

# Research on the Relationship Between Learning Motivation and Neural Activity in the Learning Process of Instructional Video: A NIRS Study

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As the intrinsic driving force to promote learner's learning, learning motivation is one of the key factors that affect learning engagement and efficiency. In terms of optimizing instructional videos and strengthening learning effects, it is particularly important to understand the cognitive neural mechanism and influencing factors of the changes of learning motivation. By using the near-infrared spectrometer technology, the paper has collected the state of neural activity while learners were learning different instructional videos, and has analyzed the relationship between the learning motivation of instructional videos and the state of neural activity in the learning process from the angle of cognitive neuroscience. It is found that both the intrinsic and extrinsic learning motivation of instructional videos will affect the state of neural activity in the learning process; the learning process will also affect the intensity of learning motivation, while the preparation of fine instructional videos will also cause the transfer of learning motivation.

*Keywords:* learning motivation, learning process, state of neural activity, NIRS

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## Introduction

With the increasing digital learning resources, learning behaviors based on instructional videos are also becoming increasingly common. Understanding the changing mechanism of instructional videos and learning motivation is helpful for the design and preparation of more reasonable instructional videos, as well as for the stimulation and maintenance of learning motivation, ensuring the learning effect of instructional videos. Bandura, an American psychologist, proposed in his “reciprocal determinism” that individual factors, learning behaviors, and learning environments interact with each other. He thought that personal cognitive would influence the learning behaviors and learning environments, and vice versa. When learners are watching instructional videos, their learning motivation may be influenced by the teaching content, teachers’ teaching methods, the presentation of teaching resources, etc. (Stagg, 2019), and the motivation may also influence the physiological status of learners in the process (Malmberg, Fincham, Pijeira-Díaz, Järvelä, & Gasevic, 2021). In order to understand the cognitive neural mechanism of the changes of learners’ learning motivation while watching different instructional videos and analyze the correlated factors that affect learning motivation, the study has collected and analyzed the data of the state of neural activity of learners while they were watching instructional videos with different topics and teaching methods. Meanwhile, the study has discussed the relationship between the learning motivation of instructional videos and the state of neural activity during the learning process.

## Literature Review

### The Concept of Learning Motivation

Motivation is one of the key factors that affect learning, which has always been the focus in the field of educational psychology. As for the meaning of motivation, Anita Woolfolk, a professor from Ohio State University in the United States (2015), believes that

motivation is an intrinsic psychological state that stimulates, directs and maintains a certain behavior. Studies on motivation mainly focus on why and how people initiate an action directed at a specific goal, how much time will cost for the action, how much they will involve once the action is started, how persistent they are to achieve their goals and how they think and feel during the whole process. (p.334)

Zhang Aiqing (1996, p.34-38), a Chinese scholar, believes that “Motivation is a dynamic factor which stimulates and maintains the behaviors through coordinating individuals’ intrinsic requirements with extrinsic inducements of behaviors under self-regulation”. It can be seen that the fundamental elements of motivation are stimulation, direction, and maintenance, and motivation is a procedural and dynamic mental phenomena with strong situationality.

As for the definition of learning motivation, Chinese scholars ChenQi and Liu Rude (1997, p.120, 125-126, 130-131) believe that “learning motivation is an intrinsic driving force that drives learners to learn and is a need that motivates and guides learners to learn” which can describe why students want to learn and where their leaning willingness comes from Dörnyei (1998), an British scholar, who defined learning motivation as

a dynamic process that includes a series of links such as stimulation the learning desire, stimulating and maintaining learning behaviors to achieve the expected goals, or terminate learning behaviors because of the effect of other factors that reduces the learning desire. (p.117-135)

He believed that the development of learning motivation can be divided into several sub-stages, each stage would be influenced by different factors and the motivation was constantly changing in the learning process. In

general, learning motivation is the intrinsic driving force that stimulates, directs, and maintains the learning behaviors such as learning interests, learning devotion, learning persistence, etc. It has strong dynamic and situational features.

