchin, 1977; Azizian, Freitas, Watson, & Squires, 2006; Näätänen, & Picton, 1986; Patel, & Azzam, 2005). The recording unit of EEG data is milliseconds, which can be used to track physiological changes in the brain. And EEG can make up for the deficiency of functional magnetic resonance imaging for the recording of physiological changes in the brain (Chiu, & Hsieh, 2016). Fox, Anderson, & Reid, (2010) compared the N1 EEG difference of continuous auditory stimulation under different concentrations, concluded that adults are better than children in simplifying continuous auditory information. Sellers, Krusienski, Mcfarland, Vaughan, & Wolpaw, (2006) adopted the ODDBALL experimental paradigm in exploring the P300 EEG signals, study the size of matrix communication effectiveness for BCI brain computer interface under different stimulation time intensity.

In the process of digital interface interaction design, due to the hierarchy and logical characteristics of digital interactive design, more and more researcher use EEG to study cognitive load of visual information (Lindberg, Näsänen, & Müller, 2006; Chan, Maclean, & Mcgrenere, 2008; Salman, Cheng, & Patterson, 2012; Yi, & Friedman, 2011; Krigolson, Heinekey, Kent, & Handy, 2012). Niu *et al*. (2014) use EEG technique to study the user's cognitive process for icons, controls, colors, layouts and interactions of interface design. Kutas (1980) extract appropriate EEG components for semantic cognitive processing, bring the possibility of successful applying EEG in cognitive science.

With the increase of user demand for interface operation, digital interface design not only required clear, readable and digestible, also need simplicity of operation and guidance. In this way, the use efficiency of the digital interface can be improved, and the mistakes that the user may encounter during the operation, feedback, and understanding of the digital interface are minimized. Therefore, it is of great significance to research the obtaining, processing and feedback of visual information using EEG physiological experiments. It is also of great significance for digital interface optimization design.

The factors of User Interface

Eliminate the reason and achieve the user requirements in the interface of the information system, it is proposed to represent the user actions in the form of mechanisms of recognize and on the bases to build a process of interface design. The main elements of digital interface include: color, icon, control, layout, interaction form and task flow refer from interface design theory, most research established the motivational factors related to color and layout (Case, Kurland, & Goldberg, 1982; Bennett, & Flach, 2011; Cassino, & Tucci, 2009).

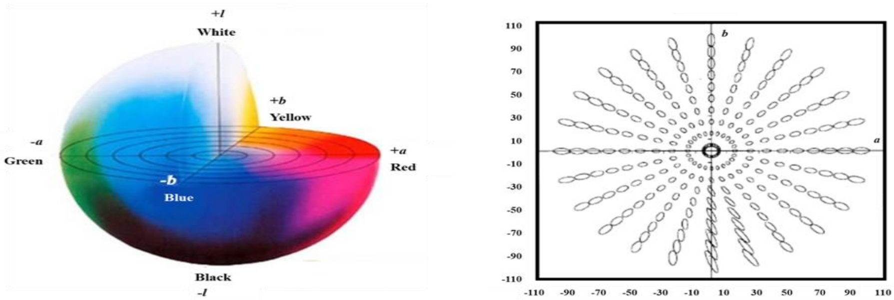


Figure 2. The distinction between color space and human eyes

According to the color space-based color difference proposed by Luo (2001), the critical value is determined, as shown in Figure 2. The layout of digital interface refers the visual elements clearly and effectively arranged in a certain area, make sure icons, texts, controls have a reasonable regional arrangement. For instance, in this paper, color difference and layout difference from performance level and structure level were selected to analyze the cognitive errors of the DIVI, as shown in Figure 3. the color coding and layout factor of dashboards give a clearly interpretation for learning mechanism of the experimental in our study.

Implications this paper contributes to a better understanding of how user conduct searches in and interact with visual search interface.

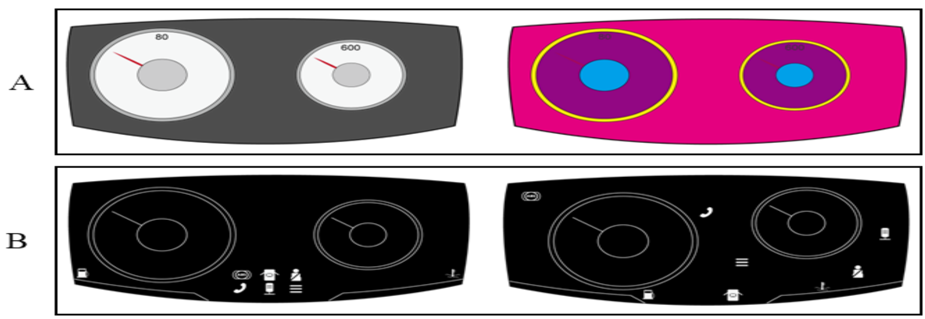


Figure 3. Color difference (A) and layout difference (B) of dashboards

The relationship of visual system and interface factors

The composition of DIVI can be sort into performance level, structure level and strategic level according to interface design theory. The main visual elements of performance level include color, icon, and control, which is "What" visual pathway, and the main visual elements of structure level include information architecture, layout, and interaction form and task flow, which is "Where" visual pathway (Mishkin, Ungerleider, & Macko, 1983).

