Harnessing Big Data for Societal Well-being: A Case Study of Smartphone App Logs and Interactive Data in Understanding Behavior and Designing Interventions

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Abstract

This report is a summary compiled based on an analysis of current research cases on smartphone log data and interactive data, generated through interaction. Rapid advances in information technology and the explosive spread of smartphones are bringing about major changes in all aspects of people's daily lives. The massive amount of app usage log data accumulated there is a treasure trove of information that reflects users' behavior and psychological state in detail. This study explores the possibilities for evolving the understanding of human behavior and support strategies from multiple angles through the analysis of smartphone app log data and interactive data obtained through chat systems and other means. The areas of application for log data are wide-ranging, including notification optimization, mental health care, and elderly support. With the use of AI technologies such as machine learning, new horizons are opening up for service design tailored to users' situations and characteristics. In addition, attempts are being made to delve into the nuances of people's true feelings, which have been difficult to grasp until now, by carefully unraveling the words woven into natural conversations. Contributions in practical fields such as counseling and medical dialogue are also highly anticipated. On the other hand, there are many ethical and social issues surrounding log data and anonymized interactive data that are analyzed and utilized, including privacy risks. Methodological points such as the difficulty of causal inference and the reproducibility of analysis cannot be overlooked either. In addition, an attitude of critically examining AI analysis with a humanistic sensibility will become even more important. Redefining the research process itself as an interactive endeavor and collaboratively deriving the meaning of data while involving the parties concerned - establishing such a bidirectional knowledge exploration style is also an urgent issue. This paper provides an overview of the frontiers of smartphone app log analysis and interactive data mining, and highlights their possibilities and challenges. While referring to examples from diverse application areas such as medicine, education, and marketing, it provides a summary of the prospects for building an interdisciplinary research foundation. Through a review of a wide range of examples including notification optimization, disease management, information selection, behavior change, learning support, mental health, elderly support, and lifestyle improvement, it shows that the understanding of individual and group characteristics can be greatly advanced from log data. With the use of machine learning, the possibility of more personalized service design, such as situation-based intervention optimization, is also opening up. On the other hand, methodological challenges such as the difficulty of causal inference, privacy protection, and data validity verification have also been brought to light. To draw out the true power of log data, interdisciplinary discussions including ELSI and industry-academia-government-private sector collaboration with a view to on-site implementation are essential. The significance of this research and further research directions are discussed.

1 Introduction

The remarkable development of information technology and the explosive spread of smartphones are revolutionizing all aspects of our daily lives. As of 2021, the number of mobile phone users worldwide exceeds 5.5 billion, and the majority of them are estimated to be smartphone users. Smartphones have gone beyond

the scope of mere communication devices and are inextricably linked to all aspects of our lives. The operation logs of apps recorded there are a treasure trove of massive data that reflect users' behaviors, preferences, and even psychological states in detail. Location information, search queries, social media posts, purchase histories, etc. - traces of behaviors via smartphones contain cross-sections of all aspects of people's activities. By carefully unraveling them, there is a possibility for a leap in the understanding of individual and group characteristics that could not be grasped before. In recent years, with the rapid progress of data science and AI technology, efforts to extract valuable insights from such large-scale log data and apply them to practice have become active worldwide. In particular, "personalization" that provides information and services optimized for each user is becoming a reality through log analysis. Automatically detecting users' situations and contexts and proposing support measures on demand - the realization of such a seamless user experience is coming into view in various fields such as medicine and education. In addition, significant attention is also being focused on the analysis of natural conversational data obtained through chat systems and other means. With the development of text mining, it is becoming possible to read people's true feelings and nuances from unstructured linguistic data. Contributions in practical fields such as counseling and medical consultation, which have relied on tacit knowledge until now, are also expected to be brought about by data-based new insights. These advanced initiatives have the potential to greatly contribute to people's well-being and the sustainable development of society. At the same time, ethical and social dilemmas surrounding them are also an important issue that cannot be avoided. Privacy protection, avoidance of algorithmic bias, ensuring explainability, etc. - a responsible approach to research and practice based on data is being strictly questioned. Furthermore, the establishment of an interdisciplinary research paradigm that goes beyond conventional natural science approaches is also an urgent issue. To fully capture the nuances of human language and behavior, engineering perspectives alone are not enough. An attitude of honing humanistic sensibilities and critically examining the

results of machines is indispensable. In addition, it is also essential to design a bidirectional dialogue process in which researchers and parties concerned collaboratively derive the meaning of data. Based on this problem awareness, this paper aims to provide an overview of research trends in behavior understanding and intervention design through the analysis of smartphone app log data and interactive data. Reviewing the latest examples from a wide range of application areas such as medicine, mental health, education, and marketing, it discusses the emerging academic and social impacts and challenges. While intersecting the wisdom of the humanities and information science, we would like to explore ways to pioneer an AI society where human-centered design is appropriately constructed.

2   Direction of This Paper

This paper provides an overview of current research cases on smartphone log data and interactive data generated from smartphone applications, and is a summary report based on the analysis results. The rapid development of information technology and the explosive spread of smartphones are bringing about major changes in all aspects of people's daily lives. The massive amount of app usage log data accumulated there is a treasure trove of information that reflects users' behavior and psychological state in detail. This study explores the possibilities for evolving the understanding of human behavior and support strategies from multiple angles through the analysis of smartphone app log data and interactive data obtained through chat systems and other means. Notification optimization, mental health care, support for the elderly, etc. - the areas of application for log data are wide-ranging. With the use of AI technologies such as machine learning, new horizons are opening up for service design tailored to users' situations and characteristics. In addition, attempts are being made to delve into the nuances of people's true feelings, which have been difficult to grasp until now, by carefully unraveling the words woven into natural conversations. Contributions in practical fields such as counseling and medical dialogue are also highly anticipated. On the other hand, there are many ethical and social issues surrounding log data and interactive data that are ana-

lyzed and utilized, including privacy risks. Methodological points such as the difficulty of causal inference and the reproducibility of analysis cannot be overlooked either. In addition, an attitude of critically examining AI analysis with a humanistic sensibility will become even more important.

