Moonshot R&D MILLENNIA* Program

*Multifaceted investigation challenge for new normal initiatives program

"Research on an ultra-diverse society with zero loneliness by building a communication infrastructure in cyberspace"

Initiative Report

July 2021

Brainstorming Team "Realization of an ultra-diverse society where no one feels alone in the world by building a next-generation communication infrastructure in cyberspace".

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I. Concept

1. proposed MS Goal

1.1 Proposed MS Goal title

"By 2050, we will achieve an ultra-diverse society with zero loneliness through the acquisition of the means of communication."

1.2 Vision for 2050 society

Our team digitized people's feelings. The research findings are that visualisation, communication, and modeling technologies will lead to an ultra-diverse society. It is possible to eliminate loneliness through mutual understanding, promoting empathy, and developing emotion-centred services. Cyber-physical systems (CPS), which combine and link artificial intelligence (AI), information and communications technology (ICT), and virtual reality (VR) technologies (cyber) with the real world (physical), are currently active in all fields. For example, self-driving cars, robots, drones, and telemedicine hold particularly high promise. On the other hand, although human information is part of the "physical" part of the CPS, information about the "heart," which is one of the most important elements of the human being, is inadequately handled. This lack of information makes it difficult to communicate directly with the heart in cyberspace through email, social networking sites, video conferencing, and other forms of communication between people and the various services in cyberspace. Furthermore, differences in language, culture, gender, and age also contribute to the mental barriers that make communication and empathy difficult.

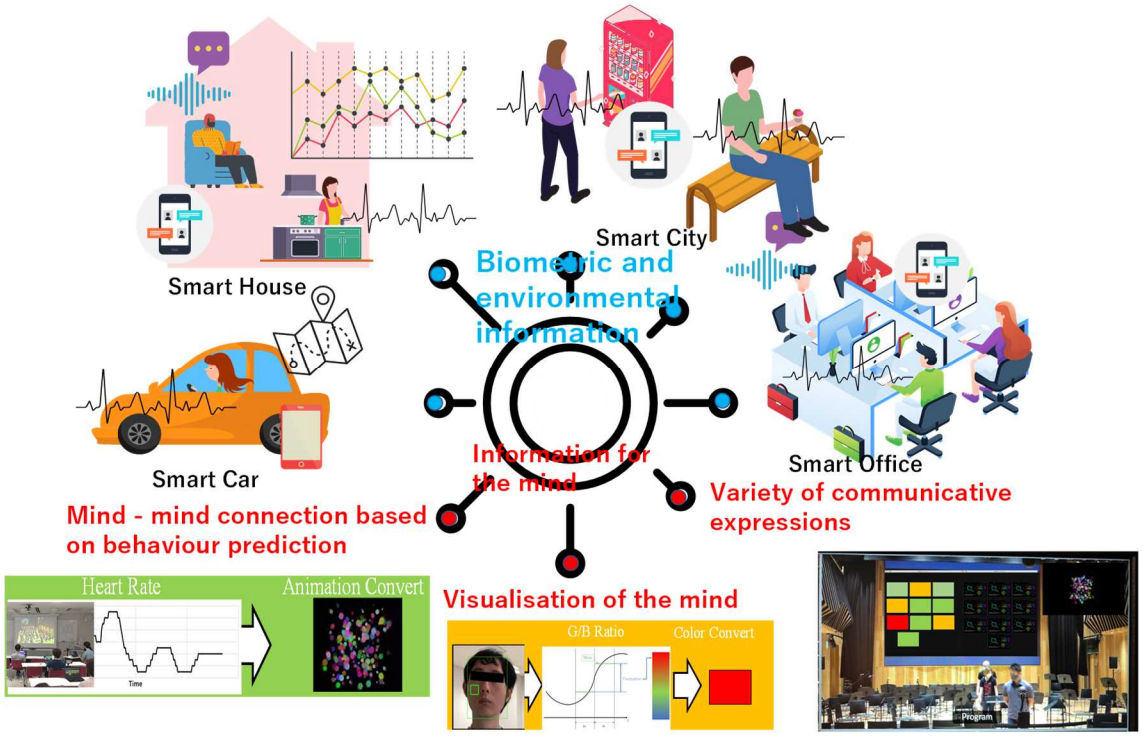
Our project aims to construct a next-generation CPS by realizing the digitalization of a person's feelings and the human "mind" and acquired a new tool of "human communication." Humanity in the future society will be able to overcome the mental barriers that cause conflict. The final goal is realizing an ultra-diverse society that creates "an emergent community of understanding and empathy among all human beings." We applied non-contact and unconscious multimodal biological information and AI analysis to model a person's feelings. These technologies make it possible to visualize the state of mind of individuals and groups. In this way, we can actively understand and acknowledge others. Through this process, everyone can benefit from self-affirmation. For example, all people in the world can understand each other and sympathize without conversation. Humanity will be able to learn, think and create together. In addition, mental modeling forecasts mental and activity changes in individuals and groups.

The model allows us to demonstrate and quantify how everyone can feel oneness and well-being and work together while respecting individuality. Researchers are currently using various services in cyberspace. Moreover, if we can understand and digitize a person's feelings with CPS and digital twin systems, users can access services they want just by thinking or feeling. It will also be necessary to create a new interface for this purpose.

Thus, in an ultra-diverse society, it will be possible to live in harmony with others and achieve self-realization using various digital services (see Figure 1). This research team has a strong will to transform a new community society with diversity and non-loneliness.

Figure 1

A Vision of Society in 2050



2. Targets

In this proposal, as a proof of concept for the developed technology, we set three targets in the following areas: "***communication between humans***," "***communication between humans and "things***," and "***social change***."

[Communication between Humans]

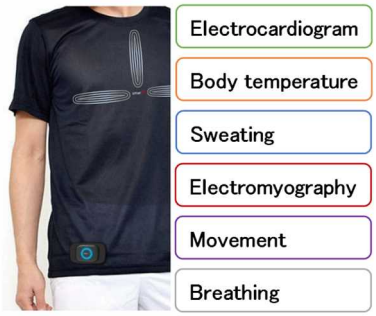
- By 2050, we will be able to make crucial decisions at the group/national level without words by visualizing and communicating the collective mind using biometric, linguistic, behavioral, and environmental data that we sense daily.
- By 2030, we will be able to understand the mental state of others by visualizing their minds using biometric, verbal, behavioural, and environmental data that we sense daily.

・Feasibility

Visualizing the mind requires measuring biometric, verbal, behavioral, and environmental data naturally so that the measurements do not interfere with daily life. Therefore, researchers are developing wearable sensors and technologies in Japan and worldwide to measure biometric, speech, and language data in a completely non-contact manner. For example, the technology to integrate various biometric sensors, electrodes, and wires into clothing is becoming practical (Ritsumeikan University, see Figure 2). Although these devices have an external circuit board, researchers are investigating various wearable biometric technologies. For instance, they are looking at biometric technology that integrates sensors and circuits on an ultra-thin film that can be attached to the body (Yamagata University) and a capsule-type sensor that can be swallowed and measures biometrics from inside the body (Tohoku University).

Figure 2

Smart Wear (Ritsumeikan University)



As for the mind's visualisation, our team conducted a feasibility experiment with 42 participants at the Music Trial WS organized by the Nishimoto Team. As a result, we succeeded in capturing the changes in the mind during the concert by non-contact autonomic nerve measurement using a camera, central nerve information using a wearable device, and text measurement, which shows the system's feasibility (Figures 3 and 4). By bringing together the above technologies, it will be possible to measure and visualize the human body and mind in everyday life as early as around 2030 and realize the core fundamental technology of this proposal.

Figure 3

Measuring the Autonomic and Central Nervous System During Orchestra Viewing Using Wearable and Non-Contact Sensors

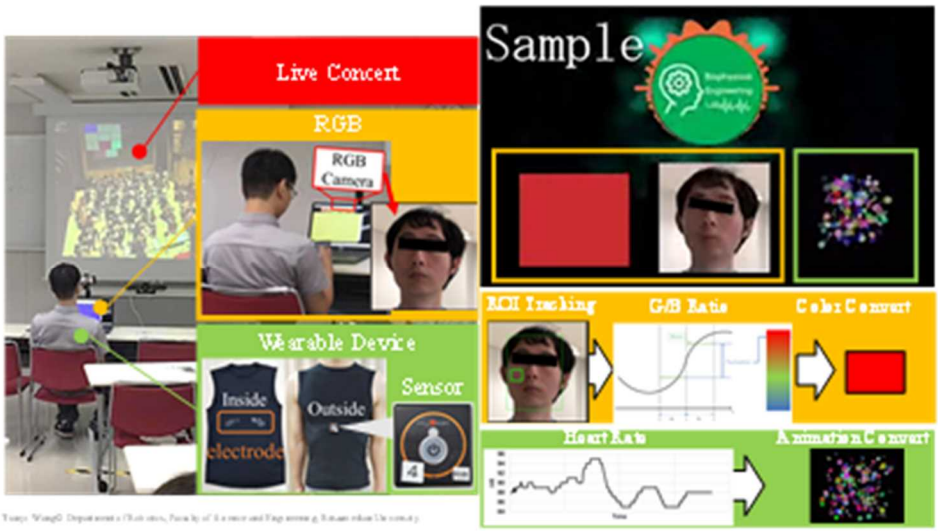


Figure 4

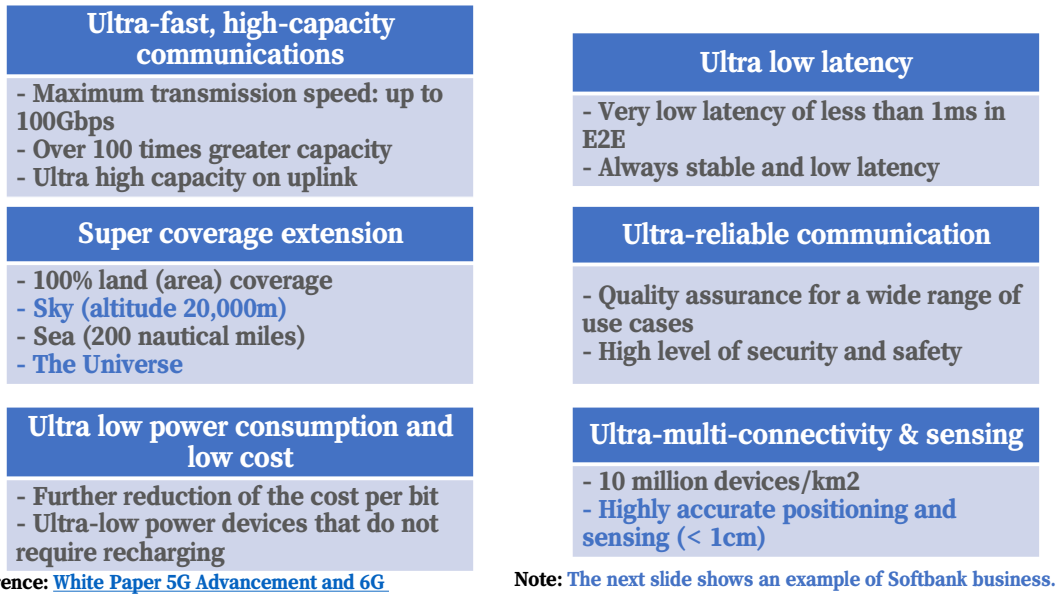
Changes in Feelings Before and After Watching the Orchestra by Text Analysis

視聴後、喜びの度合いが強くなった

The feasibility of data transmission and storage in cyberspace depends on the network traffic. It also depends on the coverage of the communication area and the number of simultaneous connections. According to the Digital 2021 Global Overview Report, Internet users account for 59.5% of the world's population. On the other hand, researchers expect the continued development of mobile communications technology will extend coverage over land, air, sea, and space. As for the number of simultaneous connections, the scope is ten million devices per square kilometer, ten times more than the one million devices per square kilometer defined for 5G. According to an international statistics website (cited above), the most densely populated region in the world is Macau, with 21,067 per capita per square kilometer, so the scope of 6G's concurrent connections could withstand 474 devices per person. Thus, the social infrastructure will be able to withstand the 2050 target. Figure 5 provides a summary of 6G requirements.

Figure 5

Technical Requirements for 6G



Reference: White Paper 5G Advancement and 6G

Note: The next slide shows an example of Softbank business.

