
The Cohort Study Related to Brain Mechanism of Motivation and Learning Efficacy by Using Non-invasive Functional Neuroimaging

Project Director, RIKEN, Center for Molecular Imaging Science/
Osaka City University Graduate School of Medicine

Yasuyoshi Watanabe

【Introduction】

Recently, decreased motivation to learn and school absenteeism in elementary school and junior high school students become an object on public concern. Some papers reported that the decrease of academic performance and the increase of troubles in school life would induce mental problems and depression afterwards. Our study group focus on 'motivation to learn' that was vague and difficult to be evaluated in the past. We established the multi-dimensional method to evaluate motivation to learn by the different field's researchers' cooperation including educators, social medical scientists, ethnologists, brain scientists, molecular biologists, pediatricians, and engineers. In our hands, we had the results through long-term research on fatigue, in which we invented various scales or biomarkers for evaluation of the extent of fatigue, and by using the scales or biomarkers we had started the development of anti-fatigue or recovering agents and methods from fatigue. We therefore started the present study to apply the know-how from fatigue study and multi-disciplinary research group if we could contribute the lowering the numbers of children with decrease of their motivation to learn and thereby school absenteeism.

【Methods and Hypotheses】

Our study group planned to investigate the motivation to learn, fatigue, and relate factors, such as life-style, school environment and individual factors at five times every six months from December 2006 to December 2008. Four junior high schools and four elementary schools were recruited and joined the study. We also performed cognitive memory tests on school children and some of these children were subjected to a fMRI (functional magnetic resonance imaging) study and genetic polymorphisms study.

On the other hand, we examined school absenteeism children as Childhood Chronic Fatigue Syndrome (CCFS) patients, who visited the Child Developmental Clinic of Kumamoto University Hospital, since these patients are supposed to be a high percentage of subjects who suffer from the decrease of their motivation. Patients were subjected to a questionnaire, cognitive memory tests, an event-related potential test, etc., every half a year. We followed up 54 patients at final. Out of 54, 25 underwent the genetic polymorphisms study, and 17 participated in fMRI study. Including such CCFS patients, it frequently happens in Japan that the classes at schools don't work out because of the

children with lower motivation to learn. Our hypotheses were one that the disorder of the biological rhythm takes part in their background, and the other that the problem of lowered motivation to learn has a big influence on the development of the normal brain function toward the mature adult brain.

When the neural basis concerning the good reputation from others was analyzed with fMRI, the activation in the caudate-putamen was found as well as the case of a sense of accomplishment in adult subjects. We obtained the hypothesis from these brain science research, that the self-efficacy and the others receptive perception which are regarded as 'reward,' and it activates "motivation to learn".

【Results and Discussion】

In the result of the cross sectional research for healthy children and students, it was confirmed that the mean motivation to learn score showed negative correlation with fatigue score. Moreover, the recovery of the mean motivation to learn score was associated with the decrease of fatigue score by the follow-up study. Low motivation to learn score was significantly associated with a high frequency of complaining daytime sleepiness. Forty percent of healthy children and students answered for 30 days or more, 'I'm sleepy also in daytime', and it rises to 80% in the school absenteeism students and CCFS. Interestingly, when one shifts from the elementary school to the junior high school, one's sleeping hours reduce by one hour, despite the fact that the mean differences in sleeping hours between the adult and junior high school student is ca. 30 min. Fatigue score increased at the same time as the fluctuating sleeping hours; on the other hand, motivation to learn tended to decline up to the same level as of the 8th or 9th grade students after some delay, in the latter half of seventh grade. This result suggest that there is no time-lag between decreasing sleeping hours and increasing fatigue level, while reduction of motivation to learn has time-lag. We speculate the possibility that the lack of sleeping hours or poor quality of sleep induces fatigue or daytime sleepiness, which causes the decrease of motivation to learn and the increase of tardiness. Therefore one cannot catch up with classes and his or her motivation to learn declines more in the vicious circle. The symptom of the daytime sleepiness was an independent risk factor for decrease of motivation to learn between the first grade of junior high-school from sixth year in the elementary school. The factor "Whether it was praised from the family or not?" besides the lifestyle was a related factor to decrease motivation to learn, and there is a possibility that the reward by the others receipt feeling is related to the motivation to learn. Our results revealed that students with low motivation to learn showed low score in a dual task, KANA-pick out test, which is consisted of two sections; picking out Japanese vowels and understanding the content of the story. The low score in the task means the decrease of divided attention function in the students. Moreover, CCFS patients who are supposed to show the decrease of motivation to learn as compared with healthy students, showed low scores in this task. In addition, the students with low divided

attention function tended to decrease motivation to learn one year later. That is, low divided attention function has not only correlation with motivation to learn, but also one of the risk factors of the decrease of motivation to learn.

