

The effect of the Panbrain EC2 on emotional regulation

1. Introduction

Emotions are the psychological and physiological reactions that humans have when facing internal and external stimuli. With the increasing pressure in modern society, the occurrence of mood swings and mild mood disorders is gradually increasing, which can easily lead to problems such as anxiety, depression, stress, etc., thereby affecting an individual's quality of life and work performance. Studying emotion regulation strategies is of great significance for mental health intervention and disease prevention.^[1]

In recent years, with the continuous development of neuroscience, non-invasive brain stimulation technology, as a new intervention method, has gradually become an important tool for emotion regulation.^[2] Among them, transcranial direct current stimulation (tDCS) regulates the excitability of the cerebral cortex through microcurrent, and has been proven to have positive effects in improving emotional states and alleviating anxiety and depression.^[3, 4] It can improve the brain's ability to respond to emotional stimuli, thereby positively regulating emotions. This study was conducted based on the Panbrain EC2 (Shenzhen Panbrain Technology Co., Ltd., using tDCS technology), aiming to evaluate the emotional regulation effect of this device.

2. Experimental method

2.1 General information

Table 1 Comparison of the general information of the two groups of subjects

Group	n	Age (years, $\bar{x} \pm s$)	Gender (n)	
			Male	Female
Stimulation	26	33.73±7.07	14	12
Control	26	30.31±5.43	11	15
t/χ^2		1.957		0.693
P		0.056		0.405

This study recruited social groups. After screening, 52 subjects were finally included and divided into stimulation group and control group using random number table method, with 26 subjects in each group. Comparing the general information of the two groups of subjects, the difference was not statistically significant. See Table 1.

Inclusion criteria: (1) Self-reported negative emotions in the past week, Simplified Chinese version of the Depression Anxiety and Stress Scale, DASS-21) score ≥ 14 points, and the negative mood subscale score of the Positive-Negative Affectiveness Scale (PANAS) ≥ 20 points; (2) no mental illness now or in the past; (3) age ≥ 18 years old; (4) voluntarily participate in the trial and sign the informed consent form.

Exclusion criteria: (1) People with organic diseases such as epilepsy and heart disease; (2) People who are sensitive or intolerant to DC stimulation; (3) People with skin lesions or skull defects in the affected area; (4) People with electronic devices (such as pacemakers) implanted in the body and metal foreign bodies in the skull;

2.2 Intervention

The stimulation group uses the Panbrain EC2 for tDCS treatment. The electrode sleeve is fixed on the electrode after being soaked in 0.9% sodium chloride solution. According to the 10-20 international standard system, the anode electrode is placed in the left dorsolateral prefrontal cortex (i.e., area F3), and the cathode electrode is placed in the right dorsolateral prefrontal cortex (i.e., area F4). Each treatment lasted 15 minutes, once a day, 5 days a week, for 4 consecutive weeks (20 sessions).

The operation of the control group was the same as that of the stimulation group, but no current stimulation was applied during the treatment process.

2.3 Evaluation indicators

Before treatment and after the completion of 4 weeks of treatment, the simplified Chinese version of the Depression-Anxiety-Stress Scale (DASS-21) and the negative emotion subscale of the Positive-Negative Affect Scale (PANAS) were used to evaluate the emotional state of the subjects.

DASS-21 is a widely used self-report scale that contains 21 items to assess an individual's depression, anxiety and stress status respectively.^[5] Each dimension consists of 7 items, and subjects rate their emotional state in the past week on a scale from 0 (never) to 3 (always). In this experiment, the total score of DASS-21 was used to reflect the comprehensive score of negative emotions, with the score ranging from 0 to 63. The higher the score, the greater the severity of the negative emotions.

The Positive-Negative Affectiveness Scale (PANAS) is also a widely used emotional scale,^[6] in which the negative emotional subscale can be used to overall assess an individual's negative emotional state. In this study, professionals assessed an individual's emotional experience over a period of time based on the individual's behavioral performance and question-and-answer situations. It included a total of 10 items, each item scored from 0 to 4 points, and the total score ranged from 0 to 40 points. The higher the score, the higher the level of negative emotions. Generally speaking, a total score of more than 20 points represents a high level of negative emotions.

After the scale evaluation, the scores of DASS-21 and PANAS are converted into a percentage scale, and the composite score is calculated based on the weight of DASS-21 accounting for 50% and PANAS accounting for 50%. The specific calculation method is as follows:

$$\text{Score} = \frac{\text{DASS}}{63} \times 100 \times 50\% + \frac{\text{PANAS}}{40} \times 100 \times 50\%$$

2.4 Statistical method

SPSS 27.0 software was used for data analysis. The Continuous data are expressed as mean $\pm$ standard deviation ($\bar{x} \pm s$), and the t test is used for comparison; the Categorical data are expressed as counts (n), and the χ^2 test is used for comparison. $P < 0.05$ was considered as a statistically significant difference.