Seen form visual pathway theory, this paper exploring the human computer interface design method based on "What" property and "Where" property, research on the combinatorial optimization between "What" property -Color code and "Where" Property-Layout code.

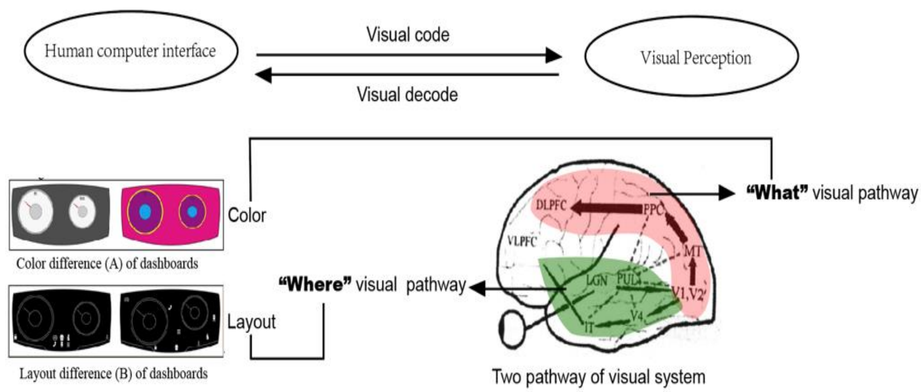
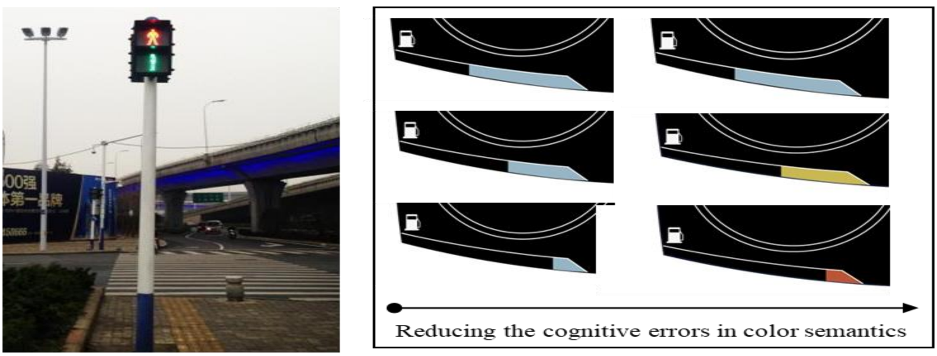


Figure 4. The cognitive information process of visual system



A B

Figure 5. Cognitive errors of colour difference

Research subject generation and concept gap

Cognitive errors of color difference

Cognitive errors of color difference in DIVI can be defined as user got the wrong comprehension of color semantics or semantic conflicts and other cognitive failures after receiving the visual stimulation. As shown in

Figure 5 (A), since the red indicator and green indicator flashing at the same time, it contradicts the normal cognition of traffic lights that pedestrians understand and result in visual cognition errors in color semantics. For another example in Figure5 (B), the function of oil-usage information is displayed by different color. And the color of blue, yellow, and red indicate oil amount of 100% to 40%, 45% to 20%, and 20% to 0%, respectively. It is better than a single color to remind the user to correctly estimate the fuel quantity of the fuel tank and avoid the cognitive errors of the color semantics in DIVI.

Cognitive errors of layout difference

And the cognitive errors of layout semantics in DIVI can be defined as the failure of the users to correctly understand the importance and logic of the layout of different elements after receiving the visual stimulus of the digital interface layout elements.

As shown in Fig 6(A), if we arrange the elements according the importance from 1 to 6 as, it’s easily leads to cognitive error. As shown in Fig 6(B), reasonable cognition order should be the S type flowchart, such as the top-down/ left to right.

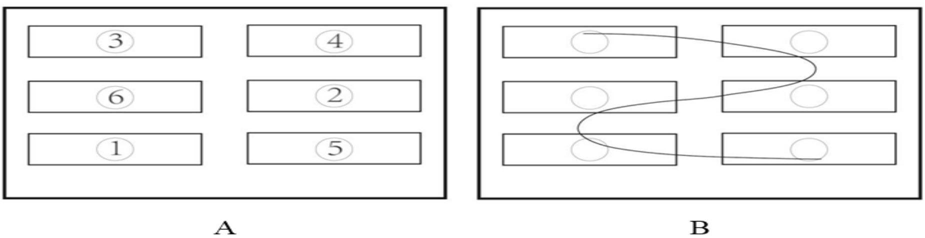


Figure 6. Recognition of digital interface layout

EEG physiological experimental for VCE of DIVI

Experimental method

The purpose of the experiment is to study the different behavior reaction and EEG responses of the user's brain to color coding of different digital interfaces. The EEG data recorded in the experiment will be processed, compared, analyzed and summarized. By analyzing the composition, amplitude and latency of the EEG indicators of the users, the evidence of EEG data that can reflect the cognitive errors of DIVI is explored.