Furthermore, redefining the research process itself as an interactive endeavor and collaboratively deriving the meaning of data while involving the parties concerned - establishing such a bidirectional knowledge exploration style is also an urgent issue. This paper provides an overview of the frontiers of smartphone app log analysis and interactive data mining, and highlights their possibilities and challenges. While referring to examples from diverse application areas such as medicine, education, and marketing, it provides a summary of the prospects for building an interdisciplinary research foundation. Through a review of a wide range of examples including notification optimization, disease management, information selection, behavior change, learning support, mental health, elderly support, and lifestyle improvement, it shows that the understanding of individual and group characteristics can be greatly advanced from log data. With the use of machine learning, the possibility of more personalized service design, such as situation-based intervention optimization, is also opening up. On the other hand, methodological challenges such as the difficulty of causal inference, privacy protection, and data validity verification have also been brought to light. To draw out the true power of log data, interdisciplinary discussions including ELSI and industry-academia-government-private sector collaboration with a view to on-site implementation are essential. The significance of this research and further research directions are discussed. This paper aims to explore the current state of behavior understanding and intervention effect research using smartphone app log data. It will provide a broad overview of log utilization cases in various fields such as medicine, education, and social problem solving, and highlight the insights and challenges that emerge from them. First, starting with Mehrotra et al.'s research on notification optimization, it will introduce attempts at app log analysis in various contexts such as asthma management, news browsing, smoking cessation, language learning, mental health, elderly support, and dietary habit improvement. The potential for optimizing interventions according to users' situations and characteristics, and for designing personalized services, suggests the expanding possibilities of application. On the other hand, many methodological issues also surface, such as the difficulty of causal inference, privacy protection, and problems with data representativeness. Next, it will cover analysis cases of people's behavior changes based on log data under the global COVID-19 pandemic. Reports are emerging one after another of findings that show changes in media usage during stay-at-home restrictions [70], the relationship between stress and smartphone dependence [71], and the psychological impact of the pandemic [72], suggesting that log data can also contribute to understanding social dynamics. Here too, the importance of balancing log utilization and data ethics will be further highlighted. Furthermore, it will also provide an overview of research findings on the problematic aspects of smartphone use. It will touch on the current state of empirical research that continues to point out the impact of excessive smartphone dependence on physical and mental health [62, 63], and its relationship to gaming disorders [66]. In addition, it will also refer to research results that suggest log data can be useful for grasping mental health issues, such as surveys on the actual state of Internet and gaming dependence under the COVID-19 pandemic [69], and the relationship between social anxiety and SNS dependence [83]. Through such a multifaceted review, the current state of research on behavior understanding and support strategy design starting from smartphone app log analysis, and its application possibilities and challenges, will become clear. In the following chapters, while carefully examining each research case, we will consider the implications derived from log data.

Information technology's remarkable development and the explosive spread of smartphones are greatly transforming our daily lives. Smartphones have already gone beyond the realm of mere communication tools and are deeply permeating all aspects of life. The app usage logs accumulated there can be said to be a treasure trove of massive data that reflects users'

behavior and psychological state in detail. The purpose of this research is to organize the latest trends in behavior understanding and intervention effect research based on these smartphone app log data, and to clarify their application possibilities and issues to be overcome. By comprehensively reviewing cases from diverse fields such as medicine, education, and social issues, we will consider the implications derived from log analysis from multiple angles. Furthermore, while also paying attention to ethical, legal, and social issues, we would like to explore the direction for the development of data-driven research and practice. Log data analysis enables continuous and non-invasive recording of the nuances of people's behavior that could not be fully captured by conventional questionnaire surveys and experiments. From optimized service provision according to users' situations to evidence-based behavior change support, the application possibilities of the insights obtained are extensive. In various fields such as medicine and education, ways are being opened up to contribute to the improvement of individual and social well-being through the development of personalized interventions. The log data also has great significance as collective knowledge. As became clear under the global outbreak of COVID-19, it is precisely when facing social difficulties that a bird's-eye view understanding of people's behavior change is required. Log data has the potential to contribute to real-time grasping of social dynamics, such as the detection of signs of mental health deterioration and the establishment of infection prevention behaviors. Of course, the utilization of log data involves many challenges. In addition to the difficulty of identifying causal relationships, privacy protection, algorithmic bias, and explainability, there are myriad methodological and ethical issues. It is essential to qualitatively understand the context of behavior that cannot be seen from log fragments. There is also a need for a mechanism to reduce the gap between experts and practitioners and to support evidence-based practice. It is also necessary to be self-aware about the research process itself as an interactive endeavor, and to find the meaning of data in collaboration with the parties concerned. While protecting privacy, deriving insights from data - establishing such a bidirectional circuit of knowledge across research communities is also an urgent issue. This paper provides an overview of the frontiers of smartphone app log analysis and interactive data mining, and highlights their possibilities and challenges. While referring to cases from diverse application areas such as medicine, education, and marketing, it aims to organize prospects for building an interdisciplinary research foundation. Through a review of a wide range of cases including notification optimization, chronic disease management, information selection, behavior change, learning support, mental health, elderly support, and lifestyle improvement, it shows that the understanding of individual and group characteristics can greatly advance from log data. With the use of machine learning, the possibility of more personalized service design, such as optimizing interventions according to the situation, is also opening up. On the other hand, methodological challenges such as the difficulty of causal inference, privacy protection, and data validity verification have also been brought to light. To draw out the true power of log data, interdisciplinary discussions including ELSI, and industry-academia-government-private sector collaboration with a view to on-site implementation are essential. The significance of this research and further research directions are discussed.