[Communication between Human and Things]

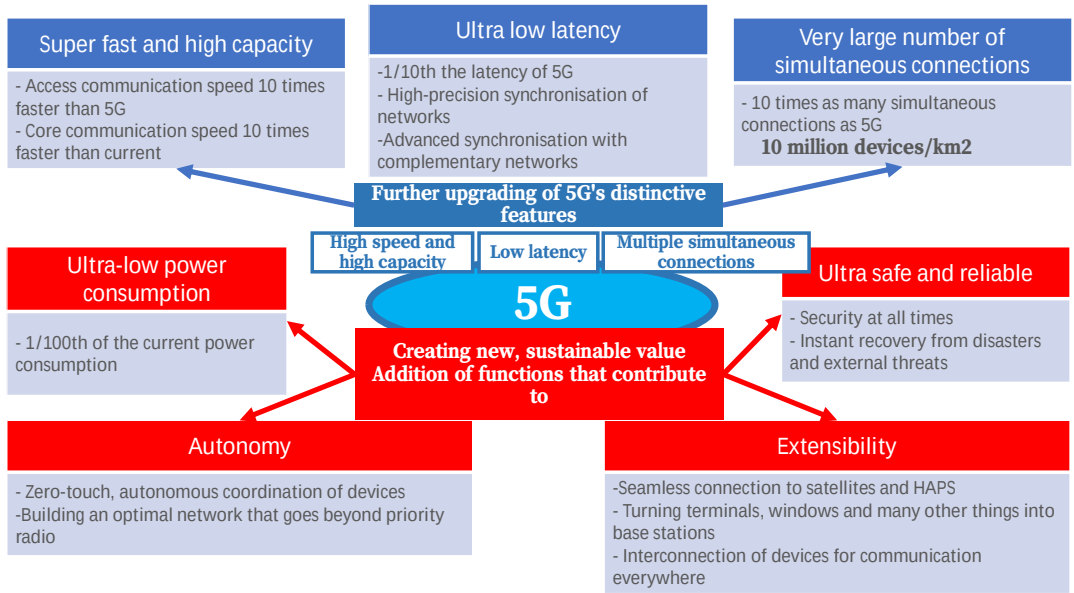
- By 2050, devices will visualize the mind using biometric, linguistic, behavioural, and environmental data, understand and predict changes in mind and behaviour, and make suggestions, reactions, and services tailored to the mind.
- By 2030, devices will visualize the mind using biometric, verbal, behavioural, and environmental data to understand the mind and complete actions according to what is felt or thought, without explicit manipulation.

・Feasibility

This project used visualisation technologies in the communication between humans as a human interface and applied operations of “things” and “things” to understand the mind and realize new services. The 2030 target is feasible as [human communication], although some “things” may require more immediate response than human communication. However, there is a problem of delay in transmission when communicating through cyberspace. According to the 2020 White Paper on Information and Communications, implementing Beyond 5G, currently under study, could reduce the delay to 1/10 of 5G. As a result, the latency in communication could be around 1msec. At the same time, ITU standard G.114 states that up to 150msec is acceptable for communication in cyberspace, so it is technically feasible.

Figure 6

Outlook for Future Communications Technology



Reference: Ministry of Internal Affairs and Communications Beyond 5G Promotion Strategy

As in communication between humans, there is a need for accurate, smaller, and more power-efficient biometric measurement methods, data transmission, and integration. However, as mentioned above, we expect a sufficiently developed communication environment to achieve the target by 2050.

[Social change]

- By 2050, heart-centred communication will have spread worldwide, and we will be able to build rich human relationships and communities without words, leading to an ultra-diverse society with no loneliness.
- By 2030 it will be possible to collaborate in the arts with anyone using the mind as the primary means of communication.

・Feasibility

It is necessary to make the products available to those who need them to achieve this goal by 2030. In this respect, researchers met the targets mentioned above. Moreover, as mentioned in the previous target, it is technically feasible to reach a practical level. Therefore, researchers can likely achieve the 2050 target since they expect the target's apparent and latent demands necessary for its diffusion (refer to II. Analysis).

3. Background

3.1 Why Now?

[The demands of society]

・The problems of Japanese society

The Harvard Study of Adult Development, followed for more than 75 years, concluded that relationships are the most important factor influencing happiness and health. We also know that mental stress, influenced by relationships, is closely related to production efficiency, work efficiency, economic profit, and learning efficiency, so building and maintaining good relationships is essential for individuals, organisations, and society. In addition, Japan's happiness ranking in the world is low, and it is necessary to solve these problems in terms of human relations and communication. In the last few years, Japan's happiness ranking has been below fiftieth place.

One of the reasons for this low ranking is Japan's meager score in generosity compared to the top 10 countries, indicating a low level of satisfaction in mental well-being and relationships with others. According to the UNICEF survey on children's well-being, Japan is in twenty-seventh place in the lowest class in social adaptability (e.g., making new friends), and 62.2% of children are satisfied with their lives in mental well-being (compared with an average of 75.7% in 38 countries). In addition, the suicide rate (the number of suicides per 100,000 people) among 15–19-year-olds is 7.5 (compared with an average of 6.5), which is considerably worse than the average among the 38 countries. Considering Japan's presence and value in the world, improving happiness through a rich and caring life is an essential social issue in Japan.

Table 1

Comparison of the Top 10 Countries in the World Happiness Survey with Japan

Country	Parameter link	Dystopia (2.43) + residual	Explained by: Freedom to make life choices	Explained by: GDP per capita	Explained by: Generosity	Explained by: Healthy life expectancy	Explained by: Perceptions of corruption	Explained by: Social support	Score
1. Finla	真	3.25	0.69	1.45	0.12	0.74	0.48	1.11	7.84
2. Denn	真	2.87	0.69	1.50	0.21	0.76	0.48	1.11	7.62
3. Switz	真	2.84	0.65	1.57	0.20	0.82	0.41	1.08	7.57
4. Icelar	真	2.97	0.70	1.48	0.29	0.77	0.17	1.17	7.55
5. Nethe	真	2.80	0.65	1.50	0.30	0.75	0.38	1.08	7.46
6. Norw	真	2.58	0.70	1.54	0.25	0.78	0.43	1.11	7.39
7. Swed	真	2.68	0.68	1.48	0.24	0.76	0.45	1.06	7.36
8. Luxer	真	2.65	0.64	1.75	0.17	0.76	0.35	1.00	7.32
9. New	真	2.61	0.67	1.40	0.28	0.78	0.44	1.09	7.28
10. Austri	真	2.78	0.64	1.49	0.22	0.78	0.29	1.06	7.27
Average		2.80	0.67	1.52	0.23	0.77	0.39	1.09	7.47
SD		0.19	0.02	0.09	0.05	0.02	0.09	0.04	0.17
56. Japan	真	2.05	0.50	1.39	0.02	0.84	0.19	0.95	5.94

・Japan's Problems in the Context of Global Trends

Today, Japan's GDP is the third-largest globally, after being overtaken by China in 2010, behind only the US and China. Therefore, Japan remains one of the richest countries in the world. In this context, a phenomenon called the happiness paradox arose. This well-being paradox indicates that countries with high GDP do not necessarily have high levels of well-being. It also signifies that rising incomes do not necessarily lead to higher levels of well-being and that there is a saturation point at which well-being levels off after reaching a certain amount of income. Thus, there is a saturation point in well-being, and well-being reaches a ceiling when income exceeds a certain level. In economic activity, as articulated in Mr. Tateishi's (founder of Omron) futurology, economic growth is represented by a logistic curve (S-curve), similar to the evolution of the population of an organism. Figure 7 illustrates this concept.

Figure 7

Growth Curve of Economic Activity

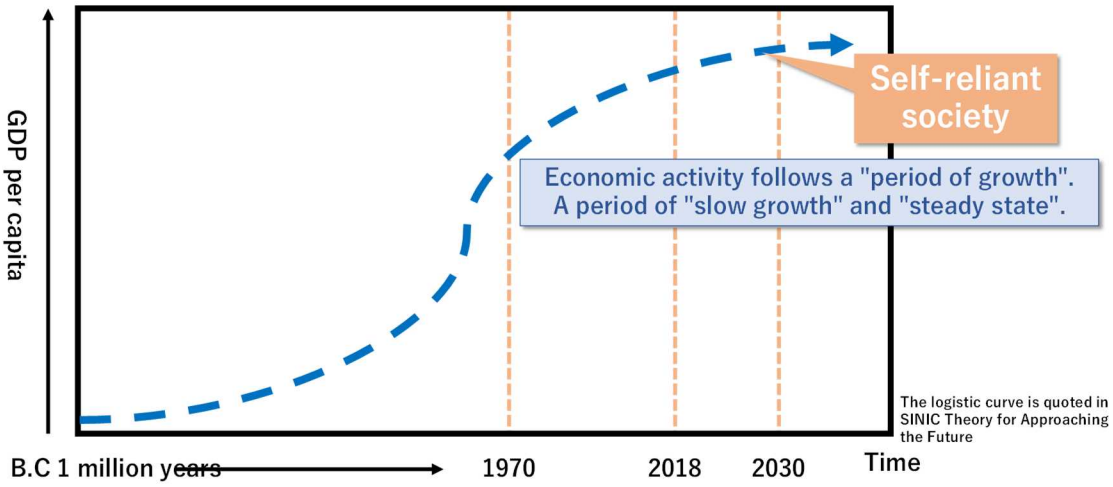


Diagram. Growth curve of economic activity

Economic activity goes through a period of growth followed by a period of slow or steady growth. Today, Japan is entering a period of slow or steady growth after a period of high growth. Economists predict that Japan will move from mass production and mass consumption to a period of moderate growth and steady-state and reach an autonomous society. To achieve this autonomous society, researchers predict that technology supporting the spirit and connection between mind and body will become more important than the

materialistic society of the past.

Mr. Tateishi, the founder of Omron, proposed the Seed-Innovation to Need-Impetus Cyclic Evolution (SINIC) theory. The theory states that our societies will move away from the industrial, automated, and informational society that has continued to grow (in pursuit of material wealth) and towards an autonomous society (in pursuit of spiritual wealth). With this movement, the 20 years between 2010 and 2030 will emerge as an optimised society. Creation and destruction will resolve the chaos and conflicts of the transition period. To achieve a paradigm shift from the current optimised society to an autonomous society, we need social transformation and technological innovation to enrich our minds towards an autonomous society at this very moment. In addition, we need to find a solution to the paradox of happiness.

・Impact of COVID-19

The World Economic Forum (WEF) chose "The Great Reset" as the theme for its Davos meeting in May 2021. The global pandemic demonstrated our interconnectedness. At the same time, the spread of the new coronavirus is having a serious impact on economic growth, public debt, employment, and human well-being. In particular, it is exacerbating and increasing the severe social and economic impacts on the poor and vulnerable, and fundamental inequalities and disparities, particularly poverty, gender inequality, and racial injustice. To bring a better world out of this crisis, we need to build an entirely new technological innovation and economic and social system.

・Requirements in Science and Technology

As mentioned above, today's society faces problems related to human relationships, such as declining happiness, mental loneliness, and bullying. Therefore, there is a growing need to transform society into one that fosters mental well-being. In the long term, it will be difficult to solve human and social relations problems, such as differences and conflicts between individuals, between individuals and groups, and between nations, without fostering mental well-being. Therefore, for everyone to develop a richness of mind, care for others and think about people in other countries as if they were our own, it is important to deal with information about the "heart," one of the essential elements of the human being. For example, you may have sent a casual email that ended up in a fight, or your social networking site unexpectedly went up in flames. In these and other instances, the sender may not convey their thoughts, and the receiver may not grasp them accurately. How we communicate also depends on one's personality, ideas, experiences, knowledge, past events, and even mood (which may also be related to one's physical condition). Is there anything that we could have done before this decisive division occurred? When people come from different countries, cultures,

religions, and other social backgrounds, sometimes it is challenging for both parties to communicate their feelings and thoughts accurately unless they spend considerable time understanding each other's situation, as described above. Can't we get on with each other right away? Can't we stop the war right now? And what if we knew how our babies felt? It could provide an opportunity for parents who are too busy with housework and work to spend time with their babies to grow up together, learning why they are crying, their minds, and their behaviour.

To do this, we first need to develop mind-reading skills. This skill requires state-of-the-art sensing technology that collects biometric and environmental information through wearable sensors that are not worn on the body or even noticed by the wearer. The central nervous system, autonomic nervous system, and behavioural analysis technologies will also be essential to characterise and make sense of this information. With this technology, it will be possible for people and "things" to perceive human feelings. Second, the technology of knowing is not enough to solve the problem of miscommunication. It is necessary to develop a technology of mind-connection, that is, a technology that connects the mind, its behaviour, state, and predictions. In this technology, machine learning and big data analysis from characterised biometric data depicts the state of mind, making possible psychological indicators, behaviour prediction, and emotion estimation. In addition to people trying to understand and connect with others, this could be a technology that allows "things" to recognise people's minds.

And what if you could use CPS to express your heart freely? What if you could learn about your relative with dementia, their favorite things, their most memorable memories, and experience their memories together in cyberspace? Do you know someone with locked-in syndrome? What if you could play music with them using your mind and form a band with them? What if you are not good at drawing, playing instruments or singing, but you can create art with your mind? In this way, the CSP-based bio-signal expression technology (mind-expression) makes it possible to do creative work without regard to place, time, ability, or function. This technology needs to be enhanced by a brain-computer interface, brain science, and the augmented reality (AR) and magnetic resonance (MR) research fields.

In addition, in research such as this, where we look at transforming social change or the social system, it is important to change people's behaviour and consciousness. However, it is not easy to change established behaviour and consciousness. Therefore, rather than science and technology changing society and individuals, societies can transform individuals using sensing and interfaces as technological tools. For this purpose, it is necessary to solve technical problems with integrated knowledge that combines engineering and information technology with psychology, social science, medicine, and other scientific disciplines, although they are currently separate fields. This goal cannot be solved in the short term and involves addressing

Japan's R&D programme issues. The goal is an attempt to use CFS to renew human communication and bring about social change. The development of the elemental technologies involved in building a communication infrastructure is challenging. It is also a technology that transforms people's consciousness and needs evaluation in the long term to track its effects.