(1) Experimental condition

The equipment of ERP contains amplifier, electrode cap and some equipment connection lines. Two computer, one is for subjects and the other is used to do data acquisition and analysis. Other experimental accessory items, such as blunt needle syringe, conductive paste, shampoo, etc. In terms of experimental software, E-prime 2 is adopted, data acquisition and analysis by EEGO, ASA and Minitab17.

(2) Experimental subject

20 students whose age between 20-30 years old were selected contain half male and half female, no color blindness or color weakness and the corrected vision all above 1. In the experiment, the subject sit on front of computer, in order to exclude the interference of visual search, the angle of view is 4.1 degree and vertical +3.1 degrees. The distance from screen to eye is 550mm-600mm.

Experimental design

In order to improve the versatility of experimental conclusions in digital interface design, EEG experimental in this paper was designed according to the ODDBALL classic experimental paradigm.

The experimental materials include the digital interface of PC terminal and mobile terminal. The PC terminal uses the car dashboard (Figure7), and the mobile terminal uses the musical instrument tuning APP (Figure 8).

Figure 7. Vehicle dashboard digital interface

Figure 8. APP digital interface

The two experimental materials will be simplified; unnecessary visual elements will be weakened in case influence the presented elements. Standard task stimulation with error trap appears in a large probability task, deviation task stimulation appears with no error trap appears in a small probability tasks. The proportion of standard task and deviation task stimulation is 4:1.

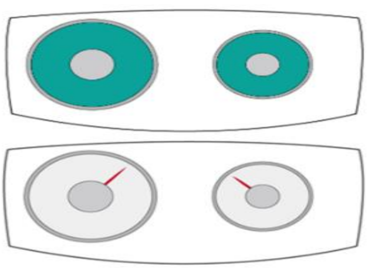


Figure 9. Comparative experimental materials of group one

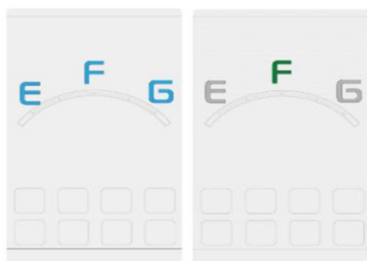


Figure 10. Comparative experimental materials of group two

The error trap is set the critical value of color difference to be distinguish, the value below the critical level can't be discernible, the color coding of digital interface is carried out under different chromatic aberration. In order to make sure the subjects can successfully complete the experimental task, we set the value of chromatic aberration close to but not below the critical value to standard task stimulation, the value which is much higher than the critical value being set to target task stimulation. Select and compare the data of target task stimulation and standard task stimulation, we can get the EEG data characteristics of different chromatic aberration.

The corresponding error traps can be set up according to the research results of Luo (2001), a stimulus material for experimental task was produced, as shown in Figure 9 and Figure 10.

The experimental materials compared to the Lab color. To materials of group one, the pointer color set as (9, -44, -5) and the dial color set as (59, -43, -8). As to materials of group two, the pointer color is set as (42, 64, 42) and the dial color set as (97, -1, -1). Due to the differences in the experimental materials presented, in order to meet the experimental design requirements of the EEG experiment, the specific color settings need to be fine-tuned according to the actual situation.

The design of EEG experiment task is judgment task in the due time. The task of Experiment 1 is to let the subjects observe and judge whether the pointers of the two dials point to the same side within 800ms. And the task of Experiment 2 is to let the subjects observe and judge whether there are letters with prominent colors in the three letters within 800ms.

Experimental process

Before the experimental, we ensure the contact part between the head and conductive cap is dry. The subjects sit in a soft light and sound insulation laboratory, eyes face the center of the screen and the distance is 550-600mm. The horizontal and vertical angles of the experimental materials are in the range of 2.5 degrees.

Wearing the electrode cap for the subjects, keeping the hands drying, and the conductive paste is injected into the electrode hole by a blunt needle syringe.