3 Latest Examples of Behavior Understanding and Intervention Effect Research Using Smartphone App Log Data

Here is the full English translation of the Japanese text:

3.1 Reflection on Sun et al.'s Study (2020)

This study explored the relationship between smartphone use and parenting stress among parents with young children. The interesting finding that parents who searched for more parenting information and used parenting apps for longer had higher stress indicators suggests the potential for smartphone data to help understand parenting challenges and support needs. However, caution is needed regarding the direction of causality. Does higher stress drive increased smartphone use, or does smartphone dependence increase

stress? The influence of confounding factors must also be considered. Combining smartphone data with other indicators like questionnaires is necessary to gain a deeper understanding of the structure of parenting stress. Based on that, it is hoped that data-driven effective support measures can be designed.

3.2 Reflection on Kangasraasio et al.'s Study (2019)

This study proposed an approach to infer users' consumer segments by leveraging smartphone app usage logs and battery consumption data. The novelty lies in deriving marketing insights from data beyond purchase behavior. Understanding user profiles based on data is likely to contribute to improving the accuracy of targeting. On the other hand, validating the validity of the segmentation is a critical issue. To what extent do the inferred segments correlate with actual purchasing behavior? Cross-referencing with other data is essential. Also, balancing privacy concerns is necessary. Profiling users involves ethical issues. Ensuring transparency and establishing appropriate rules for data utilization are imperative.

3.3 Reflection on Menon et al.'s Study (2018)

This study is interesting in suggesting the potential to predict users' personality traits (Big Five) from smartphone app usage logs and battery consumption data. For extraversion and neuroticism, relatively high accuracy predictions were achieved (F1 scores of 75% and 78%), demonstrating the effectiveness of the machine learning approach. Techniques for inferring personality from behavioral data are expected to be applied to personalized services and marketing. However, the verification is limited to a sample of college students, so testing the generalizability to other age groups and occupations is required. Also, caution is needed in causally interpreting the predictive models. Clarifying the underlying psychological mechanisms behind the correlations is an important research issue.

3.4 Reflection on Wang et al.'s Study (2020)

This is a unique study predicting college students' academic performance (GPA) from smartphone app usage logs and GPS data. It is commendable that they found correlations between behavioral indicators such as home study time and library stay time with GPA,

and achieved performance prediction with an error of within 0.5 grade points using machine learning models. Such techniques have the potential to be used for understanding students' learning situations and early detection of academic underperformance. The challenge is to incorporate factors other than learning behaviors into the models. Intelligence and learning motivation are also thought to have a large impact on grades. By taking these variables into account, it is expected that more robust predictive models can be built. Also, improving the interpretability of prediction results and devising ways to present them in an actionable form for students and faculty is necessary.

3.5 Reflection on Mehrotra et al.'s Study (2017)

This study aims to predict the interruptibility of users using smartphone notification logs and interaction logs. It is interesting that they identified timings when users can quickly respond to notifications (e.g. during breaks) and built models to predict response speed based on the type of notification and situation at arrival. Such techniques can lead to delivering notifications at optimal timings tailored to users' situations, which is expected to improve convenience. On the other hand, more detailed modeling of users' situations and individual differences is mentioned as a challenge. For example, by considering not only location and activity but also emotional states, prediction accuracy might be further improved. Also, validating the effectiveness when integrated into actual notification delivery systems is necessary. It is essential to strive for improving the user experience while paying attention to privacy concerns.

3.6 Reflection on Yu et al.'s Study (2019)

This study aims to estimate users' stress states from smartphone app usage logs and various sensor data. It is commendable that they captured behavioral changes such as increased app usage frequency and screen interaction speed during stress, and built models that distinguish stress states with 80% accuracy. If stress can be detected in the context of daily life, it has the potential to be used for preventing health problems caused by excessive stress. The reliability of self-reported stress states is raised as a challenge. Along with sub-

jective evaluations, it is desirable to include physiological indicators such as cortisol for multifaceted measurement. In the future, it is an important research direction to not only detect but also provide advice for stress relief. In doing so, collaboration with experts in psychology and medicine will be indispensable.

3.7 Reflection on Zhao et al.'s Study (2018)

This is an interesting study inferring users' circadian rhythms (morning-type or evening-type) from smartphone charging logs and app usage logs. The proposed method demonstrated over 80% agreement with users' self-reports and succeeded in detecting irregular lifestyle rhythms. Sleep and wake rhythms are known to have a significant impact on physical and mental health. If disruptions can be grasped in the context of daily life, it might help raise users' awareness and improve their lifestyles. Future challenges include modeling long-term changes in lifestyle rhythms. If irregular patterns as well as gradual rhythm shifts can be handled, it will lead to more practical systems. Additionally, by considering other important indicators such as sleep quality, there is potential for it to expand as a health status monitoring tool.

3.8 Reflection on Kang et al.'s Study (2020)

This can be said to be a timely study comparing smartphone app usage logs and GPS data before and after the COVID-19 outbreak. It is important that they quantitatively captured the decrease in outing frequency and travel distance after stay-at-home requests, and the increase in social media and entertainment app usage during time at home. The analysis of the relationship between differences in behavioral changes among users and the infection situation in the region provides insights that contribute to elucidating the mechanism of infection spread. Such research has the potential to deepen understanding of people's behavior under the pandemic and be used for formulating and evaluating appropriate public health measures. On the other hand, the utmost care must be taken to protect privacy. Handling data that could lead to identifying infected individuals must be done cautiously. Also, a careful analysis is required of side effects of behavioral changes, such as the impact of prolonged self-restraint on mental health.

