The Neural Mechanism of Positive Emotion and the Effect of AI + Education on It

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Manuscript submitted August 26, 2019; accepted May 8, 2020.
doi: 10.17706/ijeeee.2020.10.3.274-282

Abstract: Cognitive psychology, represented by the expansion-construction theory, believes that positive emotions can broaden the scope of cognition, promote cognitive processes such as creative problem solving, executive control, cognitive flexibility, attention and decision-making. However, they cannot explain the phenomena in some experiments that are contrary to this conclusion. Thus, the motivational dimension model came into being. The theory believes that the effect of emotion on cognition is related to the motivation of emotion rather than its valance. After combing the literatures, it was found that dopamine mediates the positive emotions promoting cognitive activities. The activation of frontal lobe, anterior cingulate cortex, orbitofrontal cortex, hippocampus and amygdala are all the brain mechanisms for positive emotions. Looking ahead, further research on neurophysiological mechanisms will promote scholars' more comprehensive and profound understanding of positive emotions. AI + education refers to the deep integration and development of artificial intelligence and education, taking the application of artificial intelligence based on education scenes as the path to promote education equity, improve education quality and realize education personalization. It can better perceive students' dynamic learning path and emotional change, and the teaching effect is better.

Key words: AI + education, positive emotions, cognitive neural mechanism, brain limbic systems.

1. Introduction

Positive emotions refer to the emotions accompanied by pleasant feelings, including happiness, interest, satisfaction, pride, love, etc., caused by stimulation inside and outside the body or by meeting the needs of events. Positive emotions are conscious process which includes pleasure experience, facial or physical expression, evaluation, behavior planning and activation state.

In daily life, emotions often accompany the cognitive process of people, and the impact of positive emotions on cognitive activities and the study of its neurological mechanism has gradually become a hot topic of concern for scholars at home and abroad in recent years.

No matter in academia or industry, they have basically reached a consensus on the development concept of AI + education, that is, taking learners as the center, from external technology assistance to internal technology penetration. The academic community will continue to explore the adaptability of teaching objectives and machine rules, and develop key technologies under specific education scenarios. For players in different development stages, high-quality data resources with differentiated competitive advantages will become a breakthrough point in their competition, and more application scenarios can be explored in the current special education field or other subdivisions of the track. AI + education is also helpful to promote

positive emotions in education.

2. The Influencing Factors of the Promoting Effect of Positive Emotional Cognition

2.1. Past Research

Positive emotions affect the cognitive process in a broad spectrum. Studies discovered that individuals with positive emotions show extraordinary, flexible, creative, integrated, open-minded, effective thinking patterns (Fredrickson, 2001). Positive emotions promote cognition not only in processing speed and accuracy, but also in changing cognitive functions at category and level, and in causing changes in cognitive structure in information processing, which is by affecting cognitive processes from both qualitative and quantitative aspects (Guo Xiaoyan, 2008).Past experiments supporting positive emotions to promote cognition can be concluded as broadening the scope of cognition and increasing flexibility [1].

2.1.1. Positive Emotions Broaden the Scope of Cognition

2.1.1.1. Positive Emotions Broaden Attention and Classification

Fredrickson on the expansion-construction theory claims that positive emotions can expand people's sequence of instantaneous thinking activities. The study found that positive emotions are associated with a broadening of the scope of attention. Fredrickson used the film to induce four emotional states: happiness, satisfaction, anger and anxiety, and using a neutral mood as a control, and then assessing subjects' attention in different emotional states. He found that in two positive emotional states, subjects had a greater degree of attention than the subjects in the neutral state [2].

The broadening effect of positive emotions on classification can be reflected in many tasks, such as the classification of natural projects used by Rosch *et al*., as well as the classification tasks that determine whether people belong to a particular social group (Ashby, Isen & Turken, 1999). Positive emotions increase the tendency of subjects to classify less typical things into a predefined category (Kahn & Isen, 1993).

2.1.1.2. Positive Emotions Promote Problem-solving Ability

Positive emotions can foster a feeling of connection and help to solve creative problems. For instance, positive emotions in an organizational setting can influence the decision making of executives, solving confliction, group behavior and perception of job duties (Isen *et al*., 1987). The studies show that positive emotions encourage the capacity of a person to organize thoughts in a multitude of ways [3].

