Moonshot R&D MILLENNIA Program

"Research and Study on Defining Ideal Psychological States Based on Traditional Wisdom: Methods of Measurement, Guidance, and Social Implementation"

Initiative Report

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Research Team

Team to Achieve a Society where peace and vitality coexists by a Psyche Navigation System

Team Leader: Seiji Kumagai (Associate Professor, Kyoto University)

Sub Leader: Noriyuki Miura (Professor, Osaka University)

Team member: Hiromitsu Awano (Associate Professor, Kyoto University)

Team member: Yoshiyuki Ueda (Senior Lecturer, Kyoto University)

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I.1.1. Proposed MS Goal title

"By 2050, the Research Team will realize a society where peace and vitality coexist through the integration of tradition and technology."

I.1.2. Vision for 2050 society

A CPMS (Cyber-Physical-Mental System) that integrates mind with CPS (Cyber-Physical System), which is the goal of Society 5.0, will be realized. **A society with CPMS will bring not only material wealth, but also mental peace and vitality.** Just as we change our clothes according to our environment, we can change our minds according to our personal circumstances.

The implementation of the **PNS (Psyche Navigation System)**, the core technology of CPMS, in society and its mind support will: (1) increase innovation as people gain peace of mind and vitality; (2) allow the recovery of social losses (economic effects through the return to work of those on leave due to mental illness, crime suppression, etc.), and (3) create new industries through the resolution of discrimination and the realization of diversity.

Computing infrastructure for understanding the mind will integrate findings from traditional wisdom, cognitive science, and sensor technology to establish the PNS technology that leads individuals' emotions to a state of peace and vitality. A personal space (e.g., inside a room or a car) with PNS technology will be provided. We will also establish technology to maintain mental peace and vitality even in situations where people interact with each other. Furthermore, by utilizing microsensor technologies, the project will promote the development of mental support systems that utilize the internal environment such as the brain and cells. These technologies, once realized, will form the psychological basis for the suppression of unjust attacks on others, such as bullying and slander, the fostering of resiliency in the face of unjustified aggression attacks, and the revitalization of society, economy, and culture through freedom from depression and tension.

In addition, the PNS industry, which utilizes PNS technology and emotional big data, will expand and create large and small business entities, from start-ups to unicorn companies. The expansion of the PNS industry and the involvement of PNSs in various aspects of society will increase the diversity and tolerance of communities, leading to promote the transition to an altruistic, peaceful, and vibrant society. The industry will also shift from the pursuit of hostile profits to the quest for harmonious profits, which will lead to healthy economic activities.

In the society where peace and vitality coexist, everyone will be able to express their identity, which will lead to industrial, technological, cultural, and intellectual innovations. In addition, it will

be possible to stabilize the mind even in extreme conditions such as outer space and pandemics. Finally, a society with a sense of solidarity that values each other's history and culture, and respects harmony will be realized.

I.2. Targets

What will people be able to realize in 2050?

With PNS, we can guide our minds to the most appropriate state for the situation, and bring peace and vitality, just as we change our clothes to match the situation (Fig. 1).

At the individual level, emotional support through PNS technology will help to reduce excessive and persistent anxiety and aggression, resulting in a more stable emotional state, which, in turn, will increase tolerance and altruism. By reducing excessive anxiety, people can feel a sense of purpose in life, value empathy with others, and acquire a mentality that allows them to tackle various challenges actively.

At the group/social level, members of various communities, such as families, schools, workplaces, and hobby clubs, become more tolerant of each other, and consequently, aggression and discrimination (including bullying, domestic violence, and abuse) will decrease. This leads to the elimination of psychological causes of crime and poverty and the recovery of the workforce lost and economic losses due to depression and other mental illnesses. In addition, tolerance and altruism will solve discrimination based on gender, race, etc., and social diversity will be realized, which will increase the productivity of the entire society and significantly increase the GDP.

With emotional big data at its core, the PNS industry will expand globally and increase diversity and tolerance of society. It will shift the industrial structure from self-interested competition to altruistic mutual enhancement profit-seeking. Furthermore, industrial and technological innovation will explode through the use of traditional wisdom.

In education, by interacting with “bots” of famous lecturers and outstanding people, we can achieve advanced education that fosters the basis for new ideas that have never existed before. In the arts and sports, interacting with bots of top-notch coaches, artists, and analysts will improve the quality of physical skills and mental control, enabling better preparation and activity performance. In addition, in school classrooms and music halls, technologies can help teachers and performers optimize their lessons and stage performances by collecting real-time emotional and biometric data from students and audiences, and suggest the best methods for students and audiences.

It will be possible to provide emotional support and maintain a positive and cooperative attitude even in extreme situations where physical and mental tensions arise, such as in outer space, working under low or high temperatures, and in medical situations. Alleviating the peaks of distress even in psychological extremes, it can prevent sudden suicides and depression.

Through the use of PNS, people who are considered to be socially vulnerable can regain peace

and vitality, have hope for the future, and be motivated to overcome difficulties and take action on their own initiative.

Fig. 1: Image of the Psychic Navigation System

What technologies will be achieved by the year 2050?

In the PNS system, information on the human mind, traditional intelligence, and social environment in real space is digitally transformed (DX), simulated in virtual space through the "Computing Infrastructure for Understanding the Mind." The optimal solution is then fed back to the real space using various actuators implemented in society. This leads to an ideal state of mind for individuals and groups (Fig. 2). It would be appropriate to promote technological developments in the following four areas.

① The project will establish machine learning technology to digitally transform and automatically systematize the vast amount of traditional intelligence that has been accumulated in religious and philosophical books, so that all people and industries can access and benefit from this wisdom (Traditional Wisdom AI). In addition, virtual scriptures and virtual philosophies will be created digitally based on the traditional intelligence systematized by machine learning technology. Based on this, we will create a new era of thought, philosophy, morality, and social ethics for humanity. Furthermore, this information will be culturally translated to fit the world's culture, so that

it can be transmitted to people of all cultures without misleading.

② The project will complete the technology to calculate the psychological state of an individual by mapping measured physical and mental biometric data and environmental information onto an emotion space constructed through digital transformation of books and conversational data. This approach is called Emotion DX. In addition, mapping the collective state from individual gatherings will also enable us to measure the happiness of a group. By adapting this technology to cultural differences worldwide, we can create a general emotion expression model, and finalize the AI technology to propose ideas that will lead to a peaceful and vibrant society regardless of country or culture.

③ The project will develop ultra-small sensors that can be inserted on the body surface and inside the body to directly and accurately capture a person's psychological state. Specifically, we will complete an imperceptible sensor that can be worn on the body surface for 24-hour for real-time measurement of mind state. We will also develop nano-sensor and nano-actuator technologies of a size that can be inserted into the body. By providing these as options, we can provide technology that feeds back stimuli to the five senses of an individual to bridge the gap from the ideal state and lead the mind there. In addition, we will deploy psychological measurement sensors, or what we call the System to Monitor and Support the Mind, in urban spaces to measure collective emotions and build navigation technology to improve the happiness of the group community.

④ The project will complete the technology to complete the construction of a simulation infrastructure to predict the effects of external and internal stimuli that lead the mind to the ideal state in cyberspace (Emotion Simulator). This is achieved with the individual emotional transition model through external and internal stimuli (Digital Twin of the Mind). (1) Using both the Digital Twin of the Mind and the Emotion Simulator, it will be possible to simulate the mind's response to unknown stimuli. (2) It will be possible to virtually synthesize the stimuli necessary in the digital space to obtain the mental state desired by the individual. In addition, (3) it will be possible to search for people with similar mental states in the virtual space, which will help to eliminate loneliness by allowing people to connect to people with similar mental states to their own. (4) Modeling the interaction of emotions among multiple people, predicting the effects of actuators to improve the state of the group, and completing the technology to predict social trends based on group emotions.

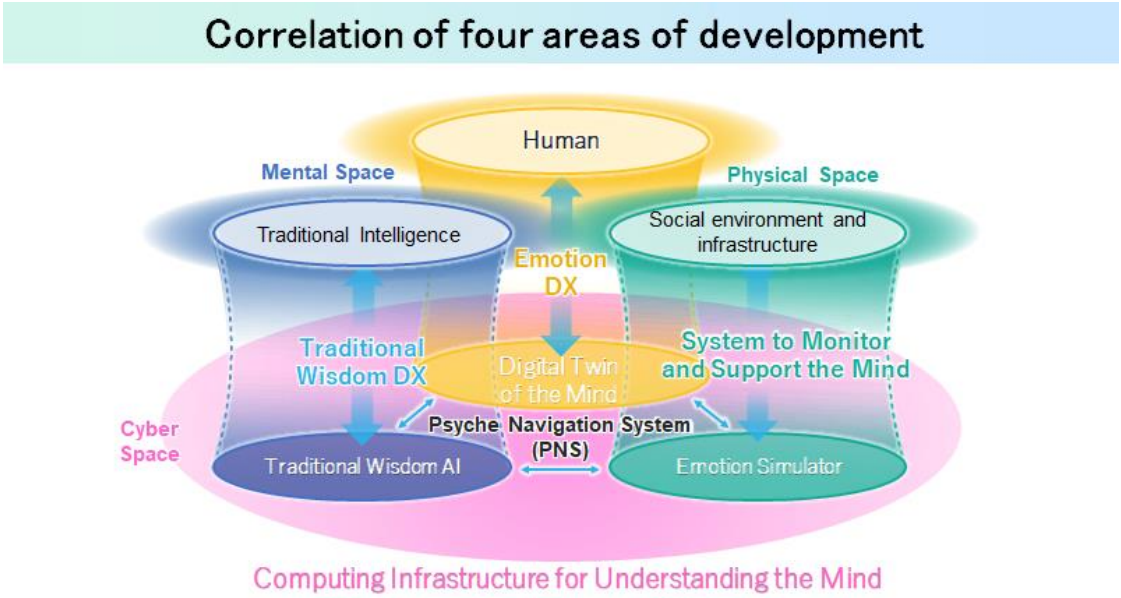

Fig. 2: Correlation of four areas of development

What should be achieved by 2030 to attain the goal in 2050?

By 2030, the project will complete the basic technologies, namely the Traditional Wisdom DX, the Emotion DX, the Emotion Simulator, the Ultra-small Powder Sensor, and Five-sense Stimulation Actuator. A device that integrates these technologies will allow people to experience the benefit of the PNS at the individual level. The PNS can make individuals achieve a certain level of mental peace and vitality, allowing them to perform activities at a high level.

For example, one can directly dialogue with "great people bots" such as the Buddha and Socrates and use them as a guide to gain peace and vitality in one's life. As a guide to their business practices, businesspersons will be able to directly interact with "management bots" such as Konosuke Matsushita, the founder of Panasonic, and Peter Ferdinand Drucker, the philosopher of the modern business corporation. By referring to virtual sutras and virtual philosophy books created via cyberspace, hints for new ideas for the future society will be generated one after another.

Actuators (projection/music/smell/air conditioning) that stimulate the senses of sight, sound, smell, and somatosensory will be activated in individual spaces, such as in a car while driving or in a room while taking a break, to automatically relax the mind when needed. When a person is about to commit an act of harm (agitated driving, domestic violence, social networking attacks), the system will alert him/her and activate the psychological actuators to calm the mind and prevent the act from occurring.

By measuring the psychological state of students in class in real-time, teachers can receive constant suggestions for improvement to guide students to their ideal state, which will greatly improve the efficiency and productivity of the class. The same technology can also be applied to

interactions between coaches and athletes, performers and audiences, etc., to improve performance in sports and the arts.

Backcasting to the year 2050, what technology will be completed by 2030？

By 2030, We will complete the PNS technology, which integrates digitally transformed traditional wisdom and quantified emotion expression space in a digital space, uses artificial intelligence to simulate a pathway to an ideal psychological state, and applies sensory stimulation actuators to guide the emotions of the "individual" to a state of peace and vitality.

In particular, by 2027 (five years after the start of MS), we will develop a system (PNS Lv0.1) that supports a mental state for a short period of time (several minutes to an hour) using images, sound, and olfactory stimuli in a small meeting room, and demonstrate the brief-time effectiveness of the system. Over the next three years, from 2028 to 2030, we will develop a system (PNS Lv1) that supports a mental state for a longer period of time (one to several days) using a business hotel or short-term accommodation, and demonstrates the short-term effectiveness of the PNS.

① The Traditional Wisdom DX: The project will complete computer technology that autonomously explores and presents the state of mind of an individual through dialogue between artificial intelligence and citizens using a large number of religious, philosophical, and ethical books. Through the semantic vector space of traditional wisdom generated by machine-learning of books, the project will create virtual sutras and virtual philosophies defining the ideal psychological state of individuals. Two technological breakthroughs will be made to speed up the Traditional Wisdom DX. First, in order to digitize ancient manuscripts, we will improve the accuracy of OCR technology so that it can analyze unclear and partially missing characters, at which current OCR technology is not good. We will also conduct machine-learning of grammatical information and establish a technology to automate critical text editing by letting the machine learn grammatical information. Furthermore, we will set up an artificial intelligence algorithm to automatically create Q&A from electronic texts.

② The Emotion DX: Using databases of books, newspapers, and media, as well as descriptions in social networking services, we will obtain the co-occurrence of descriptions of situations and contexts when each emotion arises. Based on the frequency of co-occurrence, we will represent the degree of similarity and position between emotions in a multidimensional space (i.e., Multidimensional Emotion Space). In addition, we will measure the physiological state of the body and the environmental information at the time of the occurrence of each emotion, which will be represented in another multidimensional space (i.e., Multidimensional Body-Environment Space). By corresponding these two spaces, we will develop the technology to estimate and represent the mental state of a person when he or she is in a certain environment and in a certain physiological state.

③ The System to Monitor and Support the Mind: The project will complete a mental monitoring system that keeps track of people's mental states in their living environment and guides their minds to an ideal state. In order to constantly monitor the natural state of mind without disturbance, we have developed a powder sensor that is so small that people cannot even recognize it. With this sensor (i.e., imperceptible sensor), we can estimate the psychological state of people from biometric information that can be measured on the body surface. By embedding an actuator that feeds back to the senses to fill in the gap between the estimated current state of mind and the ideal state in the environment, a social infrastructure that constantly supports the mind to be in an optimal condition can be developed.

④ Computing Infrastructure for Understanding the Mind: The project will create a simulator that can transfer the mind to the digital space (the Digital Twin of the Mind) and also predict the state of the local community and society based on the interaction of the minds. In addition, the mapping of the mind into a digital space will enable us to quantitatively evaluate the distance and difference of the mind between individuals and between groups. This will allow us to digitize the subtleties of the mind that cannot be verbalized, and to create a new cyber-community based on mental distance. In addition, by designing one's desired state of mind in a digital space and storing it in a usable form, it will be possible to transfer oneself to an appropriate mind state depending on the situation and ideal of each individual.

I.3. Background

I.3.1. Why Now?

In recent years, science and information technology have advanced to a higher level. **Yet, social problems caused by negative emotions (mind)**, such as suicide, depression, child abuse, and domestic violence, have become increasingly severe. In particular, in today's information-oriented society, many problems occur in social networking services (SNS), leading to suicides among young people, marking an urgent need to solve these problems.

Japan's current science and technology policy constitutes a groundbreaking attempt to solve various social issues through the fusion of "cyberspace" and "physical space" (CPS: Cyber-Physical System), which will significantly contribute to material wealth and the resolution of pressing social issues. **However, the technological innovation of CPS will not necessarily lead people to happiness because it does not address the issue of the "mind"**.

Therefore, **it is necessary to build a Cyber-Physical-Mental System (CPMS) that integrates the "mind space" with the "cyberspace" and the "physical space" to realize a society that values the mind**. This is a further step forward from the current "Society 5.0" to "Beyond Society 5.0." **The realization of peace and vitality for individuals, groups, and society through the Psyche Navigation System (PNS) is an initiative that meets the current social needs** (Fig. 3).

In the past, the humanities and traditional wisdom were thought to be areas that are far from technology and digitalization. However, we have focused on the fact that traditional wisdom has the great potential to benefit society and people's peace of mind and vitality. **We are working to create "comprehensive knowledge" through the fusion of digitally transformed traditional wisdom and technology**. The future we aim to build is a technology-implemented society based on this knowledge to improve the stability and vitality of individuals. This initiative will open up the future of technology, industry, and society in terms of providing a new domain for DX.