3. Test results

Before treatment, there was no statistically significant difference in the DASS, PANAS and composite scores of the two groups of subjects ($P \geq 0.05$); after 4 weeks of

Table 2 Comparison of DASS scores of the two groups of subjects before and after treatment ($\bar{x} \pm s$)

Group	Before	After	<i>t</i>	<i>P</i>
Stimulation	23.73±5.76	13.69±3.98 ^{ab}	-7.5224	<0.001
Control	22.19±4.79	19.85±4.72 ^a	-2.454	0.021
<i>t</i>	1.047	-5.082		
<i>P</i>	0.300	<0.001		

Note: Compared with before treatment, ^a*P*<0.05; Compared with the control group, ^b*P*<0.05;

Table 3 Comparison of PANAS scores of the two groups of subjects before and after treatment

($\bar{x} \pm s$)				
Group	Before	After	<i>t</i>	<i>P</i>
Stimulation	28.96±4.14	16.77±5.59 ^{ab}	-10.316	<0.001
Control	28.15±3.67	27.12±3.23 ^a	-6.845	<0.001
<i>t</i>	0.744	-8.174		
<i>P</i>	0.460	<0.001		

Note: Compared with before treatment, ^a*P*<0.05; Compared with the control group, ^b*P*<0.05;

Table 4 Comparison of the composite scores of the two groups of subjects before and after

treatment ($\bar{x} \pm s$)				
Group	Before	After	<i>t</i>	<i>P</i>
Stimulation	55.04±9.12	31.83±8.88 ^{ab}	-9.779	<0.001
Control	52.81±6.84	49.65±4.48 ^a	-3.822	<0.001
<i>t</i>	0.998	-8.978		
<i>P</i>	0.323	<0.001		

Note: compared with before treatment, ^a*P*<0.05; compared with the control group, ^b*P*<0.05;

treatment, the scores of the two groups of subjects were significantly lower than before treatment (*P*<0.05), and the stimulation group's score dropped significantly

more than the control group, and the difference was statistically significant ($P<0.05$). See Table 2-4.

4. Test conclusion

This study shows through a randomized controlled trial that the Panbrain EC2 using tDCS technology can significantly improve individuals' negative emotions after 4 weeks (20 sessions). The results showed that the DASS-21 score of the stimulation group decreased by 42.30% ($P<0.05$) with a responder rate of 84.62%; the PANAS subscale score decreased by 42.10% ($P<0.05$) with a responder rate of 84.62%; the composite scores decreased by 42.17% ($P<0.05$) with a responder rate of 88.46%. In contrast, the DASS-21 score of the control group only decreased by 10.57% ($P<0.05$) with a responder rate of 65.38%. PANAS subscale score decreased by 3.69% ($P<0.05$) with a responder rate of 73.08%. The composite scores dropped by 5.98% with a responder rate of 69.23%. Comparison between groups showed that the reduction in various indicators in the stimulation group was significantly greater than that in the control group, and the difference was statistically significant ($P<0.05$). This shows that as a non-invasive neuromodulation device, the Panbrain EC2 can provide a safe and feasible intervention option for individuals with more negative emotions.