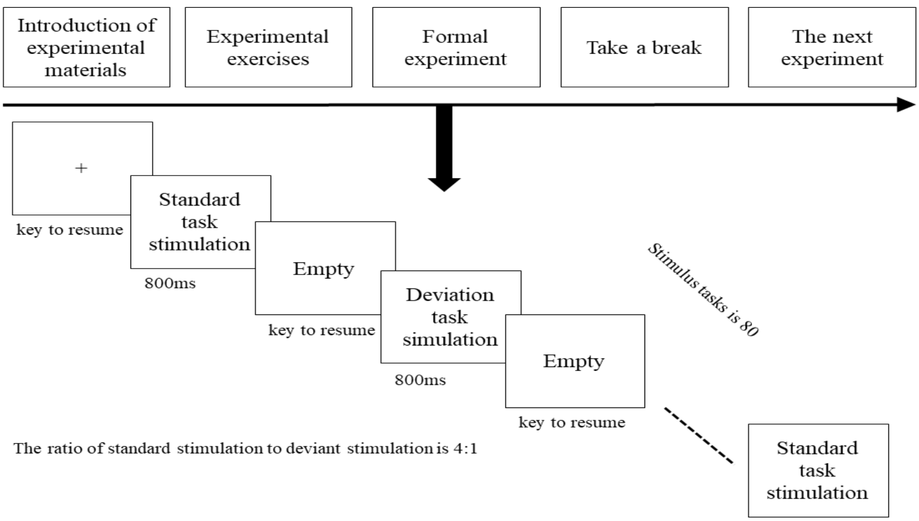


Figure 11. Framework of experimental process

As shown in Figure 11, the experiment process includes material familiarity, exercise experimental and formal experiment. In the experimental phase, the cross visual guidance is first presented, and standard task stimulation or deviation task stimulation occurs by pressing any key. The task stimulus presentation time is 800ms, and it is judged and reacted according to the design requirements of the experimental task. The interval of task stimulation is a blank screen, and the task stimulus is continued by pressing any key.

After the completion of experiment 1, the subjects were allowed to rest for five minutes to adjust, and Experiment 2 was followed. Each experimental stimulus was 80, with 48 standard task stimuli and 32 deviation task stimulus. Due to the particularity of the research object, in order to avoid the error trap fatigue caused by the test, the task stimulation ratio was set as 3:2, so that the subject always maintained a certain attention in the experiment to complete the experimental task.

Analysis of experiment data

The behavior data of the 20 subjects were generated by E-prime after the subjects completed the experiment, behavioral data include the accuracy ratio data of judgment and reaction time for each task stimulus. On the one hand, the analysis data of behavior can verify the rationality of experimental setup, on the other hand, it can explain the visual cognitive error partly.

The EEG debugging and reaction data of the experimental subjects were recorded using the EEGO recording software supplied with the EEGO amplifier. The EEG data file generated by the record is imported into the ASA analysis software for processing analysis.

Analysis of behaviour data

The behavior data of the two experiments included the accuracy and response of the subjects, as shown in Table 1.

The number of subjects was 20, and the data of off-line observation was conducted, and the obvious deviant test data be removed, 19 valid data were screened out.

Table 1
Statistical Analysis of EEG Behavior Data

Experimental result		Deviation task simulation	Standard task stimulation	Behavior data
Experiment one	Fault	-	81.39%	correctness
			932ms	Reaction time
	No Fault	97.77%	18.61%	correctness
		759ms	1276ms	Reaction time
Experiment two	Fault	-	92.13%	correctness
			817ms	Reaction time
	No Fault	98.68%	7.87%	correctness
		691ms	1174ms	Reaction time

In Table 1, the responded accuracy of subjects reach up to 97.77% in experiment 1, almost all correct except only a few people have non visual observation error, here is no discussed. And the reaction time in the experiment is within 760ms.

The response of the subjects to standard task stimulation can be shown as: The reaction is correct but the reaction time is too long, normal response time but response fault or reaction time is too long but wrong reaction. All of the three cases have wrong trap correspond to the experimental preset. Therefore, the accuracy and reaction time have verified the formulation of error trap of this experimental is reasonable. The EEG data of experiment 2 also have the same reasoning.

All in all, we can see that there are three cases of error in visual recognition in the experimental, for the reasons, except the error trap, the reaction time is too long also had the behavior data presentation. Reaction time and misjudgment are all should be considered.

Analysis of EEG data.

The experimental set up the error trap by color difference, obtain the EEG data of subjects, contrast and statistics behavior data to exploring the characteristics. ODDBALL experimental paradigm is used in the experiment. A total of 20 subjects were collected in this experiment, of which 18 were valid EEG data. Taking -200ms to 1200ms as the transverse coordinate time axis, observing the waveform characteristics of 0ms to 800ms time. On the basis of comparing the difference of the waveform difference between trigger11 and 12 (Figure 12) in Experiment 1 and the difference between trigger21 and 22 (Figure 13) in Experiment 2, the statistical analysis of EEG data is carried out to find the characteristics of EEG data related to the cognitive error of the digital interface visual information. And this research can provide data support for theory of data validation and optimization. After Averaging the EEG data of each subject, combining brain wave plane expansion region distribution graph, select nine contact electrode points of occipital lobe and parietal lobe which were P3, P4, P7, P8, PZ, POZ, OZ, O1, O2.

By observing the grand averaging of each electrode, N100 and P200 were extracted for each electrode in Experiment 1. N200 and P250 were extracted for each electrode in Experiment 2, ANOVA analysis of variance and T test were performed using Minitab. Searching for data, color coding advantages and internal connections between brain regions.

