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Topic-Setting Program to Advance Cutting-Edge

Humanities and Social Sciences Research

（Area Cultivation Program）

Progress Report

（Summary of Final Report）

[Exploration of “humanities and social science for symbiotic society” driven by neuropsychology of hyper brain functions]

Core-Researcher: Shinichi Koyama

Institution: University of Tsukuba

Academic Unit: Faculty of Art and Design

Position: Professor

Research Period： FY2017 - FY2020

1. Basic information of research project

Research Area	Research Area A ："Cognitive turn" and the transformation of identities
Project Title	Exploration of "humanities and social science for symbiotic society" driven by neuropsychology of hyper brain functions
Institution	University of Tsukuba
Core-Researcher (Name, Academic Unit & Position)	Shinichi Koyama, Faculty of Art and Design, Professor
Project Period	FY2017 - FY2020
Appropriations Plan (¥)	FY2017 2,925,000JPY
	FY2018 4,972,500JPY
	FY2019 4,095,000JPY
	FY2020 1,170,000JPY

1. Purpose of research

Neuropsychology has contributed to the understanding of the relationship between the brain and mind by examining the relationship between brain damage in a specific region and the loss of specific sensory and motor dysfunctions. Representative studies include Broca's (1861) study of speech impairment due to left temporal lobe damage, Sperry's (1962) study of functional differences between the left and right hemispheres, and Gardner's (1976) study of artists with right hemisphere damage. These neuropsychological studies have not only contributed to the understanding of the relationship between the brain and mind, but have also had a significant impact on the humanities and social sciences, such as linguistics and psychology, as well as the arts, and have contributed greatly to their development.

However, there are few studies on the relationship between hyperactivity of specific brain regions and hyperactivity of specific sensory functions. One such example is hyperactivity of the visual cortex causing visual hallucinations (e.g., Hadjikhani et al. 2001). The hyperactivity of sensory functions here refers to "a state in which specific sensory functions are markedly enhanced compared to normal state, or in which a person becomes extremely sensitive to specific stimuli." Examples include hypersensitivity to light, sound, and smell in patients with migraine and epilepsy, trypophobia (excessive discomfort with a cluster of small holes), hallucinations in epilepsy, hallucination-like visual symptoms in migraine, enhanced drawing realism in dementia patients, sensory hypersensitivity in autism spectrum disorder (ASD) patients, and pareidolia (a symptom in which patterns on walls and other objects appear to be human faces) in Lewy body dementia.

Many of the "hypersensitivities" caused by hyperactive brain functions have been overlooked and treated as negative events by our society. People with these symptoms experience various difficulties in their daily lives due to their sensitivity, but it is difficult for them to gain an understanding of those around them. For example, the use of noise-canceling headphones in schools and workplaces is finally being recognized as a rational consideration, but it is still often misunderstood as "laziness" or "indolence." Recently, people who cannot wear masks due to their hypersensitivity to textiles have received strong pressure from others.

In this project, we will deepen our understanding of the relationship between the brain and mind by developing a new cross-disciplinary research area that includes psychology, brain science, design science,

and disability science, with the neuropsychology of brain hyperactivity at its core. In addition, we will promote basic research, or symbiotic humanities and social sciences, to alleviate the "difficulty of living" felt by sensitive people and create a society where sensitive and non-sensitive people can understand and coexist with each other and demonstrate their abilities more than ever before. By promoting mutual understanding and coexistence among people with diverse sensibilities through this project, we aim to contribute to the Sustainable Development Goals (SDGs) of "realizing a sustainable, diverse, and inclusive society in which no one is left behind".