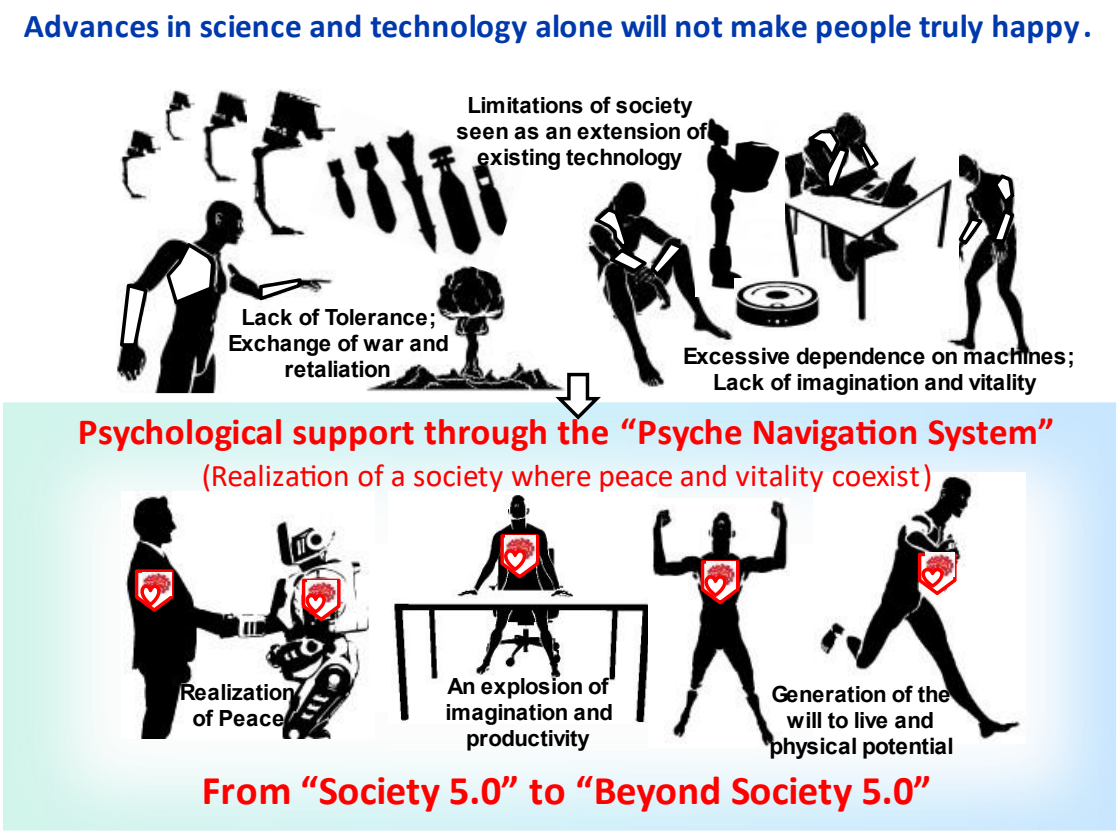

Fig. 3: From "Society 5.0" to "Beyond Society 5.0" via PNS

I.3.2. Social Significance

As mentioned above, if the technologies proposed in this report can be developed and implemented in society by 2050, individuals will gain mental stability and become more tolerant of others. In turn, society will gain peace of mind and vitality, and industry will shift from self-interest to altruism.

By easing the self-centeredness of the mind, people will become not only more tolerant of others but also accept diversity, which is expected to improve their awareness of racism, sexism, and social discrimination. As a result, we can expect to decrease the number of disputes and crimes related to mental problems in both physical and cyber spaces. The development of the PNS, the technology to support the mind, can not only curb human and psychological damage, but can also curb large

economic losses and increase other productive activities.

We can also solve the problem of the labor force and improve productivity in the age of declining birth rates by encouraging the return of people with mental problems to the workplace and the social advancement of more women. The industry will also shift from adversarial profit-seeking to harmonious and altruistic profit-seeking. In this way, the establishment of PNS will be of great significance in realizing a healthy and vibrant society and industry.

The PNS can also make social impacts on the safety net and wellbeing of people, and their culture and intellect in that the PNS can stabilize and vitalize their minds in extreme conditions. For example, it will enable people to stabilize their minds in extreme conditions such as outer space and global pandemics. In addition, children will be able to learn on their own initiative, young people will be able to take on challenges without fear of failure, and everyone, young and old, male and female, will be able to show their individuality. The diversity of individualities will lead to constant innovation in industry, technology, culture, and intellect. The PNS will also form a society that respects tradition, history and culture, and a community that values harmony and solidarity.

In addition, the PNS is also significant in terms of increasing the social contribution of academics. In recent years, the humanities and social sciences have lost their confidence and capacity to provide practical advice on social issues, which unfortunately led to the dispute over the necessity of "humanities" in academia. In this project, by digitally transforming traditional wisdom and integrating it with science, we will revitalize ancient wisdom and effectively use it for the wellbeing of future society. By fusing the humanities, the discipline once labeled as “unnecessary” by the public, with the natural sciences, we will trigger a significant academic innovation, and use the reversal of the concept of "making unnecessary things (humanities) useful" to benefit society.

I.3.3. Action Outline

The contributions to society as a whole by achieving the MS goals are outlined from the following five perspectives:

- Academic community: We are currently collaborating with researchers in the fields of religion, cognitive science, information technology, artificial intelligence, law and ethics, sociology, and anthropology to develop the technology for inducing personal emotions. The development of sensory stimulation actuators will involve researchers from manufacturing companies, which will also provide the infrastructure for implementation experiments. In addition, the PNS R&D members will play a central role in building a scholarly platform for research that integrates the humanities and sciences, utilizing traditional and humanistic knowledge. In addition, in order to implement PNS in society, we will collaborate with architects and urban engineers to study hardware for buildings and social infrastructure, pedagogical researchers to implement the technology in educational settings, and medical

researchers to prevent the onset of depression in the future.

- Political and administrative communities: Following the “6th Science, Technology and Innovation Basic Plan”, we will collaborate with the Academic Planning Office and the Office for the Promotion of Humanities and Social Sciences of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and promote the creation of “Comprehensive Knowledge” by integrating tradition with science. We can promote the Plan more effectively by demonstrating the PNS as a prototype of interdisciplinary research that integrates "human-centered" humanities and natural sciences. At the same time, we will initiate discussions on policies concerning the social implementation of the PNS.
- Industrial community: We can use the PNS as a platform to create new industrial seeds and found a startup and grow it into a unicorn conglomerate based on "*Wa*" (harmony) in Japanese. We will shift to an industrial structure where companies, workers, and consumers care for each other and conduct business transactions that satisfy everyone.
- Culture: Some traditional cultures and religions have lost their modern perspectives and capacity to meet the needs of everyday people today. This has resulted in the continuous decline of their social role and prestige, reducing their function to a mere formality. To overcome this situation, we will cooperate with agents of traditional cultures and religious leaders, and use the PNS to increase the sense of well-being through traditional cultures and religions. The PNS will thereby increase the realization of happiness through traditional cultures and religions, attracting new followers, and enabling society to mature culturally.
- Risk review (ethical, legal, medical): We will constantly check relevant policies concerning the development and social implementation of the PNS from ethical, legal, and medical perspectives. We will collaborate with medical and biological experts to examine the physical effects of the PNS on the human body and mind, and develop safer technology. We will also work with ethicists and legal scholars to continue ethical discussions on the collection of personal biometric information, alternation of emotions with actuators, and social implementation of PNS, as well as to discuss and verify legal validity (and possibly legal reform).

I.4. Benefits for Industry and Society

If the proposed MS goals are achieved, technological, industrial, cultural, and intellectual innovations will occur, bringing about the following changes in social and industrial structures.

The individual use of the PNS will increase individual tolerance and decrease aggression towards society. Specifically, the number of crimes will be reduced, discrimination will be gradually eliminated, and depression will improve as people are freed from psychological stress, thus building a safe and secure society.

By implementing the PNS in industry and turning it into an open innovation platform, we can create many new industries, including those that apply the tradition to society. In particular, there will be psychological businesses and industries that use emotional big data. The application of the PNS to industry will increase diversity and tolerance among people, and shift the industrial structure from "self-interested" competition to "altruistic" mutual enhancement, enabling healthier and more secure business.

Through altruistic and tolerant communication, diversity will be ensured beyond nationality and gender. Leaders with more diverse backgrounds will emerge, leading to more accelerated social and industrial development. Increased motivation within the organization will enable smooth and healthy operations.

The implementation of the PNS in school will make a shift from an imposed and uniform education to an advanced and highly original education, resulting in more young people with high originality and self-esteem. Many cultures and arts of the new era will be created through the fusion of tradition and technology.

Those who are in a vulnerable position in today's society, unable to find a purposeful life and self-fulfillment, will be able to regain peace and vitality through the use of the PNS. This will increase their motivation to leap forward, challenge themselves, and take action toward self-fulfillment.

II. Analysis

II.1. Essential scientific/social components

II.1.1. Essential scientific components

In order to stabilize people's psychological state with the Psyche Navigation System and realize a society where people can perform at a high level in any situations, it is necessary to capture the emotions felt by each individual into a digital space using sensing devices, calculate the distance from the ideal emotional state, and support emotional control.

To achieve this, we need: ① a Traditional Wisdom DX to find out what the ideal emotional state is by incorporating traditional wisdom such as religious and philosophical texts into the digital space, and to identify a universal emotional state that humans have not been able to find; ② an Emotion DX to capture the emotions felt by each individual and represent it in digital space; ③ a System to Monitor and Support the Mind that makes imperceptible sensing devices to measure biometric information necessary for the Emotion DX and actuators to stimulate the five senses for emotional control as a social infrastructure; and ④ a Computing Infrastructure for Understanding the Mind allows us to computationally understand the mind and simulate the emotions people feel in response to various stimuli.

① Identifying the Ideal State of Mind through Traditional Wisdom and DX

To begin with, what is the ideal state of mind? In today's world of diversified values, it is difficult to define the optimal state of mind uniformly. However, since historical, religious and philosophical texts present a wide variety of ideas, it would be beneficial to utilize the traditional wisdom of these texts. Until now, in the areas of humanities, experienced researchers have "arbitrarily" selected topics from traditional wisdom and added considerations from ethical and philosophical perspectives. It is the lack of "quantitative analysis" or “testable results” that has become a justification for the incompatibility between human and natural sciences. Consequently, there has been no dialogue between the two fields, and there was no pathway to bring the outcome of the research in humanities to society. Furthermore, since each researcher has manually collected information scattered in the vast amount of literature, there was no way to prevent fluctuations in interpretation depending on the researcher. As a result, it has been highly challenging to comprehensively analyze the literature that exists worldwide and classify and organize which traditional wisdom is universal or specific.

One way to overcome this problem is to work with quantified collective knowledge.

(i) First, we will collect electronic texts of religious and philosophical books that describe traditional wisdom. This will be digitally transformed (DX) into a form that can be handled by computers, and then systematized in a way that machine learning can extract essential components autonomously. As a result, we can quantitatively and comprehensively understand how the ideal

state of the mind has been discussed.

In recent years, scholars of classical literature have manually typed ancient documents and converted them to electronic text, but many of the ancient documents have yet to be digitized. To speed up the process of electric conversion, it is necessary to improve an OCR technology that allows artificial intelligence to analyze scanned images of ancient documents and automatically convert them into e-texts. It is, however, difficult to analyze hand-written manuscripts with 100% accuracy. For example, the latest digital technology can convert *kuzushiji* (ancient Japanese writing) characters from scanned image data into electronic text with 90% accuracy, but the remaining 10% must be done manually. Also, if there are errors in the manuscript itself, the analytic software will faithfully convert them into text. We also need to develop technology to revise these errors critically.

(ii) We will apply natural language processing algorithms such as BERT to autonomously respond to people's problems and search answers from electronic texts of religious and philosophical literature. The Buddhist chatbot AI "BuddhaBot" (Fig. 4) developed by the team leader, Kumagai, is an artificial intelligence that processes Buddhist scriptures by machine learning and presents the most appropriate answers to the user's questions from the Buddha’s perspective. If the artificial intelligence algorithm used in the BuddhaBot is trained on data from religious and philosophical texts other than Buddhism, we can realize a more versatile "traditional wisdom bot" or "great person bot". We can also create a "management bot" by having them learn the words of managers.

However, the current algorithm of the BuddhaBot uniformly presents the contents of literature to all users, and cannot be applied like PNS, which supports the user’s mind according to the individual state. It is not possible to deliver answers that consider the characteristics and preferences of individual users. Therefore, we need to improve artificial intelligence with a learning function that reflects the tastes and ideas of each individual so that it can present the best solution flexibly according to the characteristics and circumstances of the individual. In addition, the current artificial intelligence algorithms require a tremendous amount of time to create the training data, as we still need to manually generate training data in the form of Q&A that the artificial intelligence can machine learn. In order to save time, it is necessary to develop an algorithm that can directly and automatically create a Q&A list from electronic text.

If we can develop the technologies above, it will be possible to dramatically improve the quality of Traditional Wisdom DX and AI, which serves as a starting point for PNS.

(iii) In addition, since there are many aspects of the ancient traditional wisdom that do not match modern society, it is necessary to tune and update it to a usable form for modern society by integrating it with information on public opinion and world affairs.

(iv) We also need to be aware that not all traditional wisdom is written down; there is nonverbal traditional wisdom, traditional physical techniques, traditional rituals, etc. that are not verbalized. In order to use them, it is expected to develop traditional wisdom AI that accumulates non-verbal

information by using not only literature but also Emotional DX and biological data collected by powder sensors.

Fig. 4: Concept of Buddhist chatbot AI "BuddhaBot": this project plans to apply its algorithm to develop traditional wisdom AI.

② Emotion DX: To digitize emotions, it will be necessary to "reconstruct the theory of emotion" and "estimate emotions using time correlation."

(i) Reconstruction of the theory of emotion: So far, emotions have been examined from two major perspectives. One theory is the idea that they are expressed by two axes, valence and arousal (affect grid: Russel et al., 1989). The other is a categorical view based on happiness, anger, surprise, disgust, fear, and sadness (the six basic emotions), considered to be cultural universals (Ekman, 1971). However, the emotions we feel in our daily lives are more complex and diverse, and not fully expressed by either these axes or categories. In recent years, it has been pointed out that even basic emotions are not culturally universal (Barrett, 2017). In light of this, we propose a multidimensional representation of emotions, which encompasses both the valence-arousal biaxial model and the categorical model and adds axes that provide an overview of culture-specific emotion expressions.

(ii) Conversion from biometric information to Multidimensional Emotion Space: We need a method to convert from measurable physical quantities (facial expression, heartbeat, skin potential, sweating rate, etc.) to emotions actually evoked and map them in Multidimensional Emotion Space. There are three main challenges to this.

The first challenge is the refinement of emotional categories and deciding sensing modalities. The progress of machine learning has rapidly advanced attempts to make computers read emotions.

Still most researchers end up assigning labels based on the six basic emotions, and the categories are too rough to use to control the subtleties of emotions. This needs to be refined based on the theory reworked in (i). It has also been pointed out that the subtleties of emotions cannot be understood with single-measurement physiological data such as "only face images" or "only heartbeats" (Barrett, 2017). Therefore, it is necessary to estimate emotions through multimodal sensing such as combinations among voice, body movement, posture, respiration, gaze, eye blink, pupil diameter, muscle potential, stress hormones, etc., in addition to facial images, heartbeat, skin potential, and sweating rate.

The second challenge is the technology to process subjective emotions with super-resolution. Emotions are difficult to measure directly, so we have to rely on subjective reports. However, because we are not subjectively aware of minute changes in the subtleties of emotions and subjective reports are always post-descriptive, individuals may not be able to accurately classify the detailed emotional categories required in the first task. To solve this problem, it will be necessary to link the Multidimensional Emotion Space representing the correlation between the emotions constructed in (i) and the measured biometric data by data assimilation, and process the roughly reported subjective emotion with fine-resolution.

The third challenge is to utilize the continuity in the temporal direction. Currently, emotion recognition is based on time-independent information such as facial photographs, and it is difficult to say that complex forms of emotion expression can be adequately modeled. In addition, since the invention of deep learning, the emphasis of research has shifted to the collection of vast amounts of data. In measuring emotions, sensing present physical states has become the main focus, but emotions are temporary transitions and do not occur randomly. Some emotions are more likely to happen, and others are less likely to occur according to not only situations but also chronological patterns. Since contextual information (physical sensing such as temperature, humidity, and location, and purpose-oriented information such as "where," "with whom," and "for what") has also a significant impact on emotion transition, we should be able to use this to understand the state of our minds.

By solving these issues, it is possible to convert multi-sensing of contextual information and the physical state into a multi-dimensional emotion space, and represent the current state of the human mind in cyberspace (i.e., Digital Twin of the Mind).

③ Sensing and Actuation Social Infrastructure for Monitoring and Supporting the Mind

To achieve continuous measurement and control, we need to embed sensing and actuation devices as infrastructure in our daily lives. Currently, MRI machines and electroencephalography are commonly used devices to understand human psychological processes. Each of these devices has the advantage of high spatial and temporal resolution for investigating brain activities. It is, however,

impossible to continuously measure the mental state of the subject in daily life due to the significant limitations of the device, such as the posture during measurement. In addition, as explained in ②, it is difficult to capture the subtleties of the mind even if brain activities, facial expressions, and skin potential are measured alone (Barrett, 2017). Several technologies have been developed to induce psychological states, such as those that use olfaction (aroma), which has a direct link with the limbic system that controls emotions, and those that use blue light to stimulate intrinsic photosensitive retinal ganglion cells (ipRGCs), which control human arousal. However, all of them only stimulate a certain number of cells at a specific location. Even if the current state of an individual can be adequately captured, the sensitivity of each individual varies. Therefore, even if we use AI to estimate the emotional state of a person and search for a route to guide them to a particular psychological state, it would be very large-scale. Moreover, to do this in real-time, it is necessary to execute the process on small terminals such as the subject's mobile or peripheral terminals.

If the subject is aware that he or she is being measured, their behavior will change. This is why we need a device that can measure biometric data in any situation without disturbing the subject. To solve this problem, we need to develop ultra-small sensors such as "powder computers." They could be placed not only on the body surface or environmental spaces, but also inside the human body (in blood vessels or in the brain). For patients with severe or physical disabilities who cannot properly use external devices, insertion into the body may be one viable option. To implement the sensor on the body surface or inside the body, we need to solve the issues of power supply and transmission technology for the sensor, as well as psychological and legal barriers to inserting the sensor into the body. In addition, the timing and format of the feedback is another important development issue, since it makes the subject aware that he or she is being measured. In the future, we plan to develop actuation technology that leads the human mind to an ideal state by using brain-cell interface technology that directly measures brain activities and returns stimuli directly to the brain. We need to develop edge AI computer technology to realize route search for small terminals to guide people to the ideal state of mind by operating peripheral devices while considering individual sensitivity.