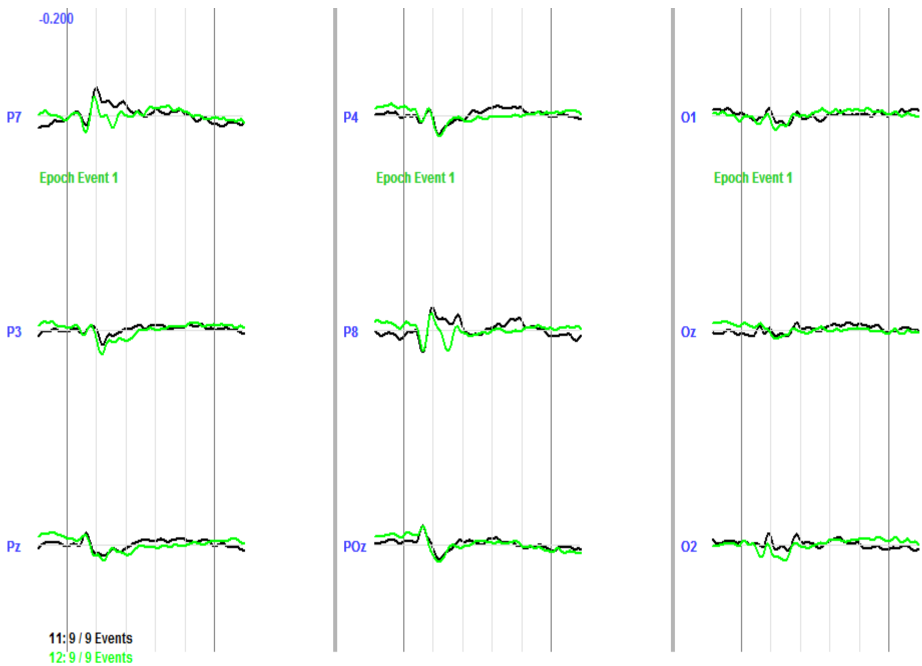


Figure 12. EGG of trigger 11 and trigger 12

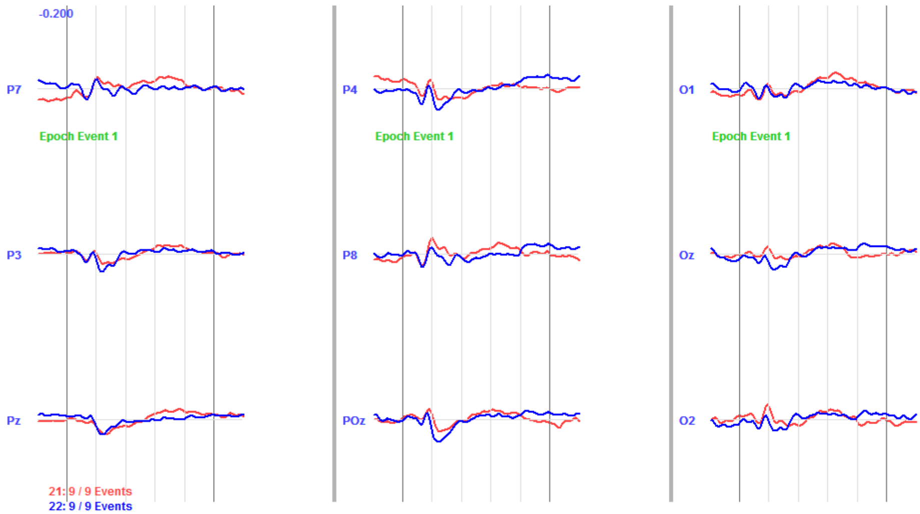


Figure 13. EGG of trigger 21 and trigger 22

(1) Analysis of N100 and P200 data in experiment 1

The peak values of color coding samples in the 50ms-150ms time interval were selected by analyzing for EEG N100 component, a general linear model was used to analyze, to explore the relationship between N100 composition and quality of experimental materials and brain regions.

Table 2
ANOVA Variance Analysis of N100

Source	degrees of freedom	F test	P test
Quality	1	0.07	0.795
Region	8	17.99	0.000

The ANOVA variance analysis shows that there is a significant effect between the emergence of the wave peak in the brain wave data and region, where the value of P test is less than 0.05. However, there are no conforming significant effect between the emergence of the wave peak in the brain wave data and quality, where the value of P test is greater than 0.05. There is no significant effect on the quality of the N100 components of EEG data indicates that there is no significant relationship between the composition of the brain wave type and the color coding design of DIVI. Therefore, the N100 component in the first experiment is no longer discussed.

As for the P200 components of EEG data, the value of the color coded samples in the 150ms -250ms time interval was selected, and analyzing the general linear model of the experimental data, to explore the relationship between the N100 components and the quality of the experimental, the brain regions, the results as table 3 shows.

Table 3
ANOVA Variance Analysis of P200

Source	degrees of freedom	F test	P test
Quality	1	9.87	0.014
Region	8	13.95	0.001

The ANOVA variance analysis shows that there is a significant effect between the emergence of the wave peak in the brain wave data and region, where the value of P test is greater than 0.05. And there is the same significant effect between the emergence of the wave peak in the brain wave data and quality. The results indicate that there is a significant relationship between P200 and the quality. Therefore, we did a further analysis of P200.

Do the T values test for the valleys of EEG wave in each electrode. P3, P4, P7, P8, PZ, POZ, OZ, O1, O2 were paired test for nine electrodes, the single sample analysis was shown in Table 4, and the results of paired T test were shown in Table 5.