2. Outline of research

The project was divided into three phases: Phase 1 was a neuropsychological study to analyze the factors that cause sensitivity and elucidate the mechanism of sensitivity, Phase 2 examined the process by which hyperactive brain function causes "difficulty in living" from the perspective of the living environment, and Phase 3 proposed and verified a comfortable living environment. In addition, since the nature of brain hyperactivity differs greatly between young people and patients with dementia/brain injury (mainly consisting of the elderly), the research project was divided into two research groups: the youth research group and the elderly research group. We actively conducted outreach activities for the general public and researchers by holding symposiums and lectures. When presenting research results, we made efforts to publish papers in English open access journals in consideration of their rapidity, internationality, and interdisciplinary nature.

Phase 1: Exploration of the mechanism of sensitivity

In the youth research group, Koyama (group leader) and Shutoh (co-investigator) used psychophysical methods to examine the sensitivities of migraine and trypophobia patients to various stimuli, as well as brain activity using near-infrared spectroscopy (NIRS). The experiments were combined with personality tests, such as the State-Trait Anxiety Inventory (STAI) and the sensory profile to examine individual differences. In addition, we standardized the Japanese version of the Visual Discomfort Scale as an index to quantitatively evaluate hypersensitivity to visual stimuli.

Ide (co-investigator) conducted an experiment (temporal order judgment task) to elucidate the perceptual and cognitive processing characteristics underlying sensory hypersensitivity in subjects with autism spectrum disorder and those with typical development. In addition, brain activity during the temporal order judgment task was measured using functional magnetic resonance imaging (fMRI), and GABA content in the cerebral cortex was measured using MR spectroscopy.

Ide and Oshima (co-investigator) conducted a survey of people with ASD to examine the relationship between sensory hypersensitivity to food ingredients and picky eating. They also attempted to form subcategories of sensory hypersensitivity through a large-scale survey of the people involved. Shutoh used neuroanatomical methods to analyze the effects of the gestational environment on the postnatal serotonin nervous system to clarify the brain mechanisms of sensory hypersensitivity through the development of an ASD mouse model.

In the elderly research group, Midorikawa (group leader) and Shigemune (co-investigator), in collaboration with Professor Olivier Piguet and Lecturer Ramon Landin-Romero of the Brain and Mind

Centre, University of Sydney, Australia, developed a Japanese version of the Hypersensory and Social/Emotional Scale (HSS), a scale designed to assess functional improvement in dementia and brain injury patients. They also conducted a qualitative analysis of a drawing task (Rey-Osterrieth Complex Figure Test (ROCFT) conducted at the University of Sydney and examined its relationship with background pathology.

Phase 2: Incorporating into the living environment factors

Koyama conducted a questionnaire survey with university students in Japan (Tsukuba University) and China (Tianjin University) regarding sensory hypersensitivity, asking them about problems in their daily lives due to sensory hypersensitivity and their coping methods. Koyama also conducted an experiment to evaluate the patterns of curtains and wood grains with people with sensory hypersensitivity and conducted a spatial frequency analysis of the patterns. Oshima conducted semi-structured interviews with supervisors who directly supervise people with high-functioning ASD in a company where people with high-functioning ASD are established to clarify the organizational climate of the workplace where people with high-functioning ASD are established and the efforts made in such an organization to establish them in the workplace.

Yamamoto (co-investigator) analyzed the base color, number of colors used, patterns, etc. of 861 commercial residential wallpapers and evaluated users' impressions of 18 of the wallpapers and the appropriateness of these wallpapers when used in reading rooms, living rooms, offices, and cafes.

Phase 3: Proposal and verification of a livable living environment

Koyama conducted interviews with the patients, their guardians, teachers at the school for independence and support, and an expert (Associate Professor Ginga Sasaki of Tsukuba University). Based on the results, Koyama and colleagues designed a prototype of a resting room called "sensory room" and products to promote relaxation for people with sensory hypersensitivity. In addition, they actively disseminated information on sensory hypersensitivities, because they thought that disseminating information, such as "shopping at supermarkets and shopping malls is very difficult for people with sensory hypersensitivity" or "people with sensory sensitivities cannot wear masks," would promote coexistence between people with and without sensory hypersensitivity. They also developed a prototype of a game that allowed users to learn about sensory hypersensitivity by simulating the daily life of a person with sensory hypersensitivity.