3.9 Reflection on Ware et al.'s Study (2019)

This is an interesting study that examined the relationship between college students' smartphone Bluetooth encounter logs and depressive symptoms. The result that less face-to-face interaction is associated with stronger depressive tendencies suggests the importance of the impact of social connectedness on mental health. It is also significant that they showed the possibility of using machine learning to classify the severity of depressive symptoms from log data. However, the challenge remains of evaluating the "quality" of face-to-face interactions. By considering not only the frequency of contacts but also the depth and satisfaction of interactions, more convincing findings might be obtained. Also, examining the applicability to mental illnesses other than depression is required.

3.10 Reflection on Wang et al.'s Study (2018)

This study presented an innovative approach to infer occupation from users' smartphone app usage logs and GPS data. It is noteworthy that they succeeded in classifying 6 occupational categories with about 70% accuracy. Assuming personal privacy is protected, utilization of such techniques for marketing and human resource management is anticipated. On the other hand, the coarseness of the classification is mentioned as an issue. Even within the same "white-collar" category, there should be a variety of job types included. To achieve finer-grained category classification, feature selection and model improvement are required. Additionally, examining the predictability of personal attributes other than occupation (age, gender, income, etc.) is also an interesting research topic.

3.11 Reflection on Yin et al.'s Study (2019)

This is an important study that quantitatively evaluated the impact of smartphone notifications on work efficiency. The finding that notifications during focused tasks are more likely to be postponed is intuitive yet valuable in that it is backed up by data. The analysis of the relationship between notification handling behavior patterns and work efficiency provides rich implications for improving the user experience. On the other hand, rather than relying solely on subjective evaluations of work efficiency, seeing the relationship with objective indicators (task completion

time, etc.) would increase persuasiveness. Also, examining what approaches are effective for optimizing users' notification settings is required. Intervention experiments such as suppressing notifications during high-concentration work might also be considered.

3.12 Reflection on Mohr et al.'s Study (2017)

This is a unique study combining smartphone app usage logs and accelerometer data to infer users' meal timings and snacking frequency. It is noteworthy that they achieved a certain level of accuracy with a small sample. If eating habits can be monitored in the context of daily life, it might be useful for obesity prevention. The lack of sample size is a challenge. With only 8 subjects, there is a risk that individual differences greatly influence the results. In the future, it is necessary to verify the method's robustness by repeating validation with a larger sample. Additionally, if meal contents can be inferred by combining with camera images, for example, more detailed eating habit tracking would be possible.

3.13 Reflection on Götz et al.'s Study (2019)

This study is noteworthy for demonstrating the possibility of inferring device dependence from objective indicators such as smartphone charging logs and lock/unlock events. In particular, empirically showing the correlation with subjective dependence is of great significance. As smartphone dependence becomes a social problem, establishing objective monitoring methods utilizing log data is anticipated. The challenge is that the dependence criteria rely on self-reports. It is necessary to verify the validity of subjective evaluations with other indicators (such as expert diagnoses). Also, beyond merely estimating dependence, developing intervention methods to improve it is an important research theme. Applications such as identifying "high-risk users" from log data and individually approaching them can also be considered.

3.14 Reflection on Hirshberg et al.'s Study (2020)

This study is noteworthy for showing the possibility of inferring users' political leanings from smartphone app usage logs and location data. In particular, it is interesting that they clarified the relationship between news app choices and location information with actual voting behavior. This approach is expected to complement traditional methods such as opinion polls as a new method of public opinion analysis. On the other hand, caution is needed in inferring political orientations. The risks of privacy violations and the fear of data misuse must also be considered. Also, elucidating the causal mechanisms behind the correlations is an important issue. To leverage the findings from data in political decision-making, more multifaceted analysis and discussion are essential.

3.15 Reflection on Wang et al.'s Study (2019)

This is a unique study presenting an approach to infer college students' friendships from smartphone location data. It is commendable that they revealed actual interaction patterns among students that are difficult to capture with traditional questionnaires and interviews. Additionally, it is interesting that they suggested a relationship between the characteristics of friendship networks and academic performance. It can be said to provide important insights for understanding the impact of students' social connections on learning attitudes and learning effects. On the other hand, the validity of judging friendships solely from location information needs to be carefully examined. Also, consideration for students' privacy is indispensable. Ethical discussions on how to handle student data are required.

3.16 Reflection on Gheisari et al.'s Study (2021)

This research is a potential contribution to improving traffic safety by evaluating driving behavior from users' smartphone app usage logs and sensor data. In particular, automatically detecting dangerous driving such as sudden acceleration and hard braking and calculating safe driving scores is practical. It might lead to improving driving habits by providing feedback to drivers. On the other hand, ensuring the accuracy and reliability of driving data is a challenge. Also, to evolve into more advanced analyses such as predicting accident risks, integrating expertise from traffic engineering and psychology is essential. Balancing privacy and data utilization is also important. A mechanism is needed to utilize data in a socially beneficial way while obtaining drivers' consent and understanding.

3.17 Reflection on Kooti et al.'s Study (2018)

This research is significant in that it clarified the reality of accessibility challenges by analyzing the iPhone operation logs of visually impaired users in detail from their perspective. It is highly commendable that they identified areas for functional improvement in line with the actual usage situations of the parties concerned. Based on the obtained insights, it is hoped that the pursuit of UI that truly balances usability and user experience will progress. However, with data limited to iPhone users, the full picture of the challenges cannot be captured. It is necessary to extract common issues across operating systems, including other platforms such as Android. In addition, beyond removing operational barriers, working to improve the accessibility of content and services is also indispensable. Under a research style with the participation of the parties concerned, a comprehensive approach that takes into account not only technology but also the transformation of the social model is required.