### **The Classification of Learning Motivation**

It has been widely accepted and applied in the academic world that learning motivation is divided into intrinsic motivation and extrinsic motivation (Ryan & Deci, 2000) according to the reason and goal of learning behaviors. Intrinsic motivation refers to learners being interested in learning who spontaneously learn, improve their skills, and attain satisfaction and encouragement from learning, while extrinsic motivation refers to the learning motivation generated due to the learners' purpose of getting rewards, reputation, position, and other additional results in learning activities. In practical studies, some scholars believe that "human behavior is on a continuum from complete 'self-determination' to complete 'extrinsic determination'", while learners' learning motivation is somewhere in between (Vansteenkiste, Lens, & Deci, 2006). Based on the different patterns of manifestation of motivations in different fields, populations, and situations, most scholars choose to classify learning motivation according to specific objects and situations. Houle (1961), an American famous adult education scholar, once put forward three types of motivations that an adult participated in learning activities, which were goal orientation, activity orientation, and learning orientation, respectively. Based on this classification, scholars carried out related studies on learning motivation on practical groups of people. Boshier (1978), a New Zealand scholar, divided adult's learning motivation into six dimensions, namely, cognitive interest, career progress, social contact, escape or stimulation, extrinsic expectation, and social service. Through investigations, Huang Feiying (2002), a Chinese scholar, found that the learning motivation of adult education college students was mainly divided into social perfection type, self-improvement type, practical utility type, and potential plastic type. Chinese scholars Zhou Yan, Gao Yihong, and Zang Qing (2011) found that the learning motivation of undergraduate students in universities and colleges in Beijing to learn English was mainly divided into intrinsic interest, academic performance, learning situation, going abroad, social responsibility, personal development, and information media.

### **The Evaluation of Learning Motivation**

The learning motivation referred in this paper is an intrinsic power to stimulate, direct, and maintain learners' learning behaviors, as well as the intervening variables between environmental stimuli and learning behaviors. Through learning purpose, learning interest, learning enthusiasm, learning choice behavior, and other explicit ways in the process of the study, the types and intensity of learning motivation have been understood.

**Evaluation indicators of learning motivation.** Due to the subjectivity, procedure, dynamics, and crypticity of learning motivation, most scholars evaluate it via learning purpose, learning enthusiasm, choice behavior, degree of effort, persistence, etc. For instance, the choice of tasks by the learner, to some extent, reflects his/her interest and type of motivation. Especially in on-line learning, where self-learning is dominant and learners have lots of options. This indicator is common and many researchers (Dong, 2015; Beaven, Codreanu, & Creuzé, 2014) have inquired learners' interests and options in the investigation of their learning motivation in on-line courses. Effort, persistence, and academic performance, to some extent, reflect the intensity of the learner's learning motivation, on the one hand; however, these factors will also be influenced by his cognitive basis and environmental factors, on the other hand; it is not easy to quantify these factors. In the actual research, they often appear in qualitative research.

**Evaluation methods of learning motivation.** In current studies, the evaluation on learning motivation mainly uses questionnaire investigations, assisted by interviews, observations, and content analysis. Due to the procedure and crypticity of learning motivation, questionnaire survey, which is a quantitative research method and is helpful to analyze the relationship between learning motivation, learning environment, and learning method, is still the primary method to study it (Qu, Liu, & Xu, 2014; Gonzales, 2010). However, due to learning contents and conditions in learning process, learning motivation changes. The changing mechanism in intensity and learning motivation is not able to be acquired through questionnaire surveys; therefore, the interviews and observations shall be an effective alternative. Teachers and parents can judge the state of learning motivation and analyze the reasons through the observation and interview. Content analysis is a method recently and frequently used in the field of on-line learning. Through the analysis on learner's interactions during the on-line learning such as questions, discussions, etc., the information related to learning motivation as well as related factors such as learners' learning interests, learning behaviors, learning needs, learning purpose, etc., can be acquired.

**Evaluation scale of learning motivation.** Combined with related theories and its classification, many scholars have designed relevant scales of learning motivation from different angles. The classification based on intrinsic motivation and extrinsic motivation was their choice in the design. Taking the "Work (Study) Motivation Scale" prepared by Amabile, Hill, Hennessey, and Tighe (1994) as an example (Working Preference Inventory, WPI), it contains two sub-scales of intrinsic motivation and extrinsic motivation. Intrinsic motivation includes two dimensions, i.e., enjoying challenges and finding pleasure in challenges; extrinsic motivation includes two dimensions, i.e., the expectation of extrinsic rewards and seeking recognition and instruction, all together 30 items included. The scale had been widely adapted and applied (Stuhlfaut, 2010). In addition, combined with the classification of motivations and their application scenarios, many scholars have designed evaluation scales with plenty of contents. Shah (1988) has designed an Achievement Motivation Scale according to academic, professional, social, and skill achievements. Han Huifang (Han & Zhang, 2015) has improved it. These scales provided us tools to understand learning motivation from more diversified prospects. With the rise of on-line education, on-line learning motivation has also begun to attract scholars' attention. In the investigation of learning motivation of some proactive MOOC learners, Schneider (2014) found that their learning motivations mainly focused on more than 10 aspects such as general interest in the subject, relevance to work, relevance to schools or degree programs, relevance to academic researches, and contribution to personal growth. Through the investigation of the learning motivation of on-line learners, Wu Feng, Wang Cixiao, and Li Jie (2015) found that under unconstrained conditions, the motivations of learners main focused on cognitive interest, career development, interpersonal relationship, getting rid of routine, external influence, social service, etc. Based on the ARCS motivation model and combined with the practical teaching in the environment of E-schoolbag, and started from four Level one indicators, i.e., attention, aptness, confidence, and satisfaction, as well as 12 Level two indicators, Zhang Wenlan (Zhang, Cheng, & Xia, 2016) has created a motivation questionnaire for learning based on E-schoolbag.