Midorikawa, Shigemune, and their colleagues in the elderly research group, together with Professor Akiyama and Assistant Professor Niwa of the Research and Development Organization of Chuo University, have started an experiment to test a public space design considering sensory hypersensitivity in people with dementia and higher brain dysfunction, using eye-tracking and behavior observation. (Full-scale implementation has been postponed due to changes in the airline industry environment caused by COVID-19.)

Study Member

1. Research Director and Group Leader of Youth Study Group

Shinichi Koyama, Ph.D.
Professor, Faculty of Art and Design, University of Tsukuba
Research Fields: neuropsychology, psychology of perception, design research

2. Group Leader of Elderly Study Group
Akira Midorikawa, Ph.D.
Professor, Faculty of Letters, Chuo University
Research Fields: neuropsychology, cognitive psychology

3. Co-Investigator
Sari Yamamoto, Ph.D.
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Research Fields: design research, color planning

4. Co-Investigator
Fumihiro Shutoh, D.V.M., Ph.D.
Lecturer, Faculty of Medicine, University of Tsukuba
Research Fields: anatomy, neuroscience

5. Co-Investigator
Masakazu Ide, Ph.D.
Researcher, Research Institute of National Rehabilitation Center for the Persons with Disabilities
Research Fields: cognitive neuroscience, neuropsychology

6. Co-Investigator
Yayoi Shigemune, Ph.D.
Assistant Professor, Research and Development Initiative, Chuo University
Research Fields: neuropsychology, neuroscience

7. Co-Investigator
Remi Oshima, Ph.D.
Lecturer, Faculty of Art and Design, Mejiro University
Research Fields: organizational psychology

4. Research results and outcomes produced

4－1. Main Research Achievements

Phase 1: Exploring the mechanism of sensitivity

Koyama and colleagues conducted a study to explore the factors that cause trypophobia (excessive aversion to polka dots) as part of their research to elucidate the mechanism of sensory hypersensitivity. While previous studies have examined in detail the effects of low-order visual information (simple visual features) on disgust in the cerebral visual cortex, such as the size, arrangement, and density of polka dot patterns (Le, Cole & Wilkins 2015), few studies have examined the effects of higher-order visual information processing, such as object recognition and the analysis of spatial relationships between objects. Koyama examined the effects of background images on disgust using Hasu-colla (a collage of lotus seed pod patterns and similar polka-dot patterns on the face and other body parts), which was once popular in Japan as a type of Internet art. They presented subjects with an upright face, an inverted face, an upright face with a dot

pattern, and an inverted face with a dot pattern and asked them to respond to the disgust they felt toward the images on a 9-point scale. They compared the disgust between the upright and inverted faces with and without the dot pattern and found that the increase in disgust in the upright face was statistically significantly greater than that in the inverted face. This result suggests that the dislike for the Hasu-colla images decreased as a result of the reduced face-like appearance of the inverted background faces (Furuno et al. 2018 i-Perception). In addition, brain activity while viewing these Hasu-colla images was measured using fNIRS. The results showed a significant increase in blood flow in the frontally mounted channel during polka dot pattern presentation, but no difference between upright and inverted background face images, which needs to be further investigated (Koyama et al. 2018, KEER2018). Next, they compared the disgust when the dot pattern was presented on the background image of an arm and when the dot pattern was presented on the background image of a rectangle with the same length and width as the arm and found that the disgust was stronger when the arm was in the background, but decreased when the arm was green or purple. Since this experiment was conducted mainly on Japanese subjects, it is thought that disgust tends to be stronger when the background image is an arm with a familiar skin color, a condition that resembles a human body (Koyama et al. 2018, VSAC).

Furthermore, a recent experiment using face images suggested that disgust decreased in participants who perceived an illusory depth between the dot pattern and their faces (Song 2019, JSKE). The results of the above series of studies support the hypothesis that polka dots are perceived as a part of the human body in higher-order visual information processing and cause disgust by reminding us of skin diseases.

