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Topic-Setting Program to Advance Cutting-Edge Humanities and Social Sciences Research

（Area Cultivation）

Progress Report

（Summary of Final Report）

[Cognitive-neuroscience approach to power to live and creation of its educational-application research]

Core-Researcher: Motoaki SUGIURA

Institution: Tohoku University

Academic Unit: Institute of Development, Aging and Cancer

Position: Professor

Research Period： FY2014 - FY2017

1. Basic information of research project

Research Area	New advances in humanities and social sciences using analytical methods incorporating praxeology, cognitive science, and neural science
Project Title	Cognitive-neuroscience approach to power to live and creation of its educational-application research
Institution	Tohoku University
Core-Researcher (Name, Academic Unit & Position)	Motoaki Sugiura; Institute of Development,Aging and Cancer; Professor
Project Period	FY2014 - FY2017
Appropriations Plan (¥)	FY2014 3,000,000 JPY
	FY2015 3,450,000 JPY
	FY2016 2,560,000 JPY
	FY2017 2,700,000 JPY

2. Purpose of research

In this research, we aimed to develop empirical and interdisciplinary research on the "power to live", which are human psychological characteristics to avoid crisis and overcome difficulties. Specifically, from various responses of victims of the Great East Japan Earthquake on the question "What personality, way of thinking, or habits are advantageous in surviving disasters?", we extracted the factors of the power to live using social-psychological methods, performed cognitive and neuroscientific validation and analysis, and aimed to cultivate the academic fields of reflecting the findings in theories and practices of disaster or general education. It is the core of current Japanese humanities and social sciences tasks in that this research is a response, in one aspect, to the disaster social science issue on how to hand down the experiences of the Great East Japan Earthquake, and, on the one hand, to the pedagogical question as to how empirically implement the 'zest for living' required for the "Children Surviving the Changing Era of the Next Era" proposed by the Central Education Council (1996) (Fig. 1).

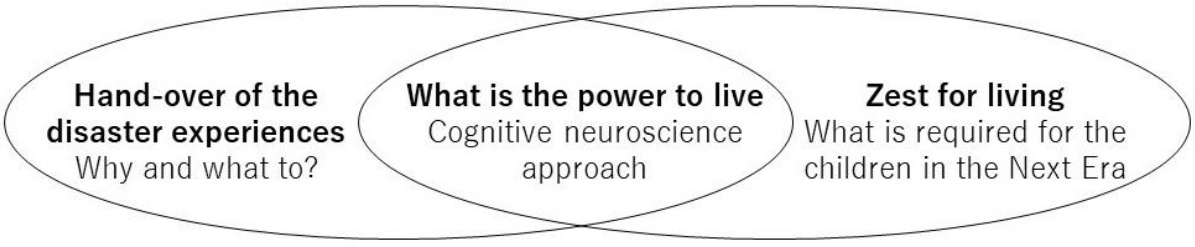

Figure 1

About the hand-over of the experiences of the earthquake, it has so far been mainly technological argument about how to hand down and the practice of steady handed down activities, and the essential research and discussion on "why and what to hand down"

was dilute. We considered the power to live with disasters one of the important contents to be handed down, and its purpose is to give children the power not only to survive the next big catastrophe to come but also to overcome the various turbulence of the future era. On the other hand, about 20 years have passed since the definition of the zest for living by the Central Education Council, "it is a qualification and ability to think and decide subjectively, act actively, solve the problem better, and a rich human nature such as a heart of cooperating with others while caring for others and controlling oneself, and a moving heart ... " has left without any academic environment that reflects this on the workplace. Because any kind of educational practice can be linked with the zest for living in any way, the term zest for living is turned into a mere catch phrase, and it is the present situation that it loses its conceptual value.

This research empirically defines the concept of the power to live and break down the current state and limit of such traditional humanities and social science approaches by clarifying cognitive and behavioral processes that bring the power to live, and the neural basis behind it. Specifically, we clarify in what kind of situations the eight factors of the power to live exert their power, and in what context in the brain it exerts as a cognitive process of perception, evaluation, judgment and behavior (that is, which part of the brain the person with strong power to live uses). By doing this, we can organize the multifacetedness of the power to live in related humanities and social sciences, empirically sort out information that brings the power to live and its relevant recipients, and quantitatively evaluate the relevance of the power to live with various factors of educational practice. In this research, we aimed to realize it and tried to explore the field of new fusion study fields.