④ Computing Infrastructure for Understanding the Mind

In PNS, traditional wisdom, mind, sensing, and actuators are interconnected through an information or cyber space. Modern computers use bit strings represented by 0/1 binary codes as input and generate output using circuit elements that operate deterministically. On the other hand, mental states and biological information have probabilistic fluctuations. To handle them with a deterministic computer, we need to pseudo-reproduce the fluctuations, which requires an enormous amount of computation time. Solving this problem will require developing a computing infrastructure that specializes in handling fluctuations (Computing Infrastructure for Understanding the Mind). In the future, it will be necessary to convert Traditional Wisdom DX and Emotion DX algorithms into

quantum algorithms so that quantum computers can take advantage of quantum fluctuations. To handle the traditional wisdom and emotions across a wide variety of regions and communities, the scalability will be insufficient. Therefore, it will be necessary to explore a hybrid form of classical and quantum algorithms.

To induce an ideal emotion, it is necessary to know in advance what kind of stimulus will evoke what kind of emotion. Therefore, we need the "Emotion Simulator" that can virtually simulate the emotions evoked by stimuli in digital space. In addition, since we are social beings, the accurate simulation of emotions will require predicting individual interactions and even the group dynamics that drive society. From this point of view, it is necessary to divide the development of the Emotion Simulators into two stages: the individual level and the group level.

(i) Individual level: It is necessary to build a computational model that can predict the emotions that each individual evokes from the stimuli given through the five senses such as sight and hearing. Since emotions have temporal continuity described in ②, the computational model must be able to handle time-serial information in order to predict emotions accurately. On the other hand, there is a concern that the temporal resolution of the correct data may be insufficient because the "correct data of emotions" necessary for the development of the Emotion Simulator must rely on the subjective report of each individual. To solve this problem, it is necessary to construct a theoretical model of emotions based on psychology. More specifically, by adjusting the theoretical model with the actual measured information through data assimilation, we need to clarify the short-time transitions of emotions that are not noticed subjectively.

(ii) Group level: To develop the Emotion Simulator to the group level, we have to (1) efficiently construct the Emotion Simulator for each individual who forms a group, and (2) investigate the transmission and interaction of emotions and implement them in the Emotion Simulator. To realize (1), we need to extract universal emotional components throughout culture and society, and serve them as templates for the Emotion Simulator. Then, we need to develop technology to accelerate the construction of the simulator by tuning the template and absorbing each person’s individuality. At the same time, it is also necessary to extract the universal cultural components of emotions along with digital transformation of traditional wisdom described above. To realize (2), we will need a computing platform that can track the transmitting process of emotions among individuals and simulate the interactions among individuals that make up a group. In today's world of video-sharing websites and social networking services, emotions between individuals can spread instantly to tens of thousands of people, making it extremely difficult to track their transmission. It would be realistic to start with a situation where the connection to the Internet is limited and the physical distance between individuals is easy to control (e.g., discussion classes at elementary and junior high schools or limited gatherings at companies), and then scale up the level of research. One of the technical challenges in incorporating the calculation of interaction into the Emotion Simulator is a significant

increase in computing power. The multiple gravitational problem, in which the orbits of gravitationally attracted celestial bodies are calculated, is well known as a simulation that takes into account the interaction. An accelerator (Grape) specialized for this calculation has been developed, since the amount of computation increases exponentially just by taking interactions into account. In addition to being a multiple-body problem such as the multiple gravitational problem, the simulation error cannot be ignored in the Emotion Simulator, so we need to develop a computing infrastructure that can enumerate various possibilities stochastically.

II.1.2. Social Components

When implementing PNS in society, we must clarify how we can solve social issues by applying the technology that enables the system to understand and support the state of mind. In addition, it is necessary to clarify to what extent the public will be interested in and welcome (or reject) the PNS technology.

II.1.2.1. Key Elements for Happiness

The Cabinet Office's "Moonshot Research & Development Program" aims to achieve "Human Well-being" by solving social, environmental, and economic problems. The PNS is a system to realize people's happiness, especially from the mental perspective, but what exactly is the kind of "mental happiness" that the PNS can foster?

In 2011, the Happiness Research Unit of the Economic and Social Research Institute, Cabinet Office, Government of Japan, conducted a survey on the factors that are important in judging the level of happiness by gender and age. At the same time (in 2012), *SuRaLa Net Co., Ltd.* conducted a survey on the level of happiness for elementary, junior high, and high school students, using almost the same items as the Economic and Social Research Institute of the Cabinet Office. The results of these surveys are summarized in Figures 5 and 6. From the graphs, it is clear that the factors of household income, health, family, and employment are essential to happiness. This was also influenced by the age and gender of the respondents, with men placing more importance on employment factors than women, and health becoming more important from the late 50s. On the other hand, up to the early 20s, free time and friendship factors were found to have a strong influence on happiness. PNS is expected to contribute mainly to the realization of mental health, a healthy home environment, and a healthy work environment. It will be necessary to develop the technology with an eye to the fact that the factors considered important will vary depending on the gender and age of the target population.

In the past, it was often thought that quantitative scientific research could not be conducted because happiness is a subjective concept. However, as introduced by Oishi (2009) and Uchida (2020), scientific and quantitative research on happiness, especially in the field of psychology, has

rapidly increased since the 1990s. In this project, we will use the PNS as a platform to work on solving social issues in collaboration with happiness researchers in Japan and abroad.

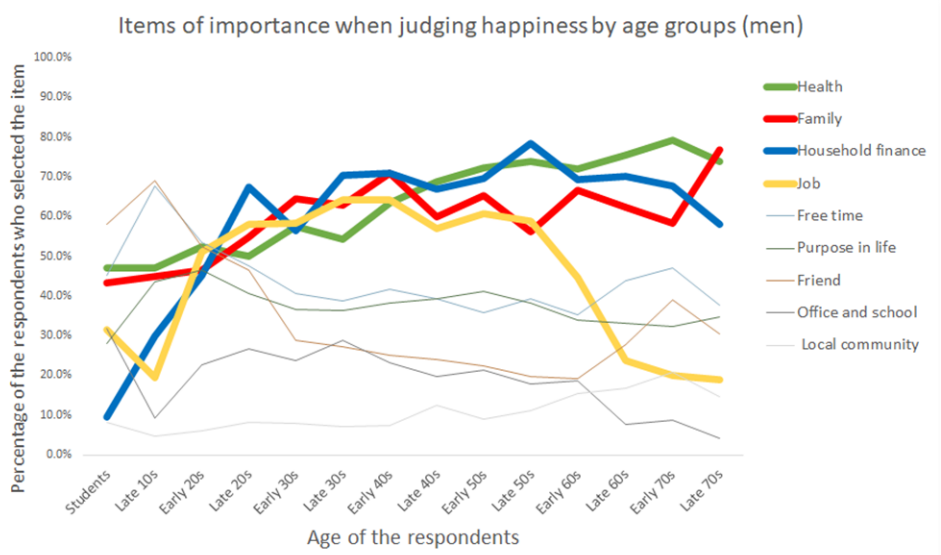

Fig. 5: Items of importance when judging happiness by age group (males) according to the Happiness Research Unit of the Economic and Social Research Institute, Cabinet Office, Government of Japan and SuRaLa Net Co., Ltd. Since the SuRaLa Net survey does not include age or gender categories, we show this as a label for "Students." For students, "pocket money" is interpreted as "household budget," "grades" as "employment," and "school/learning" as "workplace/school.

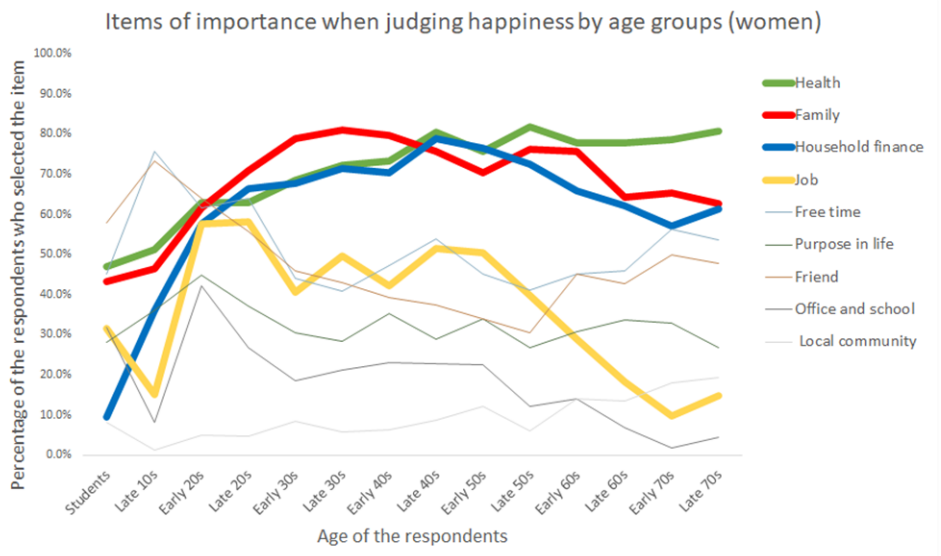

Fig. 6: Items of importance when judging happiness by age group (women), according to the Happiness Research Unit, Economic and Social Research Institute, Cabinet Office, Government of Japan, and SuRaLa Net Co., Ltd. The same as Figure 5 for the SuRaLa Net survey.

II.1.2.2. Economic Benefits of Psychological Support

The first specific issues that the PNS is expected to solve are suicide, depression, and crime. Although the economic loss due to suicide and mental illness varies depending on the survey, it is estimated to be at least several trillion to several tens of trillion Japanese Yen (JPY) per year, ranging from 2.7 trillion JPY (Kaneko and Sato, 2010) to 15.2 trillion JPY (Ikegami, 2010) as of 2010, and approximately 30 trillion JPY in 2026 (Ikegami, 2010). Preventing mental illness not only reduces medical costs and various benefits. It can also increase productive activities by avoiding the loss of working productivity caused by lack of concentration or absenteeism due to mental illness. In addition, if we can prevent people from committing suicide, we can regain what they should have been able to produce. The development of technologies to support the mind will curb not only human and psychological damage but also large economic losses and will increase other productive activities.

Stabilizing the state of mind also contributes to the suppression of crime and correctional work for criminals. According to a survey by the Ministry of Justice, the cost of correctional services has been increasing every year, reaching 290 billion JPY in the fiscal year 2015. In addition, the difficulty in controlling the mind can lead to child abuse. The burden of child abuse continues not only immediately after the act, but also throughout one's life. The cost of child abuse amounts to 1.6 trillion JPY per year in Japan as a whole (according to a survey by the Japan Research Institute for Children and Families). The psychological fear and trauma caused by this cannot always be translated into monetary terms, and the psychological damage is immeasurable. Education in a broader sense, including the family environment, is an indispensable perspective in carving out the future of our country.

In recent years, yoga, mindfulness, and healing have flourished as “spiritual industries” that provide emotional support. The market for the spiritual industry in Japan is estimated to be equivalent to one trillion JPY (Arimoto, 2011). Influenced by the spirituality industry in the U.S., which boasts a market several times larger than Japan's, the market is expected to expand further in the future. Among traditional religions, the income from Buddhist temples reaches 570 billion JPY, and the market for the wedding and funeral industry exceeds 2 trillion JPY. In recent years, the market size for traditional religions has shown a declining trend, and technologies that support peace of mind are likely to create an alternative industry.

According to the report "The Power of Parity: How Advancing Women's Equality Can Add $12 Trillion to Global Growth" published by McKinsey & Company in 2015, if gender equality is improved, it is expected to add up to $3.3 trillion to the GDP of East Asian countries, excluding China, by 2025. The McKinsey Japan report (Horii et al., 2020) also mentions a 2018 McKinsey & Company report that says that if gender inequality in Japan were improved, it would boost its GDP

by 6 percent. The emotional support provided by the PNS creates tolerance for others, which is beneficial for enhancing gender equality.

As described above, if the PNS can lead people's minds to tolerance and peace of mind, alleviate mental suffering, and make society more accepting of diversity, we can prevent economic losses of tens of trillions of JPY per year in Japan alone and open up new markets that can generate economic benefits.

II.1.2.3. Public Evaluation of PNS

To what extent is the public opinion ready to accept a technology like PNS, a computer system that grasps the state of mind and supports it? People can accept supplementary devices such as glasses or hearing aids to recover their physiological functions, such as declining eyesight and hearing. But when it comes to psychological functions, there can be a deep-rooted belief that "computers cannot understand the human mind" or "I don't want a system to measure my mental state." To examine the extent of these psychological hurdles to social adoption, we conducted questionnaire surveys.

(1) Questionnaire survey

The survey was conducted from June 29th to 30th, 2021, under the title "Questionnaire Survey on Future Science and Technology Related to the Mind" for crowd workers registered with Lancers. 485 people (277 men and 208 women, average age 41.5 (± 9.8) years) participated in the survey. We did not include explanations such as "a society where peace and vitality coexist" in the explanatory text of the survey. The attention check task ("Please answer this question with 6") mixed in the questionnaire was answered correctly by 483 participants (99.6%), suggesting that most of the participants understood the questionnaire well and answered it carefully.

They were asked to describe their ideal state of mind, good feelings, and feelings to avoid. In the analysis, the descriptions were decomposed into separate parts of speech, and highly recurring independent words were extracted. Figure 7 shows a word cloud created by making the number of words correspond to the size of the text.

Fig. 7: Free descriptions of (A) "ideal state of mind," (B) "positive emotions," and (C) "emotions to be avoided," with sizes corresponding to their frequency.

The most common description of the ideal state of mind was "calm (穏やか)." "Motivated (やる気)" was also found, indicating that the goal of "a peaceful and vibrant society" set in this project corresponded to the ideal state of mind. In this analysis, words such as "worry (心配)," "stress (ストレス)," and "anxiety (不安)" were also high on the list, but since the descriptions were broken down into parts of speech, it is assumed that these words are describing the state of "not having" these mental states.

As for the good emotions, we can see that not only transient emotions such as "joy (喜び)" but also emotions considered relatively eudemonic, such as "calm (穏やか)," "relief (安心)," "gratitude (感謝)," "satisfaction (満足)," and "achievement (達成)," are at the top of the list. It is also noteworthy that many of the descriptions mention the word "others (他人)," suggesting that they believe that a good state for us is not determined solely by our own state.

As for emotions to be avoided, negative emotions that have been considered so far were listed, such as "anxiety (不安)," "anger (怒り)," "sadness (悲しみ)," "jealousy (嫉妬)," "fear (恐怖)," and "disgust (嫌悪)." Again, it is noteworthy that the word "others (他人)" was mentioned.

When asked where they would like to see the mental support system implemented, the most popular places were their private room (69.8%), smart phone (55.8%), and study/office desk (52.0%). On the other hand, public spaces such as streets, stations, and parks were not highly desired (3.8%, 7.1%, and 6.1%, respectively), indicating that people want to use these devices in very private spaces. **In addition, only 3.2% of the respondents answered that they "do not want to use such machines or systems", indicating that there are expectations for systems that support the mind**. Figure 8 shows the response rates for all items.

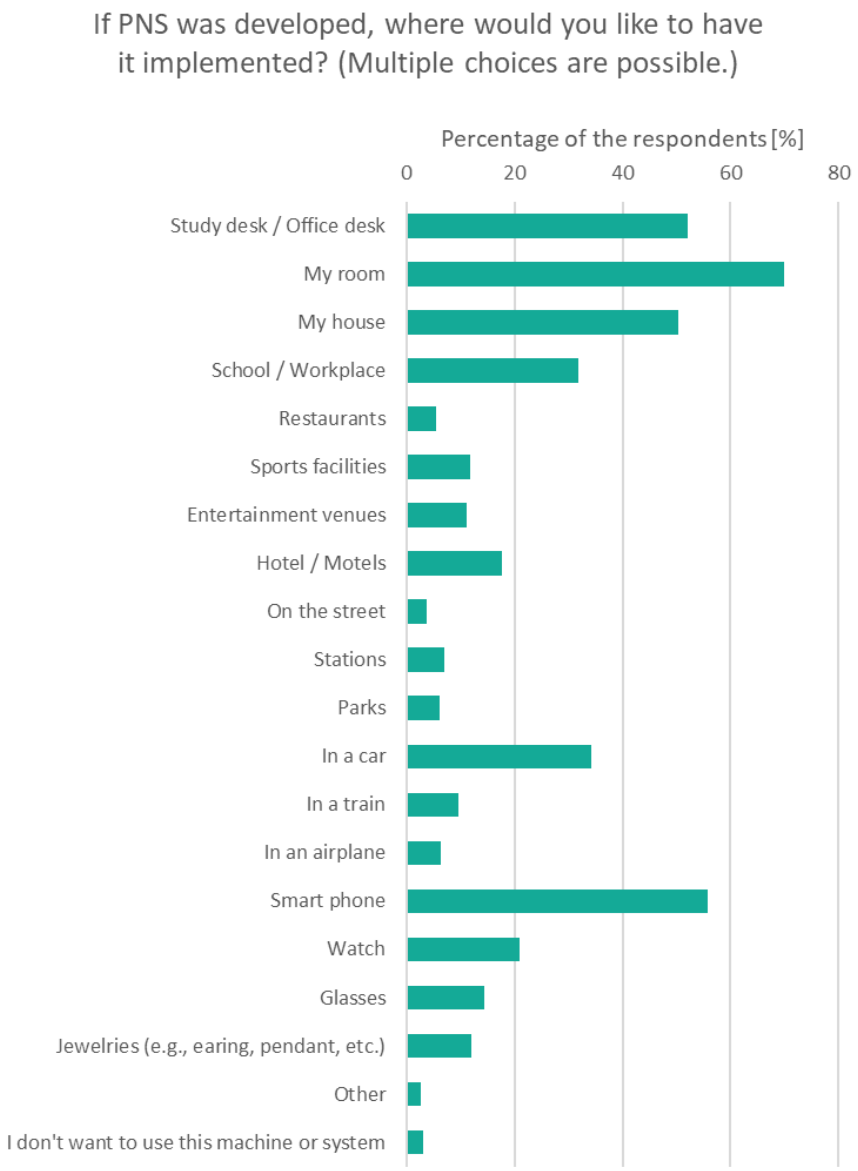

Fig. 8: If a machine or system was developed to help you feel better, where would you like to see it implemented?