In Ashby's experiment, subjects were randomly allocated to a group of neutral emotions and positive emotions, using distinct easy methods to induce positive emotions, and completing multiple assignments to test creative problem solving, and the finding were coherent.

2.1.2. Positive Emotions Promote Cognitive Flexibility

Cognitive flexibility refers to the ability to switch to another thought or behavior in response to a change in context to meet the needs of a new situation. It adapts our response to the needs of the current task, enabling individuals to produce optimal responses in a specific task context.

Dunker's candle task is a typical experiment which indicates creativity and cognitive flexibility. Isen *et al.* also found that subjects in the positive emotion group were more likely to find a solution than those in the neutral emotion group and the negative emotion group, and the difference was significant.

Execution functions can be described as the flexibility and information processing strategies to solve problems and achieve goals. Herrington used emotional Stroop task, finding the response time of positive emotional words is slightly shorter than that of negative emotional words, but the difference does not reach a significant level.

2.2. Motivation Dimension Model

2.2.1. Critique of Expansion-Construction Theory

In the past, models of positive emotions and cognitive relationship believed that positive emotions caused broaden of cognition and resulted in enhanced cognitive flexibility. However, sometimes they may have divergences in predictions and the broadened perspective predicts the expansion of attention (the overall preference), while the cognitive flexibility perspective cannot make this prediction. Gable and Harmon-Jones recently proposed the motivational dimensional model, which argues that the narrowing or broadening of attention and cognition is caused by motivational intensity rather than emotional valence.

The reason why past research has concluded that positive emotions enhance cognition is because the motivation of positive emotions induced is relatively low, thus broadening the cognitive process. In the past, the method of inducing positive emotions was to give unexpectedly small gifts (such as candy) to the subjects, to see pictures that caused positive emotions or comedy, or to imagine pleasant events and to report success in the task etc.

2.2.2. The Influence of Positive Emotions on Memory under Motivation Dimensional Model

2.2.2.1. Influence on attention

Gable and Harmon-Jones predict that positive emotions with high approach-motivated intensity will narrow the focus. In the first experiment, they used funny movies to induce low approach-motivated positive effects. The film of delicious snacks induced high approach-motivated positive effects. In addition, they found low approach-motivated positive movies induce more general focus of attention than films with high approach, illustrating that high approach-motivated reduce broadening of attention.

In addition, Gable found individual with high traits and high motivations showed a narrower range of attention to approaching motivational stimuli, indicating that trait approach motivation can also influence cognitive processes. It is further confirmed that the phenomenon of narrowing the scope of attention is that the approaching motive is at work.

2.2.2.2. Influence on memory

Gable and Harmon-Jones also examined the effects of positive emotions with different approaching intensities on memory. It is found that the stimulating memory presented in the center of visual zone is better in high approach-motivated positive state, while the stimulating memory presented in the outer periphery of visual zone is better in the low approach-motivated positive state. Thus, the positive emotions of low approach motivations have led to the broadening of cognitive resources and the promotion of peripheral memory [4].

3 The Neural Mechanism of the Promoting Effect of Positive Emotional Cognition

3.1. The Effect of Dopamine-Mediated Positive Emotions on Cognition

Ashby *et al*. proposed a neuropsychological theory regarding to how positive emotion promotes cognition. He argued that positive emotions can influence varies aspects on behavior and cognition, such as promoting creativity to solve the problem and improving cognitive flexibility. Such influences are accomplished through dopamine-mediated system. The midbrain limbic system, which consists of dopamine-producing cells, projects to ventral tegmental area (VTA) of the marginal and cortical areas. This system is important because it is related to reward and motivation. There are also other important projections of dopamine (as shown in Fig. 1) may be contributed to the neural mechanism of positive emotions on cognitive effects.

Recent study shows that the improvement of ability to solve creative problems is due to that the association of positive emotional states with increasing level of dopamine in frontal cortex. This theory is based on two assumptions according to VTA projection: First, positive emotions can change the processing of any structure receiving direct projections from the VTA. Second, modifications of behavior induced by positive emotions

may not be mediated through structures which do not receive direct projection from the VTA (Ashby *et al.*, 1999).