### **Research Review**

In general, based on the different patterns of manifestation of motivations in different fields, populations, and situations, most scholars choose to classify learning motivation according to specific objects and situations. The evaluation of learning motivation still focuses on the investigation of subjective attitude and interview, the

state of learning motivation and its changing rules in the learning process cannot be dynamically and objectively understood. When people are in cognitive activities, the concentration of oxyhemoglobin in active brain regions will increase, while the concentration of deoxyhemoglobin will decrease. A near-infrared spectrometer is a device which can test the oxyhemoglobin and deoxyhemoglobin of individuals, helping researchers to analyze the neural activity process of individuals. On this basis, through the collection of the neural activity process of the subjects when they were learning different courses using near-infrared spectroscopy and the investigation of the learning motivation of the subjects both in the beginning of and after the learning, the subjects' intrinsic motivation was understood. Through informing the subjects that they need to participate tests after watching the instructional videos, their extrinsic motivation increased. By analyzing the influence of intrinsic and extrinsic motivation on the subjects' state of neural activity, the state of learning motivation of learners when they were learning different on-line instructional videos were understood, as well as the influencing factors of learning motivation of the instructional videos, providing references for the design of instructional videos.

## **Research Design**

### **Selection of Experimental Materials**

In order to analyze the influence of learning motivation on subjects' state of neural activity, the study has referred to the ranking of course enrollment on "www.icourse163.org", a well-known MOOC platform in China. Finally, six instructional videos with a length of 10-15 min have been respectively selected from the courses with a large, medium, and small number of applicants combined with course contents, as the experimental materials. The theme and contents of the six instructional videos were sorted out before the experiment. The subjects' interest degrees of each theme were investigated through the questionnaire, and the two instructional videos which the subjects were mostly and least interested in were selected to let them watch. The subjects watched the instructional video that they were mostly interested in, and were selectively chosen to participate in the test. After that, they rested for five minutes and continued to watch the instructional video that they were least interested in to understand their state of neural activity when they were watching instructional videos under the pressure of tests and in the state of involvement. The subjects were selectively chosen to participate in the tests, so as to acquire their neural activity data when they were watching instructional videos that they were not interested in with and without extrinsic motivations, and to analyze the difference between the two occasions.

According to the different courses the subjects had chosen, it was found that the teaching themes chosen for more than 20 person-times were sports, Buddhism, high-speed rail, and first aid; the screenshots of the instructional videos are as follows.



Figure 1. Screenshot of the video course of first aid.

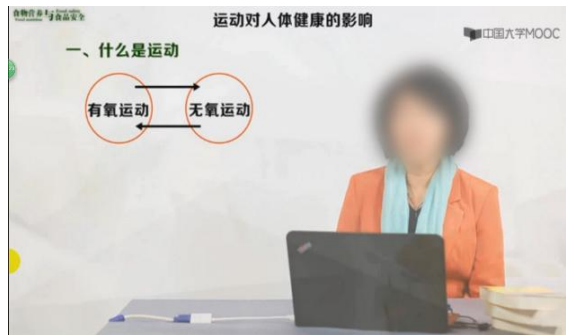


Figure 2. Screenshot of the video course of sports.



Figure 3. Screenshot of the video course of high-speed railway.



Figure 4. Screenshot of the video course of Buddhist culture.

### Experiments on the Subjects

In the NIR experiment group, 66 subjects were invited to watch two instructional videos with different intensities of learning motivation. The oxyhemoglobin and deoxyhemoglobin in the cerebral cortex of the subjects were measured by NIR in real time, and their cognitive activity states were analyzed in this process.