3. Outline of research (Including study member)

(1) Detailed analysis of survey data on the power to live with disasters and its publication

An interview survey data on how individual character, way of thinking, or habit (power to live) contributed to overcoming the difficulties of shelter life and reconstruction process, conducted in FY2012 for about 80 survivors of the Great East Japan earthquake disaster was analyzed in detail. We extracted situations where various aspects of the power to live were demonstrated, applied cross tabulation and correspondence analysis, and examined the relationship between the phase of disaster and the necessary aspects of the power to live. In addition, we analyzed questionnaire survey data carried out for about 1,400 victims in FY2013, and analyzed the relationship between eight factors of power to live and various behaviors at the time of disaster such as self-help at the tsunami evacuation and shelter, mental and physical health.

(2) Cognitive-science approach to the factors of the power to live

Experimental tasks imitating crisis avoidance and difficulty conquest scenes were conducted in healthy subjects in the MRI apparatus and brain activity was measured. We

extracted the area where the score of each factor of the power to live and brain activity correlate. Then, based on the existing neuroscience knowledge about the active area and the other questionnaire data, we tired to explain the individual difference in each factor of the power to live in terms of what kind of processes in perception, evaluation, judgment, and behavior in what context.

(3) Cultivation of the new fusion area to empirically use the "power to live"

Together with the theoretists and field parties at the disaster and other educational fields, the ways of reflecting the results obtained in (1) (2) in education theory and practice were discussed and brought into the feasibility study. Furthermore, with an eye on reflecting the findings in the humanities and social sciences including the disaster and other education fields, the necessary methods of the data analysis, presentation and interpretation of the findings, and the future research direction including the research design of the cognitive neuroscience were discussed.

Role	Name	Department, Institute; Position	Topic
Representative Brain measurement group leader	Motoaki Sugiura	Institute of Development, Aging and Cancer / International Research Institute of Disaster Sciences, Tohoku University; Professor	Supervision Brain measurement Education and practice
Collaborator	Rui Nouchi	Frontier Research Institute for Interdisciplinary Sciences, Tohoku University; Assistant Professor	Brain measurement Education and practice
Collaborator	Takayuki Nozawa	Collaborative Research Center for Happiness Co-Creation Society through Intelligent Communications, Tokyo Institute of Technology; Specially Appointed Associate Professor	Brain measurement
Social psychology group leader	Shosuke Sato	International Research Institute of Disaster	Social psychology

		Sciences, Tohoku University; Assistant Professor	Education and practice
Collaborator	Tsuneyuki Abe	Graduate School of Arts And Letters, Tohoku University; Professor	Social psychology Education and practice
Collaborator	Akio Honda	Faculty of Human Culture, Yamanashi Eiwa College; Associate Professor	Social psychology Education and practice
Education and practice group leader	Toshiaki Muramoto	International Research Institute of Disaster Sciences, Tohoku University; Professor	Education and practice
Collaborator	Fumihiko Imamura	International Research Institute of Disaster Sciences, Tohoku University; Director	Education and practice
Collaborator	Mari Yasuda	International Research Institute of Disaster Sciences, Tohoku University; Assistant	Education and practice
Collaborator	Suppasri Anawat	International Research Institute of Disaster Sciences, Tohoku University; Associate Professor	Education and practice
Collaborator	Hiroshi Yamaguchi	Faculty of Humanities and Social Sciences, Iwate University; Professor	Education and practice
Collaborator	Makoto Sasaki	Organization for Revitalization of the Sanriku Region and Regional Development, Iwate University; Associate Professor	Education and practice

4. Research results and outcomes produced

(1) Detailed analysis of survey data on the power to live with disasters and its publication