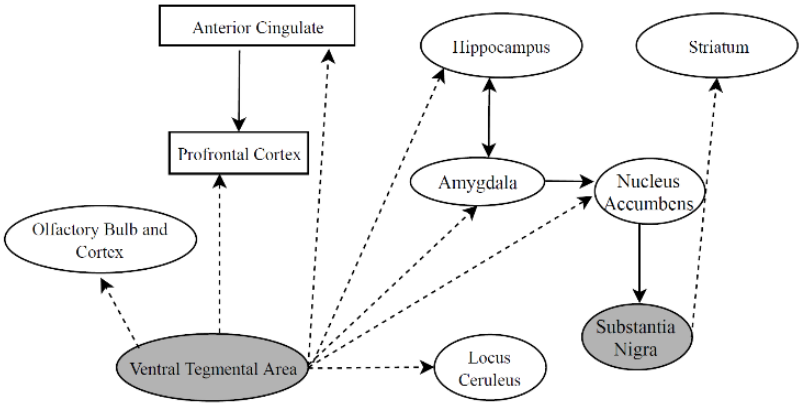

Fig. 1. Schematic diagram of dopamine production and projection in the human brain.
Note: Gray represents the dopamine producing region and the dotted line represents the dopamine projection region.

The release of dopamine has a strong association with positive emotions and can be measured through the enhancement of motor system. In experimental conditions, the increase of dopamine level causes people "dancing" and "jumping" happily and this excitement can indicate the promotion of motor activity. By contrast, if the neural pathway of dopamine production or mediation is interrupted, the motor system may have dysfunction. The most famous example is Parkinson's disease, which is caused by the senescence of dopamine-producing cells. This disease can be treated by the supplementation of L-dopa, which can be synthesized to generate dopamine in substantia nigra. Evidence shows that the major depression is associated with the lack of release of dopamine. Knowing that dopamine can mediate positive emotions on cognition, and it is likely to treat the depression through the stimulation of VTA, which can stimulate substantia nigra to release the dopamine and eventually elevate the mood.

Experiments showed that a decrease in dopamine levels is linked to an absence of enjoyment rather than negative emotions. Ashby speculates that the relationship between dopamine concentrations and performance of tasks may be inverted U-shaped, so an increase or decrease in dopamine would affect performance from optimal level.

According to the motivation dimension model, the positive effect of positive emotion on cognition in the motivational approach intensity may also be distributed as reversed U-shaped. Yet, no literature shows if there is a correlation between the level of dopamine and the intensity of positive emotions.

In fact, in comparison to the induced mild positive emotions and neutral emotions, not only the rise of dopamine levels was discovered in every brain region, but also in peripheral blood circulation system. In addition, the activity of natural killer cells under positive emotions also increases. It is important to note that in addition to dopamine, there are other neurotransmitters and neuromodulators that can affect positive emotions [5].

3.2. Brain Mechanism of Positive Emotion on Cognition

Positive emotion-related brain regions include reward centers, midbrain margins, basal ganglia, orbitofrontal cortex, nucleus accumbens, amygdala, ventral substantia nigra, etc (Li Xinwang *et al.*, Shi Changdi, Jiang Chaohao, 2009). Different positive emotions also have different activation sites. For example, animal study shows that amygdala participates in approaching relationship of positive emotions (Wang Yanmei, 2006) .The positive emotional state of "before the target" and "after the target" mentioned in the

motivation dimension model is related to different modes of neural activation in the prefrontal cortex, nucleus accumbens, anterior cingulate cortex and hippocampus.

3.2.1. Prefrontal Lobe

The prefrontal cortex is located at the forefront of the brain and is mainly divided into the dorsolateral area and the sacral area. Prefrontal cortex has a wide range of connection with the cerebral cortex and subcutaneous structures, and it plays an integral role in behavior control.

Some effects of positive emotions on cognition may be regulated by dopamine levels in the prefrontal cortex as the ability to overcome dominant responses is increased and cognitive flexibility is promoted. The projection of dopamine into prefrontal cortex enhance the working memory and normal operation of memory system. The improvement of memory results in the induction of positive feelings. However, an extreme level of dopamine may eventually decrease the working memory and thus disrupt the positive emotion. Thus, a moderate level of dopamine can trigger the optimal effect of positive emotion.