After deleting part of the data with a small number of subjects, the final results were as follows: The number of subjects who were mostly interested in sports and without pressure of tests were 42; the number of subjects who were least interested in Buddhism and without pressure of tests were 15; the number of subjects who were least interested in Buddhism and with pressure of tests were 16; the number of subjects who were least interested in high-speed railway and without pressure of tests were 12; the number of subjects who were least interested in high-speed railway and with pressure of tests were 11; the number of subjects who were least interested in first-aid and without pressure of tests were 12; the number of subjects who were least interested in high-speed railway and with pressure of tests were 0.

### Equipment for Data Acquisition in the Experiment

The NIRSport portable near-infrared functional brain imaging system developed by NIRS of the United States has been used as the main experimental device in the experimental group. This is the world's first lithium-battery powered, freely configurable, wearable, multi-channel NIRS imaging system, which has standardized probe and can accurately locate and record triggering events. It is a mature wearable brain function imaging solution for researchers. Through the NIR analysis technology, the deoxyhemoglobin and oxyhemoglobin of subjects in the learning process can be known, so as to analyze subjects' state of neural activity in the learning process.

### Data Analysis Method

Based on E-prime, NIRStar12.4, MATLAB, excel, etc., the study has analyzed the concentration change of the oxyhemoglobin, deoxyhemoglobin, and the total hemoglobin in the cortical region of the subjects during their learning process of a large number of on-line courses. Meanwhile, using the Five-Point Likert Scale, the study has investigated the intensity of initial learning motivation of the subjects before watching the instructional videos and the motivation after that.

## Research Results

### The Intensity of Initial Learning Motivation in Instructional Videos

It was found in the investigation before the experiment that the video courses that subjects were mostly interested in was sport, while Buddhism, high-speed railway technology, and first-aid common sense and other courses were not that appealing. Moreover, the interest of subjects in video courses of sports and Buddhism showed a considerable difference.

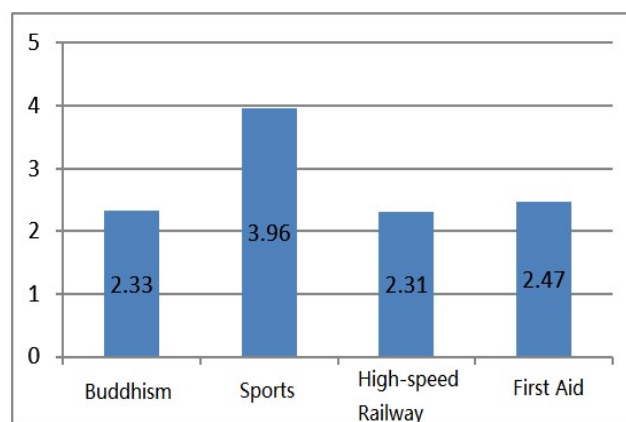


Figure 5. Average value of initial learning interest of subjects in different courses.

**Influence of Learning Motivation on HbO<sub>2</sub> in the Learning Process**

The experiment has found that there was a certain relationship between the state of neural activity in the initial stage and the initial learning motivation of subjects when they were watching instructional videos. When watching instructional videos with stronger motivations, subjects tended to show a more active state of neural activity, while watching instructional videos with weaker motivations, they tended to show a lower activity; however, whether the difference was significant was not easy to judge. As shown in the following figures, if there was no pressure of participating in tests, the average HbO<sub>2</sub> value of subjects when they were watching sports instructional videos of the strongest learning motivation started at 0.007mmol/L, and this value was -0.001mmol/L for first-aid common sense, was -0.002mmol/L for Buddhism, and was less than 0.001mmol/L for high-speed railway. Thus, it could be seen that the intrinsic learning motivation would influence the state of neural activity of the subject in the initial stage.