As we have seen, there is a common human need to visualize, understand and use the mind. However, we can only realize this by bringing together several different disciplines such as: psychology and psychiatry, where researchers have studied the mind extensively, and medical engineering, ergonomics, electronics, information science, chemistry, physiology, biochemistry, cognitive science, data science, sociology, communications engineering, and artificial intelligence. It is not possible. For example, if we want to visualize the mind based on biological information in our daily lives, we need to establish advanced and diverse means of biological sensing. This task will require collaboration between medical engineering, ergonomics, electronics, and information science.

In addition, the visualisation of the mind from biometric data requires collaboration between psychology, data science, cognitive science, and information science. In addition, when an individual's visualisation of the mind develops into a group's or society's visualisation of the mind, research and development are necessary based on each scale. This research is required because biological measurement, analysis, and expression methods differ according to the scale. In addition, it will be necessary to collaborate with sociology and other fields. Furthermore, considering the development of its application, the cooperation scope will expand to all areas related to humans. To achieve this goal, collaboration among various fields, regardless of whether they are in the natural sciences or the humanities and social sciences, is essential and cannot be achieved in the short term.

3.2 Social Significance of Achieving the Goal

Given the significance of the vision of the society we want to achieve by 2050, the goals of this project must be in line with society's desires. In addition, conducting the targeted development may require further consideration of its use and ethical and legal developments. However, if these requirements are satisfied, the range of uses will be broad. Thus, it will become the ideal social vision for 2050 and a guideline for researching and developing new mind-handling technologies. Based on the above, we will explain the significance of the vision of the society we want to achieve in 2050.

In an ultra-diverse society, people will constantly reflect on themselves and strive to understand themselves and the process of "individuals." They will firmly recognize their identity, which will normalize in the context of their connections with others. In other words, with zero loneliness and no miscommunication, everyone will have the opportunity for personal growth and fulfillment in life through the affirmation of others and self. An ultra-diverse society is an idea that links diversity to fulfilment in life. This ultra-diverse society will provide the basis for a suicide-free and vibrant society where everyone can take on the challenge of creating new experiences and values, where autonomous individuals receive nurturing.

Next, we will explain the significance of the achievement scene described in the previous section.

[Communication between humans]

- By 2050, we will be able to make important decisions at the group/national level without words by visualizing and communicating the collective mind using biometric, linguistic, behavioral, and environmental data sensed daily.

[Communication between people and things]

- By 2050, devices will be able to visualise the mind using biometric, linguistic, behavioural, and environmental data to understand and predict changes in mind and behaviour and develop proposals and services tailored to the mind.

[Social Change]

- By 2050, heart-centred communication will have spread worldwide, and we will be able to build rich human relationships and communities without words in an ultra-diverse society with no loneliness.

3.3 Action Outline

This goal aims to transform human relationships in individuals, organisations, and society, using technology to visualise and connect the mind as its core. To achieve this goal, researchers need to bring together wisdom that transcends the boundaries of research fields such as psychology, social sciences, traditional music, ethics, engineering, informatics, cognitive engineering, and bioengineering. In addition, in promoting research, researchers need to engage in dialogue with the public and academia and promote international cooperation between industry, government, academia, and overseas countries concerned about isolation. It is necessary to incorporate Generation Z's opinions and research ideas, who will be the main players in society in 2050 and implement them in society by including them as researchers in research projects during their development.

4. Benefits for Industry and Society

Suppose the goals we propose bridge the gap of time, space, age, gender, nationality, race, ethnicity, religion, language, culture, and ideology of the world's people and build good human relations. In that case, it will create a new shared world culture, not just intercultural exchange. While nurturing our respective cultures in physical space, we can enjoy the value of another society in which people worldwide can empathise with each other without borders, cultures, or languages in cyberspace. It is easy to imagine that this will lead to the maximisation of various possibilities such as employment, learning, and entertainment, which have been constrained by distance and time.

With the current new coronavirus infection (COVID-19), the proportion of work, study, and communication via the Internet is increasing rapidly. The amount of time and opportunities for communication in cyberspace has increased significantly, a complete change from how we live. We expect this use of cyberspace to continue in the post coronas to prevent the spread of new infectious diseases. Such life and relationship building in cyberspace will be essential for a sustainable society in the future. While cyberspace is a way to prevent infectious diseases, it is also a basis for building new relationships across time, space, and language if well used. Thus, this project aims to construct a sustainable society where all people worldwide can empathise and trust each other. The Gartner Hype Cycle predicts affective computing as an area of research expecting a high level of innovation. Therefore, affective computing is an area of high innovation potential. Figure 8 illustrates Gartner's Hype Cycle in 2020.

Figure 8

Hype Curve Showing Trends in Technology

For example, we could apply affective computing to the business of emotional analysis, such as analysing a consumer's reaction to an advertisement or estimating the preferred products of a shopper in a shop, or to medicine, where doctors can make quantitative judgements about a patient's pain. Furthermore, we can apply AI, computers, and calculators that care about the mind to automated driving, digital assistants, and digital humans. This application will lead to creating new system proposals in Japanese and global industry that integrate humans into various fields such as service, medical welfare, automotive, amusement, and communication.

The United States and China are the leading countries in cyber communication, cyberspace, and social networking services (SNS). However, no proposal or system uses SNS or cyberspace to build human relations or improve mental state. Caring for others is something that the Japanese are very good at, recognised around the world. If psychology and engineering can combine to offer new wisdom, this will be an essential part of the world's efforts to build databases and communication infrastructure. At present, Japan may be lagging behind the rest of the world in big data analysis and network communications. However, the new technologies we are proposing are likely to become the new communication and social infrastructure. If Japan takes the lead in developing them, we will be able to take the initiative in the world. These technologies will come after Big Data, SNS, ICT, communication technology, AI, etc., as represented by Google, Apple, Facebook, and Amazon (GAFA).

II. Analysis

1. Essential Scientific/Social Components

Issues (scientific, technological, and social) and necessary measures to achieve the MS Objectives

[On Social Issues]

Our research found that the accuracy of this mental state estimation is an important concern for the stakeholder public and users. For this technology to spread and bring about social change, researchers need to resolve social issues. We explain this in the following section based on the knowledge survey data. In the research, 2,000 people of all ages in four countries (Japan, USA, China, UK) responded to questions about the technology of knowing the human mind. The questions included:

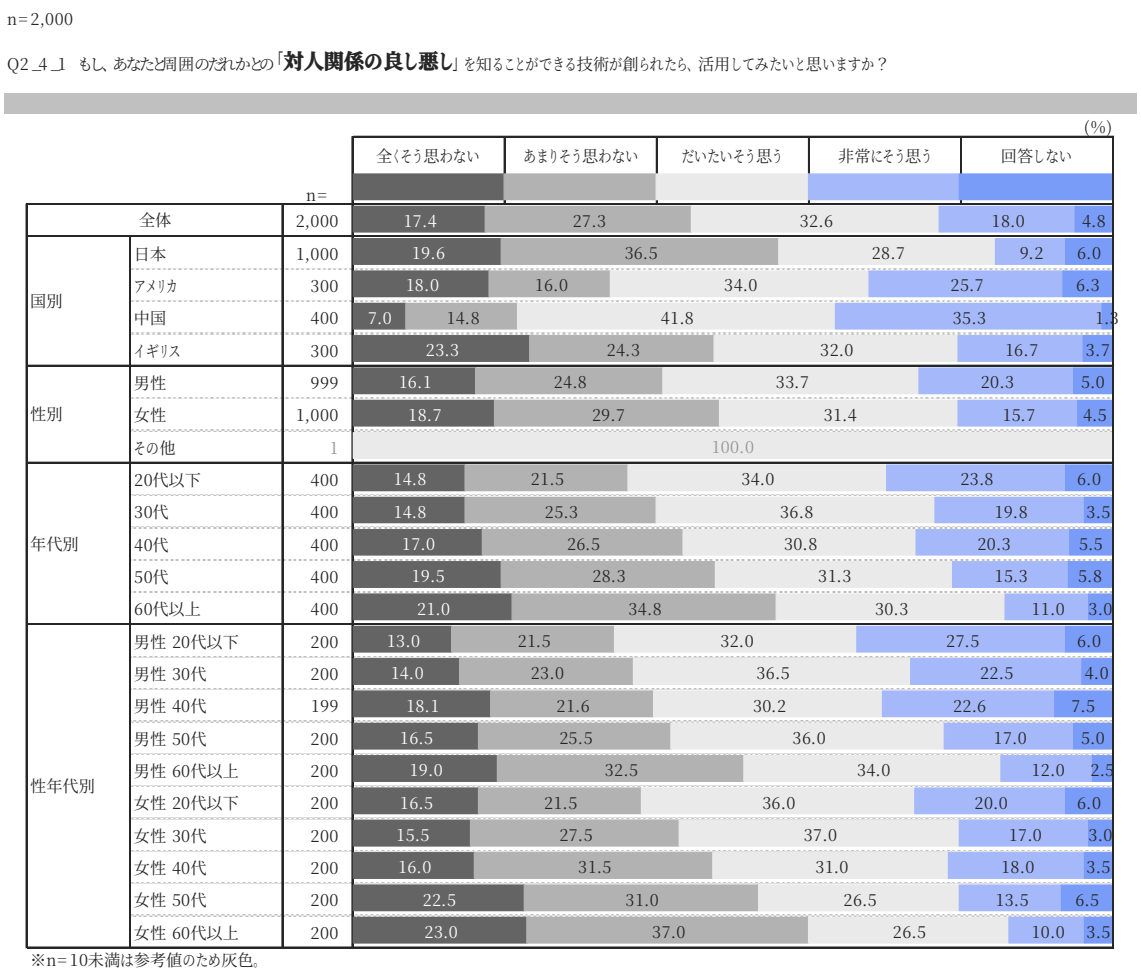
- "How much would you like to know about your own state of mind?"
- "How often do you want to know about the state of mind of the people around you?"

More than 70% of respondents answered that they felt this way at least once ("sometimes," "often," or "always") for both questions.

Researchers then asked two questions additional questions: "If a technology was developed that could tell you whether you had a good or bad interpersonal relationship with someone around you, would you want to use it?" The second question related to technology use and the "goodness or badness of interpersonal relations and atmosphere in an organisation." The results show a similar tendency of the answers to these two questions. When asked if they would like to use the technology to determine whether they have good or bad interpersonal relationships, 50.6% of respondents answered yes (approximately + "very much"), higher than the 44.7% who answered no ("not much" or "not at all").It is noteworthy that the younger the generation that will be responsible for the next generation (2050), the greater the desire to know people, and the greater the desire to use technology to know people in China than in other countries (compared to Japan, the US, and the UK). Incidentally, the respondents who wanted to use technology for "mind reading" included the following age groups: 57.8% in their 20s, 56.6% in their 30s, 51.1% in their 40s, 46.6% in their 50s, and 41.3% in their 60s. In addition, China (77.1%) was the most active in using technology to learn about interpersonal relationships, while Japan was the most reluctant (37.9%) (the US 59.7%; UK 48.7%). The same was true when asked if they would like to use technology to determine the quality of relationships and atmosphere in their organisation (see Figure 9).

Figure 9

Questions about Good and Bad Interpersonal Skills



When asked if they would like to use the technology to discover the "good or bad relationships and atmosphere in the organisation," the trend was almost the same (see Figure 10).

Figure 10

Questions about Good and Bad Interpersonal Techniques in Organisations

n=2,000

Q2_4_2 あなたが所属している「**組織内の人間関係・雰囲気の良し悪し**」がどのような状態にあるかを知ることができる技術が創られたら、活用してみたいと思いますか？

(%)

		n=	全くそう思わない	あまりそう思わない	だいたいそう思う	非常にそう思う	回答しない
全体		2,000	16.6	26.4	33.9	17.7	5.6
国別	日本	1,000	20.1	33.7	28.4	10.6	7.2
	アメリカ	300	16.7	20.0	35.0	21.0	7.3
	中国	400	4.8	14.8	44.0	35.5	1.0
	イギリス	300	20.3	23.7	37.3	14.3	4.3
性別	男性	999	15.6	23.6	35.3	20.0	5.4
	女性	1,000	17.5	29.1	32.4	15.3	5.7
	その他	1	100.0				
年代別	20代以下	400	15.3	20.5	36.5	20.5	7.3
	30代	400	15.8	24.8	36.0	19.5	4.0
	40代	400	16.0	24.0	35.0	18.3	6.8
	50代	400	16.8	29.8	32.3	15.8	5.5
	60代以上	400	19.0	32.8	29.5	14.5	4.3
性年代別	男性 20代以下	200	13.5	18.0	38.0	23.5	7.0
	男性 30代	200	16.0	20.0	38.0	21.5	4.5
	男性 40代	199	16.6	20.6	34.7	20.1	8.0
	男性 50代	200	15.0	25.0	37.5	18.0	4.5
	男性 60代以上	200	17.0	34.5	28.5	17.0	3.0
	女性 20代以下	200	17.0	23.0	35.0	17.5	7.5
	女性 30代	200	15.5	29.5	34.0	17.5	3.5
	女性 40代	200	15.5	27.5	35.5	16.0	5.5
	女性 50代	200	18.5	34.5	27.0	13.5	6.5
	女性 60代以上	200	21.0	31.0	30.5	12.0	5.5

※n=10未満は参考値のため灰色。

In light of the above, it is necessary to promote technology through local authorities and institutions, even if technological innovations connect people. This promotion is especially so in case some people turn their back on society and new technologies. Some people (the older they are, the more likely they are to use information systems) do not like using information systems. It is also necessary to promote the use of the technology in cooperation with medical institutions, educational institutions, and various facilities through careful dialogue on security and the use of information.