References

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Appendix A

Table A.1 General information and scores of the two groups of subjects

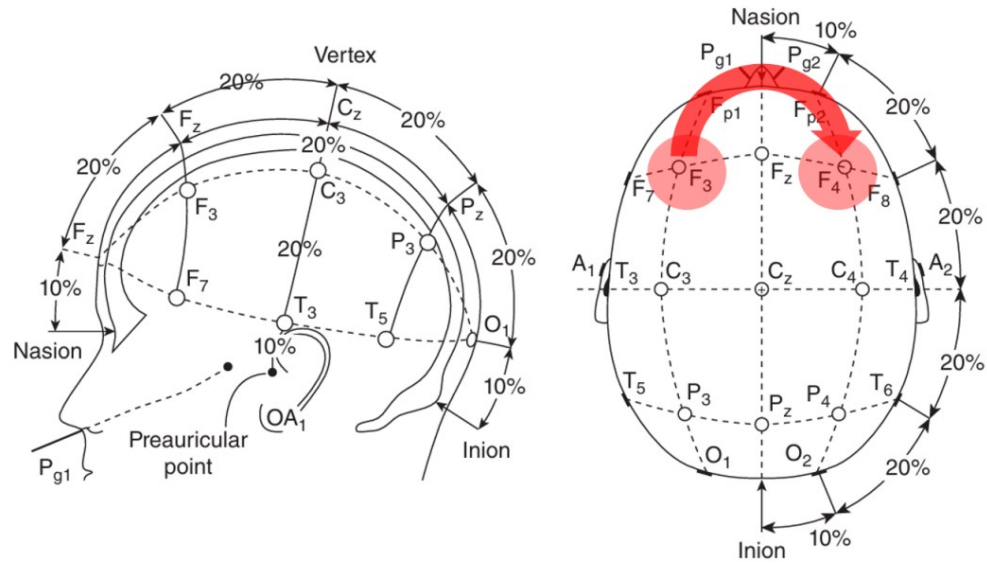
Group	Subject	Gender	Age	Before treatment			After treatment		
				DASS	PANAS	Composite scores	DASS	PANAS	Composite scores
Stimulation group (1~26)	1	Female	33	26	28	55.63	10	11	21.69
	2	Male	40	20	25	47.12	22	14	34.96
	3	Male	19	27	31	60.18	13	15	29.07
	4	Female	35	28	26	54.72	16	15	31.45
	5	Male	32	24	26	51.55	12	10	22.02
	6	Female	24	23	34	60.75	9	20	32.14
	7	Male	28	15	23	40.65	7	13	21.81
	8	Female	32	19	27	48.83	20	27	49.62
	9	Male	49	32	36	70.40	16	23	41.45
	10	Female	45	18	32	54.29	10	18	30.44
	11	Male	23	30	29	60.06	16	13	28.95
	12	Female	46	25	28	54.84	14	13	27.36
	13	Female	34	33	35	69.94	13	20	35.32
	14	Male	30	14	24	41.11	19	24	45.08
	15	Male	34	23	27	52.00	6	10	17.26
	16	Male	29	17	22	40.99	8	10	18.85
	17	Female	30	26	30	58.13	13	17	31.57
	18	Male	38	29	33	64.27	16	19	36.45
	19	Male	38	32	37	71.65	16	21	38.95
	20	Female	38	18	25	45.54	15	14	29.40
	21	Male	34	21	29	52.92	13	14	27.82
	22	Female	24	22	31	56.21	12	10	22.02
	23	Female	34	31	34	67.10	11	16	28.73
	24	Male	39	22	29	53.71	14	30	48.61
	25	Female	33	28	28	57.22	18	14	31.79
	26	Male	36	14	24	41.11	17	25	44.74

Table A.1 General information and scores of the two groups of subjects

Group	Subject	Gender	Age	Before treatment			After treatment		
				DASS	PANAS	Composite scores	DASS	PANAS	Composite scores
Control group (27~52)	27	Female	29	22	28	52.46	16	26	45.20
	28	Male	29	19	26	47.58	17	25	44.74
	29	Female	38	15	22	39.40	19	22	42.58
	30	Male	32	27	31	60.18	18	29	50.54
	31	Female	31	26	27	54.38	16	27	46.45
	32	Female	39	24	25	50.30	26	24	50.63
	33	Female	26	16	33	53.95	13	32	50.32
	34	Male	34	31	35	68.35	25	33	61.09
	35	Male	35	26	29	56.88	21	28	51.67
	36	Male	29	22	24	47.46	19	23	43.83
	37	Female	32	24	32	59.05	20	30	53.37
	38	Female	24	22	25	48.71	14	24	41.11
	39	Female	24	15	23	40.65	18	23	43.04
	40	Male	31	22	26	49.96	25	25	51.09
	41	Male	34	19	27	48.83	20	27	49.62
	42	Female	44	18	29	50.54	19	27	48.83
	43	Male	27	17	30	50.99	15	29	48.15
	44	Female	31	21	31	55.42	19	29	51.33
	45	Female	30	14	25	42.36	20	24	45.87
	46	Male	20	30	34	66.31	22	32	57.46
	47	Female	28	27	30	58.93	17	30	50.99
	48	Male	21	24	27	52.80	18	26	46.79
	49	Female	35	24	26	51.55	31	25	55.85
	50	Female	26	19	35	58.83	15	33	53.15
	51	Female	31	30	24	53.81	32	24	55.40
	52	Male	28	23	28	53.25	21	28	51.67

Appendix B

Diagram of intervention points based on the 10-20 international standard system



Appendix C Simplified Chinese version of the Depression-Anxiety-Stress Scale
(sample format)