3.18 Reflection on Rook et al.'s Study (2020)

This study, which predicted users' energy-saving consciousness from app usage logs and battery consumption data, presents a new approach to elucidate and promote environmentally conscious behavior. It is interesting that they identified individuals' energy-saving orientations as expressed in device settings and usage, suggesting the possibility of designing interventions using them as leverage. Effective power-saving advice tailored to each user's needs and lifestyle may also contribute to optimizing electricity demand. However, in the analysis, considering the context is essential. Even for the same app usage, the acceptable level of power consumption varies between at home and outside. It is necessary to incorporate environmental factors surrounding users into the model. Also, attention must be paid to the trade-off with privacy. Electricity data can draw a detailed map of life. Robust security measures and careful consent acquisition throughout the entire process of data collection and utilization are major prerequisites.

3.19 Reflection on Servia-Rodríguez et al.'s Study (2017)

This study, which quantified users' multitasking behavior from app usage logs and found associations with productivity, etc., opens up new possibilities for behavioral log analysis in the HCI field. It is suggestive that a negative correlation was found between the frequency of parallel work and cognitive and emotional costs. It provided an important clue to understanding the reality of how digital environments promote the fragmentation of thought. By longitudinally analyzing log data, the impact of multitasking habits on performance may also become clear. On the other hand, it should be noted that parallel work other than smartphones, such as PC operations, cannot be captured. Also, a careful reading of the cognitive processes at work behind the operation logs, such as the nature of tasks and the context of switching, is indispensable. Through multimodal data collection to capture the back-and-forth between behavior and cognition, and consideration using insights from cognitive science, we look forward to the development of research that deepens the understanding of multitasking.

3.20 Reflection on Umematsu et al.'s Study (2019)

This study, which analyzes the touring behavior of travelers visiting tourist destinations from their smartphone GPS logs and aims to use it for congestion mitigation, etc., opens up a new phase of big data utilization in tourism management. If the flow of people within an area can be grasped in real time, it will be possible to design solutions that directly lead to improving traveler satisfaction, such as optimizing transportation operations based on demand forecasting and avoiding congestion at popular spots. It can be said to be a promising approach toward realizing sustainable tourism that maximizes the operating capacity of the region. However, when collecting location information, consideration for travelers' privacy is a major premise. It is essential to consider technical and institutional measures such as data anonymization and the creation of an opt-out mechanism. Also, to evaluate tourism satisfaction from data, it is necessary to combine other behavioral and subjective indicators

in addition to GPS logs. Furthermore, a comprehensive discussion that takes into account a wide range of stakeholders in tourism destination management, such as the impact on the living environment of residents, is required.

3.21 Reflection on Wang et al.'s Study (2022)

This study, which estimated physical activity levels from older adults' smartphone app usage logs and sensor data and explored the relationship with cognitive function, provides important insights for considering a healthy lifestyle in old age. The finding that the use of pedometer apps was associated with cognitive function is interesting. Although the direction of causality is unclear, there is a strong possibility that promoting physical activity contributes to maintaining cognition. It suggests the potential for behavior change approaches mediated by smartphones. The challenge is the diversity of attributes of the subjects. This time, relatively healthy older adults were the main focus, but it is necessary to collect data from a wider range of physical and mental states. On top of that, it is essential to consider detailed support measures that take individual differences into account. Also, for evidence-based policy making, it is indispensable to scrutinize the indicators for evaluating cognitive function. While determining the possibilities and limitations of the data, it is necessary to carefully promote practical application.

3.22 Reflection on Lee et al.'s Study (2019)

This study examined the relationship between smartphone app usage logs in university libraries and learning behaviors. The finding that frequent use of learning-related apps was associated with self-regulated learning strategies, while long-time use of SNS apps was associated with shorter study time, is interesting. It is significant in that it empirically captured patterns of learning in digital environments. It will also provide implications for the design of ICT-enabled learning spaces such as learning commons in university libraries. The challenge is the difficulty of identifying causal relationships. Do app usage behaviors influence learning behaviors, or do learning approaches influence app choices? A cautious analysis considering confounding factors is required. In addi-

tion, examining how to encourage effective app use, such as educational interventions, is also an important research theme.

3.23 Reflection on Chen et al.'s Study (2020)

This research, which infers lifestyle habits (smoking and drinking) from smartphone battery consumption and location information, opens up new possibilities for preventive medicine. The approach of predicting risk factors from spatio-temporal patterns of behavior, such as late-night movement and staying at specific locations, is innovative. It is expected to provide insights that will be useful for early interventions aimed at improving health literacy and lifestyle. However, there are many challenges to overcome, such as ensuring data accuracy and securing a representative sample, and protecting privacy. It is necessary to accumulate ethical considerations and evidence of intervention effects through interdisciplinary discussions involving medical professionals and other experts. Log data is not a panacea. It is essential to combine it with traditional approaches, recognize its limitations, and utilize it.

3.24 Reflection on Wu et al.'s Study (2022)

This study analyzed the smartphone operation logs of museum visitors and explored the relationship between artwork appreciation behavior patterns and popular artworks. The finding that photography and sharing apps were used more and visitors stayed longer in front of popular artworks is interesting. It is commendable that they also clarified the relationship between the viewing status of artwork descriptions on the app and satisfaction. It can be said to be an ambitious attempt to draw out the immersive experience in art museums from multiple perspectives using data. The obtained insights should be applicable to layout design of exhibition spaces and development of appreciation guides utilizing smartphones. On the other hand, attention should be paid to the bias in the attributes of art museum visitors. Surveys targeting people with diverse attributes need to be accumulated. In addition, there are aspects of the artistic experience, such as dialogue with artworks, that cannot be captured by operation logs alone. A qualitative approach must be used in combination.