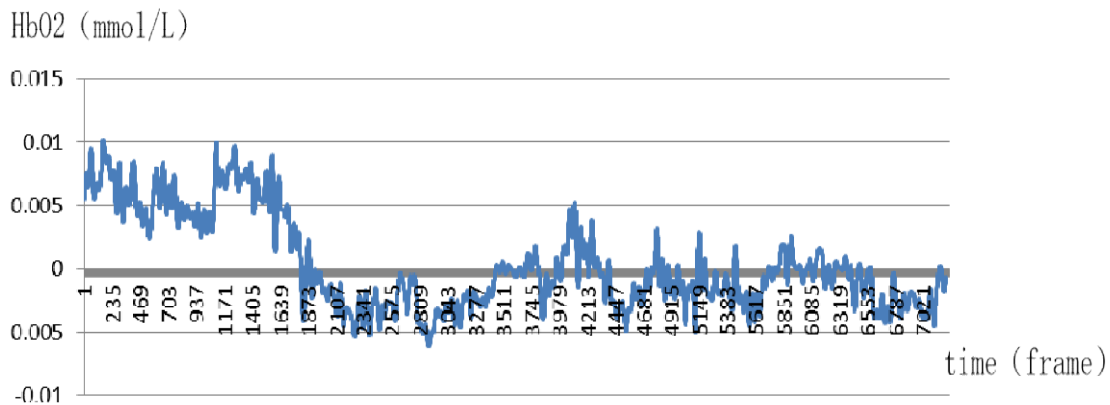


Figure 6. Average waveform of HbO<sub>2</sub> when the subjects were watching the sports courses without pressure of tests.

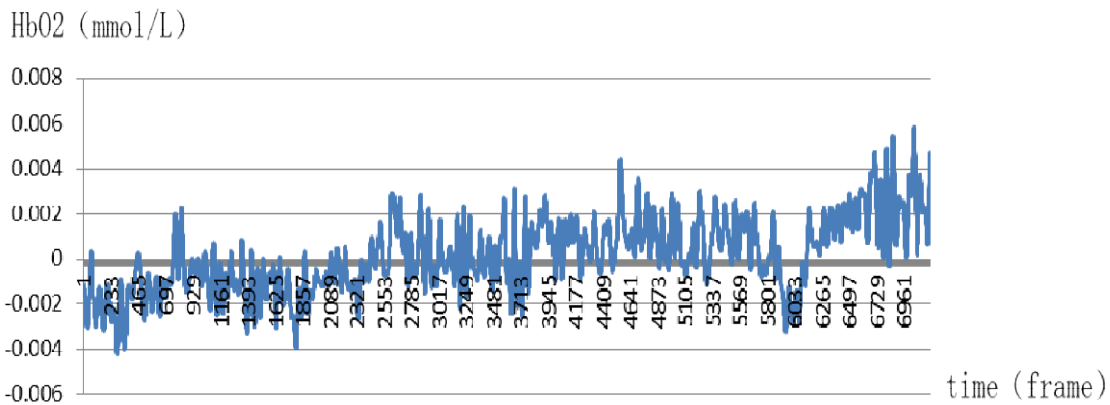


Figure 7. Average waveform of HbO<sub>2</sub> when the subjects were watching the first-aid courses without pressure of tests.

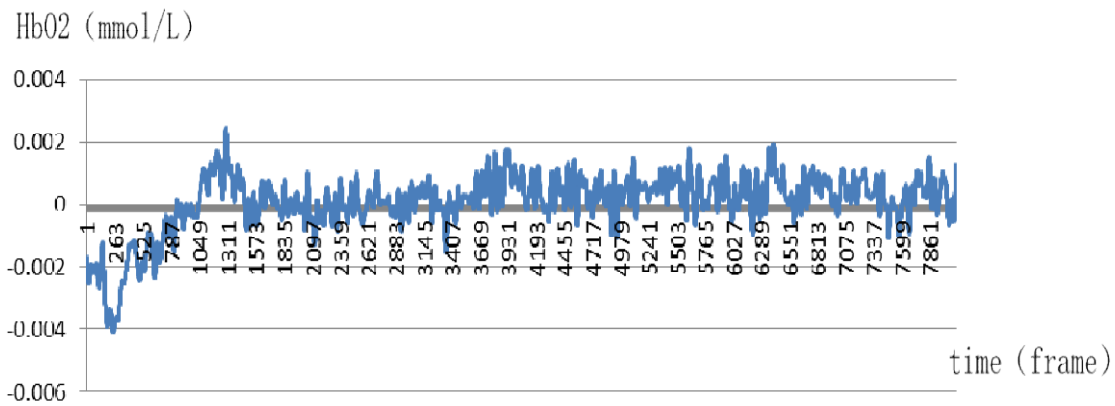


Figure 8. Average waveform of HbO<sub>2</sub> when the subjects were watching Buddhism courses without pressure of tests.