[On Scientific and Technical Issues]

This paper describes interviews with several experts related to sensing, emotion estimation, cognitive engineering, and brain science. Researchers have proposed various methods to understand mental states at home and abroad. However, most of them are at the laboratory level, while some used physiological information from the central nervous system or autonomic nervous system, and others based their methods on behaviour. In addition, some of them estimate the state of mind from verbal information, such as language processing using social networking sites and chat rooms, and speech by speakers.

When we think about the technology that will lead to the proposed social image in the future, it is necessary to leap from biometric measurement that can estimate the state of mind at the laboratory level. Instead, we need to use biometric measures that can detect the state of mind of users in daily life in a non-contact, low-constraint, and unconscious manner. However, interviews with sports and health science experts on measurement devices and several companies related to the smart wear business indicate several problems with wearable biometric devices such as smartwatches. These problems include that the devices are cumbersome to wear, the types of measurement data are limited, and the use of data is limited to healthcare and sports. In addition, there are only a few types of measurement data available, and data use is limited to healthcare and sports. Therefore, we need breakthroughs in sensing systems beyond the currently developed smartwatches and smart wear.

For example, microsensors, ultra-low constraint wearable sensors, human tracking sensors using small drones, and sensors embedded in houses, cars, and cities. In addition, by expanding the range of measurement opportunities and methods in everyday life, it will be possible to collect large-scale training data to model the biometric mind and dramatically improve the accuracy of AI technology to visualise mental states. Moreover, by using multimodal and unconscious biological sensing, it will be possible to obtain and utilize multiple biological signals according to the situation in which the mind changes, enabling a highly accurate estimation of the mental state.

[International Collaboration, Cross-Sectoral Collaboration, ELSI and Other Initiatives]

In terms of international collaboration, it will be important to collaborate with institutions that examine the social aspects of happiness and well-being from a scientific perspective. For example, this could include the grant study research team at Harvard University and overseas institutions in sensing and AI technology for measuring mental information. In addition, since we are dealing with biological information, we will need experts in law and bioethics, considering the issues of information regulation and privacy. In addition, there is a wide range of areas where the technology will be put to practical use and implemented in society,

including education, healthcare, welfare, and government. Collaboration with practitioners in the field, such as educators, social workers, careers, free schools, etc., is also essential.

(Supplement 1: Survey on Well-being Towards the Use of Mental Information)

To identify the potential demands in society to overcome the challenges, we refer to the results of the following questions (Figure 11). Is it important for our well-being that diverse people connect beyond physical space? The questionnaire posed such a question. The results showed that across the four countries, 67% of respondents said it was important (the sum of those who said it was very important and those who said it was mostly important). In the three countries other than Japan, almost 80% of respondents said it was important (

Figure 11).

Figure 11

Questions about Relationships and Happiness

n=2,000

Q3_6_1 年齢や性別（ジェンダー）、人種、民族、学歴、社会的地位、障がいの有無など **様々な人たちと「良好な関係を築くこと」は、あなたが幸せを感じる上でどのくらい重要**なことだと思いますか？

(%)

		n=	全く重要なことだと思わない	あまり重要なことだと思わない	だいたい重要なことだと思う	非常に重要なことだと思う	回答しない
全体		2,000	6.2	18.5	42.2	24.4	8.8
国別	日本	1,000	7.6	26.4	40.9	12.0	13.1
	アメリカ	300	6.7	8.0	37.7	38.7	9.0
	中国	400	3.0	13.0	50.5	32.5	1.0
	イギリス	300	5.3	10.0	40.0	40.3	4.3
性別	男性	999	7.6	18.3	41.5	23.0	9.5
	女性	1,000	4.8	18.7	42.8	25.7	8.0
	その他	1			100.0		
年代別	20代以下	400	8.0	15.3	40.8	26.5	9.5
	30代	400	6.8	19.3	42.0	22.3	9.8
	40代	400	6.8	19.5	41.8	21.8	10.3
	50代	400	5.0	21.3	37.5	27.3	9.0
	60代以上	400	4.5	17.3	49.0	24.0	5.3
性年代別	男性 20代以下	200	9.0	15.5	43.5	22.5	9.5
	男性 30代	200	8.5	19.5	40.5	21.5	10.0
	男性 40代	199	9.5	18.6	38.7	19.1	14.1
	男性 50代	200	5.5	21.5	35.5	27.5	10.0
	男性 60代以上	200	5.5	16.5	49.5	24.5	4.0
	女性 20代以下	200	7.0	15.0	38.0	30.5	9.5
	女性 30代	200	5.0	19.0	43.5	23.0	9.5
	女性 40代	200	4.0	20.5	44.5	24.5	6.5
	女性 50代	200	4.5	21.0	39.5	27.0	8.0
	女性 60代以上	200	3.5	18.0	48.5	23.5	6.5

※n=10未満は参考値のため灰色。

Also, the more we connect with others, the more we experience the annoyance of relationships and the difficulty of maintaining them. However, when asked to express our state of mind when someone with whom we have a spiritual connection is no longer with us in terms

of a score, our sense of well-being seems to be about half of a perfect score out of 100 (Figure 12). The low scores of the Japanese are particularly striking.

Figure 12

Happiness Scores (When not Connected to Others)

n=1,451

Q3_7_1_もし、あなたが、**精神的な繋がりのある人がいなくて生活をしたとしたら**、あなたの「幸せ」の程度は何点くらいでしょうか？0点（全く満足していない）～100点（とても幸せ）

		n=	M	SD
全体		1,451	52.1	30.7
国別	日本	663	41.7	29.2
	アメリカ	213	59.9	31.0
	中国	338	64.6	26.6
	イギリス	237	56.6	30.0
性別	男性	699	55.0	29.6
	女性	752	49.5	31.4
	その他	0	-	-
年代別	20代以下	262	50.5	30.5
	30代	279	53.5	30.7
	40代	283	52.2	30.5
	50代	295	50.9	31.8
	60代以上	332	53.3	29.9
性年代別	男性 20代以下	134	51.7	27.9
	男性 30代	135	57.1	29.8
	男性 40代	123	57.6	28.9
	男性 50代	144	53.5	31.3
	男性 60代以上	163	55.2	29.6
	女性 20代以下	128	49.2	33.0
	女性 30代	144	50.2	31.3
	女性 40代	160	48.1	31.2
	女性 50代	151	48.4	32.2
	女性 60代以上	169	51.5	30.0

※n=10未満は参考値のため灰色。

Figure12.　Happiness scores (when not connected to others)

It is noteworthy that in both countries, there is a common recognition of the need for diverse people to connect and that this (spiritual) connection creates a sense of well-being for all of us. But, at the same time, it is clear that they want to make it a better relationship.

(Supplement 2: Expected Technology for Knowing the State of Mind)

Researchers extracted the stakeholders' expectations regarding mind-reading technology using a questionnaire survey (same target as the above questionnaire). We focused on people who have a high need for "mind-reading" technology and tried to collect their ideas and requests. The questionnaire asked respondents to select one of four options for their "current" and "ideal" ways of interacting with diverse people: a. narrow and shallow, b. shallow and deep, c. broad and shallow, d. broad and deep (and NA. cannot answer). Based on these responses, researchers classified the current-ideal combinations of involvement into four types as follows (1,744 valid responses out of 2,000 respondents; 87.2%)

1. Type of agreement between present and ideal [1,036 valid responses]. Example. Present "narrow and shallow involvement," ideal also "shallow and narrow involvement."
2. The type of person whose ideal is the opposite of the present [185 valid responses]. Example. Currently "narrow and shallow involvement," ideally "broad and deep involvement
3. Ideally, they are looking for a broader or deeper relationship [422 valid responses]. Example. Currently "narrow and shallow involvement" - ideally "shallow and deep involvement."
4. Ideally, they want a narrower or shallower relationship: [101 valid responses]. Example. Currently “narrow and deep involvement,’ ideally “narrow and shallow involvement.”

We asked, "Would you like to use mind-reading technology to understand people's minds?” This question indicates that a certain number of people, except for Type (1) "Present-ideal is the same," who have some kind of problem or sense of annoyance in their current relationships and therefore consider another type to be ideal. In particular, looking at the mean of the data from this survey, Type (4) (the type whose ideal is a narrower or shallower relationship) scored 2.36 (SD = 1.02) on a 4-point scale (overall M = 2.04, SD = .95). They experienced a slightly higher level of feeling "troublesome and wanting to keep a little distance" from that difference between the variety of social categories such as age, gender, and sex.

In asking for suggestions on closing this gap, we decided to tally up the ideas about "mind-reading" technology among the respondents who fell into these three types. We asked: "If you could create a technology that would support you in building relationships that are

comfortable for you and the people you interact with, what would it be, and how would it work? If you could create a technology that would support people in building comfortable relationships, what would it be?" Table 2 below summarizes the results for the 588 cases describing ideas and requests.

Table 2

Aggregation of Technical Ideas for "Mind-Reading" (Knowing People)

	タイプ（現状の関係性のカタチ － 理想のカタチ）	②	③	④
	具体例	今と理想が真逆	理想はより広くor深く	理想はより狭くor浅く
	言及・記述者数 ／ タイプの人数 （1744名中）	65 / 185 名 (35.1%)	148 / 422 名 (35.1%)	28 / 101 名 (27.7%)
「自分の心の状態」に対するサポート技術	・相手にストレスを感じたときの対処法を教えてくれるサポート. ・AIに悩みを打ち明けた時に、適格なアドバイスをしてくれたとしたら、心が晴れるような気がする. ・意図せずに相手を傷つけるような発言や行為をしてしまい、相手がそれを指摘しづらいときに、それとなくダメ出しして教えてくれる技術.	15 名	28 名	5 名
「相手の心の状態」に対するサポート技術	・相手の本当の好みや人に対する認識が分かる技術. ・本音と建前の両方がわかるツール. ・相手が心の底から喜んでいるかどうかわかる「幸福メーター」. ・映画のように、眼鏡で他人の考えていることを正確に読み取れる技術.	23 名	59 名	9 名
「自分と相手の関係性」を良好にするサポート技術	・多くの人達のいろいろな考えを肯定的にまとめてくれる技術. ・誤解をされた時、仲介して仲直りできるサポート. ・意図のすれ違いの誤解を防ぐもの. ・自分と同じ価値観を持ち、付き合うのに適した人を選び出してくれる技術.	14 名	33 名	8 名
その他のアイデア	・思考回路が画面にアイコンとして表示されるなど. ・人の問題の原因を素早く見つける方法。非常に迅速なセラピーセッションのようなもの. ・思想の違う人が関わらない技術. ・人を親切で理性的にする薬.	13 名	28 名	6 名

Note.「今と理想が一致」型:1036名/1744名中(59.4%)

The most common was the ability to understand the state of the other person. Following this response, the most common were techniques for coping with (calming) one's psychological state in interpersonal relationships, and adjusting behaviour, so that the relationship between the two parties can cope, even when miscommunication occurs.

（Supplement 3: Rationale for the Need for Highly Accurate Mental State Estimation and Expectations for the Technology）

We used a word cloud of responses of reasons for not using the technology to analyse why people do not want to use the technology (Figure 13). We translated the free words into Japanese before conducting the survey. As a result, we clarified that we cannot understand the mind using technology and that some things are better not to know. In addition, the words technology, judgment, and fear tend to make people feel insecure about their trust in technology and its performance. Figure 14 shows an example of the results of a three-week workshop for high school students (Japanese and Thai) to discuss the advantages and disadvantages of technology for handling the mind. There were many presentations from several groups, such as "because I don't think I really understand Kokoro" and "because if I make a mistake, I will be in trouble." In other words, there is a need for techniques to estimate mental states with a very high degree of accuracy.