As a result of examining the relationship between the phase of disaster and the

necessary aspects of the power to live by extracting the situations in which various powers to live were demonstrated on the results of the cross-tabulation and correspondence analysis of the interview conducted in FY 2012, we found that the powers to live that contributed in the crisis avoidance context and overcoming difficulty of restoration or reconstruction were qualitatively and quantitatively different. We published this result in peer reviewed journal (Sato et al., Proceedings of Regional Safety Association, 2014). In addition, we analyzed questionnaire survey data for about 1,400 survivors in FY2013, and presented the eight factors of the power to live and their relationship with the behavior in the disaster in peer-reviewed international journal (Sugiura et et al. al., PLoS ONE, 2015). The findings will be outlined below for each factor. We ranked in descending order of factors that are considered to be of high importance at a relatively early stage (disaster occurrence) in the disaster phase. The abbreviations F1 to F8 indicate the order extracted in the factor analysis and are irrelevant to the significance and importance of the factor. The name of each factor is the result of our discussion based on the items constituting the questionnaire scale and the predecessor psychology findings (i.e., there is a possibility of change due to future research progress). Regarding the relationship with the behavior and experience at the time of the earthquake, in addition to the relationship with the prompt tsunami evacuation, problem solving at the refugee setting, and mental and physical health, in the present paper some unpublished data were also included.

· F6 Emotional regulation

The factor composed of four items including "During difficult times, I endeavor not to brood" and "When something happens, I try to stay calm and not panic". The score of this factor was related to the rapid tsunami evacuation, problem solving at shelter, and mental and physical health.

· F2 Problem solving

The factor composed of five items including "When I am fretting about what I should do, I compare several alternative actions" and "To resolve a problem, I first of all initiate action". The score of this factor was related to problem solving at the shelter.

· F3 Altruism

The factor composed of five items including "I like it when other people rely on me and are grateful to me" and "When I see someone having trouble, I have to help them". The score of this factor was also related to problem solving at the shelter. It is also related to actions that help others in evacuation (unpublished data).

· F5 Etiquette

The factor composed of three items including "On a daily basis, I take the initiative in greeting family members and people living in the neighborhood" and "In everyday life, I take care of myself as much as possible". There is a relationship between the score of this factor and the perception of social support at evacuation (unpublished

data).

· F7 Self-transcendence

The factor composed of four items including "I am aware that I am alive, and have a sense of responsibility in living" and "I am aware of the role I should play in society". The score of this factor was related to the action to help others in evacuation (unpublished data).

· F1 Leadership

The factor composed of five items including "To resolve problems, I gather together everyone involved to discuss the matter" and "Sophisticated words that move people's hearts come out of my mouth". The score of this factor was related to the mental health after the earthquake. Also, when evacuating, it is related to voice acts to others (unpublished data).

· F8 Active well-being

The factor composed of three items including "In everyday life, I have habitual practices that are essential for relieving stress or giving me a change of pace" and "In everyday life, I endeavor to find opportunities to acquire new knowledge, skills, and attitudes". The score of this factor was related to mental and physical health after the disaster. Also, when evacuating, it is related to voice acts to others (unpublished data).

· F4 Stubbornness

The factor composed of five items including "I am stubborn and always get my own way" and "I am highly motivated with regard to things that I like or want to do". The score of this factor was related to the physical health after the disaster. It is also related to progress of housing reconstruction (unpublished data).

(2) Cognitive-science approach to the factors of the power to live

i) Functional MRI experiment of the crisis avoidance context

We designed a functional MRI experiment of crisis avoidance context in FY2014. From the interview survey data for the survivors of the Great East Japan Earthquake and available collections of testimony of the victims of other disasters, we extracted contexts where people could or could not avoid the crisis in the immediate aftermath of the disaster. Analyzing each case, extracting the essential aspects of the context, and classifying them, we put them into experimental tasks that can be carried out inside the MRI scanner. We conducted brain activity measurement experiments using two kinds of tasks created, identified the neural basis of each factor of the power to live, and interpreted the findings in the context of the cognitive neuroscience. The research plan was reviewed and approved by the Ethics Committee of the Graduate School of Medicine, Tohoku University. For brain activity measurement, we used about 30 healthy right-handed university students as subjects and a research-dedicated 3T-MRI scanner and experimental equipment (e.g., stimulus presentation and response recording apparatus) installed in the IDAC, Tohoku University. In the first "unexpected event response task" (a problem modeling the problem