3.25 Reflection on Zhang et al.'s Study (2021)

This is an ambitious study that aims to proactively detect the decline of driving ability from the smartphone app logs of elderly drivers. It is important that they identified behavioral indicators that lead to driving risks, such as decreased reaction speed and increased operation errors, through association with cognitive function tests. Ensuring driving safety is of great significance in a super-aging society. The finding that smartphones can become preventive monitoring tools is socially impactful. However, it is necessary to carefully examine how well the results of simulator experiments apply to actual driving. The influence of factors other than age must also be considered. Ethical research conduct with consideration for privacy and careful social implementation are required in this field. We hope to gather wisdom to support the dignity of elderly drivers through discussions involving stakeholders.

3.26 Reflection on Li et al.'s Study (2020)

This study, which analyzed the relationship between tourists' smartphone GPS data and satisfaction/revisit intention, provides insights that contribute to destination management. The discovery that the choice of touring routes affects satisfaction opens up a new perspective on tourist behavior research. It will also lead to improving the quality of tourism experiences utilizing smartphones, such as providing information and navigation according to the characteristics of the destination. At the same time, ingenuity is required in the accuracy of GPS data and the handling of areas where radio waves do not reach, such as indoor facilities. In addition, there is room for reconsidering the validity of measuring tourism evaluation solely by satisfaction. We would also like to take on the challenge of indexing qualitative experiential values such as "unexpected discoveries". Above all, a careful attitude is required to strike a balance between the purpose of the analysis and the privacy of the subjects. The harmony between tourism DX and data ethics holds the key to sustainable tourism.

3.27 Reflection on Wang et al.'s Study (2019)

This research, which estimates interpersonal skills from smartphone app usage logs and sensor data, sug-gests the possibility of new personality assessments using behavioral data. The association between the usage time of communication apps and high self-rated sociability is intuitive. Attempting to measure social skills from nonverbal behavioral indicators is a challenge that opens up new frontiers in psychological assessment. On the other hand, there is room for reconsideration in how interpersonal relationship skills are captured. "Getting along well" and "building good relationships" are not necessarily equal. It is necessary to take into account qualitative elements such as the motivation for using apps. In addition, there are many challenges to overcome, such as ensuring the validity of self-reports and considering differences in behavior depending on the situation. Consideration for privacy protection and appropriate feedback is also indispensable. We hope for the integrated development of diverse approaches to explore the multifaceted nature of interpersonal skills.

3.28 Reflection on Kim et al.'s Study (2021)

This study, which associated children's smartphone usage logs with the quality of parent-child relationships, is suggestive for considering the state of families in the digital age. The result that parent-child pairs with less communication at home also have fewer interactions via messaging apps tells a story of the continuity between real and virtual. It is a significant finding in suggesting that smartphones can become a new yardstick for measuring intimacy. At the same time, a careful interpretation of the direction of causality is required. Does a distant relationship reduce smartphone use, or does reliance on smartphones neglect face-to-face conversation? Hypothesis testing using more multifaceted indicators is necessary. There is also room for reconsidering whether it is appropriate to measure the qualitative meaning of intimacy solely with log data. It is essential to reconcile with qualitative research that carefully delves into the substance of offline interactions.

3.29 Reflection on Mehrotra et al.'s Study (2017)

This study provides insights that contribute to improving the user experience through the proposal of a model that predicts the acceptability of smartphone

notifications. It is commendable that they empirically demonstrated the importance of optimizing notification timing according to the user's situation. Notifications tend to be a trade-off between convenience and annoyance, but adaptive delivery based on behavioral data may lead to resolving that dilemma. On the other hand, the challenge remains of how detailed user situations and individual differences can be modeled. Consideration of contexts other than location and time of day (e.g., task importance), and situation estimation with consideration for privacy are required. In addition, it is necessary to take into account the characteristics of the notification content itself (urgency, relevance, etc.). It is expected that research will evolve into comprehensive notification management.

3.30 Reflection on Kökciyan et al.'s Study (2021)

This attempt to identify behavioral patterns effective for symptom control from log data analysis of an asthma management app has the potential to contribute to optimizing treatment and empowering patients. It is significant that they clarified the characteristics of behaviors that are key to self-management, such as medication adherence. The patient's active involvement is indispensable for the treatment of chronic diseases. It can be said to be research that presented evidence for apps to function as a support tool for that. However, identifying the causal relationship between app usage and symptom management is not easy. The influence of confounding factors needs to be carefully examined. Also, considering that the symptoms vary greatly from person to person, it is necessary to consider a more individualized intervention approach. It is also important to consider synergistic effects with elements other than apps, such as improving the quality of communication with medical professionals.

3.31 Reflection on Lee et al.'s Study (2020)

This study, which infers users' political stances from news app browsing histories, is suggestive for reading the dynamics of public opinion formation. It is noteworthy that they delved into the reality of the echo chamber phenomenon. The risk of division and polarization brought about by selective information exposure is an important issue that goes to the root of

democracy. Log data can become a mirror that vividly reflects the reality of media consumption. However, caution is needed in inferring political stances. The risks of privacy violations and discrimination must be fully examined. It is also necessary to pay attention to the influence of the content and context of the news. It is expected that hypotheses obtained from log data will be explored by combining them with qualitative analyses such as interviews, and by delving into the motivations and interpretive frameworks behind information behaviors. To break out of echo chambers, it is necessary to consider constructive utilization measures such as providing opportunities to be exposed to diverse opinions.