Ide conducted an fMRI experiment with ASD cases with enhanced perceptual function in the temporal processing of tactile stimuli and found that the left superior temporal gyrus and left ventral premotor cortex (vPMC) of the brain were involved in this processing (Ide et al., 2020 Frontiers in Neuroscience). Analysis of the concentration of GABA, an inhibitory neurotransmitter, using MR spectroscopy revealed that ASD patients with low GABA concentration in the vPMC tended to have more complaints of sensory hypersensitivity as assessed by sensory profiles (Umesawa et al., 2020 Frontiers in Neuroscience). The neural basis of sensory hypersensitivity in ASD overlapped with the neural basis of temporal processing accuracy with respect to external stimuli, suggesting that inadequate regulation of neural activity by GABA may be involved. Ide's study has demonstrated that that reduced GABA concentration in the supplementary motor area is associated with difficulties in coordinated movements in individuals with ASD (Umesawa et al., 2020 Frontiers in Neuroscience). The results suggested that abnormalities in GABA concentration and metabolism in different parts of the brain in individuals with ASD may be related to different aspects of the disorder. Furthermore, the temporal processing accuracy of visual stimuli was improved in individuals with ASD when presented with anxiety-evoking facial stimuli (Ide et al., INSAR2020) and found that psychological care regarding the anxiety of the individuals involved may be linked to the alleviation of sensory hypersensitivity.

An interview study conducted by Oshima et al. with parents and children with ASD suggested that sensory hypersensitivity to food ingredients is associated with picky eating (Wang et al., INSAR2019). In a large-scale survey of 72 pairs of parents and children of the affected individuals, the degree of sensory responsiveness problems was assessed using the Short Sensory Profile (SSP), and the degree of core symptoms using the Social Responsiveness Scale (SRS-2). The results suggest that individuals with ASD can be classified into four clusters: a "sensory adaptation group" that showed no sensory problems, a "high

sensory problem group" that scored high in general, a "taste and smell adaptation group" with low scores for taste and smell sensitivity, and a "low activity group" with high scores for low activity and weakness. When the SRS-2 scores were compared for each cluster, the sensory adaptation group showed low scores on the SRS-2 as well, while the high sensory problem group showed high scores. The low-activity group showed higher scores for both low activity and weakness on the SSP and social motivation scores on the SRS-2, suggesting that the intensity of physical fatigue increases interpersonal anxiety. These results suggest that the characteristics of sensory processing processes influence cognitive processes, such as social skills.

To clarify the brain mechanism of sensory hypersensitivity through the development of ASD model mice, Shutoh used neuroanatomical methods to analyze the effects of the gestational environment on the postnatal serotonin nervous system. The results showed that viral infections in early and middle pregnancy caused developmental abnormalities in the serotonin system like human ASD (Li et al. 2019 42nd Annual Meeting of the Japanese Neuroscience Society).

Midorikawa et al. compared the preoperative and postoperative emotional cognition performance in patients with brain tumors who underwent surgical damage to the temporal lobe for tumor removal. In this study, we used the partial point method of the HSS to consider the inter-individual fluctuations in emotional cognition and succeeded in clarifying the changes in emotional cognition before and after surgery. Thus, brain damage does not merely result in functional decline, but also in dynamic changes in each cognitive function, including cognitive bias and its release. In addition, a study of successive changes in drawing performance in dementia showed that patients with semantic dementia, in which the left temporal region is the main lesion, maintained or improved their drawing performance despite the progression of dementia symptoms, indicating that the left temporal lobe lesion or language impairment plays a major role in visual cognition (Midorikawa et al. 2019 Frontiers in Psychology). Furthermore, a study of sensory changes in patients with brain tumors using the Visual Analogue Scale showed that 13%-29% of the total number of patients experienced sensory hypersensitivity or insensitivity, with many patients experiencing auditory hypersensitivity (Midorikawa et al., in preparation).