of how to deal with events that were not presupposed at the time of the Great East Japan Earthquake), the subjects were beforehand trained to manipulate complex control system, and to deal with some troubles in the manual. During the fMRI, they conducted a task to deal with the trouble situation that have never been coped with in the training (but can be dealt with by a combination of learned operation and background theory). As a result, subjects with a higher "F2 Problems solving" score showed less brain activity in a part of the frontal lobe and part of the temporal lobe (Fig. 2). Since these areas are related to knowledge and its utilization, those who have high "F2 Problems solving" scores may already have the relevant skills when they encounter an unexpected trouble, that is, the individual difference stems from the skill acquisition at the training. In the second "difficult choice task" (a task modeling the judgment situation with no single correct answers, which was confronted by many victims in the Great East Japan Earthquake), the subjects were in a complex situation (presented with detailed information on two people) and required an instantaneous decision making (personnel recruitment situation). The brain activity was also analyzed for the relation with the power-to-live factors, but unfortunately statistically significant correlation was not identified. It is speculated that the influence of individual differences other than the power to live in the task execution strategy was predominant.

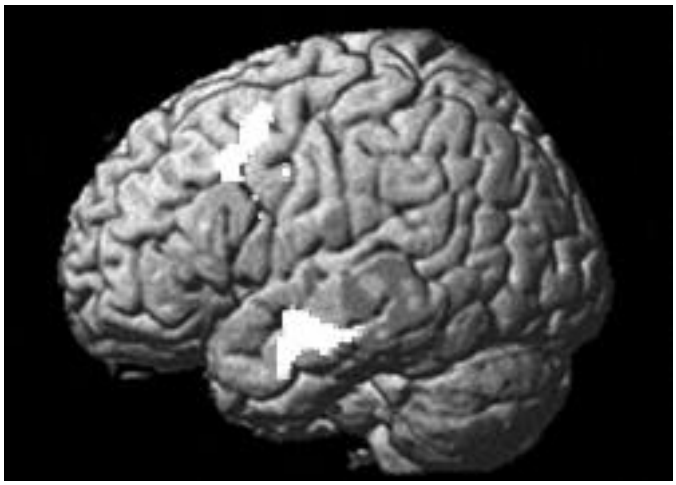

Figure 2 Higher activation in low F2 subjects during dealing with the unexpected trouble events

ii) Functional MRI experiment in the context of overcoming hardship

We designed a functional MRI experiment for the context of overcoming hardship in FY2015. From the interview data for victims of the Great East Japan Earthquake and from other publicly reported evidence collections of evacuees, we extracted contexts that could not overcome some difficulties at the shelter life or in the reconstruction processes. Analyzing the cases, extracting the essence of a typical difficult-to-overcome context, and classifying them, we put them into the experimental tasks that can be carried out inside the MRI scanner. We conducted brain activity measurement experiments using two kinds of tasks created, identified the neural basis of each factor of the power to live,

and interpreted the findings in the context of the cognitive neuroscience. Experiments were conducted using approximately 40 healthy right-handed university students as subjects, and the same procedures and equipment as in i). In the first "emotion regulation task" (a task modeling a situation required to control inappropriate emotions to overcome various difficult situations in shelter life or reconstruction process), negative emotional pictures were presented. The subject with a higher "F6 Emotion regulation" score showed less brain activity in parts of the temporal and parietal lobes (Fig. 3). Since these areas are areas related to auditory and somatosensory processing, those with a high "F6 Emotion regulation" scores may possess skills to suppress processing at the level of sensory input to the cerebrum. In the second "communication task" (a task modeling a situation in which communication was required to solve various difficulties that can not be solved by an individual), subjects were asked to recognize social situations and to give an advice to the protagonist of the situation. The correlation of brain activity and the score of each factor of the power to live was analyzed, but unfortunately statistically significant correlation was not identified. It is presumed that the influence of individual differences other than the power to live in task execution was large.

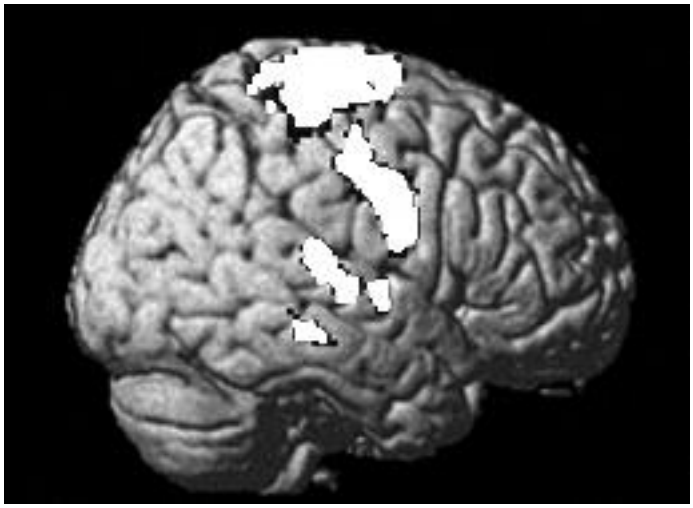

Figure 3 Higher activation in low F6 subjects during viewing of negative emotional pictures