3.32 Reflection on Wang et al.'s Study (2021)

This study, which analyzed the relationship between food logging app log data and weight change, suggests the potential for weight loss support through behavior change approaches. It is commendable that they empirically showed that the continuation of self-monitoring contributes to the establishment of desirable eating habits and successful weight loss. By visualizing daily dietary content and receiving feedback, the cycle of reflecting on one's own behavior and linking it to improvement is likely to be promoted. The provision of personalized advice utilizing log data is also expected to create added value unique to apps. On the other hand, factors other than diet are intricately intertwined with weight change. It is necessary to collect and analyze data covering the entire lifestyle, including exercise habits and sleep. In addition, the pros and cons of increasing dependence on apps should be carefully examined. In parallel with creating mechanisms that encourage autonomous behavior change, it is essential to skillfully combine professional support.

3.33 Reflection on Lee et al.'s Study (2020)

The attempt to visualize users' thinking patterns from the operation logs of mind map apps holds the potential as a tool to support metacognition. If the flow of thoughts and the spread of ideas can be overviewed, it may lead to awareness of one's strengths and weaknesses and improvement in the quality of creative thinking. Opportunities for reflection based on log data will also contribute to improving problem-solving

skills. However, evaluating creativity is not easy. The skillfulness of using the tool and the quality of the generated output are not necessarily equal. A multifaceted analysis of the relationship between operation logs and deliverables is indispensable. Also, when considering application to collaborative ideation situations, in addition to visualizing individual thinking processes, the development of functions to support the sharing and integration of thoughts among team members is expected. Through research that approaches the dynamics of creation through operation logs, we hope it will be an opportunity to rethink the nature of ideation support.

3.34 Reflection on Chen et al.'s Study (2019)

This study, which explored the relationship between usage status of meditation apps and stress biomarkers, suggests the usefulness of mindfulness practice through digital tools. If the continuity and concentration of meditation can be inferred from behavioral logs on the app, it is expected to be useful for predicting stress reduction effects and optimizing practice. However, app usage does not necessarily guarantee a mindful state. It is necessary to carefully match behaviors on the app with the quality of the actual meditation experience. Comparison with qualitative data such as reports of subjective awareness is required. Also, it should be noted that individual differences in stress responses are large. How to link signs of stress reduction that can be read from log data to personalized feedback. It is essential to explore effective ways to utilize apps while collaborating with mindfulness instruction experts.

3.35 Reflection on Zhang et al.'s Study (2021)

This study, which analyzed log data from a cognitive training app for the elderly and verified the effect of maintaining and improving cognitive function, suggests new possibilities for dementia prevention in anticipation of a super-aging society. Evidence-based app design has the potential to contribute to extending the healthy life expectancy of the elderly. App log data can be a powerful tool for longitudinally tracking changes in cognitive function. Applications such as estimating the state of cognitive function from training task performance and usage frequency and proposing optimal training plans are expected. However, a

multifaceted approach is indispensable for evaluating cognitive function. There may be aspects of cognition that cannot be captured by operation logs alone. Collation with other objective indicators such as neuropsychological tests is essential. Also, consideration for usability issues unique to the elderly, such as the ease of use of apps, is indispensable. It is desirable to develop training apps that combine evidence and usability by integrating knowledge from cognitive science and psychology of aging.

3.36 Reflection on Patel et al.'s Study (2020)

This study, which predicts users' smoking cessation success from log data of smoking cessation apps, opens up the possibility of individually optimized smoking cessation support. If behavioral patterns that determine the success or failure of smoking cessation can be identified, it will be possible to identify high-risk users early and provide appropriate interventions. Personalized advice utilizing log data is expected to increase motivation for smoking cessation and improve success rates. However, it is difficult to grasp the entire smoking cessation process only with behaviors on the app. Important events that occur in offline contexts, such as coping behaviors for smoking urges, cannot be overlooked. It is necessary to combine log data with ecological momentary assessment to conduct a comprehensive assessment. Furthermore, coordination with pharmacotherapy such as nicotine replacement therapy must also be considered. We aim to build an effective smoking cessation program based on data by bringing together the wisdom of behavioral science and medicine.

3.37 Reflection on Singh et al.'s Study (2019)

This study, which explored the relationship between the usage status of mood diary apps and mental health, suggests the potential of digital tools for emotion regulation. Verbalization of emotions is known to contribute to calming negative emotions and improving stress tolerance. Developing the habit of keeping a diary through apps will contribute to improving the mental health of many people. Clues that can be read from log data, such as recording frequency and diversity of emotional expressions, can be a valuable source of information for assessing emotional health

status. On the other hand, there are individual differences in the skill of verbalizing emotions. Careful attention is required to read the true intentions behind the expressed words. It will be necessary to carefully interpret the data while utilizing techniques such as text mining and incorporating expert interpretations. In addition, the perspective of how expressions on the app are reflected in offline well-being is indispensable. It is necessary to use other indicators such as questionnaires to verify the validity of the data from multiple angles.

3.38 Reflection on Kim et al.'s Study (2021)

This study, which analyzed log data from a physical activity tracking app for the elderly and attempted to detect frailty risk early, is a good example that shows the potential for utilizing digital technology in preventive medicine. Physical activity plays a large role in maintaining health in old age. By visualizing daily step counts and exercise intensity through apps, it is expected to encourage behavior change in the elderly and prevent frailty. A decrease in activity level that can be read from log data may be a signal to quickly catch signs of functional decline. Optimization of preventive approaches, such as intervention at the optimal timing for establishing exercise habits, is expected. However, the QOL of the elderly cannot be measured by physical aspects alone. It is necessary to combine comprehensive indicators such as social participation status and cognitive engagement. In addition, consideration for usability issues unique to the elderly, such as the ease of use of apps, is indispensable. We should aim to build an integrated frailty prevention system that looks beyond physical function to psychological and social health.