Phase 2: Incorporating into the living environment factors

In a questionnaire survey conducted by Koyama on university students in Japan (Tsukuba University) and China (Tianjin University), "too much glare from classroom lights" and "inability to ignore surrounding sounds" were cited as problems in school in both countries. Interestingly, however, when asked how to cope with the problem, a large percentage of Japanese respondents said they would "be patient" while a large percentage of Chinese respondents said they would "avoid" the problem (Zhang et al. 2019 JSKE). In a study of spatial frequency analysis of curtain and wood grain patterns, hypersensitive people tended to find patterns with high contrast in the medium band of 5–15 cycles per degree of visual angle unpleasant, but it was also suggested that the discomfort may decrease with habituation (Otake et al. 2020 JSKE).

The results of semi-structured interviews conducted by Oshima with the supervisors of high-functioning ASD employees suggested that companies that retain high-functioning ASD employees consider assigning them to tasks that match their aptitudes and abilities, understanding their disabilities, creating an environment that is easy to work in, and devising ways to communicate with them. It was also indicated that behind the implementation of these measures, there is a possibility that there is an influence of organizational policies and organizational culture, such as the emphasis on social responsibility, the expectation of workers to be capable, and respect for members as equals (Oshima et al. 2018).

In an experiment conducted by Yamamoto to evaluate the impressions of wallpaper, it was suggested that light yellow wallpaper gave the impression of warmth, brightness, flamboyance, softness, and friendliness and was appropriate for cafes and common rooms. On the other hand, pale achromatic wallpapers gave the impression of luxury, maturity, and calmness, suggesting that they are appropriate for meeting rooms and quiet, calm rooms (Yi et al. 2019).

Phase 3: Proposal and verification of a livable living environment

Koyama and colleagues conducted interviews with the patients, teachers at the school for independence and support, and an expert (Associate Professor Ginga Sasaki of Tsukuba University), and based on the results of the interviews, they made prototypes of sensory rooms and products, such as cushions and musical instruments, to promote relaxation for patients with sensory hypersensitivity. They also made a prototype of a game that allowed users to learn about sensory sensitivities while simulating the daily lives of people with sensory hypersensitivity (Koyama et al. 2018 Japanese Society for the Science of Design).

In the VR experiment conducted by Yamamoto, it was suggested that wallpapers with a small number of colors and fine patterns are suitable for a room where one wants to concentrate calmly, such as for studying, while yellow wallpaper with medium-fine patterns (8 to 12 cm) is suitable for a room where one feels friendly, such as for dining. (Abe et al. 2020).

4－2. Impacts on related academic fields

As the most important ripple effect on related academic fields, this project has led to the expansion of a network of researchers in Japan and abroad with the keywords of "hypersensitivity" and "difficulty in living," as well as the expansion of a human network of concerned parties, researchers, and practitioners in Japan, including concerned parties, families, workplaces, university student counseling offices, and housing manufacturers. In addition, a good cycle between theory and practice has been established. Outreach activities were also actively carried out to promote mutual understanding among the parties concerned, medical professionals, researchers, designers, and the general public. In addition, because we thought that the coexistence of people with various senses would be promoted by disseminating information, we actively disseminated information to mass media, such as newspapers, magazines, and yahoo news, for general readers, such as "shopping at supermarkets and shopping malls is very difficult for people with hypersensitivity" and "people with hypersensitivity cannot wear masks."