A neurophysiological study (Gable *et al*., 2010) suggests that attentional local preferences resulting from high approach-positive emotions are associated with potential asymmetry in the central and top regions of the frontal lobe. The high approach-positive emotion causes the left frontal cortex to activate more than the right side and the late positive potential caused by the appetite-stimulated picture is relatively high in the left frontal cortex. This also provide support for motivational dimension model (Price & Harmon-Jones, 2010).

The above experimental results show that the frontal lobe should be responsible for the brain mechanism of positive emotions on cognitive processes such as cognitive flexibility, executive function and attention. In addition, the induced approaching positive emotions can alter the asymmetry of prefrontal cortical EEG activation. (Davidson, Jackson & Kalin, 2000; Gable *et al*., 2010) Therefore, the prefrontal cortex may be extremely important to study the physiological mechanism.

3.2.2. Anterior Cingulate Cortex

The cingulate cortex is arched around the callosum and consists of important contact fibers in the limbic system. (Sun Jiurong, 2004) The anterior cingulate cortex is brought back to the inside of brain and is responsible for execution function (see Fig. 2). There is a significant dopamine projection from the VTA to anterior cingulate cortex. Many studies argue that this projection may involve in several kinds of cognitive-related effects. (Ashby *et al*., 1999), thus associating with the effect of positive emotion on cognition.

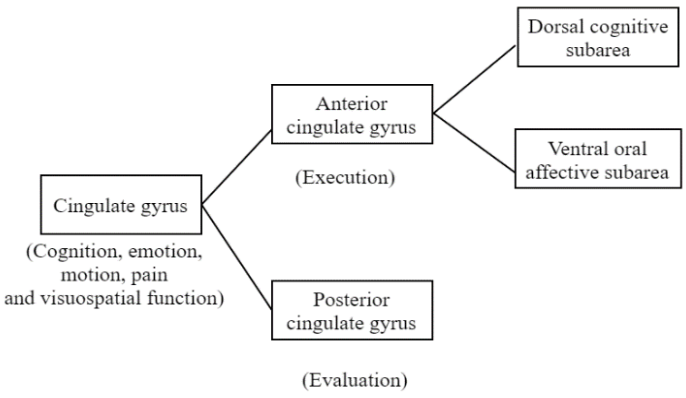

Fig. 2. Classification and function of cingulate gyrus.

The projection from VTA to anterior cingulate cortex facilitates various types of cognitive functions. Different areas are responsible for different function. In addition, if those areas are stimulated by electric impulse, it can elicit different emotional response such as happy, anger and sadness. The neuroimaging techniques also demonstrates activation of anterior cingulate in people during the transition of emotion from sad to happy. Therefore, anterior cingulate plays an important role to facilitate a positive emotion.

Experiments show that the projection of dopamine to the anterior cingulate cortex favors the selection or switching of executive attention and cognitive perspectives. (Ashby *et al*., 1999) Similarly, the anterior cingulate cortex also plays a role in the impact of positive emotions on the conversion task. Wang Yanmei used emotional pictures to induce positive emotions and shows that positive emotions enhance the intensity and range of the activity in anterior cingulate cortex. The main function of the anterior cingulate cortex in the transition is to monitor the distribution of attentional orientation and establish a new attention orientation.

3.2.3. Other Related Brain Regions

3.2.3.1. Orbitofrontal cortex

The Orbitofrontal cortex is located at the base of frontal lobe and is a brain region that characterizes the value of stimulus rewards. (Li Xinwang *et al*., 2008) The orbitofrontal cortex characterizes the reward or emotional value of the primary enforcement to characterize the goal of the action and thus has a key effect on the emotion. Its damage may affect emotional learning and behavior. (Rolls, & Grabenhorst, 2008)

When a happy picture is processed or expected for a reward, the orbitofrontal cortex is activated. Studies found that highly attractive faces facilitate the activation of medial orbitofrontal cortex. Researchers conclude that this area can characterizes the value of stimulus reward. Highly attractive faces are valuable rewards and thus can trigger positive emotion.

In the past fMRI studies using emotional images, positive emotions were found to be closely related to the medial orbitofrontal cortex. Each evidence reminds the researchers that when discussing the role of emotions in cognition, the role of orbitofrontal cortex should not be underestimated.