When asked about the use of mental support systems in the form of chips or micro-sensors implanted in the brain, 29.6% of the respondents said they would like to use such systems. When those who avoided this type of system were asked what type of system they would like to use, portable devices (52.8%) and environmentally implantable devices (35.2%) were the most popular. Those who do not want to have a chip implanted in their brains also tend to avoid internal sensors such as medication (only 3.5% said that medication was admissible instead of implanting a chip). Only 6.4% said they did not want to use such a system, which is similar to the answer in Figure 7. However, note that this questionnaire assumes that the system is medically and legally secure, and

ELSI issues cannot be avoided in implementation. In addition, the participants were those who voluntarily participated in the "Questionnaire on Future Science and Technology Related to the Mind." We need to carefully consider the possibility that people interested in this kind of content responded to the questionnaire (sampling bias). The results of the questions are shown in Figure 9.

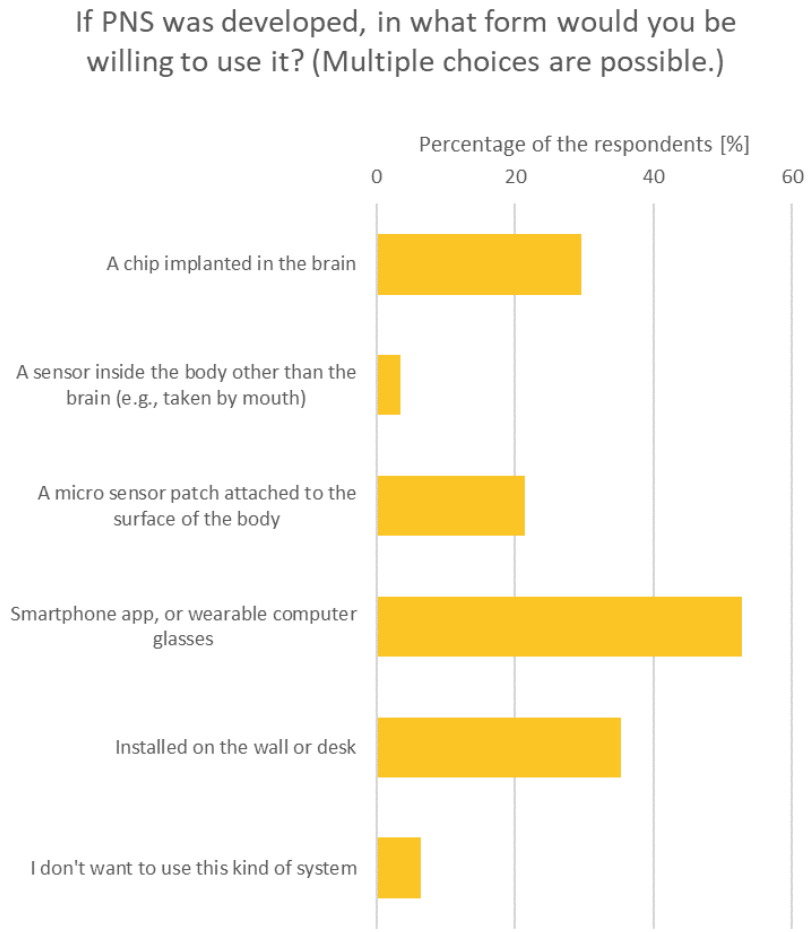

Fig. 9: If a machine or system was developed to help you feel better, in what form would you want to use it? (Please answer only if you selected "No" for "implantation of a brain chip" for "internal sensor using medication, etc.")

To examine the economic sustainability of such a system, we asked people how much they were willing to pay per month to use a mental support system. The results are shown in Fig. 10, indicating that most of the respondents chose less than 1,000 JPY, while a large number of respondents were willing to pay more than 5,000 JPY. The median was 1,000 JPY.

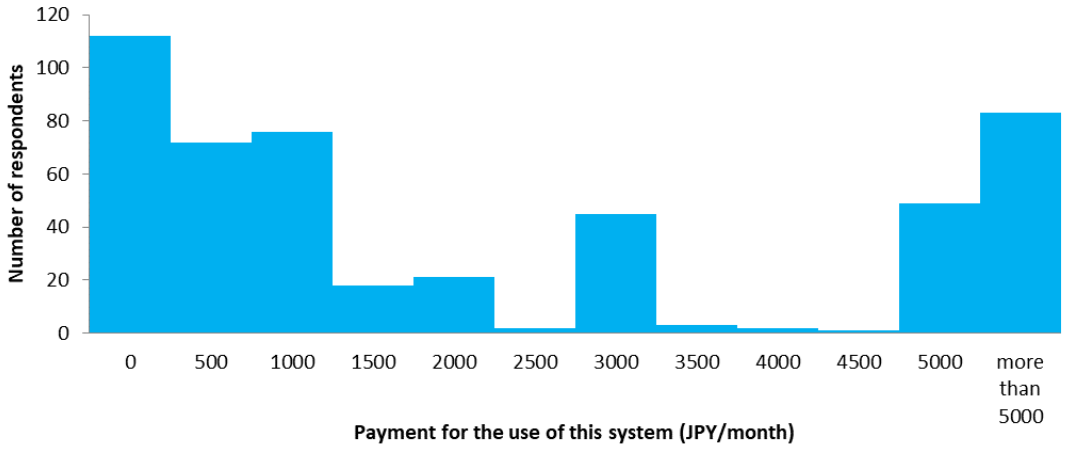

Fig. 10: If a system could be developed and used to help you maintain your emotions in your ideal state, how much would you be willing to pay per month?

Finally, the respondents were asked to respond to the Life Satisfaction Scale (Diener et al., 1985), the Information Overload Scale (Williamson & Eaker, 2012), and the Information Overload Perception Scale (Misra & Stokols, 2011). The results are shown in Table 1.

Table 1: Results of Life Satisfaction Scale, Information Overload Scale, and Perceived Information Overload Scale

	Scale of life satisfaction (7 point Likert)	Information overload scale (7 point Likert)	Perceived information overload scale (0: Never ～ 4: Very Often)	
			Cyber-based information overload	Physical-based information overload
Average	3.02	3.76	1.12	1.47
SD	1.42	1.15	0.78	0.86

There was a negative correlation between life satisfaction and information overload, with life satisfaction decreasing when people felt that there was too much information around them, $r(484) = -.26$. This suggests that it is crucial not only to simply present the measured physiological state of the body to the individuals, but also to provide feedback so that they does not feel overloaded with information.

(2) Questionnaire after the Moonshot Goal Evaluation Symposium (held on May 22, 2021)

We also asked the participants of the symposium organized by our research team on May 22, 2021 (Moonshot Goal Evaluation Symposium "Mental State in Extreme Conditions") about the future science and technology related to the mind (Fig. 11). In this symposium, the technical elements of the PNS were also explained. The survey respondents probably had a better understanding of the technical elements.

When asked to describe their ideal state of mind and what they do to calm their mind, the

positive responses included those related to peace of mind, such as "calm (穏やか)" and "relief (安心)," and vitality, such as "goal-oriented (目標)" and "concentration (集中)." The negative ones to be avoided included "tension (緊張)," "stress (ストレス)," and "anxiety (不安)," which is consistent with the results of the questionnaire in (1). In terms of practices to calm the mind, breathing-related behaviors such as "deep breathing (深呼吸)" and "breathing (呼吸)" were mentioned, as well as "music (音楽)," "walking (散歩)," and "meditation (瞑想)." These actions are considered to be easily taken daily to calm the mind, and may be candidates for efficient actuators to support the mind.

Fig. 11: (A) "Ideal state of mind" and (B) "What I do to calm my mind" as described in the symposium questionnaire.

When asked where they would like to see a psychological support system installed, the most popular places were private spaces such as their private room (44.6%) and home (38.8%). Public spaces were not highly desired (6.2% on the street, 8% at stations, and 7.1% in parks). **5.6% of respondents "do not want to use" such systems, that is to say, it is clear that there are high expectations for systems that support the mind**. Figure 12 shows the response rates for all items.

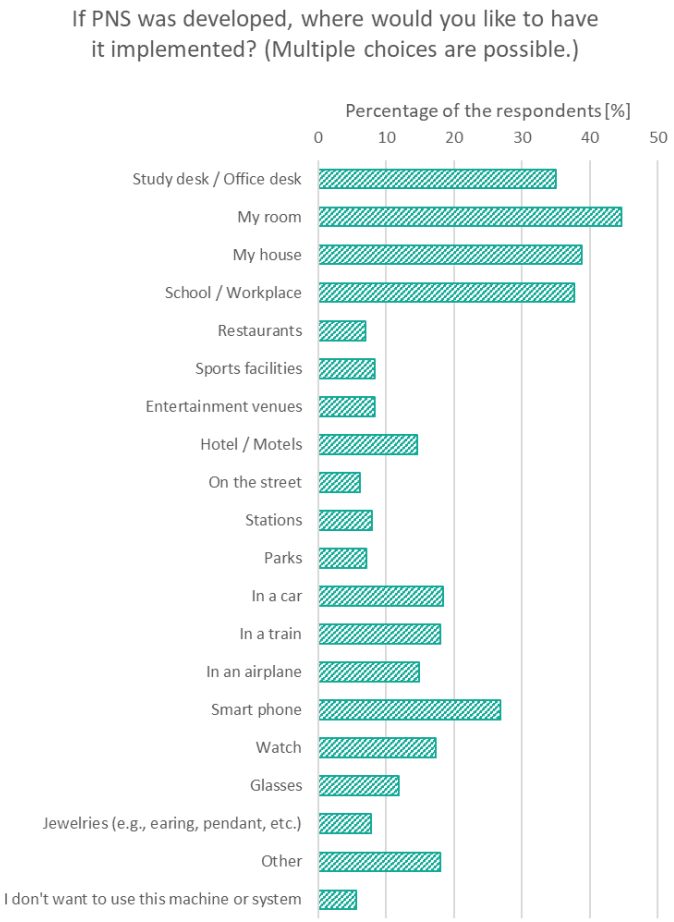

Fig. 12: If a machine or system was developed to help you feel better, where would you like to see it implemented? (From the symposium questionnaire)

Through the two surveys, **it was found that the majority of the public expects the development of a mental support system using technology and machines like PNS**. (Only 3-5% of people do not want it.)

There were many qualitatively consistent points between the two surveys in terms of the elements required for the mind and its support technologies. These surveys show that i) systems to support the mind are relatively easy to accept, ii) peaceful states such as "calm" and "stable" and energetic states such as "accomplished," "positive," and "goal-oriented" are considered to be ideal states of mind, and iii) in the case of information overload, subjective satisfaction is likely to decline.

II.1.2.4. Level of attention to PNS (evaluation by mass media and experts)

The evaluation of PNSs in the mass media is one of the testimonies that the public considers the proposed project to be "imaginative," "inspiring," and "credible".

The following summarizes the mass media coverage of the PNS and its component technologies

since the launch of the Millennia Program in January 2021.

News related to PNS

NHK News (May 22, 2021)

NHK Radio "N-Raj" (July 2, 2021)

Kyoto Shimbun (June 23, 2021, evening edition, page 3)

Chūgai Nippo (May 21, 2021, page 1)

Bunka Jiho (May 20, 2021, page 1)

NHK website news

News on the website of the China Foreign Daily

Culture Times website news

News related to PNS component technologies

・Buddhist chatbot AI "BuddhaBot"

NHK "Asaichi" (to be broadcast on July 15)

NHK News (March 26, 27)

NHK Radio "N-Raj" (July 2, 2021)

J-WAVE radio "Tokyo United" "Takenaka Future Focus" (April 23)

TBS Radio "Tamao Akae Tamamusubi" "Weekly Nippon no Kuki" (March 29)

Kyoto Shimbun (June 23, 2021, evening edition, page 3)

Mainichi Shimbun (April 21, 2021)

Chūgai Nippo (April 2, 2021, page 1)

Bunka Jiho (April 1, 2021, page 1)

Asahi Shimbun (March 27, 2021, social column)

Kyoto Shimbun (March 27, 2021, social page 3, page 31)

Asahi Shimbun Website News (*English)

Mainichi Shimbun Website News (*English)

Immediate Newspaper Website News (*Chinese)

Old Daily News website news (*Chinese)

NHK website news

Asahi Broadcasting Corporation ABC website news

Asahi Shimbun Website News

Mainichi Shimbun Website News

Kyoto Shimbun Website News

Bunka Jiho Website News

China Foreign Daily Website News

Yahoo News

・“Powder Computer”

Asahi Shimbun (March 1, 20201)
Abema TV (March 4, 20201)
Yahoo News (March 5, 20201)

As mentioned above, the overwhelming majority of the media featured the Buddhist chatbot AI "BuddhaBot," an elemental technology of the PNS. This is because a prototype has already been built (although there are some problems with accuracy), and the fusion of tradition and technology can be seen at a glance. On the other hand, Abema TV broadcasted a lengthy program on powder computers, which can be applied to micro-sensors. These media coverages show a strong public attractiveness to know every detail of the technology.

Surprisingly, numerous media outlets have already reported on the PNS even though it is still in the conceptual stage of development. In particular, the PNS is often reported together with the Buddhabot because of its novelty and originality in terms of fusing traditional wisdom and technology. In any case, **through the many media reports, it has become clear that the public has high expectations for the development of the PNS**.

In response to these media reports and the public response, **we also had many opportunities to discuss with government agencies and experts, which indicate their strong expectations for the PNS from the perspective of policy making**.

The Academic Planning Office of the MEXT (Ministry of Education, Culture, Sports, Science and Technology) requested us to provide ideas for the promotion of the humanities and social sciences, and on April 27, 2021, the Office and the Kumagai team held a meeting. The team shared their view of the importance of DX in promoting the humanities and social sciences. At the 7th meeting of the Special Committee for the Humanities and Social Sciences of the MEXT (June 28, 2021), the Buddhist chatbot AI "BuddhaBot" was introduced as an example of DX in the humanities. The case study of "BuddhaBot" will be used as a resource when the Ministry considers measures to promote DX.

In addition, on May 20, 2021, Dr. Kumagai, the team leader, gave a lecture titled "The Possibility of Creating Comprehensive Knowledge through the Fusion of Humanities and Science and Traditional Wisdom DX!” Ms. Hinako Takahashi, Vice Minister of the MEXT, and Mr. Masaaki Akaike, Chairman of the Subcommittee on the MEXT, drew particular attention to the fact that Dr. Kumagai developed artificial intelligence by studying the sciences despite being a scholar in humanities, and led a research project that combined the humanities and sciences. This attempt was

highly evaluated as one of the models of humanities-led interdisciplinary research.

On May 27, 2021, the PNS initiative was introduced on the official Facebook page of the Office of Science, Technology and Innovation Promotion, Cabinet Office. The Kumagai team has also been actively sharing information with the Secretariat, including a meeting on July 7, 2021 at the request of the Secretariat to discuss the policy making with "comprehensive knowledge." The PNS and BuddhaBot have been highly evaluated in terms of the "comprehensive knowledge" strategy, including the promotion of humanities and social sciences.

II.2. Science and technology map

The Psyche Navigation System transcribes the emotions of each individual into an information space. Based on the deviation from the ideal psychological state in each situation, PNS synthesizes and presents appropriate stimuli to continuously support the person's emotional control. To achieve this, we need to ① find an "ideal psychological state" to guide emotion control, ② map each person's emotions into a digital space (Emotion DX) that can be handled by a computer, ③ develop sensors and actuators to measure and control emotions without placing a burden on people, and ④ create a system to synthesize appropriate stimuli and guide emotion control.

① The ideal state of mind can be effectively found in traditional wisdom, such as religious scriptures that have taught on this issue for thousands of years. However, traditional wisdom has missing pieces of information lost and deformed in the long transmission process, making it challenging to extract essences related to the universal state of mind directly from the scriptures. Therefore, it is necessary to rediscover what the universal teachings and values are by digitizing traditional wisdom (Traditional Wisdom DX) and using computers to search for common factors in the vast amount of literature. To support emotional control continuously, we need not only instantaneous emotions, but also spatio-temporal sensing of emotional changes that consider the contextual information of the individual's culture and community.

To achieve this, ② Emotion DX will need to find out what kinds of emotion are recognized and what kinds of emotional changes are likely to occur (emotional transition model) in each culture. The types of emotions can be based on Traditional Wisdom DX. This attempt allows us to estimate the subtleties of emotions by measuring biometric information. Sensors will collect biometric information necessary for Emotion DX and actuators will control emotions by providing stimuli. Both devices to measure and control individual emotions should be small and unnoticeable.