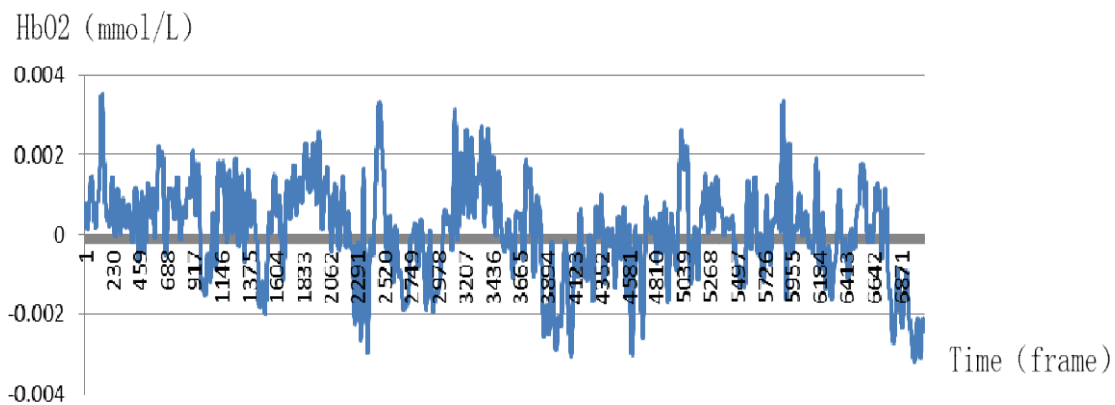


Figure 9. Average waveform of HbO<sub>2</sub> when the subjects were watching the high-speed railway courses without pressure of tests.

Learning motivation can influence the state of neural activity in the initial stage of learning, but this influence is limited in the middle and later stages of the learning process. As shown in the above figure, as the learning process progressed, the state of neural activity of subjects has changed. The HbO<sub>2</sub> of sports courses dropped below the horizontal line in the 1873th frame (at about 2'30''), and then fluctuated right below the horizontal line, which showed a low state of neural activity; the HbO<sub>2</sub> continued to rise when subjects were watching first-aid videos until the 6033th frame (at about 8'20''), where it suddenly dropped below the horizontal line and rose again until the end of the course, which showed a relatively active state of neural activity; the starting value of HbO<sub>2</sub> was low when subjects were watching Buddhism videos, and it continued to rise until the 1311th frame (at about 2'); it began to fall and finally kept staying above the horizontal line until the end of the course, which showed a low but stable waveform; the starting value of HbO<sub>2</sub> was low when subjects were watching high-speed railway videos; the average value was low during the learning process, which had a large volatility centered on the horizontal line.

### The Influence of Extrinsic Learning Motivation on the State of Neural Activity in the Learning Process

In order to understand the influence of extrinsic learning motivation on the state of neural activity in the learning process, the research team informed some of the subjects to participate in the test before they watched the videos, so as to understand the influence of intrinsic motivations of the subjects on their state of neural activity. Through the analysis of HbO<sub>2</sub> when the subjects were watching the videos, the average value of

HbO<sub>2</sub> was significantly higher in subjects with pressure of test than that of without pressure. While without pressure, most of the average values of HbO<sub>2</sub> of subjects were below 0.002mmol/L, while with pressure the values were higher; even some were close to 0.01mmol/L. Similarly, the average value and volatility of HbO<sub>2</sub> of subjects when they were watching high-speed railway videos with pressures were larger than without pressures. Therefore, extrinsic learning motivation can influence the degree of neural activity in the learning process.

**The Influence of Learning Process on Learning Motivation**

After the experiment, the learning motivations of the courses learned by the subjects were re-understood through interviews; it was found that the learning motivation of many subjects in sports, Buddhism, and first-aid had changed. Through case analysis, it was found that individuals’ neural activity when learning Buddhism courses was more active than that of sports courses. As shown in the figure below.

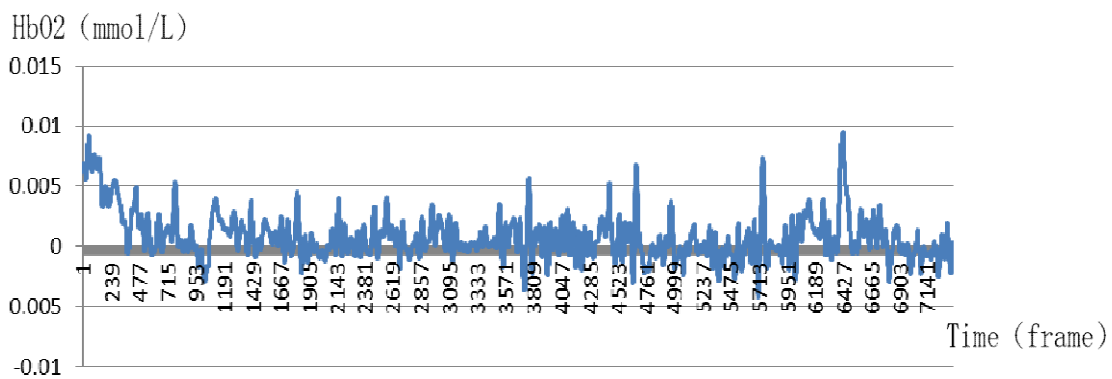


Figure 10. Average waveform of HbO<sub>2</sub> when the subjects were watching Buddhism courses with pressure of tests.