Figure 13

Word Cloud Results of Reasons for not Wanting to use Mental State Estimation Technology

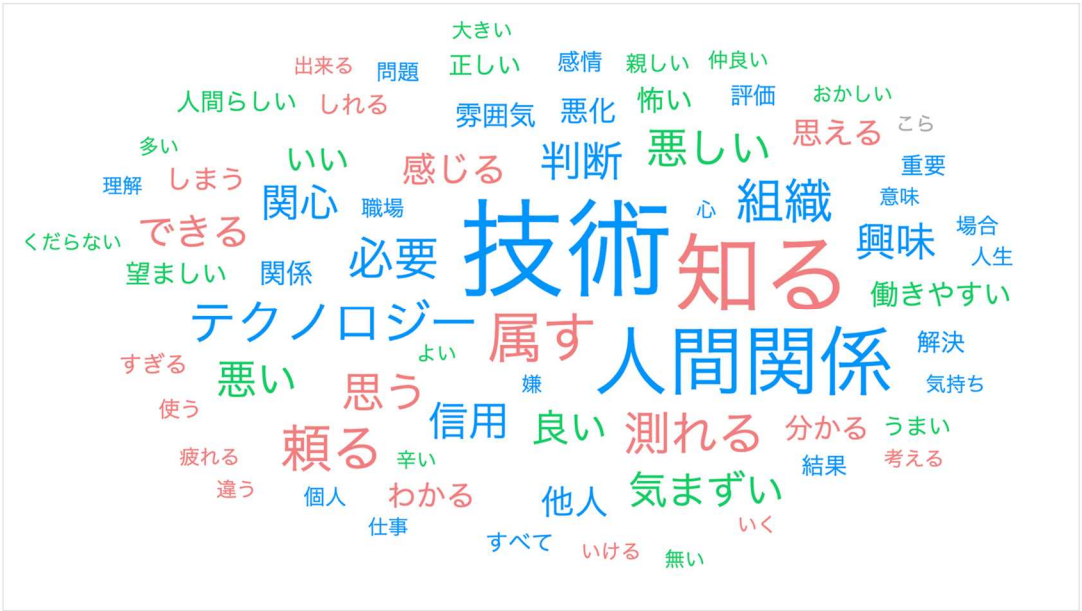
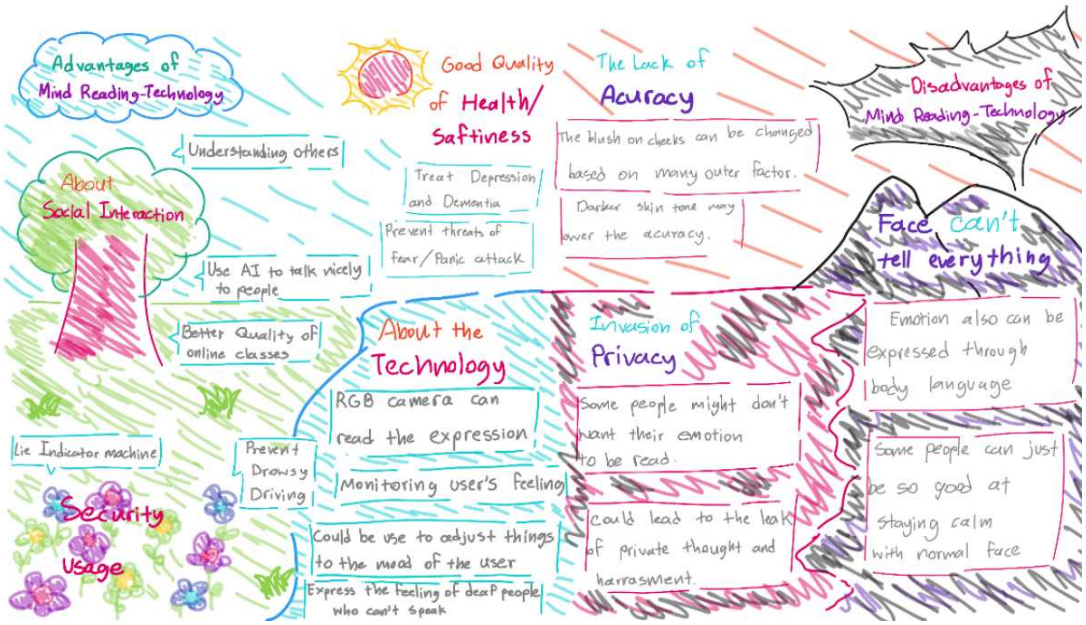


Figure 14

Concept of the Advantages and Disadvantages of Using Mental State Estimation Techniques



(Supplement 4: What Stakeholders Would Like to See)

Identify what technologies are available in the future society that we can imagine today.

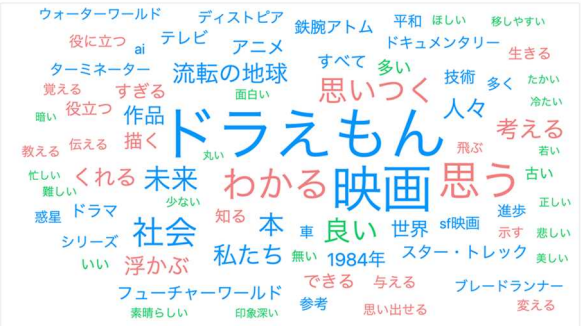
These are the questions that we asked:

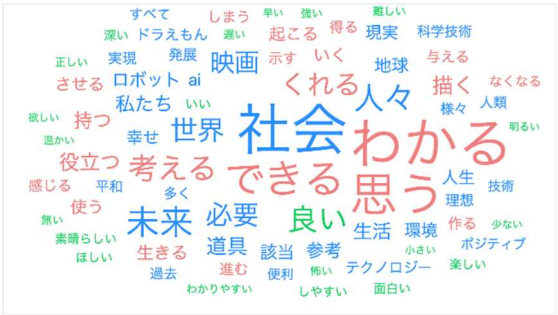
- When you think about the society of the future, please tell us about one film, drama, book, comic, video, or image that is helpful or striking to you.
- When you think about the future society, please tell us how the answers you have given above are helpful or impressive, and why.

The most common answer to this question set was Doraemon. A textual analysis of the free words used in this question revealed that the words "give," "understand," and "think" were scattered around, indicating that respondents chose Doraemon for its human nature, the beauty of nature, and the importance of compassion. We initially assumed that stakeholders chose Doraemon because of the convenience of the secret tools and the high technology (future technology). However, we confirmed that it was the function of being close to the heart, or in other words, Doraemon as a counselor for Nobita-kun. These results indicate a certain understanding of the idea of communicating with something that is not a person, in all generations and all countries surveyed.

Figure 15

Word Cloud Results for Imagining the Future





（Supplement 5: Empathic Techniques Using Mental States ）

We experimented at the Moonshot Music Trial Workshop, organised by the Nishimoto MS Music Emotional Co-Creation Project. We wanted to see if it is possible to evaluate whether music can bring about a sense of emotion and togetherness in audiences' venues, including satellite venues and private homes.

Objective data: (electroencephalogram, electrocardiogram by smart wear, autonomic index by image analysis)
Subjective data: PANAS measurements in Pre and Post
Measured by: 34 people

According to the subjective data, it is possible to identify central and autonomic nervous system fluctuations in response to changes in the sound pressure and frequency of the music. The responses at different parts of the music for each venue and subject were consistent, but some subjects deviated significantly. However, as the concert progressed, responses synchronised; we found synchronisation in most subjects' responses by the final performance.

The results of the subjective analysis show that, as the concert progressed and the audience encountered more and more memorable pieces of music, the effect of the audience's emotions became stronger. In particular, the impressions received from the music created a sense of unity between the audience, including themselves, the performers, and other audience members. This unity had a strong effect on the sense of well-being after the concert. These results show that it is possible to visualise the state of mind and that the medium of music can provide a sense of unity and happiness even in different places. Figures 16 and 17 illustrate these results.

Figure 16

Example of Bio-Signal Measurement by Ue-Raburu Sensing During a Music Workshop

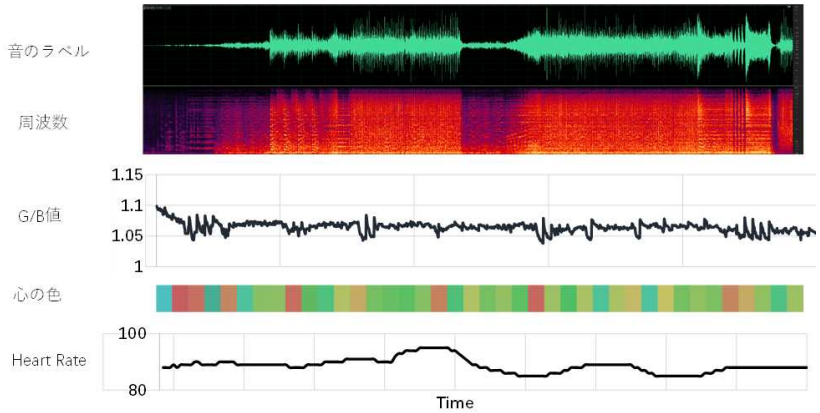
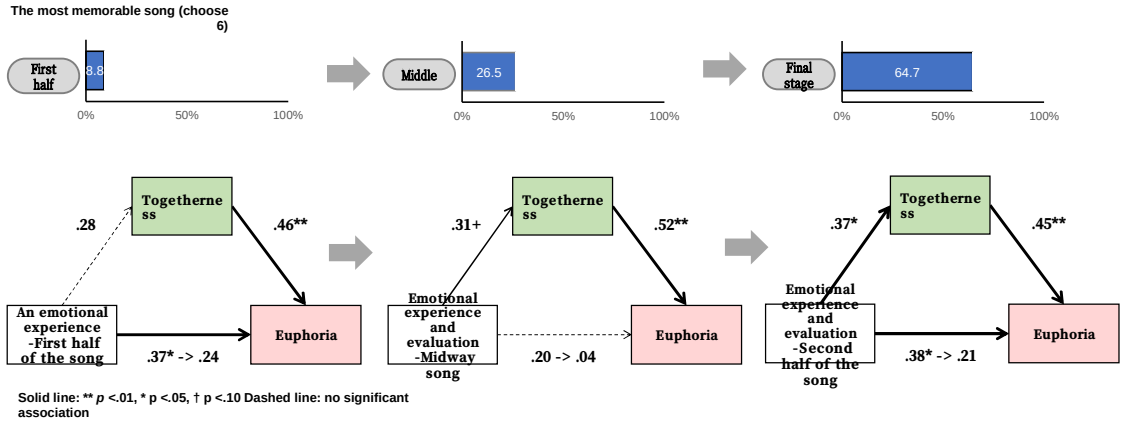


Figure 17

The Relationship Between the Emotional Experience/Evaluation of Music and Well-Being: The Mediating Effect of Togetherness (N = 34)

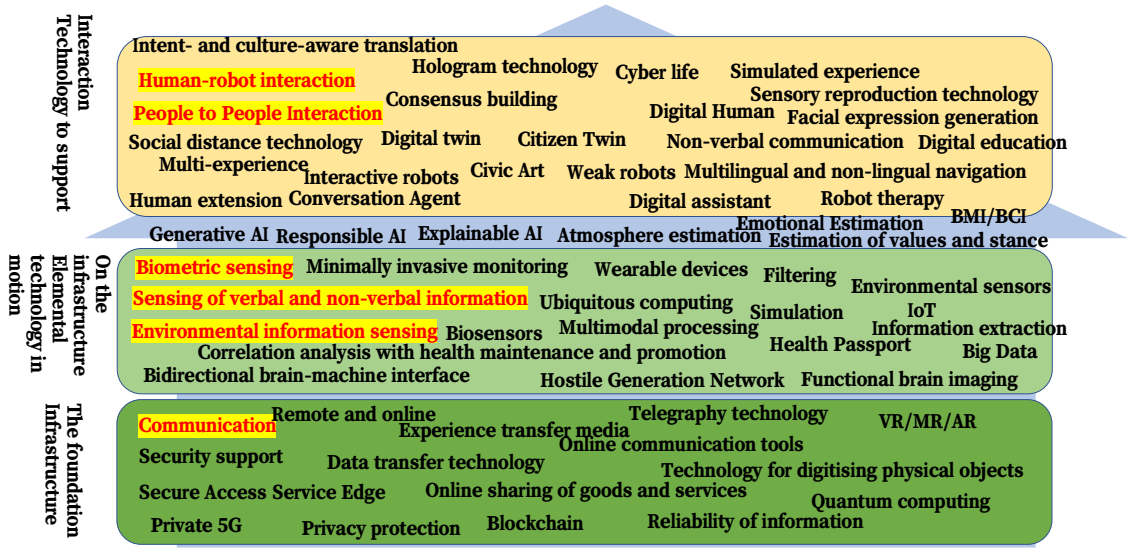


2. Science and Technology Map

The key perspectives for achieving the MS targets are high accuracy in the technologies related to sensing systems and estimation methods. These tools are relevant to estimating mental states. It is essential to diffuse these technologies to households and fields (industry, education, medical welfare, etc.) that use communication infrastructure and CFS. When considering the achievement of these targets by 2050, we can consider a three-stage structure (Figure 18): infrastructure related to communications, elemental technologies that operate on the infrastructure, and technologies that support interaction. We expect that the government will develop the infrastructure for information and communication in the future. The challenge is that society is not currently using the communication infrastructure. Therefore, it is necessary to accelerate the development of the elemental technologies that run on the infrastructure to promote the communication infrastructure and the technologies that support the interaction to implement it in society and achieve the goal.