We can see that the peak value of the Oz electrode produced by color coding in the single sample analysis is largest, and P3 electrode showed significant difference in the T analysis, and the P4 electrode had an approximate significant effect.

Table 4
One-Sample Statistics of the P200 Component

Trough values for good reaction	Mean	Standard deviation	Trough values for bad reaction	Mean	Standard deviation
O1	2.419	1.941	O1	2.872	2.083
O2	0.871	3.622	O2	3.330	3.239
Oz	3.116	3.252	Oz	3.89	5.49
P3	2.350	1.206	P3	3.551	2.329
P4	2.229	2.163	P4	3.401	1.294
P7	-0.42	4.91	P7	1.322	2.162
P8	-0.90	5.16	P8	1.295	2.713
Pz	2.272	3.609	Pz	2.912	1.863
POz	1.325	2.822	POz	3.405	1.786

Table 5
Paired T test of the P200 component

Pair for good and bad reaction	Mean	Standard deviation	T test	P test
O1	-0.454	2.097	-0.81	0.433
O2	-2.46	5.47	-1.68	0.117
Oz	-0.77	3.86	-0.75	0.468
P3	-1.201	1.922	-2.34	0.036
P4	-1.173	2.157	-2.03	0.063
P7	-1.74	5.67	-1.15	0.272
P8	-2.17	6.93	-1.13	0.282
Pz	-1.133	3.269	-1.30	0.217
POz	-1.587	3.214	-1.85	0.088

Table 6
ANOVA Variance Analysis of the Latency Period of P200

Source	Degrees of freedom	F test	P test
Quality	1	2.68	0.140
Region	8	1.85	0.200

(2) Analysis of N200 and P250 data in experiment 2

For the P200 components of EEG data, the Wave F peak value in the 150ms -250ms time interval of the color coded samples was selected, and analyzing the general linear model of the experimental data, to explore the relationship between the P200 components and the quality of the experimental, the brain regions, the results as table 7 shows.

Table7

ANOVA Variance Analysis of Peak Value of N200

Source	Degrees of freedom	F test	P test
Quality	1	13.51	0.006
Region	8	0.89	0.562

The ANOVA variance analysis shows that there is a significant effect between the emergence of the wave peak in the brain wave data and quality, where the value of P test is less than 0.05. And there is inconformity significant effect with region, where the value of P test is greater than 0.05. The results indicate that the peak value of the N200 component is related to the color coding of the digital interface but does not have a correlation with brain region. Therefore, there is no further discussion about P200 in Experiment 2.

For the P250 components of EEG data, the value of the color coded samples in the 200ms-300ms time interval was selected. Through the general linear model analysis of the experimental data, we explored the relationship between the P250 composition and the experimental material quality and brain region. And the analysis results shown in table 8.

Table 8

ANOVA Variance Analysis of P250

Source	Degrees of freedom	F test	P test
Quality	1	31.08	0.001
Region	8	4.44	0.025

The ANOVA variance analysis shows that there is a significant effect between the emergence of the wave peak in the brain wave data and region, where the value of P test is less than 0.05. And it is the same significant effect with quality. The results indicate that there is a significant relationship between P250 and the quality. Therefore, we did the further analysis of P200.

Do the T values test for the valleys of EEG wave in each electrode. P3, P4, P7, P8, PZ, POZ, OZ, O1, O2 were paired test for nine electrodes, the single sample analysis was shown in Table 9, and the results of paired T test were shown in Table 10.

Table 9

One-Sample Statistics of the P250 Component

Trough values for good reaction	Mean	Standard deviation	Trough values for bad reaction	Mean	Standard deviation
O1	1.229	3.313	O1	2.406	2.217
O2	0.82	4.84	O2	3.13	4.85
Oz	4.04	9.17	Oz	1.55	9.46
P3	1.815	1.974	P3	3.637	2.288
P4	2.505	3.207	P4	4.323	2.825
P7	-1.039	2.867	P7	1.786	2.031
P8	-1.24	3.79	P8	2.78	5.39
POz	2.288	2.802	POz	5.209	2.363
Pz	2.495	1.778	Pz	3.411	2.434

We can see that the peak mean value of the POz electrode produced by color coding in the single sample analysis is largest, and O1, P3, P7, POz electrode showed significant difference in the T analysis, and the Oz electrode had an approximate significant effect, where the value of P test is less than 0.05.

Table 10
Paired T test of the P250 component

Pair for good and bad reaction	Mean	Standard deviation	T test	P test
O1	-1.178	2.022	-2.18	0.048
O2	-2.31	8.93	-0.97	0.352
Oz	2.49	18.31	0.51	0.620
P3	-1.822	2.972	-2.29	0.39
P4	-1.82	4.47	-1.52	0.152
P7	-2.83	4.13	-2.56	0.024
P8	-4.01	8.06	-1.86	0.085
POz	2.921	3.629	-3.01	0.010
Pz	--0.916	2.489	-1.38	0.192

For the P250 components of EEG data, the latent period value of the color coded samples in the 200ms-300ms time interval was selected, and analyzing the general linear model of the experimental data, to explore the relationship between the P250 components and the quality of the experimental, the brain regions, the results as table 8 shows. We can conclude that there is no significant effect between the latency of P250 on color coding and brain regions, where the value of P test is greater than 0.05.