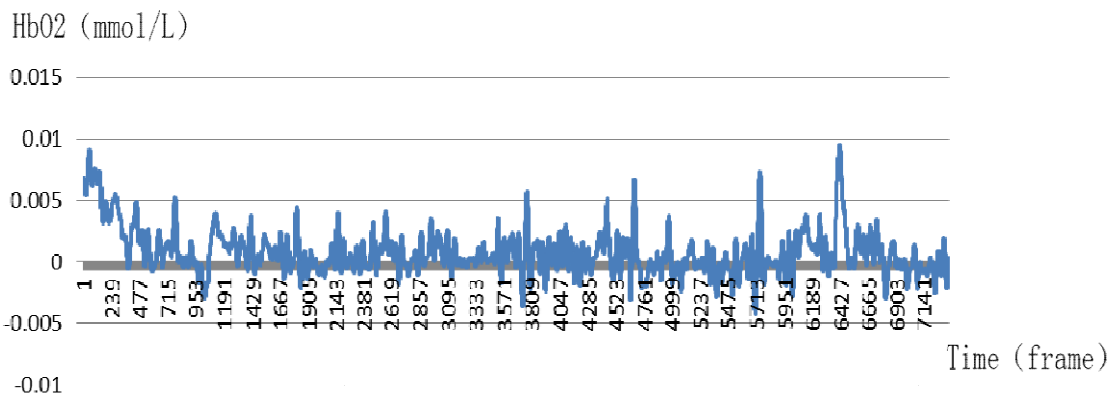


Figure 11. Average waveform of HbO<sub>2</sub> when the subjects were watching the high-speed railway courses with test pressure.

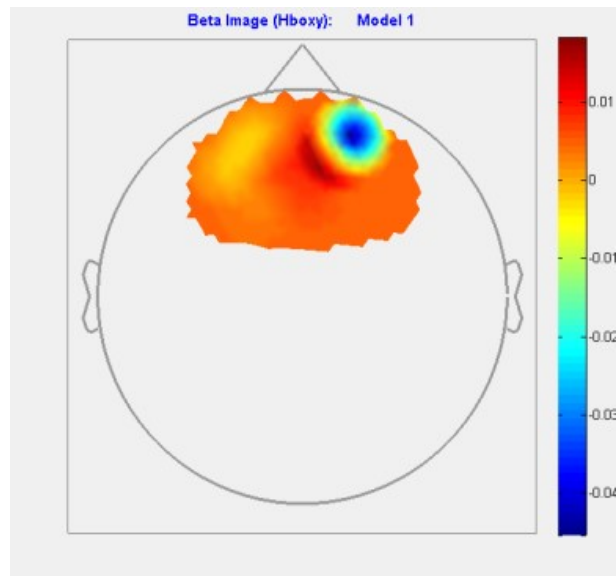


Figure 12. Topology map of GLM analysis when subjects were watching Buddhism videos.

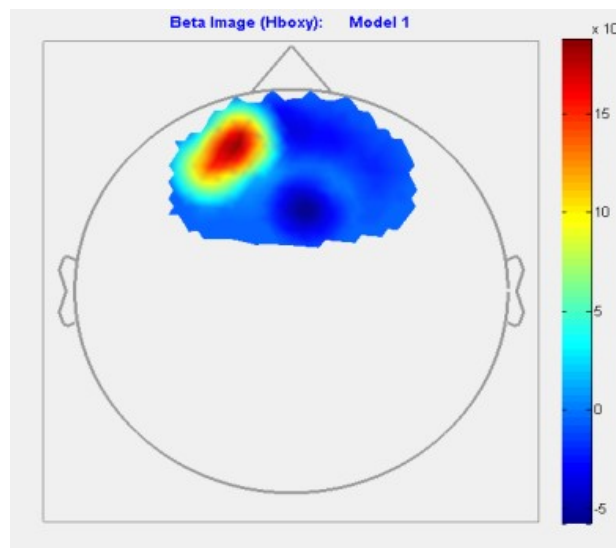


Figure 13. Topology map of GLM analysis when subjects were watching sports videos.