(3) Cultivation of the new fusion area to empirically use the "power to live"

Starting in FY2014, we held a research group that gathered people of various fields and parties involved in disaster education in FY2105 ("To nurture the power to live?: Towards collaboration between academia and the practice field" The 4th Disaster, Cognition, and Brain Science Seminar), Sendai, 2015.07.24). We also conducted joint research and discussions with various municipalities and NPOs involved in disaster education. We also developed the "state measurement version" of questionnaire and brought into the practice in three research projects (Toyama, Tokyo, Sendai). The original questionnaire calls for evaluation on the relatively long range of past that respondents

can think as their own "present", as typified by question words such as "daily ~". Therefore, it is not very natural for the score to change in this questionnaire in a short period of time, and it is hard to use to verify the educational effect before and after disaster prevention classes such as half a day or one hour. So we developed a "status question paper" so that we can measure aspects that change in a short time. This is to change the wording of the original questionnaire and measure the subjective importance (~ important is vs. not important) and confidence (~ confident vs. no confidence) for each item . By introducing this state questionnaire, it has become possible to apply it in a wide range of fields for the purpose of evaluating educational effects such as disaster prevention lessons and training. Meanwhile, the original "characteristic question paper" still has the overwhelming advantage that validity has been academically verified, and recommended in the cases, such as the comparison between groups (e.g., intervention group vs. control group), and the evaluating changes in the period of as long as 3 months.

In the FY2016, the achievement so far was presented in conferences or seminars in Disaster Psychology, Disaster Education, and Disaster Medicine, and discussions on educational application in the future were conducted (3 domestic 2 international). While getting a generally high evaluation, critical and constructive feedback on necessity of reconsidering the interpretation and name of the eight factors in the first place, appropriate analysis method and expression or interpretation of the cognitive neuroscience data to apply them in educational practice. For practical application of education, the questionnaire (state question paper or characteristic question paper) was used in Miyagi prefecture's education committee, four junior high schools, three high schools, two universities, and NPOs providing disaster prevention drills (1 organization; 2 cases) as evaluation tool or content of lesson or educational program. Evaluation of the effectiveness of this type of educational program (with no established assessment tool) has inevitably had to rely on qualitative evaluation (such as free comment on impressions). Our inventories is introduced to the site where some quantitative evaluation is expected, and both have recognized that it was able to meet this expectation. Of course, simply evaluating quantitatively can not be called an evaluation "tool". It is hoped that the evaluation will be "utilized", such as linking the evaluation to the educational program. For that purpose, while considering various data analysis methods at various sites, we examined ways of effective utilization as an evaluation tool.

As one result of such a study, we show examples of the use of the trait version of our questionnaire in the three junior high schools (A to C) in a certain city. A school-specific educational program was implemented, and in order to evaluate the educational effect, we measured the score change of eight factors in three months before and after the implementation period. The average change in the score was generally A <B <C, but when examining the score change patterns of all the students grouped, the difference in the average score change was explained by the ratio of the non-responsive

group (Fig. 4). Among three schools, the number of students is A> B> C, and schools A and B had to adopt a group learning. It was thought that the results reflect the weaknesses of the group leaning where the difference in the baseline motivation of the students are enhanced.