Figure 18

Overview of the Challenges to be Overcome by Science and Technology and their Structure



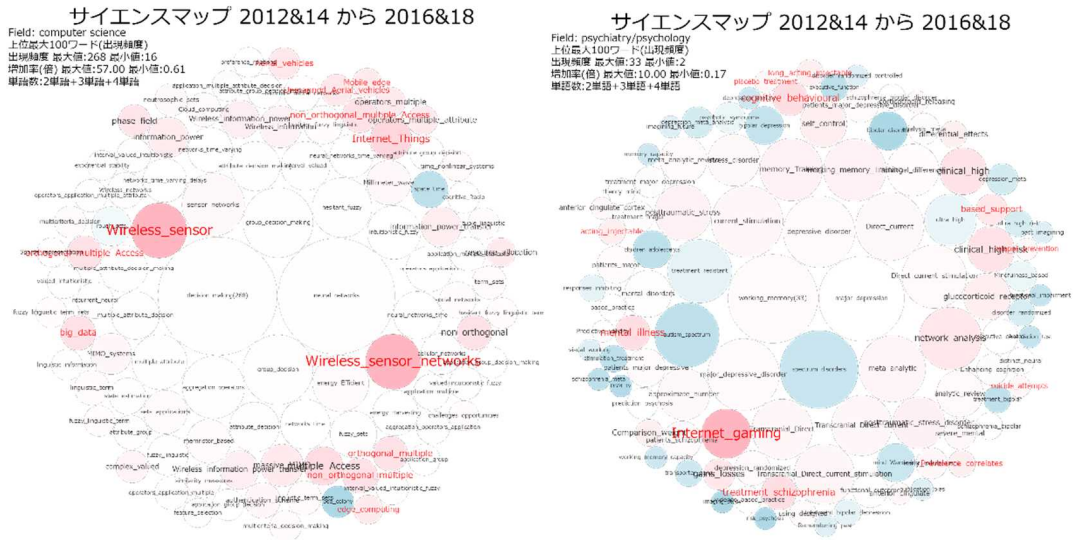
In particular, we need bold technological innovation in the elemental technologies that run on the infrastructure. In terms of hardware, it will be important to make progress in miniaturisation, power-saving, and energy harvesting of sensors that people wear. Further research is also required for visual sensing/processing technology such as image pulse wave, which enables completely non-contact autonomic nerve measurement and behavioural measurement, and for natural language processing using voice and text. Moreover, from the viewpoint of application development and mind visualisation, in addition to signal processing technologies such as optimal characterization, filtering, integration, and dimensionality reduction of sensing information, it is important to develop technologies related to the modeling of biometric information and the mind through machine learning using psychological indicators that accurately express the "mind." Realising these technologies will make it possible to achieve highly accurate emotion and mood estimation and create AI assistants with a heart.

3. Japan's position in overseas trends

According to the science map (Figure 19), there is a growing interest in biometric and environmental collection technologies, such as sensing networks and wearable sensing. There is a growing interest in cyberspace, such as the Internet and gaming, in psychology-related technologies. According to interviews with experts in biomedical engineering, Japanese technology is strong in wearable sensing in device development, new material development, MEMS, and LSI development. We found that Japan is strong in biomedical engineering, Kansei engineering, and interdisciplinary fields related to affective computing. We will explain this from an academic and industrial point of view.

Figure 19

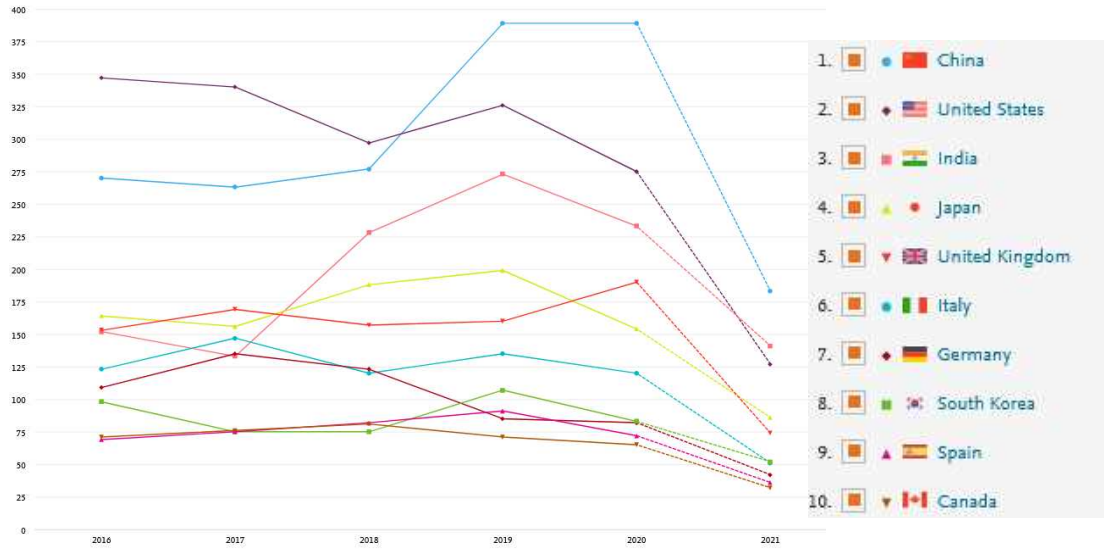
Science Map for Sensing Networks and Wearable Sensing



To confirm Japan's academic strength in wearable sensing, we checked the position of international academic papers with the keywords "sensors; accelerometers; smartphones." As shown in Figure 20, Japan is in fourth place behind China, the United States, and India, the latter three countries with large populations. Thus, Japan has a strong presence in the world.

Figure 20

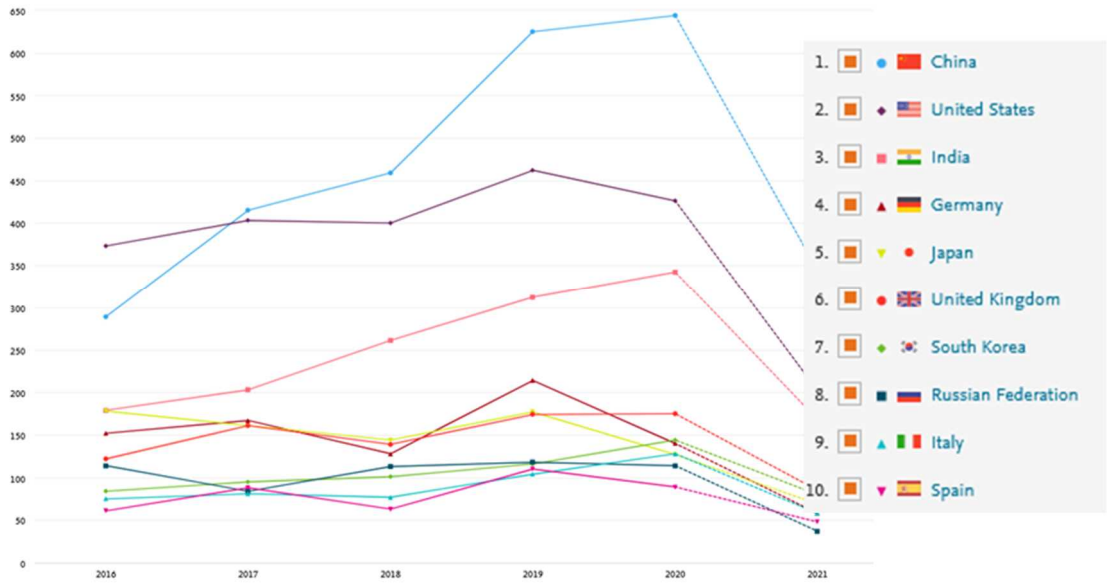
Number of Article Submissions: Keywords "Sensors; Accelerometers; Smartphones"



Next, we checked the position of international academic papers with the keywords "electroencephalography; brain-computer interface; electrophysiology" as biometric analysis technology and human interaction technology. As shown in Figure 21, we rank fifth in the world, behind China with the largest population, the USA, India, and Germany. Japan has a strong presence in the world.

Figure 21

Number of Article Submissions: Keywords Electroencephalography; Brain-Computer Interface; Electrophysiology



Regarding technological trends in artificial intelligence (semantic understanding), Japan has a good balance of patents granted, with particular strength in natural language processing, machine translation, speech processing, image processing, computational modelling, and machine learning. In addition, many papers related to speech recognition and robotics.

Figure 22

Technology Trends in the Field of Artificial Intelligence (Semantic Understanding)

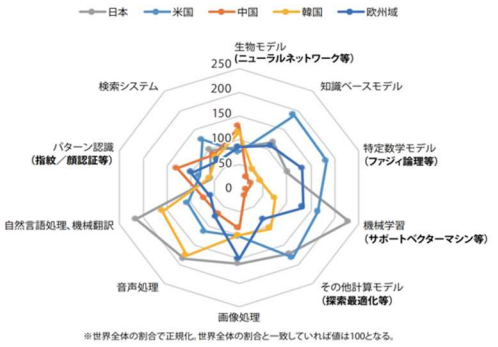


図6 国地域別特許出願の技術傾向
出所：Derwent Innovationでの検索結果を基にNEDO技術戦略研究センター作成（2018）

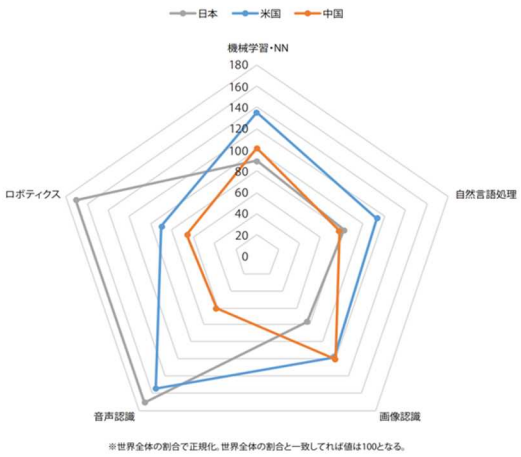


図9 国別AI関連論文の技術傾向
出所：Derwent Innovationでの検索結果を基にNEDO技術戦略研究センター作成（2019）

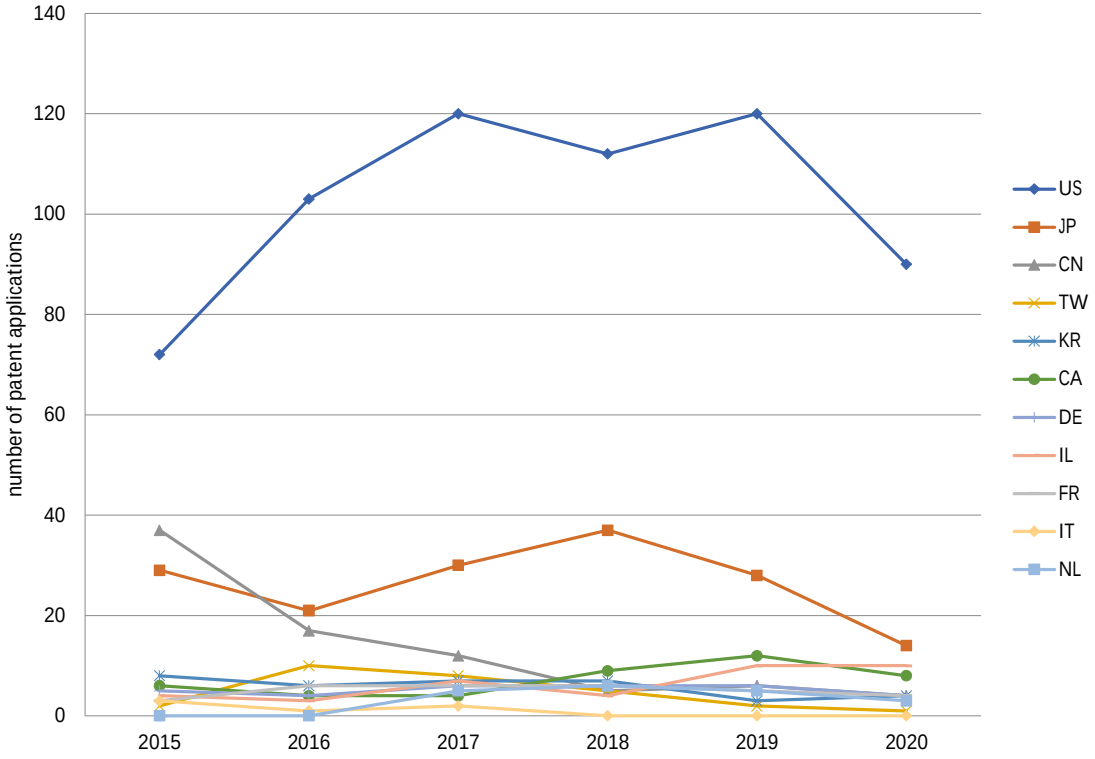
We also explain the strengths of Japan in the industrial world. We compared international patents using the keywords "physiology, brain mind, biomedical, affective."

- Document type: Based on WIPO, US, EP, Japan, China, Korea, UK, Germany, France, Switzerland, and Canada application information.
- Scope of study: IPC = A61B5/00 (measurement for diagnostic purposes), Keywords = (physiology brain mind biomedical affective)
- Statistics by year and country from 2015–2020. Note that for 2020, only August public knowledge is available due to the lack of public information.

In this technical field, we found more than 200 applications per year consistently filed worldwide. In this field, Japan has the second-highest number of applications after the USA. Overall, there is a trend towards more applications from research institutes and universities.