Table 11
ANOVA Variance Analysis of the Latency Period of P250

Source	Degrees of freedom	F test	P test
Quality	1	2.68	0.140
Region	8	1.85	0.200

Discussion of Experiment results

In the experimental 1, The N100 and P200 components are produced by the visual task stimulation of color coding design, in which the N100 were related to visual attention and irrelevant to color coding. While the generation of P200 EEG components has significant effects on color coding and brain regions (Figure 14).

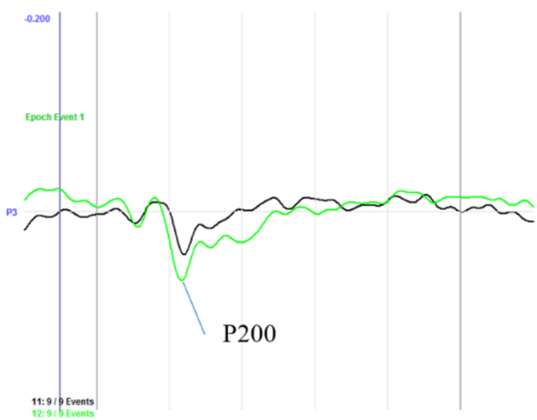


Figure 14. Comparison of P200 EEG waveforms of P3 electrode

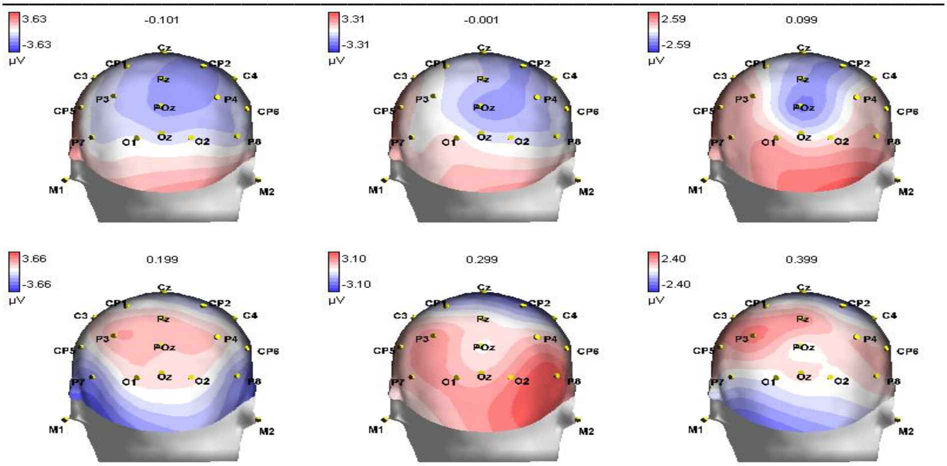


Figure 15. The topographic map of Trigger 12 in the -100ms-400ms time section

Response to the digital interface color coding, the brain generates the related P200 EEG near the P3 electrode, the greater absolute value, the more unreasonable color coding design. The comparison map of P200 EEG waveforms of P3 electrode and the topographic map of Trigger 12 in the -100ms-400ms time section as follows (Figure 15).

Processing the cognitive error data of experimental 2, we can conclude that N200 and P250 components be produced in the task. The N200 is produced by visual attention and has no relationship with color coding, but the generation of P200 has a significant effect on color coding design and brain region.

Response to the digital interface color coding, the brain produced P250 brain components near O1, P3, P7, POz electrodes. The greater absolute value, the more unreasonable design, the easier cause user misleading. The comparison map of P250 EEG waveforms of O1, P3, P7, POz electrode (Figure16) and the topographic map of Trigger 22 in the -100ms-400ms time section as follows(Figure17).