Depression anxiety and stress scale, DASS-21

No.: _____ Date of Completion: _____ Gender: ☐ M ☐ F Age: _____

Based on the situation in the past week, select the level of options that apply to your situation in each item. (mark your answer with “ ✓ ”)	Rating			
1. I find it difficult to calm down.	0	1	2	3
2. My mouth feels dry.	0	1	2	3
3. I don't seem to feel any pleasure or comfort at all.	0	1	2	3
4. I have difficulty breathing (e.g. wheezing or feeling out of breath).	0	1	2	3
5. I find it difficult to take the initiative to start work.	0	1	2	3
6. I tend to have allergic reactions to things.	0	1	2	3
7. I feel shaky (for example, my hands shake).	0	1	2	3
8. I feel like I use up a lot of energy.	0	1	2	3
9. I worry about situations where I might panic or make a fool of myself.	0	1	2	3
10. I feel like I have nothing to look forward to in the near future.	0	1	2	3
11. I feel uneasy.	0	1	2	3
12. I find it difficult to relax.	0	1	2	3
13. I feel depressed.	0	1	2	3
14. I cannot tolerate anything that prevents me from continuing to work.	0	1	2	3
15. I feel like I am about to collapse.	0	1	2	3
16. I can't be enthusiastic about anything.	0	1	2	3
17. I feel that I am not worthy of being a human being.	0	1	2	3
18. I find myself easily offended.	0	1	2	3
19. I experience an abnormal heart rhythm even when I am not physically active.	0	1	2	3

20. I feel scared for no reason.	0	1	2	3
21. I feel that life is meaningless.	0	1	2	3

Note: All items adopt a 4-level scoring method from 0 to 3 points. The standards for each level are: "0" means not in compliance, "1" means sometimes incompatibility, "2" means often in compliance, and "3" is always in compliance.

The following information is summarized by the evaluator based on the
information filled in by the subjects

Total score T_____ = _____×1 + _____×2 + _____×3

Evaluator:_____

Appendix D Positive-Negative Affect Scale (Negative Affect Subscale, sample format)

Positive and Negative Affect Schedule, PANAS

No.: _____ Date of Completion: _____ Gender: ☐ M ☐ F Age: _____

The following information is filled in by the evaluator based on the interview with the subject

Project	Performance	Rating				
1. Upset	Frequent frowning or drooping of the corners of the mouth, short and stiff speech, fidgeting or repeatedly fiddling with objects, and loss of patience with daily tasks.	0	1	2	3	4
2. Guilt	Avoiding eye contact with the other person, repeatedly apologizing or over-explaining, self-deprecating language (such as "It's all my fault"), curling up, lowering your head and covering your chest.	0	1	2	3	4
3. Panic	Dilated pupils, rapid breathing, trembling or cold sweating, screaming or making meaningless syllables, freezing in place and unable to move.	0	1	2	3	4
4. Hostility	Crossing arms in a defensive posture, provocative or sarcastic language, deliberately violating rules/social etiquette, staring or rolling eyes.	0	1	2	3	4
5. Irritability	Extremely sensitive to slight noises, frequently smacking the tongue or making "tsk" sounds, slamming doors/throwing objects to vent, and suddenly raising the volume over trivial matters.	0	1	2	3	4
6. Shame	Blushing to the roots of the ears, covering the face with hands or turning away, speaking at a significantly lower volume, and deliberately hiding the things that cause shame.	0	1	2	3	4
7. Nervousness	Frequent swallowing or licking lips, checking the same thing repeatedly, legs shaking unconsciously, speaking faster or stammering.	0	1	2	3	4
8. Restlessness	Unable to maintain a sitting position for more than 1 minute, tapping fingers on the table quickly,	0	1	2	3	4

	frequently getting up and pacing and sitting down, short and irregular breathing.					
9. Afraid	Huddle in corners/behind shelters, teeth chatter or lips turn white, make gasping/gasping sounds, and hold on to objects around you with both hands.	0	1	2	3	4
10. Trembling	The pupils are trembling irregularly, the speech is incoherent and the logic is confusing, the hands are tightly grasping the clothes on the chest, and the back/palms are soaked in cold sweat.	0	1	2	3	4

Note: All items adopt a 5-level scoring method of 0-4 points. The standards for each level: "0" means completely inconsistent, "1" means somewhat inconsistent, "2" means somewhat consistent, "3" relatively consistent, and "4" means very consistent.

Total score T ____ = ____ × 1 + ____ × 2 + ____ × 3 + ____ × 4

Evaluator: _____