As part of our outreach activities for the general public, we co-hosted a developmental disability symposium with Light It Up Blue Tokorozawa, an event for the world autism awareness day held by Tokorozawa City in Saitama Prefecture in April 2018 and 2019. Koyama, Midorikawa, Ide, and Oshima gave lectures on the theme of "Society Living with Individualistic Senses." The lecture was a great success, filling the Seibu Tokorozawa Waltz Hall, which has a capacity of 160 people, with many participants from the general public and researchers. In 2019, a symposium on developmental disabilities was held at the Tokorozawa City Miraikan, attended by 200 participants, the general public, and researchers. The theme was "What is a comfortable environment for sensitive senses?" Ryuichiro Iwanaga (occupational therapy) of Nagasaki University, Ginga Sasaki (disability science) of Tsukuba University, Takeshi Atsumi (experimental psychology) of the National Rehabilitation Center Research Institute for Persons with Disabilities, and Hiroki Ota (architect) of the Hidamari Design Office gave lectures from their respective professional standpoints. Panel talks were held by Koyama, Ide, Iwanaga, Sasaki, Atsumi, and Ota. In addition, a "sensory experience plaza" was set up at the venue, where visitors could experience various tactile flooring materials, a ball pool, furniture with a pleasant wooden scent, lighting fixtures, and an assembled private room space. The Symposium on Developmental Disabilities 2020 was originally planned for April 2020, but was postponed for a year due to the spread of COVID-19 and was held online on April 3, 2021. Koyama, Ide, Ai Koizumi of Sony Computer Science Laboratories, and Fusako Kusunoki of Tama Art University gave lectures on the theme of "Pictures are the mysterious windows to the senses" and artists with sensory hypersensitivity introduced their works. The event was a great success with 1,154 participants.

In addition, we held three symposia sessions and six public lectures. At the annual meeting of the Japanese Psychological Association, we held a public symposium, "Neuropsychology of Social Information: Exploring the Nature of 'Symbiosis'" in 2018, a public symposium, "Neuropsychology of Creativity" in 2019, and a public symposium, "Neuropsychology of Sensitivity and Excess" in 2020. At the first-year symposium, Midorikawa and Kenjiro Komori of the Juzen Yurinoki Hospital gave lectures on "A case of qualitative

change in drawing after head injury" and "Semantic dementia and art," respectively, from the standpoint of clinical neuropsychology on the enhancement of sensitivity to details observed in patients with brain injury and dementia. Hideaki Kawabata of Keio University and Koyama made designated discussions from the perspectives of brain science and psychology, respectively. Artist GOMA, who is also a survivor of head trauma, was invited to share his experiences of changes in sensitivity and artistic expression after head trauma. The 2020 symposium was held online, with lectures by Koyama, Ide, Kosuke Takahashi of Chukyo University, and Yoshiyuki Nishio of Tokyo Metropolitan Matsuzawa Hospital.

In the public lectures, prominent researchers from related research fields were invited to give lectures, and discussions were held among the speakers, people involved in this project, and the general public. The lectures were provided by Tomohisa Asai, a researcher at the Advanced Telecommunications Research Institute International (ATR), and Shuji Abe, an associate professor at Kyoto University's Center for the Study of the Future of the Mind, at the Chuo University Surugadai Memorial Hall on July 14, 2008. Asai's topic was "Visualizing Invisible Connections: Hierarchical Network Structure of Mind, Body, and Brain," and Abe's topic was "Cognitive Neuroscience of Honesty." On August 3 of the same year, Ramon Landin-Romero and Aurelie Manuel Stocker of the University of Sydney, Australia, presented a paper titled "MRI biomarkers of differential diagnosis and prognosis in neuropsychiatry and neurodegeneration" and "Non-invasive brain stimulation: a tool for the neurorehabilitation of neurological and psychiatric disorders? and Noninvasive brain stimulation: a tool for the neurorehabilitation of neurological and psychiatric disorders?" On December 26 of the same year, Sachine Yoshida, Assistant Professor at Toho University, and Hiroki Ota, Architect at Sunflower Design Office, were invited to the Tokyo Campus of the University of Tsukuba to give a lecture on "The Science of "Painful" and "Comfortable" Senses. Science of "Painful" and "Comfortable" Senses: Toward Symbiosis with Diverse Senses" was held. On March 26, 2019, Shuhei Iimura, Faculty of Letters, Chuo University, gave a lecture on "Highly Sensitive Person (HSP) from the perspective of development, genes, and evolution" at Chuo University's Korakuen Campus. On Saturday, January 25, 2020, Yoshiyuki Nishio, Tokyo Metropolitan Matsuzawa Hospital, gave a lecture on "Cerebral Cortex State Change and Perceptual Error" at Chuo University Korakuen Campus. On Tuesday, February 23, 2021, we hosted lectures by Keiko Kumagai of Tsukuba University, Muneto Tatsumoto of Dokkyo Medical University, Tomoji Ishikawa of Utsunomiya University, and Co-PI Yayoi Shigemune. These symposia and lectures were a great opportunity to promote joint research with Iwanaga, Sasaki, and Landin-Romero.