Figure 23

Japan's Patent Presence in International Comparison (Physiology Brain Mind Biomedical Affective)



In addition, we found domestic national applications classified in detail. Tables 3 and 4 describe the data classified by applicant and theme. Applications from automobile-related companies, electrical appliance manufacturers, and health-related equipment manufacturers stand out as applicants. By theme, applications for measurement technology related to psychological responses are also prominent. This finding indicates that the technological development base of automobile-related, electrical appliance, and health-related equipment manufacturers is in place. We can refer to these as the strength of Japanese companies in terms of industrial applications and accumulated experience.

Table 3

By Applicant

出願日	オムロン株式会社	コーニンクレッカフィリップスエヌベ	シチズン時計株式会社	ソニー株式会社	トヨタ紡織株式会社	パナソニックインテレクチュアルプロパティコーポレーションオブアメリカ	パナソニックipマネジメント株式会社	マツダ株式会社	京セラ株式会社	国立大学法人東京工業大学	富士ゼロックス株式会社	富士フイルムビジネスイノベーション株式会社	富士通株式会社	本田技研工業株式会社	株式会社デンソー	株式会社日立製作所	株式会社東芝	沖電気工業株式会社	koninklijkephilips n. v.	panasonicintellectualpropertycorporationofamerica
2015年	2	0	0	1	0	0	0	7	0	2	0	0	0	0	0	0	1	0	0	0
2016年	1	0	0	1	0	5	2	1	0	1	1	1	2	2	1	0	4	0	0	5
2017年	2	3	2	2	0	0	6	0	4	1	2	2	0	2	1	1	2	4	3	0
2018年	2	2	2	1	2	0	3	4	0	0	5	2	0	4	2	2	0	1	2	0
2019年	0	0	0	0	3	0	4	0	0	0	1	1	4	3	4	1	1	1	0	0
2020年	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4

F by Term

	Fターム																			
	4C017AA02	4C038PP01	4C038PP03	4C038PP05	4C038PQ03	4C038PQ04	4C038PQ06	4C038PR01	4C038PR04	4C038PS00	4C038PS03	4C038PS05	4C038PS07	4C038VA04	4C038VB03	4C038VC05	4C127AA03	5E555FA00	5H181AA01	5H181CC04
出願日	脈拍・心拍・血圧・血流の測定（心拍数）	生体の呼吸・聴力・形態・血液特性等の測定（疲労度）	生体の呼吸・聴力・形態・血液特性等の測定（精神，心理，感情）	生体の呼吸・聴力・形態・血液特性等の測定（睡眠度，意識状態）	生体の呼吸・聴力・形態・血液特性等の測定（運転者用）	生体の呼吸・聴力・形態・血液特性等の測定（車両と結合したもの）	生体の呼吸・聴力・形態・血液特性等の測定（携帯用）	生体の呼吸・聴力・形態・血液特性等の測定（視覚刺激）	生体の呼吸・聴力・形態・血液特性等の測定（聴覚刺激）	生体の呼吸・聴力・形態・血液特性等の測定（心理反応検査（心拍，体温））	生体の呼吸・聴力・形態・血液特性等の測定（脳波）	生体の呼吸・聴力・形態・血液特性等の測定（発声状態）	生体の呼吸・聴力・形態・血液特性等の測定（動き（眼球））	生体の呼吸・聴力・形態・血液特性等の測定（人体の特定部位の測定）	生体の呼吸・聴力・形態・血液特性等の測定（腺）	生体の呼吸・聴力・形態・血液特性等の測定（写真撮影，ビデオ録画など）	生体の電気現象及び電気的特性の測定・記録（脳波）	デジタル計算機のユーザインターフェイス	交通制御システム（道路上の車両）	交通制御システム（撮像手段を利用するもの）
2015年	2	4	27	4	8	6	7	7	9	7	5	2	5	4	1	1	5	4	3	3
2016年	8	4	40	7	5	6	3	5	5	5	11	9	6	8	2	4	6	3	5	4
2017年	8	7	53	10	1	8	9	6	5	18	11	10	11	9	7	12	3	6	4	5
2018年	4	4	46	8	5	7	10	10	11	17	10	11	8	5	6	13	8	4	3	4
2019年	1	2	34	4	6	5	5	4	4	12	6	7	2	1	4	6	6	5	7	7
2020年	1	1	3	0	0	0	0	1	0	3	0	0	0	1	0	0	0	1	0	0

III. Plan for Realization

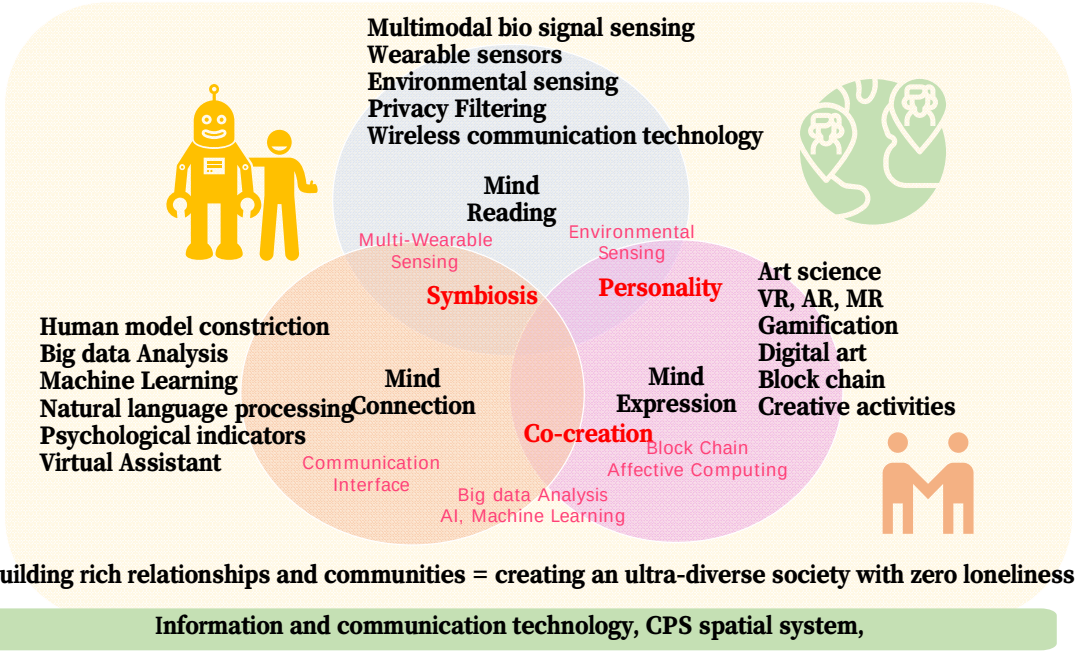
1. Area and Field of Challenging R&D, Research Subject for Realization of Goals

[Area and field to promote challenging R&D]

This proposal will help understand and eliminate the causes of miscommunication between people and between people and services due to national, cultural, age, and gender differences. This increased understanding means transforming society into a new community with diversity and zero loneliness, where people can live in harmony with others and services and achieve self-realisation. From a technological perspective, research into the human mind is currently actively conducted in psychology and psychiatry. However, as mentioned above, we need tools to visualise the state of mind and interfaces to realise a happy and healthy life. By optimally integrating the psychological and psychiatric analysis of the mind with technological tools such as bio-sensing, AI, and communication, effective interactive action becomes possible (Figure 24).

Figure 24

Overview of Fields and Areas for Challenging Research and Development



[Research subject for realization of MS Goal]

In this proposal, we set the following goals: **"communication between people," "communication between people and "things," and "social change."**

[Communication between Human]

By 2050, devices will be able to visualise the mind using biometric, linguistic, behavioural, and environmental data to understand and predict changes in mind and behaviour, and develop proposals and services tailored to the mind.

[Communication between people and things]

By 2050, devices will be able to visualise the mind using biometric, linguistic, behavioural and environmental data, to understand and predict changes in mind and behaviour, and to develop proposals and services tailored to the mind.

[Social Change]

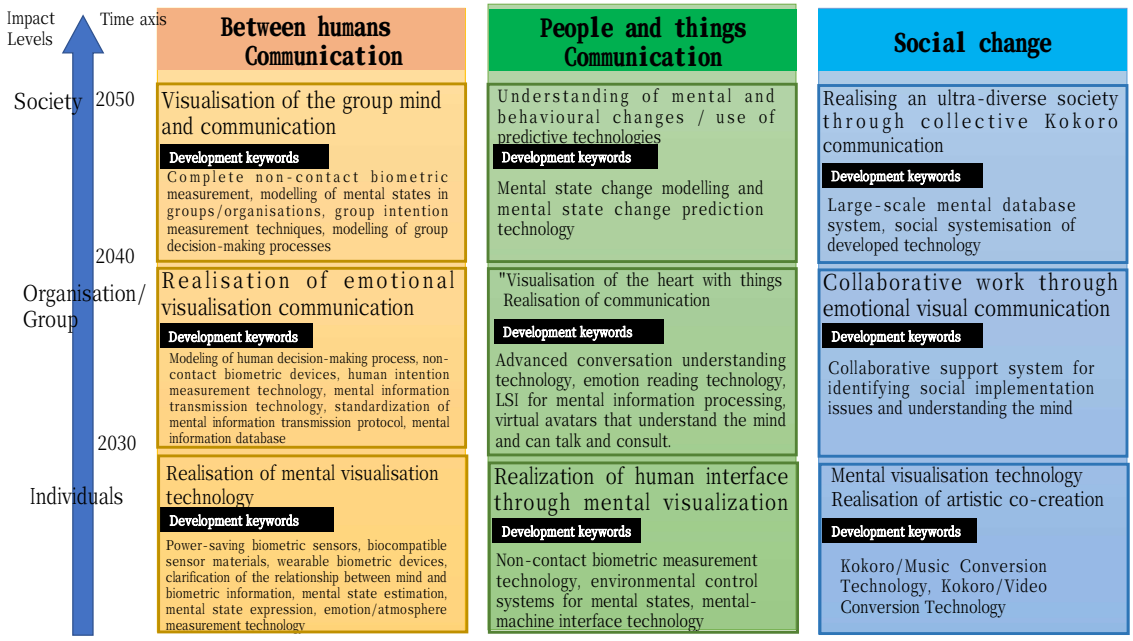
By 2050, heart-centred communication will have spread worldwide, and we will be able to build rich human relationships and communities without words = an ultra-diverse society with no loneliness.

2. Direction of R&D for Realization of Goals

In this proposal, we set goals for "communication between humans," "communication between humans and "things," and "social change." Figure 25 depicts the outline of the research and development process and the keywords. As shown in the figure, we will use mental visualisation as a basic technology, and expand the range of its application as the year progresses, ultimately realising an ultra-diverse society.

Figure 25

Milestone for Future Society



Details of (1) milestones, (2) R&D tasks to achieve the milestones, and (3) ripple effects in 2030, 2040, and 2050 for each target are as follows.

[Communication between humans]

By 2050, we will be able to make important decisions at the group/national level without words by visualising and communicating our collective minds using biometric, linguistic, behavioral, and environmental data sensed daily.

・2030

Milestones

The visualisation of the mind using biometric, verbal, behavioral, and environmental data sensed daily will enable us to understand the mental state of others.

Research and Development Themes

- Development of a power-saving biometric sensor
- Development of biocompatible sensor materials
- Development of wearable biometric devices
- Understanding the relationship between mind and biological information
- Estimation of mental state using biometric data
- Development of a method for expressing mental states
- Development of emotion and mood measurement techniques using text data

The Social Benefits of Achieving the Milestones

The visualisation of the mind makes it possible to know the changes in the mind of others, which the individual cannot feel at present. This visualisation improves the user's ability to build human relationships, and makes communication in cyberspace, such as web conferences, web classes, and SNS, where emotions and moods are difficult to convey, as meaningful as face-to-face communication. It also realises smooth communication that transcends time and space. In addition, unintentional incidents such as "flaming" on SNS can be detected, avoided, or reduced. In addition, the system will facilitate communication with infants who have not yet mastered language, improving the quality of childcare and reducing its burden.

・2040

Milestones

Visual communication of the mind using biometric, linguistic, behavioural, and environmental data sensed daily will enable one-to-one decision-making between individuals without words.

Research and development themes

- Modelling the human decision-making process
- Development of non-contact biometric devices
- Development of human intention measurement technology
- Development of emotional information transmission technology
- Standardisation of protocols for the transmission of emotional information
- Development of a mental information database

The Social Benefits of Achieving the Milestones

The ability to communicate with people with whom you do not have a common language facilitates business opportunities and previously unattainable networking opportunities due to language barriers. In addition, visual communication will eliminate cultural, gender, and age barriers to communication even with a common language.

・2050

Milestones

Visualisation and communication of the collective mind using biometric, linguistic, behavioral, and environmental data sensed daily will enable important decisions at the collective/national level without words.

Research and Development Themes.

- Completely non-contact biometric measurement for psychological measurement
- Modelling the mental state of a group/organisation
- Development of technology for measuring group intentions
- Modelling the decision-making process in groups

The Social Benefits of Achieving the Milestones

The decision-making process based on Kokoro-Measurement fosters trust and creates new communities between governments, local authorities, organisations, and the citizens and members of these organisations. In addition, in group decision-making, it is possible to extract a variety of opinions, including those of minority groups, rather than simply express approval or disapproval or extract the majority's opinions, and find common ground between these opinions and make decisions that reflect diverse feelings. This method will lead to the realisation of an ultra-diverse society.