Therefore, ③ it will also be necessary to integrate sensing and actuators into everyday space (the System to Monitor and Support the Mind). Then, based on the discrepancy between the emotions digitized by Emotion DX and the ideal psychological state indicated by Traditional Wisdom DX, we will need technology to synthesize stimuli that lead the emotions to the optimal state.

For such purposes, we will need technology to ④ simulate what kind of stimuli will induce

what sort of emotions in digital space (Computing Infrastructure for Understanding the Mind). Since the mind and biometric information have probabilistic fluctuations, computers should efficiently handle similar fluctuations and simulate the mind instantly. Hence, we need to develop quantum emotional simulations using quantum fluctuations and a hybrid classical-quantum simulator with scalability to predict the emotional trends of society.

In light of the above, the realization of this MS goal will require the promotion of the following four projects that interconnect the philosophical, emotional, physical, and information spaces through digital technology, starting with the mind (Fig. 13).

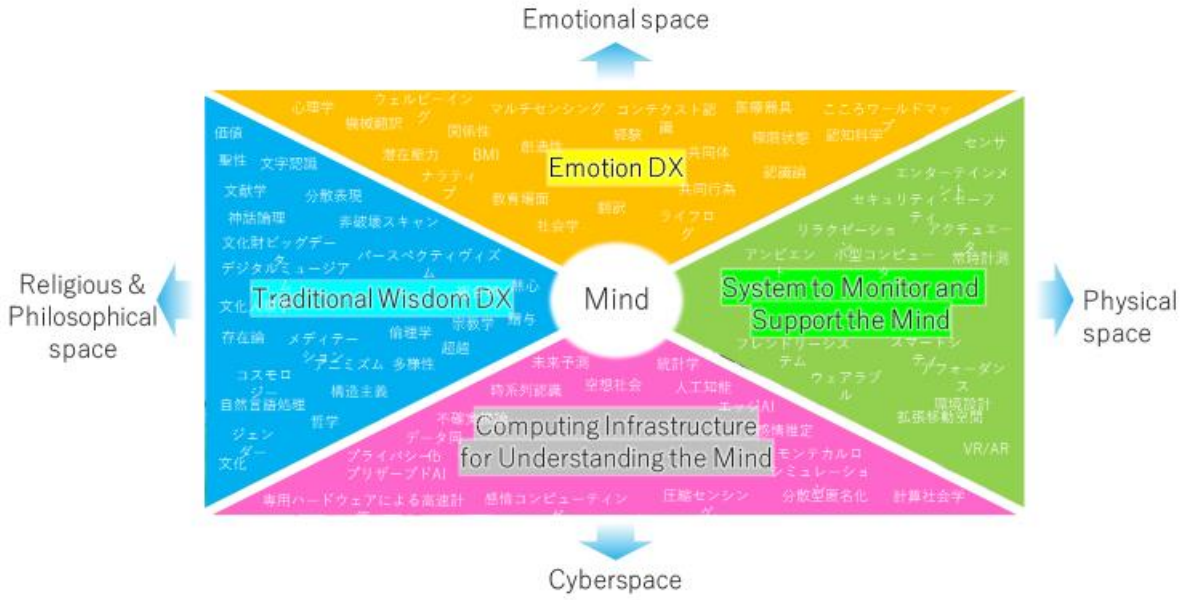

Fig. 13: Fields and elemental technologies for which challenging research and development should be promoted

① Autonomous Search and Presentation of the Ideal State of Mind and Society through Traditional Wisdom DX

The traditional wisdom described in religious, philosophical, and ethical texts is non-quantitative in its original form. By digitally transforming (DX) these texts, we can extract the necessary information quantitatively and capture the whole mindscape from a bird's eye view.

(i) Digitizing all the traditional wisdom literature would cost a great deal of time and money, making it difficult to achieve effective results immediately. The first step is to carefully collect and integrate the existing electronic texts on traditional wisdom. With the support of artificial intelligence, we also need to improve the current technology for automatically converting scanned images of ancient manuscripts into electronic texts. We will also develop artificial intelligence that can learn grammar by machine and automatically correct the critical revision of ancient manuscripts, which has been done manually by philologists.

(ii) Furthermore, we will develop artificial intelligence to extract ideal psychological states from the existing electronic texts of traditional wisdom. Dr. Kumagai, the research team leader, has already published a prototype of a Buddhist chatbot AI, the "BuddhaBot." The AI learned the oldest Buddhist scripture, *Suttanipata*, to answer the concerns of general users (Kumagai et al., 2021). By applying this technology, we aim to autonomously present the ideal state of mind and society by integrating digitized information of religious, philosophical, and ethical texts, public opinion, world affairs, and personal taste and biometric data.

At the current stage of technology, we need to manually create a list of Questions and Answers (Q&As) based on the literature on traditional wisdom to let the AI learn. However, since it takes an enormous amount of time to create training data manually, we will develop an algorithm to generate Q&As from electronic texts automatically and dramatically speed up the creation of training data.

We will also conduct monitoring experiments to determine the accuracy of the system's responses by inviting volunteering participants. Researchers in humanities will examine the experimental data to identify what has been previously overlooked in traditional wisdom and define how useful such knowledge is. Specifically, it will be possible to create virtual scriptures and virtual philosophies based on learned data by advancing natural language processing AI. Humanities researchers will critically analyze the result to improve their output. By doing so, we aim to complete an artificial intelligence that can search for the ideal state of mind and society and present new thoughts and ideas based on traditional wisdom. Once this system of autonomous search and presentation for ideal states is complete, it can make a significant contribution as guidelines for individual life and policies for organizational and social managements.

Traditional wisdom also includes non-verbal traditional wisdom such as physical techniques and rituals. We will digitally transform and quantify such undocumented information based on the Emotion DX and biometric data collected by powder sensors. By accumulating such non-verbal information, we will make the "Traditional Wisdom AI" more comprehensive.

② Quantification and Visualization of Emotions through the Definition of Emotion Space

To clarify the overall picture of the emotion space, it is first necessary to understand what kinds of emotions exist. For this purpose, we use (i) open-ended surveys on emotions, and (ii) dialogues such as conversations and SNS, and texts used in books and newspapers to identify the co-occurrence of words as an indicator, such as what physical state is described together when each emotion occurs, and what context each emotion is described in. The data will be used to construct a model (Multidimensional Emotion Space) that reflects the similarity between emotions. In addition to information from "people living in the modern age" as in (i) and (ii), we will use (iii) traditional wisdom texts such as religious and philosophical books by utilizing the Traditional Wisdom DX described above, to incorporate inherited knowledge from ancient times. Although there has also

been some progress in the conversion of physical books to electronic text and in methods for analyzing social networking sites, these developments have focused on a few languages, such as English. Moreover, it has not spread to the field of traditional wisdom, such as religious literature, which deals with mental issues in detail. To understand the whole picture of human emotion space, it is necessary to extract the components that can better explain the state of the human mind by approaching the issue from both contemporary and ancient knowledges.

Furthermore, it will be necessary to actually measure the physical biometrics and environmental information when each emotion is generated. We will then construct a model (Multidimensional Body-Environment Space) that reflects the similarity of the physical responses. For this purpose, the emotion induction techniques often used in experimental psychology (recalling episodes when a particular emotion occurred, presenting either images or videos, etc.) can be applied. In addition, by combining lifelogging technology, which constantly records bodily responses, and the experience sampling method, in which participants are asked to report their emotional states at various times using either smartphone apps or other devices. In this way, we can examine the relationship between emotions and physical states in everyday life as well as in laboratory situations. We will extract elements to explain human mental states from measured physiological indices in this way, such as brain activities, voice, facial expression, body movement/posture, body temperature, heart rate, respiration, sweating rate, eye gaze/blink/pupil, muscle potential, skin potential, and stress hormones. By taking the correspondence between the Multidimensional Emotion Space with the Multidimensional Body-Environment Space, emotions can be objectively quantified and visualized from the outside.

To improve the accuracy of emotion estimation, we also consider the use of continuity in the temporal direction. Since the emotions that occur in each scene are not random, we can increase the accuracy of emotion estimation by modeling what emotions are likely to occur (prior knowledge) and which emotional transitions are likely to occur (identification of transition probabilities).

Physiological information, which contributes greatly to this quantification and visualization, will be incorporated into the System to Monitor and Support the Mind described below. In addition, since people's behavior changes when they are aware that they are being measured, the ultra-small sensor developed in ③ will also be used for measurement.

Some emotions do not occur when people are alone, but appear only when they are in a group. For example, they are related to behavior such as sympathy, obedience, and bystandership. In addition, it has been reported that physical synchronization with others enhances group belonging and group performance. Therefore, although the understanding of the emotional state of a group can follow the same process as that of the individual level, namely "reconstruction of the theory of emotion" and "conversion from biometric information to Multidimensional Emotion Space," it must also be considered in light of the interactions between individuals in the situation.

③ Fundamental Technologies for Developing a Social Infrastructure to Monitor and Support the Mind

We will develop a system that monitors the mind and actuates it to the ideal state and install it as an infrastructure in the social environment (the System to Monitor and Support the Mind). In particular, sensors for measuring human biometric data and estimating the state of mind need to be miniaturized so that they can be used daily in a wide range of social environments. The evolution of semiconductor manufacturing technology has already made it possible to produce 1mm-sized sensors. By aggressively using advanced semiconductor technology to miniaturize sensors, and by making power supply and communication completely wireless, we can realize ultra-small sensors as small as 0.1mm. In addition, it is necessary to develop an automatic charging system that keeps the battery running for 24 hours without recharging. If we can develop such a system, it will be possible to imperceptibly measure body-mind biometric data in real time, 24 hours a day, anywhere.

Based on the biometric data collected from the ultra-small imperceptible sensors, we will install actuators that guide the user to the ideal psychological state and implement them in various parts of society. For private spaces, we will develop bedrooms and interior devices equipped with visual, auditory, and olfactory actuators. The interior devices can automatically generate projections (visual), music (auditory), and scents (olfactory) based on biometric data, and through the co-operation with the Emotion Simulator in ④, they can provide optimal psychological guidance in real time.

We will also develop a navigator that can select the ideal environment in terms of vision, hearing, and smell to enjoy the perfect environment. For example, artificial intelligence technology can already navigate people to a cool, shady sidewalk without getting exposed to direct sunlight. By integrating such technologies, we will establish a comprehensive actuator technology that effectively uses the external environment to lead the mind to a state of peace and vitality.

In addition to the actuators using external stimuli described above, we will develop internal measurement and internal actuators to complete the whole processes inside the body. We will also build a computational infrastructure to predict the results of human actuations in advance.

We will also explore the possibility that sensors and actuators can be inserted into the body. This direction is to improve the accuracy of estimation and guidance of mental states and to promote the embedding of the mental monitoring system into the social environment. Compared to bioindicators measured on the body surface, bioindicators such as saliva and tears are known to have a higher correlation with emotions. Ultimately, it is necessary to pursue the possibility of sensing and actuating brain waves and nerve signals in the body, which are thought to have a higher correlation with emotions.

By harmonizing the sensors and actuators with the environment, we can develop an infrastructure that constantly monitors the state of mind in society. It is necessary to implement the

system in gradually wider areas to develop effective sensors and actuators. Experimentally, we can explore and demonstrate the effectiveness of social infrastructure systems suitable for each of the following environments: living, working, urban, and mobile environments.

The entire society will share the mental information that transitions in a system deployed over a wide area. Then, we can identify the direction in which sensors and actuators should be advanced and where the society should really go. It is also necessary to protect mental information, the ultimate personal information, safely and securely, and the high-speed communication infrastructure to aggregate the mental states of the entire society in real time.

④ Computing Infrastructure for Understanding the Mind

We need to develop core algorithms for the Emotion Simulator and the computing infrastructure to support these algorithms. The development of the Emotion Simulator will require the promotion of the following research areas.

(i) Stimulus morphing technology: As a first step toward realizing the Emotion Simulator, it is necessary to investigate the emotions evoked by stimuli. There are many types of stimuli. For example, audio stimuli can be voice, music, environmental sounds, etc. Even if we limit it to the voice, various factors such as voice quality, pitch, speaking speed, and inflection are involved. It is desirable to control a single element independently in order to identify the correspondence between the stimulus and the recalled emotion. This synthesis technology is the first issue we need to realize. In the case of voice, speech morphing technologies such as STRAIGHT have been actively developed. Still, morphing technologies are also required for other modalities (environmental sounds, scenic images, smells such as perfume, tactile sensations such as touch, and taste).

(ii) Emotional measurement and modeling: Stimuli that change certain elements such as intonation are presented to the observer by stimulus morphing technology, and biological information is sensed by sensing technology developed in ③. Furthermore, by mapping the sensed data of the physical world to the emotion model discussed in ②, we can obtain paired information of stimuli and emotions. Next, we use a machine learning method to obtain a conversion function from feeling to stimulus, and construct a computational model that can infer what kind of stimulus evokes the desired emotion (Emotion Simulator) effectively.

(iii) Modeling of mental interaction: In (i) and (ii) above, we can obtain the stimuli necessary to lead an individual's emotions to the ideal state found in ①. On the other hand, if the model in ② does not take into account the social aspect of human beings, it has the problem of poor simulation and controllability. To solve this problem, we need to create an emotion propagation model that considers the relationships between individuals. The relationships include people known by the subject, such as acquaintances, superiors, subordinates, and friends, as well as physical locations such as passers-by and people who happen to be in the same train car. In the future, it will be

necessary to predict the propagation of emotions in combination with the System to Monitor and Support the Mind to be built in ③. We should also consider the possibility of emotion control integrated with infrastructure (e.g., when infrastructure sensors detect that people are irritated in a crowded area, the system can navigate them walking around to avoid problem areas).

(iv) To realize emotional simulations that take into account interactions and infrastructures, it is essential to develop a new computing paradigm that is skilled in handling probabilistic fluctuations. Human emotions fluctuate and do not always follow the model predictions. To address this fluctuation, many agent simulations generate a large number of hypothetical scenarios by random sampling and statistically predict the future. This is because modern computers are only capable of handling deterministic calculations. If we try to include interactions in a model with stochastic fluctuations, the number of assumed scenarios will explode, and modern computers will not be able to handle it. To solve this problem, it will be necessary to develop a computer that simulates fluctuations, such as the CMOS Ising computer, or to develop a quantum emotion simulation algorithm that can utilize a quantum computer to search a massive number of scenarios in parallel by quantum superposition.

II.3. Japan's Position within Overseas Trends

The level of scientific and technological development in Japan is high. Japan has a concept of the mind that is different from that of Western countries. Accordingly, there is potential for new ideas about the integration of mind and science which differs from Western perspectives.

For example, the Buddhist chatbot AI "BuddhaBot" (Kumagai et al., 2021) applied a natural language processing mechanism called BERT to Buddhist scriptures. The BERT, developed by Google, succeeded in autonomously searching for the Buddha's teachings from the scriptures and answering problems. This technology was developed in Japan, which has high levels of both Buddhist literature and artificial intelligence development, and a large number of Buddhists. This means that both development capabilities and Buddhist needs are high. Japan has a great advantage in combining such cutting-edge technology with Eastern traditional wisdom.

As for measurement technology, we have embarked on the development of an ultra-small powder computer in the JST Strategic Basic Research Project. There is a great deal of research on small computers in Japan and abroad, but none of it has gone beyond the trade-off between function and physical size. IBM's Crypto Anchor (announced in 2018) adds cryptographic functions to RFID and has a larger chip size of 1 mm square. Smart Dust, a U.S.-led research project, was developed by the University of Michigan in 2011 as a sensor node with multiple functions. Still, its physical size was limited by the need for multiple stacked 1mm square chips, batteries, and electrodes for power supply and communication. Neural Dust (published in 2016) used ultrasound to eliminate the battery. However, the elements that convert ultrasound to power and their connecting components

are large (1 mm x 3 mm), making the miniaturization unfeasible (Fig. 14). The powder computer is a multifaceted and comprehensive approach that spans the hierarchy of semiconductor devices, packaging, circuits, computer architecture, and algorithms to achieve both miniaturization of individual chips and an improved system performance by subdividing and reconfiguring multiple computational functions.

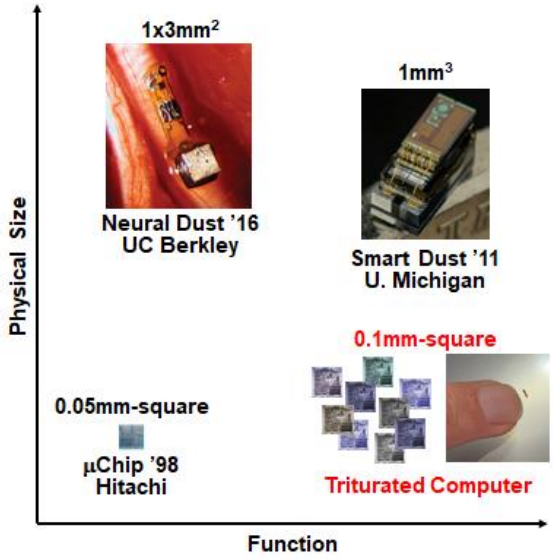

Fig. 14: Function and physical size of small computers

It has long been pointed out that the human mind may be influenced by the culture. For example, the facial expression recognition system developed in the U.S. is not accurate in estimating the facial expressions of Japanese people. In the last 30 years or so, there has been a great deal of research on the differences in mental states between the West, mainly North America and Europe, and the East, particularly Japan and China (Markus & Kitayama, 1991). Japan has taken a leading role in this field. More recently, online surveys have been used to identify differences in concepts of the mind not only between Eastern and Western but also worldwide (Awad, 2020; Sorokowska et al., 2017). A research team led by Hokkaido University has also contributed to such kind of attempt (Thomson et al., 2018). To clarify how the human mind is formed, an attempt called "*Kokoro* (Mind) World Map" has been initiated by Dr. Ueda, the them member, to gather not only such online surveys but also various psychological experiments into one platform (Ueda et al., 2021). The aim is to understand the mind by considering differences in culture, language, and individuals.