The investigation of the subject before he watched the video courses has shown that he had the strongest learning motivation in sports courses and weakest in Buddhism. In the learning process, however, he was found to have more active state of neural activity when he was watching Buddhism videos. In the interaction with the subject after the experiment, the factor that had the biggest effect on his learning motivation was the teacher's teaching style. He was originally not interested in Buddhism, but the teacher explained Buddhist ideas in the form of storytelling, which was interesting and surprising and overthrew his previous views on Buddhism; however, the sports courses let him down because the teacher had an ordinary teaching style with a slow speaking speed, which affected his learning motivation. Therefore, it is seen that learning motivation changes in the learning process.

The learning of instructional videos can change the type of learning motivation. In the investigation before the experiment, most subjects had medium or no interest in first aid because they believed that the knowledge

were seldom used in their daily life. However, when they were watching the videos, their cognitive activity state was becoming more and more active, as shown in the figure below.

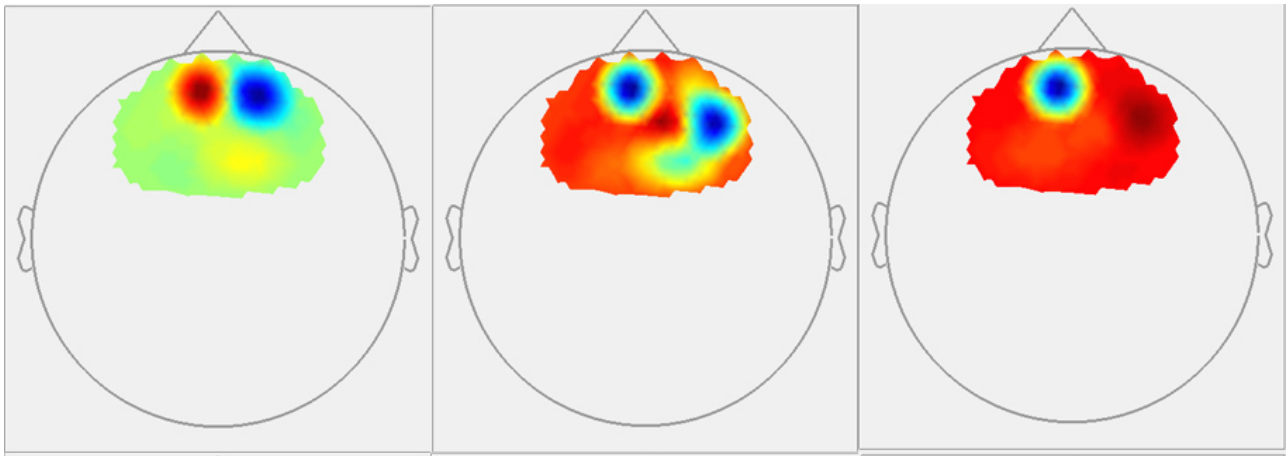


Figure 14. Topology map of GLM analysis when subjects were watching videos of first-aid common sense.

The three figures have respectively reflected the subjects' map of cognitive activity in the brain in the first, middle, and last stages of watching the first-aid videos. It can be seen from the figures that the state of their cognitive activity is becoming more and more active. Many of the subjects experienced a process from inhibitory to active in their cognitive activity in the brain when they were watching first-aid videos. In the interview, they stressed that the video was novel, which had truly showed first-aid scenarios to the students as school, vividly and simply expressed the scenarios and methods of first aid. In addition, the instructional videos were well prepared from the opening to the diversity of shooting scenes, as well as the perfection in the variety of multimedia presentation, making people feel that it was more like a movie than instructional videos. Moreover, they used to think that first aid was far from life that was not a necessary for them to learn. But they found it useful to their life after they watched the videos and said that they would search the Internet for more relevant courses to learn. Therefore, learning interests will affect the state of neural activity in the learning process, while teaching style and how well the course resources are made will also affect learning motivation.

### Discussion and Summary

Using the NIR to measure the data, it was found that there was a certain relationship between the state of neural activity in the initial stage and the initial learning motivation of subjects when they were watching instructional videos. When watching instructional videos with stronger motivations, subjects tended to show a more active state of neural activity, while watching instructional videos with weaker motivations, they tended to show a lower activity; however, whether the difference was significant was not easy to judge. Extrinsic learning motivations can affect the degree of neural activity in the learning process. People have more active state of neural activity with pressure of tests. Learning motivation changes with the learning process of instructional videos, teaching style, how well the course resources are made are important factors that affect learning motivation.

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