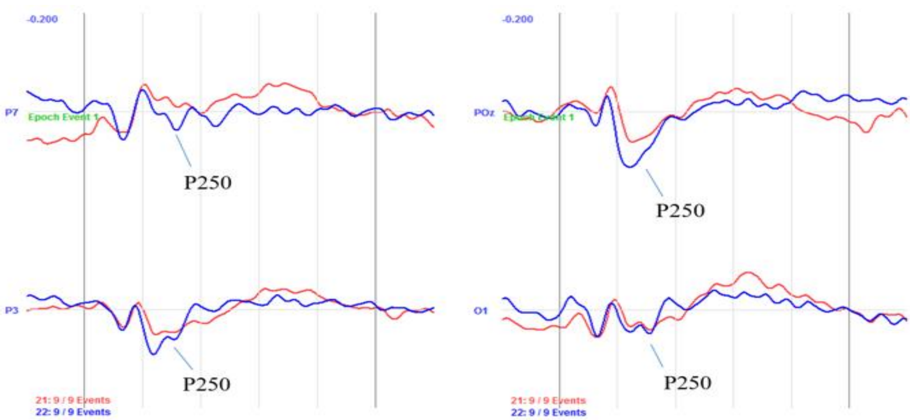


Figure 16. Comparison of P250 EEG waveforms of O1、P3、P7、POz electrode

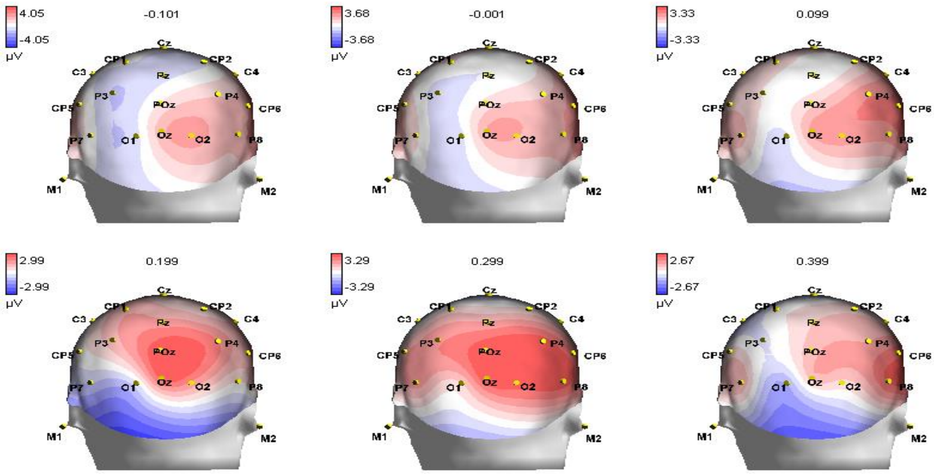


Figure 17. The topographic map of Trigger 22 in the -100ms-400ms time section

It can be seen from the statistical analysis results of the experimental data that the behavioral data and brainwave data of the EEG experiment can be used as the basis for judging the cognitive errors of the digital interface visual information.

For the difference of experiment 1 and experiment 2, there are certain otherness in EEG components and topographic map. The color coding of experiment 1 set to overlap type, like two panels with different sizes and colors; while the color coding of experiment 2 set to parallel type, same as different panels with different color.

On the one hand, the difference in color coding classification enriches the physiological data of cognitive error. On the other hand, it also indicated that there are many branches in the stratified model of digital interface cognitive error. All of this will help the establishment of research method of cognitive error.

Conclusion

Take advantage of electroencephalogram (EEG) physiological experiments to analysis the visualization cognitive errors (VCE) could help designers understand the cognition process of digital interface visual information (DIVI) by different users and improve the overall efficiency of digital interface design. Based on the composition of DIVI, VCE of DIVI were analyzed from color and layout difference. According to the experimental factors of the error trap, this paper designed two EEG physiological experiments to study the behavioral responses and EEG responses of the brain to DIVI. In order to improve the versatility of experimental conclusions in digital interface design, the EEG physiological experiments in this paper was designed under the Oddball experimental paradigm. And the experimental materials include the digital interface of PC terminal and mobile terminal.

The results of Experiment 1 show that the N100 and P200 components are produced by the stimulation of color coding, N100 components are related to visual attention not color coding design, while the generation of P200 components has significant effects on color coding and brain regions. The greater absolute value, the more unreasonable color coding design, the easier cause user misleading.

The analysis results of Experiment 2 shows that the N200 and P250 components are produced by the stimulation of color coding, N200 components are related to visual attention not color coding design, while the generation of P200 components has significant effects on color coding and brain regions. The greater absolute value of P250 components which produced near O1, P3, P7, POz electrode, the more unreasonable design, the easier cause user misleading.

However, EEG components and EEG topographic maps related to digital interface visual information cognition may vary significantly due to differences in visual information materials. In addition, the differences in experimental results brought by different experimental materials can enrich the interpretation of VCE through EEG physiological data. The research in this paper also indicates that there are many branches in the EEG experiments to analysis the VCE of DIVI. It is helpful to improve the reliability of digital interface design by perfecting the EEG physiological experiments of these branches.

In this paper, the progress of teaching EEG in user interface be divided into these steps: First, gave the concept of methodologies contain theories of cognitive neuroscience and the factors of User Interface; Second, exploring the relationship of visual system and interface factors beyond methodologies. The color coding corresponding “What” visual pathway and layout factor of dashboards corresponding “Where” visual pathway gave a clearly interpretation for learning mechanism of the experimental in our study. In this stage students got the general idea of the recognition of interface in human brain visual system, but it is not near enough. Therefore, in the third stage, we should give a specific concept of the experimental with more examples interpretation, help to research subject generation and to fulfil the concept gap, Forth, EEG physiological experimental for VCE of DIVI, in this section experimental method, experimental design and experimental progress in details. Fifth, analysis of experiment data, behavior data, EEG data and discussion of experiment results setting according to an original experimental routine. Students learn how to use them immediately in practice. The results have important practical for the design education of curriculum setting.

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