As for the understanding of the mind through body measurements, a new academic field called "Face and Body Studies" has been established under the Innovative Areas of the Science Research

Fund (Construction of the Face-Body Studies in Transcultural Conditions). There is a growing momentum for Japanese researchers to go beyond the fields of philosophy, psychology, and anthropology to try to understand the mind through the face and body.

III. Scenarios for the Realization of the Social Vision

III.1. Fields/Areas and Research Topics of Challenging Research and Development

III.1.1. Fields and Areas Where Challenging Research and Development Should Be Promoted

To complete the Psyche Navigation System, which constantly monitors and supports the human mind, and to realize a society in which peace and vitality coexist, challenging research and development should be promoted in the following fields and areas: ① to ④.

① Exploration and Presenting the Ideal State of Mind and Society through Traditional Wisdom DX

Human beings have been searching for the ideal state of mind and the ideal state of society. It is hoped that the ideal state of mind that should be cultivated by people living in modern society, and the ideal state of society formed by the collective mind of those people, will be explored and presented to people, by integrating all the knowledge accumulated since the beginning of time, and by tuning it to the modern context and individual differences.

② A Theory of Visualization of Mind, Using Multidimensional Emotion Space and Emotional Transition Model

Science has not yet been able to understand human emotions properly. In what kind of cartesian coordinate system can we understand the distribution of various human emotions and mental subtleties, including culture-specific emotions that have been overlooked so far? It is necessary to construct a theoretical system to map emotions on a multidimensional space and quantify their transitions, based not only on multimodal sensing of biometrics, but also on contextual information about what kind of the environmental space we are in.

③ Social Infrastructure to Monitor and Support the Mind

Society is formed by a set of human minds. Therefore, an environment that constantly monitors and supports the minds of all people should be developed as an infrastructure for society as a whole. To achieve this, it is necessary to develop sensors and actuators that harmonize with the environment and provide constant support to the mind without placing a burden on it. In addition, to deploy these sensors and actuators throughout society, it is necessary to build a physical environment to validate the technologies in a wide-area public implementation environment, and also a network environment that shares information about the mental state safely, securely and in real time.

④ Computing Infrastructure for Understanding the Mind

The technology that guides the mind and society requires accurate. We should construct a virtual space to forecast the results of the guidance precisely and to search for that which will realize the ideal image of society that we should be heading toward. It is necessary to build a computing infrastructure to explore the guidance that supports people's minds throughout society.

We integrate the knowledge in the mind space obtained by ① and ② and the information in the physical space collected by ③ into the cyberspace by ④. Based on the knowledge in the mind space, we synthesize the inducing stimuli to support the mind in the cyberspace, actuate using them in the physical space, and analyze their result again in the cyberspace. This cycle can improve the knowledge in the mind space, and lead to development the Psyche Navigation System (Fig. 2).

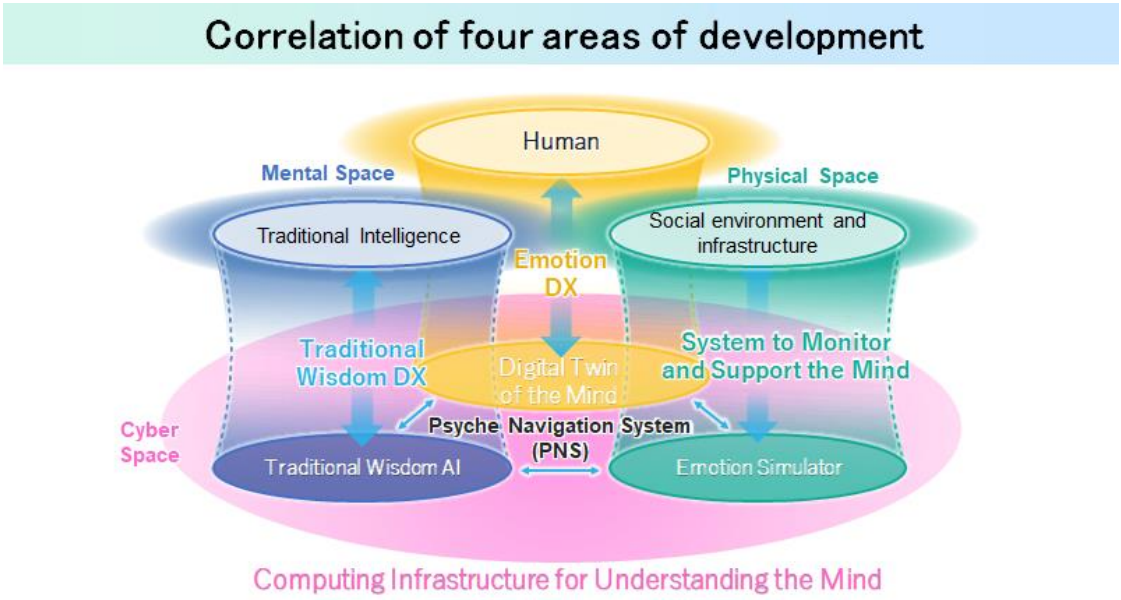

Fig.2 (Reprinted)

III.1.2. Research issues to be addressed in achieving the goals

In the aforementioned research fields ① through ④, the following research issues are identified and will be addressed.

① Autonomous Exploration and Presentation of Ideal State of Mind and Society by Traditional Wisdom DX

We will digitize the semantic systems and correlations of all the textual information on religion, philosophy, ethics, etc., accumulated so far in human history. We will develop computing technology that can autonomously search for the ideal state of mind and society for each individual and society,

and autonomously present the ideas to individuals and society, by integrating text data of traditional wisdom with modern context and biological data, offering advice to people living in contemporary society, and collecting responses from users.

② Multidimensional Emotion Space and Emotional Transition Model for Understanding the Mind

We divide the multidimensional space for quantifying individual emotional state into two parts: the "Emotion Expression Space" constructed from literature information (i.e., text) and the "Body-Environment Space" constructed from the physiological data of the body and environmental information. By making these two spaces correspond, we can grasp the individual mental state from the measured information. In the Emotion Expression Space, the degrees of similarity between emotions are represented on a multidimensional space with a Cartesian coordinate system based on what physical states and contexts are described together when emotions occur (co-occurrence). In the Body-Environment Space, the physical state is represented in a multidimensional space using multimodal biometric sensing and environmental information (contextual information). By considering the mind as a system that continuously transitions in such a space, it is possible to set the mental state of peace and vitality obtained from traditional wisdom in ① on this space, and express it as a vector to guide the mental state to that state using the computing infrastructure in ④.

In addition to understanding individual emotions, we also aim to understand the emotions of several to a dozen people as a group (i.e., collective emotions). Collective emotions are not necessarily the average of individual emotions, but must also include the position of the person within the group and how that emotion is transmitted. Therefore, in order to understand collective emotions, it is not enough to simply extend the individual emotion estimation process to multiple processes, but we need to develop a separate process for predicting collective emotions. By achieving this, the System to Monitor and Support the Mind described in ③ can be implemented in not only individual spaces, but also places where multiple people interact with each other to support a state of collective mental peace and vitality.

③ Social Infrastructure for Mental Health

We have yet to understand effective mental measurement and guidance methods to genuinely capture and naturally support the mind. We will develop the environment-harmonized System to Monitor and Support the Mind that can be embedded in the living environment by creating an imperceptible metal sensing technology to capture the mind without disturbance and a five-sense actuation technology to guide the human mind effectively. We will establish social infrastructure technology with the flexibility to select the appropriate form of support system according to gender, age, and lifestyle such as lifelog information. In addition, we will develop a public implementation

environment for the development and testing of environmentally harmonized mental sensing and actuation technologies in cooperation with housing, urban development, and automobile manufacturers. We will examine the ethical requirements for social implementation, and research the ideal form of sensors/actuators that may be accepted by society and the methodology for their introduction. We will also develop the Internet of Mind (IoM), which integrates robust information security technology to share mental information fairly, safely, and securely, and high-speed information communication infrastructure technology to aggregate large amounts of mental information in real time and provide appropriate feedback.

④ Computing Infrastructure for Understanding the Mind

What kind of emotions will be induced when certain types of stimuli are given? To maintain and control the mind in the desired state, it is necessary to model and simulate the mind's response (i.e., the conversion process from stimulus to emotion), which is called emotional simulator. There are four major challenges in this development.

(i) Stimulus morphing: First of all, we need a technology that synthesizes stimuli in order to investigate what kind of emotions are associated with the stimuli. For example, in the case of voice, we need to morph the inflection, voice quality, and pitch independently and investigate which elements are associated with which emotions. For this purpose, it is necessary to develop "stimulus morphing technology."

(ii) Mutual conversion model of stimuli and emotions: The second issue is to construct a mutual conversion model from stimuli to emotions and emotions to stimuli, which is the core technology to build an emotional simulator. To achieve this, we need to synthesize various stimuli by stimulus morphing, and capture the subject's emotions in the digital space with "Emotion DX" described in ② to accumulate a database of stimulus-emotion pairs. Next, we use a machine learning model to learn a mutual conversion model from emotion to stimulus and from stimulus to emotion, enabling us to estimate the stimulus required to evoke the desired emotion.

(iii) Modeling the process of emotion propagation: Humans are social, and an individual's emotions will propagate to the people around that person. By simulating this process as well, we will be able to navigate the emotions of the entire community properly. To do this, we need to model the process of how emotions propagate among individuals. There are three possible routes for their propagation: through human relationships such as acquaintances (friends, superiors, subordinates), through physical distance such as people who happen to pass by, and through video distribution sites on the internet. We are required to investigate the strength and influence of emotional propagation for each route.

(iv) Developing a computing paradigm that handles fluctuations: All of the above models are applied to human beings. It is necessary to model them in a way that allows for probabilistic

fluctuations. Therefore, in our simulation, we need to generate multiple scenarios based on the modeled fluctuations and obtain predictions for each scenario. In particular, the number of scenarios to be considered exponentially increases when we take the propagation of emotions among individuals into account. We are required to develop a computing paradigm that can cope with this issue. Specifically, it is necessary to develop pseudo-fluctuation computers such as CMOS Ising machines, and to implement quantum algorithms for emotional simulations through which we may explore numerous scenarios in parallel by quantum superposition.

III.2. Targets (Milestones) to Be Achieved, Research and Development Aimed at Achieving the Milestones, and Their Ripple Effects in 2030, 2040, and 2050

III.2.1. Specific Targets (Milestones) to Be Achieved and Expected to Be Achieved in 2030, 2040, and 2050 (Figures 15 and 16)

The following outlines the milestones to be achieved in research and development, industrialization, and social implementation over the next 30 years.

Year 2030

We will build an individual-level Psyche Navigation System Level 1 (PNS Lv.1) that guides people to an ideal state of mind, based on a quantitative definition of the state of mind of the individual that leads society to a state of peace and vitality. We will start PNS startup companies that provide mental support services based on PNS Lv.1.

By 2027 (five years after the start of the MS), we will develop a system (PNS Lv.0.1) that controls emotions for a brief period (several minutes to an hour) using images, sounds, and olfactory stimuli in a small conference room, and demonstrate the brief-term effectiveness of the PNS. **Over the next three years, from 2028 to 2030, we will develop a system (PNS Lv.1) that controls emotions for a short period of time (one to several days)** using a business hotel or a university's short-term accommodation to demonstrate the short-term effectiveness of PNS.

Year 2040

We will develop PNS startup companies into unicorn companies, and distribute the PNS to society through those industry. We will accelerate the spread of PNS Lv.1 by updating the configuration of the "mental monitoring infrastructure" that is socially acceptable based on user feedback.

Based on the accumulated information, we convert the Digital Twin of the Mind into big data, and try to understand the emotional interactions of multiple people. It will enable us to build a "group-level" PNS technology (PNS Lv.2) to watch over and support the mind in a group.

Year 2050

We will create a unicorn corporate conglomerate that provides not only individual mental support, but also collective emotional support services in situations such as education and consensus-building, and expand the community of PNS users in various domains and aspects.

We will build a "social level" PNS technology (PNS Lv.3) that supports individual and collective feelings in various aspects of each community, allowing for diversity due to cultural and religious differences. Thus, we will bring peace and vitality to communities around the world.

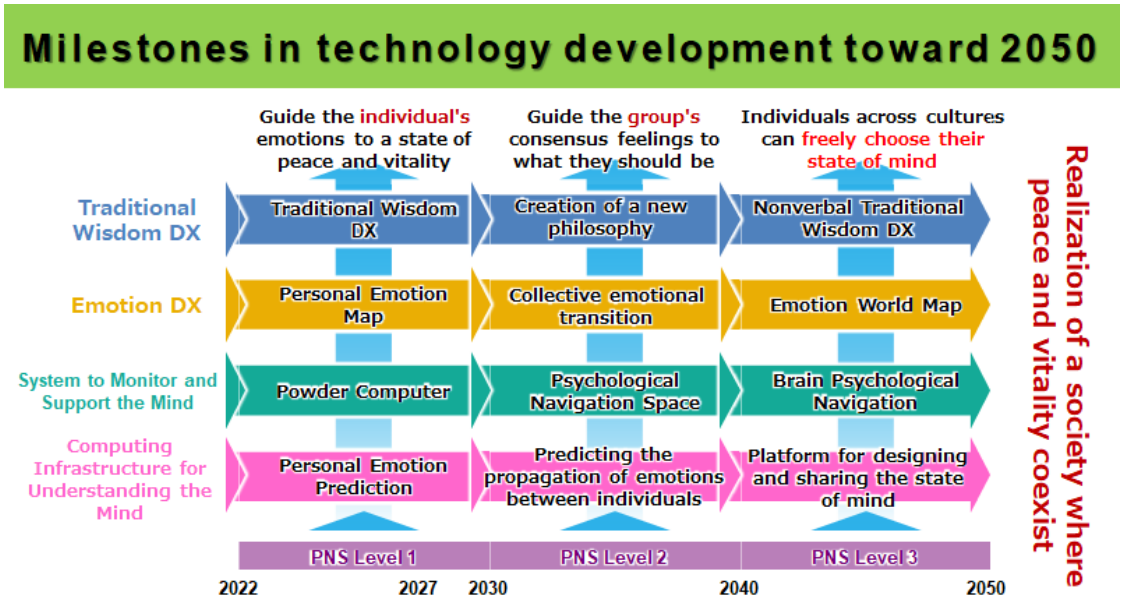

Fig. 15: Milestones in technology development toward 2050

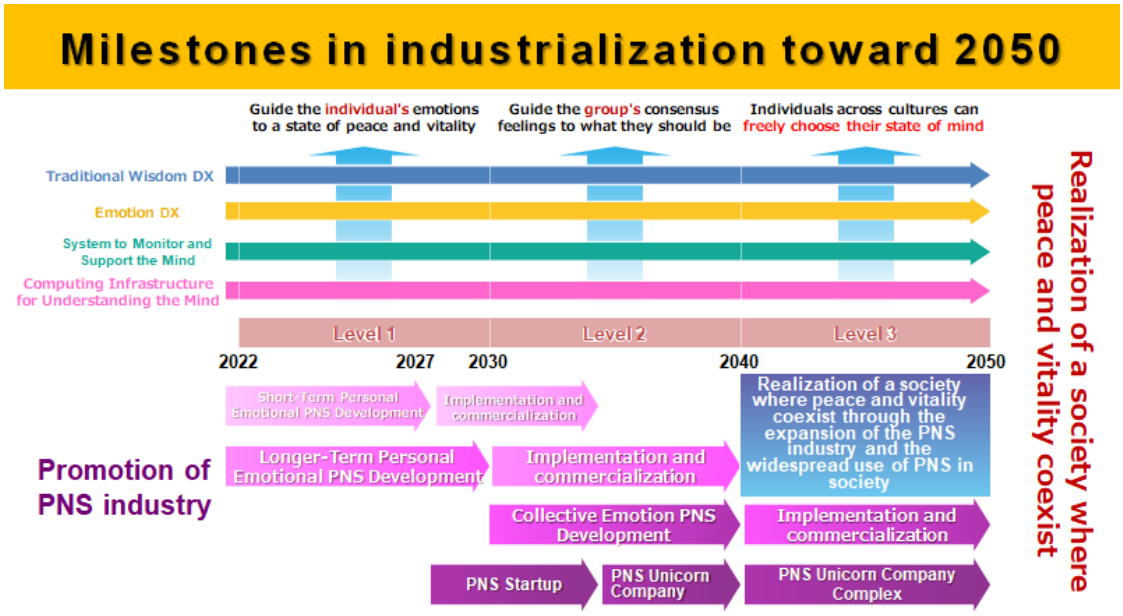

Fig. 16: Milestones in industrialization toward 2050

III.2.2. Specific Research and Development Themes to Be Addressed to Achieve the Milestones

Specific Research and Development themes to be addressed are outlined below, one for each decade.

Specific R&D Themes to Be Addressed by 2030

① We will digitize a large number of religious and philosophical books, and develop computer technology that can autonomously search for the state of mind of individuals and autonomously present it to people. This will lead to the creation of virtual sutras and virtual philosophies that define the ideal psychological state of individuals through semantic vector space.

We aim to create virtual sutras and virtual philosophies by developing a higher-performance Chatbot of Traditional Wisdom and improving the accuracy of each of the following four technologies.