3.2.3.2. Hippocampus and amygdala

Positive emotion can trigger the release of dopamine, which can project from VTA into hippocampus to stimulate the production of acetylcholine, thus improving the episodic memories. Evidence also shows that positive emotions can enhance the recall of positive materials rather than negative memories.

The amygdala is composed of multiple nucleus, mainly including the basolateral nucleus, the cortical medial nucleus and the central nucleus. They have two-way neural connections with hypothalamus, thalamus, hippocampus and cerebral cortex. Studies has demonstrated the role of the amygdala in negative emotions, such as fear and aversive feelings. By contrast, some studies also found that amygdala is also participated in the processing of positive emotions. For example, Morris J S *et al*. found that the responses of subjects to different valency emotion pictures found that positive emotion pictures triggered activation of the left amygdala, whilst negative emotion pictures triggered the activation of bilateral amygdala.

4. A Study of AI + Education on Positive Emotion Promoting Education and Learning

No matter in academia or industry, they have basically reached a consensus on the development concept of AI + education, that is, taking learners as the center, from external technology assistance to internal technology penetration. The academic community will continue to explore the adaptability of teaching objectives and machine rules, and develop key technologies under specific education scenarios. For players in different development stages, high-quality data resources with differentiated competitive advantages will become a breakthrough point in their competition, and more application scenarios can be explored in the current special education field or other subdivisions of the track. AI + education is also helpful to promote positive emotions in education [6].

4.1. Adaptive Learning of Artificial Intelligence: Cognitive Intelligence will Help Fine Teaching Based on Teaching Process and Interaction between Teachers and Students

The teaching link has the greatest impact on the learning effect, and it is also the most core, complex and difficult link in the whole education process. However, the evaluation and practice links are relatively

peripheral, light and simple, so the adaptive learning products are first applied in the evaluation and practice scenarios. The development of adaptive teaching products needs effective data of teaching links, which is difficult to obtain, specifically reflected in: 1) teaching process data is unstructured in the natural state; 2) data can be mined in many dimensions, not limited to test results and assignments, but also including learning path, content, speed, preferences, laws and other in-depth data; 3) different data The relationship between points is complex. Based on this, in the process of the development of artificial intelligence technology to cognitive intelligence, the machine is expected to further understand the meaning behind the interaction between teachers and students in the teaching process, including the emotional analysis of students' expressions, the measurement of teachers' teaching attitude, and finally realize the refined teaching based on the teaching process and the interaction between teachers and students [7].

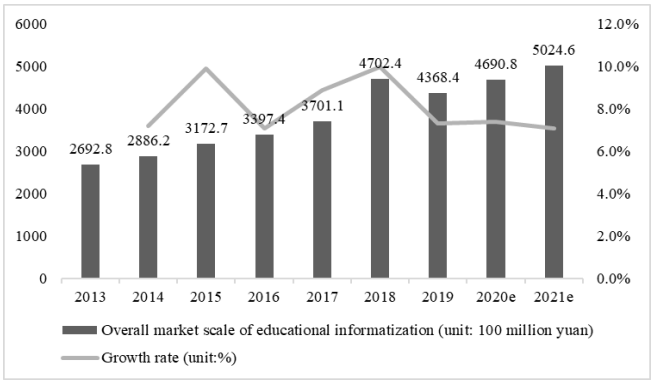

Fig. 3. Overall market scale of China's education informatization in 2013-2021.
Source: 2019 China Education Information Industry Research Report

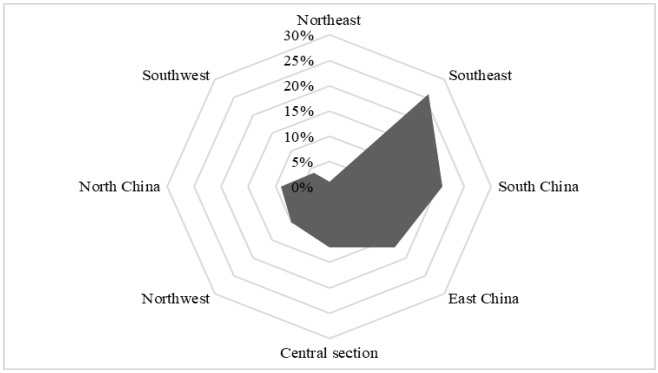

Fig. 4. Regional distribution of the number of smart classroom projects in China in 2018.
Source: China government procurement network