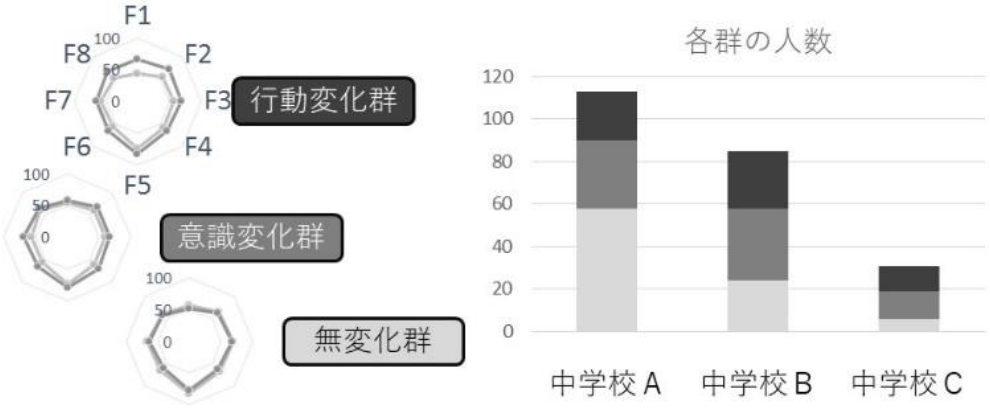

Figure 4 The ratio of the non-responsive group was larger in the order of the school A, B, and C, which corresponds to the number of entire students.

In this way, by establishing a place for the discussion of the results of cognitive neuroscience research and the application research of the questionnaire by cognitive neuroscience, researchers in various psychology fields, and theorists and field parties at the educational site, we believe that it was successful to create a new field of cross-disciplinary research that empirically utilizes the power of live. We had realized the power of the results of cognitive neuroscience research in the establishment of collaborative relationship, and the possibility in the use of the eight factors as the educational goal from the beginning of the research. By imposing feasibility studies to utilize results for educational practice, we succeeded in securing the interactivity (cognitive neuroscience ⇔ humanity and social sciences) and constructability of that discussion (creation of academic field). The model of the eight factors of the power to live was extracted from the testimony of the victims of the Great East Japan Earthquake, and its verification and correction in various circumstances was necessary to generalize the model. In the forum of discussion and verification, people in the disaster and general education, business and local government officials were also involved; this resulted in the development of multiple verification studies in parallel. In addition, educational engineering discussions have been born for the purpose of developing the education and training technology targeting each factor, combining basic educational program elements through cognitive neuroscience conceptions. Furthermore, discussion on whether characteristics of each factor is genetic or plastic has begun; it has been argued that in the former case social institution design is called for considering genetic individual difference of the power to live and in the latter case the development of education and training technologies to nurture the power is to be studied in the future. As a model of collaborative research envisioning the close cooperation and comprehensiveness of the

academic fields, and targeting the general understanding of human beings, society, and nature, a wide ripple effect to related academic fields is expected in the future.

In this research, researchers from various fields have been united and succeeded in showing some examples of the feasibility of development of empirical and interdisciplinary research on the powerto live, and some examples of research systems and approaches. Based on the findings obtained in this research and issues that have emerged, future research developments will be organized as follows.

(1) Cognitive scientific elucidation of the power-to-live factors

Currently, the cognitive neuroscience research findings on eight factors are overwhelmingly deficient. It became clearer that a single experimental finding is insufficient for the understanding of each factor in terms of "what cognitive process of perception, evaluation, judgment, behavior in what kind of context explains the individual difference". From now on, it is necessary to accelerate this research with a heavier organization, particularly in the manpower. Also, regarding the plasticity of the brain activity reflecting each factor, it is necessary to consider genetic methods as to whether the brain activity characteristics are genetic or plastic. In the former case, social institution design that takes into consideration the genetic individual differences of the power to live, in the latter case technical development of education and training that fosters the power to live will be subject to research in the future. Also, depending on the time constant of plasticity (ease of change), the policy of education and training and the method of evaluation its effect (the current questionnaire does not take time constant of change into consideration) may differ.

(2) Promotion of new a fusion research empirically utilizing "power to live"

To further advance the on-site implementation of the questionnaires, manualization of the procedures for the administration, scoring, interpretation, and application are necessary. In addition, in order to advance the development of education and training techniques targeting the neural basis of each factor, we will advance research to verify the protocol designed based on intuition at the educational site and theory in terms of cognitive neuroscience. It is necessary to realize the idea born from the discussion place involving disaster or general education people, business and local government officials, as a concrete project. Also, based on educational engineering discussions born in this research on the development of education and training techniques targeted at each factor, we integrate basic educational program elements into a coherent educational system based on the cognitive neuroscience ideas.

With these paths, the goal of promoting the new cross-disciplinary academic field that empirically makes use of "power to live" to develop cognitive neuroscience research knowledge to full-scale educational practical application has come to be seen.