(i) Collection of e-texts of traditional wisdom: First, we will collect e-texts of representative literature from the religious texts of the world's three major religions (Buddhism, Christianity, and Islam), as well as from Greek, Indian, and Chinese philosophy. Then, we will collect all existing e-texts, including religious and philosophical literature from the surrounding regions. As a technological breakthrough to expand the data of e-texts, we will improve a program (OCR technology) to analyze the scanned images of ancient documents in each language, so that we can "automatically" create e-texts from the images. (*Note that manual correction of typographical errors will be still required.)

(ii) Creation of learning data: First, we will create a Q&A list manually from scratch based on the electronic texts of typical religious and philosophical books, and then manually input data to accumulate learning data.

As a technological breakthrough for speeding up the creation of learning data, we will apply the new algorithm GPT-3 provided by openAI to develop an algorithm that can automatically create Q&A from electronic texts, and automatically create a learning Q&A list from electronic texts of traditional wisdom. (*Note that manual correction of typographical errors will be required).

(iii) Production of Traditional Wisdom Bot: We will use the algorithm of the Buddhist chatbot "BuddhaBot" to machine-learn Q&A lists extracted from various religious and philosophical literature to produce a "Traditional Wisdom Bot".

(iv) Improvement of Traditional Wisdom Bot: We will improve the Traditional Wisdom Bot for the 21st century by getting feedback from actual users as they try them out. By having users use the PNS system to store their personal information and biometric data in the chatbot of traditional wisdom, we will develop a learning function that can provide appropriate personalized answers for each individual, thereby improving the current type of chatbot offering only uniform advice.

② We will map emotional states in a multidimensional space with digitized books/texts and

conversational dialogues. Then, we will take the correspondence between the information on emotional states, physiological states of the body, and the environmental space (context) to represent the current state of the mind in cyberspace. Specifically, we need to extend the current technology to (i) explore dialogues to see what physical states and contexts are described together when emotions emerge, (ii) utilize multimodal information such as facial expressions, body temperature, skin potential, sweating rate, and heart rate fluctuation, and (iii) incorporate temporal changes of the above multimodal information.

(i) Construction of an Emotion Expression Space: We search for what bodily states and contexts co-occur when emotions arise, from books and conversational dialogues. Based on these co-occurrence relations, we represent them in a Cartesian coordinate system that reflects the degree of similarity between emotions.

(ii) Use of multimodal information: As mentioned above, emotion estimation based on facial expressions has experienced some progress lately with the invention of deep learning. However, since facial expressions and emotions do not necessarily have a one-to-one correspondence and emotion estimation, understanding the mind only based on facial expressions is still extremely difficult. In addition, facial expression measurement inevitably requires the use of a camera to capture facial images, which poses a variety of problems such as privacy and the potential stress of being photographed. Therefore, we will first investigate the correlation between biometric/environmental data such as heartbeat, sweating rate, skin potential, body temperature, brightness, and voice tone, which can be obtained at low cost with wristwatch devices, and the subjective emotions reported by each individual, and then conduct a basic study to clarify the accuracy of emotion sensing from multimodal sensing.

(iii) Utilization of temporal correlation: Many of the existing technologies that claim to estimate mental states ignore the fact that the mind is a system with memory. For example, facial expression recognition technology attempts to estimate the state of the mind from the current instantaneous facial expression but does not deal with their specific contexts. Therefore, we aim to estimate the wide emotional transition by continuously sensing biological information over a long timespan, raging from a few days to a few months, and comparing it with the emotions felt at the time.

③ We will develop a social infrastructure in a wide-area environment to monitor and support the minds of individuals daily. Specifically, we will construct (i) the environment-harmonized System to Monitor and Support the Mind which consists of mind sensors and actuators embedded in the wide-area social environment, (ii) a public implementation environment that explores and validates the ideal form of the System to Monitor and Support the Mind, and (iii) Internet of Mind (IoM), a mind information network which collects and aggregates individual mind information safely, securely, and in real time.

(i) Environment-harmonized System to Monitor and Support the Mind: The awareness that one's mind is monitored and guided may be a great source of stress. We will develop a mental sensing and actuation system that does not cause unnecessary stress or disturbance to the mind by harmonizing with the daily living environment. To develop such a system as a social infrastructure, it is necessary to provide a number of options that can meet the demands of various people in the form of a system. In the field of sensing, the options include cameras, infrared sensors, and radar which can be implanted in space, and wearable sensors mounted on glasses, watches, and rings that people usually wear. However, many people find that these sensors lead to mental and physical stress. Therefore, we will develop a powder sensor so tiny that the sensing subject cannot detect it. Using the advanced semiconductor manufacturing technology, sensing and computing functions can be reduced to less than 1mm square. In PNS Lv.1, we collect biometric information measured on the body surface through a powder sensor and estimate the mental state. Concerning actuators, we attempt to enhance environmental harmonization through integrating the function of presenting stimuli synthesized by an emotional simulator to lighting, air conditioning, sound equipment, windows, walls, desks, and displays installed in daily spaces.

(ii) Social implementation environment: To develop the System to Monitor and Support the Mind as a social infrastructure in a wide-area environment, it is necessary to develop a system that can be used not only at home but also in offices, cities, and while traveling. However, there is no ground for evaluating and examining ethical issues such as the effectiveness of mental support in each environment and whether the introduction of technology into external environments other than home is socially acceptable. Therefore, in collaboration with urban development companies, local governments, automobile manufacturers, etc., we will establish a public implementation environment to conduct demonstration experiments on the System to Monitor and Support the Mind. In parallel with technological development, we will discuss and predict the results with ELSI researchers, identify the ethical issues to be addressed, and plan an effective form of experiment to evaluate the social acceptability of the introduced System to Monitor and Support the Mind. Based on the analysis of the experiment results, we will feed back the results to the specification of the sensor and actuator that may be accepted by society.

(iii) Internet of Mind (IoM): We will analyze the information on the mind states and the state transitions in response to induced stimuli in cyberspace. We can effectively use the analysis results to improve the configuration of sensors and actuators in the System to Monitor and Support the Mind to improve the accuracy of stimulus synthesis by the Emotion Simulator, and to create new services on the PNS platform. However, the state of the mind is not the same as the state of the body. Since the state of mind is the ultimate personal information and cannot be easily shared, we will build an information network environment (IoM) in the physical space to store mind state data safely by incorporating advanced information security technology. We will realize edge AI that real-time

estimates the state of mind and synthesizes guiding stimuli at the terminal end. In addition, we protect personal information by applying differential privacy, which adds a certain amount of noise to the information aggregated by the IoM so that individuals cannot be identified. We will issue Non-Fungible Tokens (NFT) for the aggregated information to prevent tampering and store and manage it appropriately. This will allow us to utilize information that is beneficial to society, to improve the performance of the system itself, and to expand the number of users of the PNS platform by enhanced sense of security.

④ Emotion Simulator Lv.1: We will complete the prediction system of individual emotions by 2030. Specifically, we will (i) start the development from stimulations limited to a single modality and (ii) develop research in a hierarchical manner to integrate multiple modalities.

(i) Emotional simulator specializing in a single modality: We will investigate the correspondence between the emotions evoked when the five senses are stimulated individually, and create a model that links both by machine learning. As shown below, we will start with the visual and auditory senses, which are considered to be easy to control via displays and speakers, and then expand to the olfactory, tactile, and gustatory senses.

[Visual Sense] We will investigate the correlation between lighting (color temperature) in indoor environments, scenery, and images created by projection mapping, and the emotions they evoke. As for the visual actuation, since there are initiatives such as lighting color design by housing manufacturers and "digital forest bathing," development can be accelerated by utilizing these initiatives.

[Auditory Sense] Auditory perception can be subdivided into environmental sound, voice, and music. To control emotions using environmental sounds, it will be necessary to automatically synthesize the sounds of rain, crowded streets, bamboo leaves scraping in a bamboo grove, birds singing in a forest, etc. We will then experimentally find out, for example, what level of rainfall is effective in calming emotions. In the case of human voice, it is necessary to find out what a "persuasive voice" and a "soothing voice" are by assigning parameters such as F0 fundamental frequency. AIs for music, it is necessary to investigate the correlation between what kind of tone and musical scale induces what kind of emotion by using statistical music modeling technology and instrumental tone conversion technology.

(ii) Integration of multiple modalities: Compared to vision and hearing, olfaction, tactile sensation, and gustatory sensation have more obstacles for actuators to present stimuli because of their limited temporal responsiveness and spatial diffusivity. Therefore, they may be used in combination with vision and hearing to improve the precision of emotion control.

[Olfaction] The sense of smell has attracted attention as a modality that can effectively stimulate emotion. Smell is used for corporate branding by introducing specific scents in stores and car

interiors. The smart conference room (*point 0 Marunouchi*) reads the emotions of participants from their voices during a meeting and mists a suitable scent to stimulate discussion. On the other hand, since there is a time delay in the diffusion of odorants, poor time responsiveness is a problem in controlling emotions that can change from moment to moment. To solve this problem, it is necessary to explore the combination of other modalities (e.g. vision, hearing, etc.) with superior temporal responsiveness (e.g. spraying the smell of rain simultaneously with the sound of rain) to improve the precision of emotion control.

[Tactile Sense] It is often pointed out that the sense of touch is associated with primitive emotions because it is a basic sense possessed by all living things (Titchner 1908). However, except for its role as a sense of pain, which is directly related to survival, the variation of emotions evoked by touch is limited. Therefore, it is necessary to combine the sense of touch with other modalities (e.g., inducing air vibrations in time with music) to improve the accuracy of emotional control.

Specific Research and Development Themes to Be Addressed by 2040

①Virtual scriptures and virtual philosophies will be created in cyberspace using the traditional wisdom data collected by the "Traditional Wisdom Bot." Their content will be carefully examined and philosophically tuned by experts in humanities. Develop an artificial intelligence into "Traditional Wisdom AI" by having it learn the discussions between modern experts in humanities and "Traditional Wisdom Bots," and learn the perspectives of modern philosophy. It will be able to present new ideas, ethics, and morality that have never been seen before.

By combining this "Traditional Wisdom AI" with the collective emotion map and linking it with the emotion simulator Lv.2, we can create new ethics for smooth organizational management and new ideas for social management to help expand the scope of support for social infrastructure to monitor the mind.

② We will move on from the estimation of individual emotions, applying the Multidimensional Emotion Space to the understanding of emotions among individuals and groups (collective emotions). In this step, we aim to extend beyond the estimation of individual emotions to the understanding of groups of several or a dozen people. The difficulty in understanding collective emotions lies in the fact that they are not averages of individual emotions. Even if the people present the same kind of emotion (e.g., joy), the intensity of the emotion may differ depending on individuals. When individuals are feeling different kinds of emotions, we must understand the collective emotion as a combination of them. In addition, considering that people in leadership positions contribute more to collective emotions than those who are not, the "relationships" between people in the group, which position they hold, and what emotion they have, is also an important factor. The other important factors are "synchronization" and "propagation." Therefore, we must understand collective emotions

as a model that adds a process for predicting collective emotions to that for estimating individual emotions, rather than simply multiplying processes for estimating individual emotions.

To study the collective emotions, the above three factors have to be considered: i) the relationships among the members of the group are recognized from explicit or implicit behaviors, and they are used as weights to estimate type and intensity of collective emotions ; ii) synchronization of behaviors and physiological indices should be included, since the more cooperative the group is, the more likely the synchronization will occur; and iii) we need to clarify how emotions propagate in a group to examine the transition of collective emotions. We will examine the synchronization of movement and physiological indices in collaboration with the sensor system developed in ③. We will look into the propagation of emotions in conjunction with psychological experiments and the emotion simulator developed ④. In addition, we need to examine the effect of awareness of collective emotions on individual emotions. This awareness is called the "cognitive mode," and it depends on whether we emphasize the "individual" aspect of each member or the "collective" aspect more. Particularly in situations where the collective aspect is emphasized, we need to take in consideration the feedback pathway from collective emotions to individual emotions.

Once this stage of the research and development is completed, we can extend the PNS services from individual spaces to collective spaces where multiple people collaborate (e.g., living rooms, conference rooms, concert stages, team sports situations).

③ In order to expand the scope of Social Infrastructure to Monitor and Support the Mind, we will improve the accuracy of mind estimation, and guidance by sensors and actuators and also improve the environmental compatibility of system. From the viewpoint of improving accuracy, it is important to move further from sensing the surface of the human body parameter and step into sensing inside the human body parameter. For example, saliva and tears contain proteins that are strongly correlated with stress and emotional arousal. We can introduce chemical substance sensors to measure their concentrations. By using advanced manufacturing technology as of 2040 and scaling the powder sensor further down to 0.1mm square, we can place the sensors on the teeth or contact lenses in the eyes to detect chemical substances. This technology could be one option to improve environmental compatibility for mental sensing. We can also present visual stimuli independent of the external physical environment by turning contact lenses into a display. At this stage, we need to consider not only ethical issues but also biocompatibility and safety from a medical point of view in research and development, requiring animal experiments and clinical trials. Here in addition, we can use IoM, and collect and analyze feedback on conditions from users of the PNS services developed by unicorn companies. We can utilize the results to develop the next generation shape of sensors and actuators. The PNS service can be expanded with the updated System to Monitor and Support the Mind that is more accurate and environmentally friendly.

④ Emotional simulator Lv.2: By investigating the propagation processes of emotion among individuals at a group level and incorporating this into the emotional simulator Lv.1, we will construct an emotional simulator Lv.2 that can predict emotions as a group. Specifically, the following research topics are considered.

(i) Constructing a generalized model: In order to widely implement the PNS in society, we need to implement "Emotion DX" for each individual efficiently. Therefore, it is necessary to extract the universal components at the communal and social levels from the "Emotion DX" specialized for each individual. To construct a template model, the parts that may vary among individuals are replaced by model parameters. The template model should be based on a statistical model such as a Bayesian model so that individual differences can be objectively treated as numerical values. In addition, to make the template model specific to each individual, it is necessary to acquire several stimuli, evoked emotion patterns, and derive model parameters that reflect the characteristics of each individual. To reduce the amount of data obtained at that time, we need active sensing refinement of statistical modeling methods such as sparse modeling.

(ii) Modeling the propagation processes of emotion among individuals: We will clarify the process of how emotions are propagated. The propagation pathway may be based on acquaintance (where the proximity of the relationship influences the propagation), accidental (where the physical proximity influences the propagation), or via the Internet to an unspecified number of people. Specifically, we will investigate the propagation of emotions within a small community of people, and then expand the scope of the investigation to examine the broader propagation process of emotions, either between communities or when people move from one community to another.

(iii) Pioneering a computing infrastructure to handle fluctuations: It is extremely difficult to predict individual emotions perfectly. We need, therefore, to build a simulator that assumes prediction errors (i.e., fluctuations). To do so, it is necessary to insert pseudo-fluctuations into the prediction model and generate multiple scenarios to predict the future, which may increase the computational cost. In addition, the number of assumed scenarios will increase exponentially if individual correlations are included. In order to cope with this, we are developing a computing infrastructure specialized for simulating fluctuating models. Specifically, it will be necessary to develop an architecture that can simulate fluctuations using modern deterministic computers such as the CMOS Ising computer. We also need to develop a quantum emotion simulator that attempts to utilize a quantum computer and explore many scenarios simultaneously by quantum superposition.

(iv) Emotion DX without invading privacy: Privacy issues are inevitable when dealing with emotions and the mind. Therefore, we are developing Emotion DX without invading privacy, which allows users to digitize only those attributes they wish to conceal. For example, a part of facial expression or voice can be made non-attributable and input into the Emotion DX. Furthermore, if a part of the emotion can identify an individual, it will be necessary to make them non-attributable in

the emotion space.

Specific Research and Development Themes to Be Addressed by 2050

① To make the Traditional Wisdom AI deeper (vertically) and wider (horizontally), we will train it with more diverse data. Based on the Emotion DX and biometric data collected by powder sensors, we will quantify non-verbal traditional wisdom, traditional physical techniques, and traditional rituals that have not been written down (documented). We can then improve the Traditional Wisdom AI to have more depth by accumulating non-verbal information. In addition, by collecting information on traditional wisdom from all over the world and letting the artificial intelligence learn from it, we will establish a system (cultural translation technology) that translates the ideas created by the Traditional Wisdom AI into a form more widely applicable to each cultural sphere.

② To lead to a peaceful and vibrant society in response to diverse backgrounds, we will extend the Multidimensional Emotion Space in two directions and present it as a general model of emotion expression. The first direction is adapting to cultural differences in the world. As we will complete the model for expressing individual and collective emotions by 2040, we can use this model as prior knowledge to tune it to cultural differences in various regions of the world and individual experiences even within the same culture. The second direction is to expand the domains in which we can implement the model. Individual emotions in personal spaces by 2030, and collective emotions in spaces where several to a dozen people collaborate by 2040, but the applications are still limited. Specifically, we will apply the model in a larger group (such as a society), and use the way of thinking developed in ① and the sensor in ③.

③ The ultimate form of mind sensors and actuators which harmonize with the environment is the sensing of electrical signals of neurons in the brain and the direct feedback of stimulation signals to neurons. Even now, intracerebral devices can detect and quiesce epileptic seizures and Brain Machine Interfaces can contact the brain electrically. As these devices are being put into practical use, intracerebral mental monitoring systems will not be impossible if their advantages and safety are demonstrated. The powder sensor is small enough to be inserted into a catheter without any physical difficulty. The development of a radar to identify activated neurons and a stimulator to insert stimulation signals at the required locations will be necessary to determine the extent of brain activity.