As shown in Fig. 3 and Fig. 4, the construction of smart classroom in public schools is a part of educational informatization. At present, it shows the mixed construction of general smart classroom and AI smart classroom, with the proportion reaching about 10% of AI smart classroom. From the perspective of development space, the mainstream users of smart classroom are primary and secondary school students. There are 214000 primary and secondary schools in China. The total construction space of smart classroom is about 200 billion yuan. In the long term, AI classroom can complete the high penetration of smart classroom [8]. From the current situation, in 2018, China's education information market scale is about 400 billion yuan, and smart classroom related construction accounts for about 3.7%, i.e. about 15 billion yuan, of which software system accounts for about 38%, teachers and students' flat-panel terminals account for about 50%, and the rest are wireless network AP and electricity facilities [9]. In terms of the regional distribution of the project, the construction of smart classroom in Southeast (26%), South China (21%), East China (17%)

and other coastal areas is at the forefront.

4.2. Application Scenario: There Are relatively Few Researches and Practices on artificial Intelligence in the Field of Special Education

At present, the integration of artificial intelligence and education is mainly focused on the field of basic education and higher education, and some achievements have been made. As an important part of the whole national education, special education, the application scenarios of artificial intelligence are also worth exploring, and are consistent with the concept of "science and technology for the better". As a powerful tool to enhance the function of human organs, artificial intelligence can provide defect compensation services for deaf mute Students, deaf students, visually impaired students, mentally disabled students, autistic patients and physically disabled people, help students narrow the gap with the mainstream population, and realize the leap to the healthy people. In addition to the supplement of body function, artificial intelligence can also provide targeted solutions for the education and teaching problems in the field of special education [10].

5. Conclusion

5.1. Summary

Previous research shows that positive emotions have promotion effects on different types of cognitive processes, including memory, attention, psychological rotation, problem solving and social cognition. In the recent motivational dimension model, researchers incorporate the motivational intensity into the experimental variables. Through the study of cognitive tasks such as classification, attention and memory through positive emotions, they found positive emotions with lower approaching motivation can broaden the cognition and vice versa. In addition, this article also explores the neurochemical mechanism of positive emotions on cognition, in which dopamine is the most important biochemical substance and the frontal lobe, anterior cingulate cortex, orbitofrontal cortex, hippocampus and amygdala may be involved in this process as well.

Combined with the application research and technology development at home and abroad, we found that the research concept of AI + education mostly revolved around "taking learners as the center, focusing on skill literacy and non intelligence factors", and the research thinking changed from the past teaching environment intelligence to the teaching process intelligence. In terms of applied research, in the future, we need to pay more attention to the measurability of some teaching objectives that have not been quantified in the field of pedagogy and establish more operational evaluation rules, so as to realize the docking of education evaluation rules and machine rules. In terms of technology development, in the future, we will explore the cognitive characteristics, learning essence and educational value of the era of intelligence, and develop key technologies under specific educational scenarios based on the basic technologies of artificial intelligence and the research results of pedagogy, psychology, brain science and other fields.

5.2. Expectation

This study can comprehend ordinary and abnormal neuropsychological functions. For instance, reducing positive feelings may make it hard to perform tasks that depend on performing functions, which is a prevalent phenomenon in depressed people. This research is also significant in education. Teachers should regard each student as having creative potential. They should provide an atmosphere that enables them to be creative and in positive emotional states. Similarly, this research is also helpful to companies and corporate leaders who are trying to promote employee’s creativity and problem-solving ability.

Conflict of Interest

There is no conflict of interest in this paper. The author hereby declare that I have never received any third-

party funding or services for this research. There is no economic relationship between the author and other units or enterprises. There are no other relationships or activities that may affect or potentially affect the content of this article.

Author Contributions

This paper is written by the author alone, and its contributions to the article include: 1. topic selection and design, data analysis and interpretation; 2. drafting and revising key theories and other main contents of the paper; 3. checking and revising according to the editorial department's revision opinions, answering academic questions, and finally agreeing to the publication of the paper; 4. research work Responsible for all aspects of integrity issues.

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