[Communication between People and Things]

By 2050, devices will understand and predict changes in mind and behaviour by visualising the mind using biometric, linguistic, behavioural, and environmental data, and develop proposals and services tailored to the mind.

・2030

Milestones

By visualising the mind using biometric, verbal, behavioural, and environmental data, the device can understand the mind and complete its actions according to what is felt or thought without explicit manipulation.

Research and Development Themes

- Development of non-contact biometric measurement technology
- Development of environmental control systems tailored to mental states
- Development of mind-machine interface technology

The Social Benefits of Achieving the Milestones

The use of mental visualisation technology in operation and control of devices will create a new human interface. At present, the market for speech recognition technology, such as voice control, is expanding as technology improves. This human interface through speech is intuitive and reduces the distance between people and cyberspace devices. However, an interface that allows the user to control a device simply by thinking or feeling is more intuitive than voice control and could make operation unnecessary.

・2040

Milestones

The device visualises the mind using biometric, linguistic, behavioural and environmental data, enabling conversation and consultation based on understanding the mind.

Research and Development Themes

- Development of advanced conversation understanding technology
- Development of emotion-reading technology
- Development of LSI for emotional information processing
- Development of a virtual avatar that understands the mind and can talk and consult with others

The Social Benefits of Achieving the Milestones

With the evolution of AI, conversations between people and machines are becoming possible. On the other hand, as mentioned in II. Analysis, there is a need for a relationship between people and cyberspace devices and services to communicate. What is important here is not to get a clear answer but to understand the heart and listen to the conversation. By having a virtual avatar, a person you can talk to and who understands your feelings, we can reduce the number of lonely people.

・2050

Milestones

By visualising the mind using biometric, verbal, behavioural, and environmental data, the devices will understand and predict changes in the mind and behaviour and develop proposals and services tailored to the mind.

Research and Development Themes

- Modelling mental state change
- Development of technology to predict changes in mental state

The Social Benefits of Achieving the Milestones.

The practical application of technology that predicts mental changes will enable new services tailored to the user's wishes.

[Social Change]

By 2050, heart-centred communication will have spread throughout the world, and we will be able to build rich human relationships and communities without words in an ultra-diverse society with no loneliness.

・2030

Milestones

With the heart as the main means of communication, it is possible to collaborate with anyone in the art field.

Research and Development Themes

- Development of Kokoro/Music Conversion Technology
- Development of Kokoro/video conversion technology

The Social Benefits of Achieving the Milestones

The evolution of mental visualisation technology and its high precision will expand the range of adaptation of communication through the mind and eliminate the barriers to communication and language. For example, people with severe disabilities will be able to attend classes together in regular classes. In addition, they will be able to play an active role in foreign countries where language barriers are not understood.

・2040

Milestones

With the mind as the main means of communication, it is possible to collaborate with anyone in any field.

Research and Development Themes

- Extracting implementation issues through social implementation experiments of psychological measurement technology
- Development of a collaborative support system for understanding the mind

The Social Benefits of Achieving the Milestones

T The evolution of mental visualisation technology and its high precision will expand the range of adaptation of communication through the mind and eliminate the barriers to communication and language. For example, people with severe disabilities will be able to attend classes together in regular classes. In addition, they will be able to play an active role

in foreign countries where language barriers are not understood.

・2050

Milestones

Communication based on the heart will spread worldwide, building rich relationships and communities without words creating an ultra-diverse society with no loneliness.

Research and Development Themes

- Development of a large-scale mental database system
- Social systematisation of developed technologies

The Social Benefits of Achieving the Milestones

The widespread use of the proposed technology will eliminate language, culture, age, gender, ideology, and time and space barriers and create an ultra-diverse society with zero loneliness.

3. International Cooperation

Working with a team that studies well-being from a social science perspective, such as the Grant Study Team at Harvard University, can address the human mind and examine the sociological implications of effective technology for well-being. In terms of technology, biometric sensing technology, remote sensing technology, and AI technology are essential for this research. Of these, Japan has a high percentage of patents for bio-sensing technology, which is considered a strength of Japan. Therefore, further research into bio-sensing technology will enable Japan to lead the world in this field.

Regarding remote-control technology, Japan is second only to the USA in terms of the percentage of patents granted. We can further divide remote-control technology into five elemental technologies, of which Japan has the largest share of patents in the fields of haptics and robotics. In contrast, the US has the largest share of patents in telecommunications, AI, and XR. The target user base for this research technology is people from all over the world. Therefore, it is essential to cooperate and collaborate with other countries to achieve true ultra-diversity. While holding haptics and robotics as the core of our strength, we can collaborate with countries like the United States and China, which have patents and technologies, to advance our research.

Finally, there is AI technology, which we can divide into elemental technologies: natural language processing, machine translation, speech processing, image processing, computational modelling, and machine learning. Japan has a well-balanced portfolio of patents in these areas and is a world leader, particularly in robotics and speech recognition. AI technology is essential for processing information obtained from humans. Because of the wide variety of information modalities, having a good balance of patents and technologies is advantageous for this research. In addition, Japan has an advantage in terms of the number of patents in the health and care sector, but South Korea leads the world by a similar amount. In terms of well-being rankings, Japan and Korea are in a similar situation. Therefore, we believe that it is possible to cooperate and collaborate in this research.

4. Interdisciplinary Cooperation

In working together across sectors and disciplines to achieve the goals, we believe it is important to understand, cooperate and collaborate on the following

[Public Understanding and Cooperation]

Public understanding and cooperation include disclosure and provision of information, dissemination of understanding, and participation in research and studies (public relations, education, especially for children and their parents, etc.) to help as many tax-paying citizens as possible to achieve the MS objectives and imagine a better society, and create and realise it together.

・New Development and Strengthening of Cooperation Between Industry, Academia and Government

- We will combine our wisdom and create further innovations.
- We will establish partnerships as a forum for implementation and feedback on research findings and developed technologies and carry out economic gain-loss calculations.
- We will build relationships with other organisations selected for MS research studies and to create opportunities for co-creation.

・Promotion of International Cooperation

- We will provide information and recommendations to countries and regions where well-being is declining (developing countries) and where community functions are breaking down or becoming weak (expert panel).
- We will collaborate with China, which has a high level of curiosity and willingness to exploit Japan's sophisticated technological capabilities.
- We will research implementation cooperation and organisation.
- We will work with companies that employ a large number of foreign workers/interns.

5. ELSI (Ethical, Legal, Social Issues)

In this area, the questionnaire asked, "If a technology was created that could tell you the state of 'good or bad relationships and atmosphere in your organisation,' would you be interested in using it?" We analysed the responses of those who disagreed (not at all or not very much) with this question. We summarize the reasons for disagreement in the following points

First, respondents indicated that they want to value the original human activity (feeling, thinking, judging, and communicating by oneself). There are some aspects that we do not need to know.

- *"I want to think for myself."*
- *"Even if you don't have the skills, you can understand what's going on."*
- *"I think it's better to be who you are" and, "I think it's better to be natural."*
- *"Some things are better left unknown," "I don't want to know what's in people's hearts."*
- *"No need. We're all in one group and it's normal to have some friction."*

The above is a reminder of the ethics of mind-body manipulation. In contrast, the debate about the disparities created by mind-body manipulation and what self-determination means as various data influence human behaviour are examples of issues that need to be considered in the future.

As well as resistance to the technology, many people did not see the need for it and were sceptical about its development.

- *"Too much control by technology," "AI is not compassionate."*
- *"I'm not interested," "I don't want such technology," "I don't need it."*
- *"It's just not possible," "There are too many variables to make the right decision using AI."*
- *"I'm not sure what the technology is" "How can the technology determine this?"*

We noted concerns about using the technology, its possible (negative) impact of use, fears about knowing and using it, and privacy issues if such technology developed.

- *“I can’t handle all that technology.”*
- *"This technique does not solve the problem; it just points it out. This technique does not solve problems; it merely points them out."*
- *"I'm afraid that such technology will be developed," "I'm afraid to know what they really think."*
- *"It's too much of an invasion of privacy."*

The above are notes on the handling of personal data and the ethics of data management and use. In response to this, we should consider the following issues: social consensus on balance between the common good and self-determination and choice; social agreement on the preconditions for legal regulation, such as fairness, transparency, and trust; and public understanding of the directed use of large amounts of data.

We also envisaged concerns about changes in relationships. We can address these concerns by creating a shared narrative through discussion of diverse values. People tend to have a lot of fear and psychological resistance to new challenges and innovations because they cannot predict or imagine them. Therefore, while we need to overcome some issues, there are still expectations for technology to understand the state of mind of ourselves and others.

As shown in Figure 26, the expectation and potential for building good relationships through using technology are highest in China (83.1% of the total number of respondents agreeing or strongly agreeing), followed by the USA, the UK, and Japan. The younger the generation, the more likely they are to see the potential. The trend by country and age is consistent with the trend in the question, "Would you like to use mind reading technology if it were developed?” The trend by country and age is consistent with the trend in the question, "Would you like to use mind reading technology if it were developed?”

Figure 26

Building Good Relationships through the use of Technology International Comparison

n=2,000

Q2_6 あなたは、自分や相手の心の状態を知ることができる**技術を活用すると、お互いのより良好な人間関係が築ける**と思いますか？

(%)

		n=	全くそう思わない	あまりそう思わない	だいたいそう思う	非常にそう思う	回答しない
全体		2,000	11.6	27.0	39.9	12.5	9.1
国別	日本	1,000	13.5	35.1	34.8	6.7	9.9
	アメリカ	300	12.0	20.0	39.0	13.7	15.3
	中国	400	2.5	12.8	53.8	29.3	1.8
	イギリス	300	17.0	26.0	39.0	8.0	10.0
性別	男性	999	12.8	24.4	39.4	13.9	9.4
	女性	1,000	10.4	29.6	40.2	11.0	8.8
	その他	1			100.0		
年代別	20代以下	400	8.0	21.5	43.5	15.5	11.5
	30代	400	10.3	23.8	43.8	12.3	10.0
	40代	400	11.0	27.3	40.0	13.3	8.5
	50代	400	12.0	32.8	33.8	12.0	9.5
	60代以上	400	16.8	29.8	38.3	9.3	6.0
性年代別	男性 20代以下	200	11.0	18.5	44.0	16.5	10.0
	男性 30代	200	11.0	20.5	41.5	15.0	12.0
	男性 40代	199	13.1	25.6	35.7	14.6	11.1
	男性 50代	200	11.0	28.5	38.5	13.5	8.5
	男性 60代以上	200	18.0	29.0	37.5	10.0	5.5
	女性 20代以下	200	5.0	24.5	43.0	14.5	13.0
	女性 30代	200	9.5	27.0	46.0	9.5	8.0
	女性 40代	200	9.0	29.0	44.0	12.0	6.0
	女性 50代	200	13.0	37.0	29.0	10.5	10.5
	女性 60代以上	200	15.5	30.5	39.0	8.5	6.5

※n=10未満は参考値のため灰色。

IV. Conclusion

In this team, we examined the set goals from various perspectives. Specifically, we reconstructed the set goals, their feasibility, social acceptability and extracted issues for resolution. To achieve this, we used interviews with experts, workshops with high school students from Japan and abroad who will be the core generation of the future development research and beneficiaries of the proposed goals, verification experiments, and literature research. As a result, it became clear that the proposed moonshot goal has great significance and demand from society and that its implementation should be a national project.

Based on the above discussion, the team set the moonshot goal as follows: "By 2050, we will achieve an ultra-diverse society with zero loneliness through the acquisition of the means of communication" as a candidate moonshot goal.

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Other Supplements

・Conducting surveys

Sample overview

Surveyed by: Cross Marketing Inc.

Implementation date: June 2021

Total sample N=2,000

-Country: Japan n=1,000 USA n=300 China n=400 UK n=300

-200 samples were allocated and collected for each of the 10 categories of gender x age (1) to 20s and below, 2) 30s, 3) 40s, 4) 50s, and 5) 60s and above).

・Symposium 1)

Joint symposium of "Flex Infrastructure Thinkers", "Ultra Diversity Society Realization Team" and "Intelligent Living Cell - Realization of Ultimate Personalized Medicine".
Living in 2050: Life, place, communication and wellbeing
Date: 21 June 2021 On line

・Symposium 2)

The 60th Annual Meeting of the Japanese Society for Biomedical Engineering
Title: Technology to support human well being through interdisciplinary research
Date: 17 June 2021 On line

・Workshop 1)

Title: Acquaintance - Face - Mind Human Relation in Physical & Cyber Space
Date: 2021.05.18～2021.06.08
Participates: 76 senior high school students (40 from Ritsumeikan Junior and Senior High School, Japan36 from Mahidol Wittayanusorn School, Thailand) Location: Japan (On-site) and Thailand (Online)

・Workshop 2)

Moonshot Music Trial Workshop", organized by Nishimoto MS Music Inspiration Co-Creation Project
Data: 23 June 2021