④ Building a platform to design and share the ideal state of mind: Research and development until 2040 will provide the core technologies to realize a society in which people can change their minds according to their individual situations, just as they change their clothes according to their

circumstances. Even though we can use templates based on traditional wisdom as reference, it will be still necessary for users to find out how to “dress their minds” (i.e., control guidelines such as boosting their mood when exercising or improving their concentration when studying) through trial and error. To overcome this problem and promote the social implementation of the PNS, we need a platform where users can freely disclose "mental control guidelines" as software. In the same way that the world is flooded with a wide variety of clothing designs through the commodification of clothes, it will be possible to distribute a wide variety of "minds" by commercializing "Mental Control Guidelines" through the platform. We need to have a mechanism to objectively evaluate whether or not the "Mental Control Guidelines" are safe, that is, whether or not they contain adverse functions like viruses. Specifically, it is necessary to embed the "Mental Control Guidelines" created by a third party in an emotional simulator, and examine the responses to various stimuli to see if they induce behaviors harmful to society, such as crime. Since the number of stimulus patterns is expected to be immense, we need to further expand the computing infrastructure and develop sampling algorithms that can focus on dangerous patterns.

III.2.3. Effects of achieving milestones on society

The following three steps explain how achieving the milestones will have an effect on society.

Year 2030

We will establish technology (PNS Lv.1) that leads individuals to a state of peace and vitality in their emotions, establishing the technological basis for suppressing unjustified attacks on others such as bullying and slander, fostering resiliency in the face of unjustified aggression from others, and revitalizing society, economy, and culture by freeing people from depression and anxiety.

Year 2040

We will promote the industrialization of PNS Lv.1, which will lead to the social diffusion of the PNS. In addition, we will establish a further technology (PNS Lv.2) that leads to a state of peace and vitality in group emotions. Such technology will be able to provide benchmarks for realizing community well-being by supporting consensus building in groups.

Year 2050

We will expand the PNS industry, make PNS Lv.2 practical in various aspects of society, and promote the PNS worldwide. We will also establish "PNS Lv. 3," which combines measurement and actuator technology using the body's internal environment (brain and cells) and cross-cultural translation technology. The PNS will thus be used to lead the world to a state of peace and vitality.

III.3. International cooperation

In developing the PNS, we will promote the following international collaborations.

- **Traditional wisdom**: Many of the original texts of representative religious and philosophical books are already available in electronic form. Modern translations are also available. In recent years, electronic texts have become increasingly open source, so the number of literature data that have already been converted into electronic texts will continue to increase. On the other hand, small databases of scanned images of manuscripts are scattered all over the world, and there is no database that integrates them all. In this project, we will collaborate with scholars of religion and philosophy from various countries to collect publicly scanned images of manuscripts and create an integrated database of traditional wisdom manuscripts.
- **Emotion DX**: To create a Multidimensional Emotion Space based on culturally rooted emotions, we need to examine each culture separately. To begin with, we will conduct primary studies in Japan and in the English-speaking and European regions where emotion study is active. This is because these regions are equipped with the infrastructure for machine-learning text analysis and psychological experiments. In the first stage, we will avoid excessive fine-tuning but aim at understanding the approximate shape of the Multidimensional Emotion Space (how much it differs among cultures, how universal it is, and how much data is needed to construct it). By making this available, researchers and companies from other cultural and language-area will join us, increasing the number of adaptable regions.
- **Sensors and Artificial Intelligence**: Being independent of nations and regions, science and technology can be easily developed and applied universally. To proactively introduce the latest technology, we need to form a strategic international collaboration with countries that are highly active in the relevant technological fields. In particular, the pace of development of AI technology is very fast. AI programs for emotion control, for example, need to be open sourced. Their development will be accelerated by the international community because it will be difficult to keep the algorithms secret when the service is deployed. In the development of sensor technology and other hardware, we need to protect the know-how that is not publicized in papers and patents. This is why we need selective collaboration with countries where beneficial information exchange.
- **"Happiness" Research and Policies**: As introduced by Oishi (2009) and Uchida (2020), there has been a rapid increase in scientific research on happiness, especially in the field of psychology, since the 1990s. This project will use the PNS as a platform to work with happiness researchers in Japan and abroad to solve social issues. Bhutan is well known as a representative nation that promotes happiness policies. Based on its Gross National Happiness (GNH) policy, Bhutan is conducting a GNH census, led by the Royal Bhutan Institute. In this project, information on happiness policy and social implementation will be shared with the Royal Bhutan Institute by promoting joint research.

III.4. Interdisciplinary cooperation

To achieve this MS goal, we will promote collaboration in the following areas.

- **Academic**: We are already conducting joint research with a number of researchers from universities and companies. At universities, we will steadily promote basic research that is difficult for companies to conduct. For the development of products that include sensory stimulation actuators, we will encourage the active participation not only of university researchers but also researchers from manufacturer companies, and ask them to provide the infrastructure for social implementation experiments. In addition, the PNS R&D members will play a central role in building an academic platform for interdisciplinary research that utilizes traditional and humanities knowledge, promoting collaboration and information sharing among researchers and creating a movement for interdisciplinary research with greater impact.
- **Government and administration**: By integrating traditional wisdom and technology, we will promote the PNS effectively in line with the 6th Science and Technology Innovation Basic Plan. In collaboration with the Academic Planning Office and the Office for the Promotion of Humanities and Social Sciences of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), we will create comprehensive knowledge through "humanities-led" interdisciplinary research, with the PNS at its core. Furthermore, we will promote discussions on the social implementation of the PNS, deepen cooperation with local governments in Japan and abroad, and conduct large-scale surveys and implementation experiments.
- **Industry**: We will invite companies that share our altruistic business philosophy and create new industrial seeds using the PNS as a platform. We will create a PNS industrial community and shift the industrial structure from self-interested competition to altruistic mutual aid and giving.
- **Culture**: We will support traditional cultures and religions that have become formalistic and unresponsive to the needs of citizens. By collaborating with practitioners of traditional cultures and religions, we can transform their role and lead people's happiness by implementing the PNS. There will be an increasing number of new followers if they can revitalize their cultures and religions in the matured society.

III.5. ELSI (Ethical, Legal, Social Issues)

The PNS, when completed, will bring great benefits to humanity. There are, however, many ethical, legal, and social challenges in the development and implementation of the PNS.

We need to ethically examine the extent to which the act of using artificial intelligence is permissible to guide human emotions, including a survey of citizens' attitudes. In practice, as seen in the survey in section II-2, it will be implemented in individuals and society to the extent citizens deem it acceptable. However, we will continue to develop the technology itself with a view to future

social implementation.

We also need to verify medical and biological effects of the PNS on the human body and mind. We will refer to the data of experimental results already published on the effects of Buddhist meditation on the mind and body.

Regarding the collection of biometric data from the subject, we will discuss the legal and ethical aspects, including the anxiety of the subject, the risk of data leakage, and security measures, after examining past leakage problems.

It is also necessary to discuss with legal scholars and political scientists, ethicists, administrative and legislative officials, and citizens the various requirements and obstacles to the social implementation of the PNS.

Old literature on traditional wisdom contains gender-discriminatory expressions. It will be problematic to apply the information in its original form to modern society. It is necessary to retranslate the traditional wisdom information into a form that fits the context of modern society from a philosophical and religious perspective.

IV. Conclusion

What lies behind this research is a problem of the mind in modern society. Technology are developing at an ever-increasing pace, and we are becoming more materially and informationally affluent. Still, we are yet to achieve mental happiness. As a result, the number of suicides and depressive patients has not decreased. Even young people are committing suicide because of the slanderous comments on social networking sites.

Therefore, this research group decided to develop a Psyche Navigation System (PNS) that combines traditional wisdom and technology to bring peace and vitality to people's minds and society. In the Millennia Program, we made a concrete development plan for the PNS and conducted a survey on the social significance, economic benefits, and technological and academic innovations that PNS will bring.

Through this research, **we found that the development of a PNS, the promotion of the PNS industry, and the widespread implementation of the PNS in individuals, groups, and societies will increase the wellbeing and vitality of people and societies, bringing about significant innovations in academia, industry, culture, and intelligence**.

The PNS has great potential to accelerate DX of traditional wisdom, create unprecedented "comprehensive knowledge," and enhance the wellbeing of people and society through the integration of traditional wisdom and technology. In other words, **the PNS will make a significant contribution to Japan's science and technology policy in that it is consistent with and will greatly promote the "6th Science and Technology Innovation Basic Plan" that Japan is currently pursuing**. In addition, despite the criticism of those who claim there is "no need for the humanities," it will be the humanities that will come up with an effective solution to this problem. The PNS, on the other hand, has brought new possibilities to the humanities through research that combines the humanities and latest science. It has become clear that the PNS will also contribute to academic promotion by raising the value of the humanities and revitalizing humanities research.

The investigation of secondary sources shows that a large number of social and economic losses exist due to mental misfortune. The number of suicides in Japan is among the top ten in the world, and the situation is extremely serious. The economic losses due to suicide, depression, crime, and child abuse amount to several tens of trillions of JPY. In addition, the industrial market related to the human mind amounts to several trillion JPY. The mental care market in Japan alone is extremely large. We also found out that if gender equality and social diversity were improved, it could significantly boost our country's GDP. If the PNS is completed, it is highly likely that it will bring significant economic benefits and solve social issues such as suicide, depression, inequality and discrimination by introducing peace and vitality into the society. In addition to mental health, the PNS has the potential to create new businesses in various industrial fields such as consulting and education, in particular, those areas that utilize the big data of emotion.

Through the PNS industrial community, Japan can take the lead in shifting from a profit-seeking model of self-interested competition to that of altruistic mutual aid. In the midst of modernization and information technology, Japan has taken the lead in building a new industrial structure.

In the context of modernization and information technology, some traditional cultures and religions are becoming formalistic and declining. In addition, some of the traditional wisdom is in conflict with modern values, which makes it difficult to apply it to modern society in its original form. To overcome such an obstacle, we can work with the leaders of traditional cultures and religions to implement the PNS. This collaboration will enhance the happiness effect in a way that is appropriate to the times, transform the social role of traditional cultures and religions to one that leads to people's happiness, increase the number of new followers, revitalize cultures and religions, and enable society to mature culturally. These are the prospects envisioned in this research.

In conclusion, the development, industrialization, and social implementation of the PNS can greatly promote the peace and vitality of people and society.

V. References

Arimoto, Y. (2011). Spiritual shijō no kenkyū: data de yomu kyūkakudai market. Tōyō keizai shinpōsha.

Awad, E., Dsouza, S., Shariff, A. Rahwan, I., & Bonnefon, J.-F. (2020). Universals and variations in moral decisions made in 42 countries by 70,000 participants. Proceedings of the National Academy of Sciences, 117, 2332–2337.

Barrett, L. F. (2017). How Emotions Are Made: The Secret Life of the Brain. Houghton Mifflin Harcourt.

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The Satisfaction with Life Scale. Journal of Personality Assessment, 49, 71–75.

Ekman, P. (1971). Universals and cultural differences in facial expressions of emotion. Nebraska Symposium on Motivation, 19, 207–283.

Horii, M., Yamakawa N., Sogi M., Inoue M., & Higuchi M. (2020). Yori ōku no nihon no josei leader no yakushin o mezashite. McKinsey & Company, McKinsey Japan, https://www.mckinsey.com/jp/~/media/McKinsey/Locations/Asia/Japan/Our%20Insights/Mobilizing%20Women/Mobilizing-Women-in-Japan-to-Step-Up.pdf.

Ikegami, M. (2010). Jisatsu ya seishin shikkan ni yoru keizai sonshitsu wa nenkan yaku 15.2 chō en? Taisaku o okotattekita nihon ga kōmuru “ōkina tsuke.” Diamond Online, https://diamond.jp/articles/-/9555.

Kaneko, Y., & Sato, I. (2010). Jisatsu utsu taisaku no keizaiteki beneki (jisatsu utsu ni yoru shakaiteki sonshitsu) no suikei no gaiyō. Kokuritsu shakai hoshō jinkō mondai kenkyūjo shakai hoshō kiso riron kenkyūbu, https://www.mhlw.go.jp/stf/houdou/2r9852000000qvsy-att/2r9852000000qvuo.pdf.

Kumagai, S., Furuya, T., Higashifushimi, K., Yasuda, A., Matsushita, T. G., Kameyama, T., & Hasegawa, Y. (2021). Using traditional wisdom with AI (Buddhabot) to establish a “Psyche Navigation System.” RIEC International Symposium, When AI Meets Human Science: The 4th Tohoku – NTU Symposium on Interdisciplinary AI and Human Studies, On Zoom.

Lee, Y., Kim, G., Bang, S., Kim, Y., Lee, I., Dutta, P., Sylvester, D., & Blaauw, D. (2012). A modular 1mm 3 die-stacked sensing platform with optical communication and multi-modal energy harvesting. International Solid-State Circuits Conference Digest of Technical Papers, 2p.

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. Psychological Review, 98(2), 224–253.

Misra, S, & Stokols, D. (2012). Psychological and health outcomes of perceived information overload. Environment and Behavior, 44(6), 737–759.

Naikakufu keizai shakai sōgō kenkyūjo kōfukudo kenkyū unit (2011). Kokumin seikatsu senkōdo chōsa kara mita kōfukudo. Dai nikai kōfukudo ni kansuru kenkyūkai, https://www5.cao.go.jp/keizai2/koufukudo/shiryou/2shiryou/2.pdf.

Oishi, S. (2009). Shiawase o kagaku suru: shinrigaku kara wakatta koto. Shinyōsha.

Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). Affect grid: A single-item scale of pleasure and arousal. Journal of Personality and Social Psychology, 57(3), 493–502.

Seo, D., Neely, R. M., Shen, K., & Singhal, U. (2016). Wireless recording in the peripheral nervous system with ultrasonic neural dust. Neuron, 91(3), 528–539p.

Sorokowska, A., Sorokowski, P., Hilpert, P., Cantarero, K., Frackowiak, T., Ahmadi, K., Alghraibeh, A. M., Aryeetey, R., Bertoni, A., Bettache, K., Blumen, S., Błażejewska, M., Bortolini, T., Butovskaya, M., Castro, F. N., Cetinkaya, H., Cunha, D., David, D., David, O. A., . . . Pierce, J. D., Jr. (2017). Preferred interpersonal distances: A global comparison. Journal of Cross-Cultural Psychology, 48(4), 577–592.

Sturgill, R., Martinasek, M., Schmidt, T., & Goyal, R. (2021). A novel artificial intelligence-powered emotional intelligence and mindfulness app (Ajivar) for the college student population during the COVID-19 pandemic: Quantitative questionnaire study. JMIR Formative Research, 5(1), https://formative.jmir.org/2021/1/e25372.

SuRaLa Net Co., Ltd. (2012). “Shōchūkōsei no kōfukudo” towa? Shōchūkōsei no kōfukudo chōsa. PR Times, https://prtimes.jp/main/html/rd/p/000000016.000003287.html.

Thomson, R., Yuki, M., Talhelm, T., Schug, J., Kito, M., Ayanian, A. H., Becker, J. C., Becker, M., Chiu, C.-Y., Choi, H.-S., Ferreira, C. M., Fülöp, M., Gul, P., Houghton-Illera, A. M., Joasoo, M., Jong, J., Kavanagh, C. M., Khutkyy, D., Manzi, C., . . . Visserman, M. L. (2018). Relational mobility predicts social behaviors in 39 countries and is tied to historical farming and threat. Proceedings of the National Academy of Sciences, 115(29), 7521–7526.

Titchener, E. B. (1908). Lectures on the Elementary Psychology of Feeling and Emotion. MacMillan.

Uchida, Y. (2020). Korekara no kōfuku ni tsuite: bunkateki kōfukukan no susume. Shinyōsha.

Ueda, Y., Otsuka, S., & Saiki, J. (2021). A three-level approach to understand cultural variability and the evolution of human attention. Psychologia, advanced in online. https://doi.org/10.2117/psysoc.2021-B015.

Usami, M., Tanabe, H., Sato, A., Sakama, I., Maki, Y., Iwamatsu, T., Ipposhi, T., & Inoue, Y. (2007). A 0.05×0.05mm2 RFID chip with easily scaled-down ID-memory. International Solid-State Circuits Conference Digest of Technical Papers, 2p.

Williamson, J., & Eaker, P. E. (2012). The information overload scale. Proceedings of the 75th Annual Conference of the American Society for Information Science & Technology, Baltimore, 26-30 October 2012, conference abstract.

Woetzel, J., Madgavkar, A., Ellingrud, K., Labaye, E., Devillard, S., Kutcher, E., Manyika, J., Dobbs, R., & Krishnan, M. (2015). The power of parity: How advancing women's equality can add $12 trillion to global growth. McKinsey & Company, McKinsey Global Institute, https://www.mckinsey.com/~/media/mckinsey/featured%20insights/employment%20and%20growth/how%20advancing%20womens%20equality%20can%20add%2012%20trillion%20to%20global%20growth/mgi%20power%20of%20parity_full%20report_september%202015.pdf.

Woetzel, J., Madgavkar, A., Sneader, K., Tonby, O., Lin, D., Lydon, J., Sha, S., Krishnan, M., Ellingrud, K., & Gubieski, M. (2018). The power of parity: Advancing women's equality in Asia Pacific. McKinsey & Company, McKinsey Global Institute, https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/Gender%20Equality/The%20power%20of%20parity%20Advancing%20womens%20equality%20in%20Asia

%20Pacific/MGI-The-power-of-parity-Advancing-womens-equality-in-Asia-pacific-Executive-summary.pdf.