Adjusting sleeping hours and proper the reward feeling were admitted in CCFS patients whose school attendance situation was improved by the follow-up survey. There was no significant difference in reward score at the first survey between improved patients and unimproved patients. Therefore, the students with basically high reward feeling might not be related to the improvement of school attendance, but the improvement of school attendance takes place those patients to increase their reward feelings. CCFS patients showed low scores of the reward dependence, and this is the one assumed character pattern of the child who appeared problematic behavior. Thus, CCFS patients showed problems in 'Reward' and 'Divided attention' as compared with healthy students. Following the improvement of school attendance in CCFS patients, adjustment of their sleeping hours, which is related to 'Attention' and the increase of 'Reward' feeling, made our hypothesis clearer that 'motivation to learn' is consisted of these two components. Adjustment of sleeping hours does not mean long hours of sleep, but sleeping in the time of having to sleep. CCFS patients tended to be active in the night time compared with their day time. It is important to cure such disorders in biological rhythm.

From these results, we concluded that the most risky period of the decrease in motivation to learn is when one shifting from elementary schools to junior high schools and it is important to take care of the lifestyle that improves 'Reward' and 'Attention' enough in the period. As for this tendency, it is possible to prove even by the results of the cognitive functional test. The students spending with the family longer and/or more praised from the family showed high and well-developed divided attention function and these students showed high motivation to learn. In another words, the students who frequently spend with the family pay attention to each family member at the same time and it turns the improvement of one's divided attention function. It also suggests that the increase of chance praised from family induces others receptive perception and it directly connects to improve motivation to learn. Further interventional studies were needed to make this point much clearer.

We developed 'KANA-pick out test' for fMRI to investigate the neural basis of the decreasing divided attention in CCFS patients and healthy controls with low motivation. As a result, inactivation level of medial prefrontal cortex area during the test showed positive correlation with motivation for the test in students. The previous report showed that anxiety levels in subjects were correlated to the activation of medial prefrontal area. Therefore, it is hypothesized that the control of negative feelings by medial prefrontal area is related to the motivation.

The frequency of minor allele in one of the genetic polymorphisms, which related to the decrease of the activation of prefrontal cortex, was high in adult chronic fatigue syndrome

patients as compared with healthy controls. The number of DNA samples in children was not enough to be analyzed and further studies are needed in children. When these results were obtained, the students with high motivation for the divided attention task have an enough ability to restrain negative feelings to the problem, and are regarded that it is possible to work by concentrating on the problem or more. Moreover, there is a possibility that the students who are highly disordered their divided attention ability show genetic differences as compared with healthy controls.

The positive teacher's response to students increased the rate of students' attendance in the classes. It is considered that negative emotion to classes in students was removed by the teacher's response and it induces the positive response from students. From these results, we suggest to develop the methods to inactivate medial frontal area in students by the teacher's positive responses, and it turns to be close to construct education based on brain science. The series of our results resemble the tendency that teachers have been experienced for a long time, and our results are highly valuable to tie up with guidance-based data in the future.

【Out of Research】

As social action work, we made a simple report on each survey and distributed it to teachers and student's guardians. Moreover, brief sessions were held if requested by schools. It is essential for education to report the part of results in each survey, even if it became a kind of intervention. This efforts might have helped to increase the motivation of teachers and students to participate in our study. One teacher picked up 'sleep' as the subject of his classes after this survey. We could find that our study introduced the teachers and through them to guardians and students to understand gradually. Moreover, the attempt to raise concentration level in the class and the motivation to learn by the individual counseling was executed in 2008. It obtained the result that it was possible a six' graded student with low motivation to learn and have a difficulty in arithmetic to hear teacher's story by concentration and to solve the problems after individual counseling. The more counseling were hold, the more motivation to learn in students increased. We cannot conclude that this method will induce the inactivation of prefrontal cortex from the series of data, but it might be one way in good examples of increasing motivation to learn.

We should take care of sound development of attention, concentration others receptive perception, and self-directedness personality in children by healthy environment, such as praising from family, taking dinner with the family, increasing the time such as speaking the event that happened in a day with family, and so forth. Family supports are really important to create good lifestyle, sleeping and eating, and good environment.

Intrinsic factors, such as personality and perception, might also be important for motivation. We are planning to make a predicting model which attribute may contribute to avoid the decrease of motivation by simulating various methods and open the website.