As for the provision of information to the mass media, this project was introduced in detail on two pages in the October 2019 issue of AXIS magazine, the most prestigious design-related magazine in Japan, and in the April 2019 issue of TSUKU COMM, a public relations magazine of the University of Tsukuba. Recently, an article in the Nishinippon Shimbun dated June 19, 2020, titled "I can't wear a mask...the agony of 'hypersensitivity', misunderstood as selfishness," featured a commentary by Ide, co-investigator, which was reprinted on Yahoo News and rose to second place in terms of access. In October 2019, Midorikawa was interviewed by the director of NHK about the enhancement of brain function in higher brain dysfunction and dementia prior to planning the program, and the issue of hypersensitivity was also discussed in NHK's "Ohayo Nippon" broadcast on July 16, 2020, and Ide was invited as a commentator.

The sensory room (a room for people with sensory sensitivities to calm down), which the project's representatives have repeatedly stressed the need for through outreach activities, has been introduced in public facilities, such as the New National Olympic Stadium. In addition, several supermarkets and drugstores are introducing "quiet hours" (a time when the lights and sound are turned down to make it easier for people with sensory sensitivities to shop). Consideration for people with sensitivities to patterns, sounds, and smells is also becoming more prevalent in society. Although we cannot say that all these changes are the result of this project, we are proud that our proactive outreach activities, supported by scientific research results and the empathy and problem-solving thinking created by design thinking have deepened people's understanding of sensory diversity and have a certain effect.

4－3. Future research plan

In the future, we will continue to study the mechanism of hypersensitivity in more detail and aim to "reduce the difficulty of living" and "increase the sense of comfort" through design. Specifically, we will continue to clarify the characteristics of sensitivity through psychophysical experiments, and aim to clarify the temporal and spatial characteristics of brain activity related to sensitivity by conducting brain research combining fNIRS (electroencephalography with excellent temporal resolution) and fMRI (magnetic resonance imaging with excellent spatial resolution). Our understanding of the brain mechanism of hypersensitivity will be greatly enhanced by comparing brain activities revealed by fMRI with the conventional mapping of brain lesions and symptoms in neuropsychology. Research on the design for coexistence among people with sensory diversity will be continued with a Grant-in-Aid for Scientific Research B ("Promotion of Design for Coexistence in Consideration of Sensory Diversity," PI: Shinichi Koyama) in FY2021–2023.

In addition, it is important to continue to identify the factors that make people with sensory hypersensitivity feel uncomfortable in their lives and resolve them through design. It is also necessary to develop the design of learning and living spaces where people with sensory sensitivities and those without sensory sensitivities can live together comfortably and improve the design of sensory rooms where people with sensory hypersensitivity can regain their composure. It is also important to develop educational materials for learning about sensory diversity for people with diverse senses to understand each other and use their strengths to create a better society together. To promote these studies in the future, it is necessary not only to continue to promote research in design, psychology, and brain science, but also to broaden the scope of research by adding researchers specializing in architecture and disability science (schooling and employment support for people with sensory sensitivities). We will apply for a new Grant-in-Aid for Transformative Research Areas to promote research. As for practical research on the design of living spaces, discussions are already underway for joint research with a major domestic housing sales company. We would like to promote the social implementation of our research results through the cooperation of companies.