3.39 Reflection on Liu et al.'s Study (2020)

This study, which clarified the relationship between time management app log data and user productivity, suggests new application scenarios for personal informatics. Objectively grasping how one uses time is an important step toward optimizing behavior. If effective time management strategies can be acquired through apps, it is expected to have a wide range of effects, including not only productivity improvement but also work-life balance improvement. Be-

havioral tendencies extracted from log data, such as task scheduling and prioritization techniques, should provide hints for self-understanding and improvement. However, caution is required in interpreting log data. The relationship between records on the app and the actual performance of tasks is not necessarily self-evident. In addition, it is one-sided to capture productivity only from the aspect of time management. It is essential to assess from multiple perspectives, such as the quality of deliverables and motivation for work. While using log data as a trigger for behavior change, what may be important is to cultivate the ability to autonomously make sense of it.

3.40 Reflection on Hirshberg et al.'s Study (2020)

This study is groundbreaking in that it demonstrated that users' political leanings can be predicted with high accuracy from smartphone app usage logs and location data. It is noteworthy that they found a strong correlation between inferred political orientations from news app selection tendencies and behavioral areas with actual voting behavior. It will greatly contribute to the understanding of the digital-age voter profile. On the other hand, the utmost care must be taken regarding the risk of misuse of such predictive technologies. Situations that could threaten the soundness of democracy, such as voter profiling and targeted advertising, can also be envisioned. How to balance privacy protection and the fairness of political processes.

3.41 Reflection on Wang et al.'s research (2019)

This research, which estimated friend relationships from students' smartphone GPS logs on campus and found a correlation with academic performance, opens up new horizons in educational big data analysis. The finding that high-performing students tend to form denser networks with each other is insightful. The approach of getting closer to the reality of intellectual exchanges between students from behavioral logs is expected to be widely applicable to designing learning support environments and more. However, validating the appropriateness of identifying friendships solely from GPS data is essential. Commonality in lo-

cations does not necessarily equate to intimacy. We need to consider the influence of diverse friendships beyond academics and the dynamics of community formation both online and offline. Additionally, the handling of students' location and connection data demands ethical considerations. While sincerely listening to students' privacy concerns, we would like to engage in constructive discussions to evolve educational IR.

3.42 Reflection on Gheisari et al.'s research (2021)

This research, which detected dangerous driving events with high accuracy using acceleration data and other information from drivers' smartphones, is an excellent example demonstrating the usefulness of smartphone sensing in the field of traffic safety. The ability to immediately identify near-miss incidents and utilize them for alerts and feedback is significant. Tailored preventive interventions based on each driver's tendencies could potentially reduce accident risks. However, there are ethical and legal issues surrounding the provision of driving data to third parties. Scenarios that could disadvantage data subjects, such as insurance companies using the data for driver risk assessment, must be considered. It is urgent to establish rules for data utilization through discussions involving various stakeholders such as automakers, relevant government agencies, and consumer groups. While premising on the driver's consent and control, we aim to create a system that contributes to society's safety and security.

3.43 Reflection on Kooti et al.'s research (2018)

This research, which conducted a detailed analysis of visually impaired iPhone users' operation logs and highlighted accessibility issues, provides valuable insights that serve as a guiding compass for inclusive design. The fact that it clarified areas for functional improvement based on the actual usage situation of users is highly commendable. We hope that the gained insights will propel the pursuit of a UI that truly combines usability and user experience. However, data limited to iPhone users alone cannot fully capture the entire scope of issues. It is necessary to include other platforms like Android and extract cross-platform common issues. Moreover, in addition to removing operational barriers, efforts to improve the accessibility of content and services are indispensable. Under a user-participatory research style, a comprehensive approach that incorporates not only technological but also social model reforms is required, keeping both possibilities and limitations of data in perspective.

3.44 Reflection on Rook et al.'s research (2020)

This research, which predicted users' energy-saving awareness from app usage logs and battery consumption data, presents a new approach towards understanding and promoting environmentally conscious behavior. The ability to identify individual users' propensity for energy conservation as reflected in device settings and usage patterns, and then design interventions leveraging that, is intriguing. Tailored energy-saving advice based on each user's needs and lifestyle could potentially contribute to optimizing power demand. However, considering context is essential in the analysis. The tolerance for power consumption can vary depending on whether the same app is used at home or out. Incorporating environmental factors surrounding users into the model is necessary. Privacy trade-offs also require attention. Power data can reveal a detailed picture of one's life. Robust security measures and careful consent acquisition across the entire data collection and utilization process are prerequisites.

3.45 Reflection on Servia-Rodríguez et al.'s research (2017)

This research, which quantified users' multitasking behavior from app usage logs and found a

relationship with productivity, opens up new possibilities for behavioral log analysis in the HCI field. The finding of a negative correlation between the frequency of parallel work and cognitive/emotional costs is insightful. It provided important clues for understanding the reality of how digital environments are facilitating fragmented thinking. Longitudinal analysis of log data may also reveal the impact of multitasking habits on performance. However, caution is needed as

parallel work outside of smartphones, such as on PCs, cannot be captured. A careful examination of the underlying cognitive processes at work behind the operation logs, such as the nature of tasks and the context of switching, is also indispensable. We hope for the development of research that deepens the understanding of multitasking through multimodal data collection and consideration utilizing insights from cognitive science to capture the interplay between behavior and cognition.

3.46 Reflection on Umematsu et al.'s research (2019)

This research, which analyzed the sightseeing behavior of tourists visiting tourist destinations from their smartphone GPS logs and aimed to utilize the findings for crowd management, opens up a new phase in the application of big data to tourism management. Being able to grasp the flow of people in real-time within an area would enable the design of solutions directly linked to enhancing visitor satisfaction, such as optimizing transportation operations based on demand forecasting and avoiding crowding at popular spots. It can be considered a powerful approach towards realizing sustainable tourism that maximizes the operational capacity of the region. However, collecting location information requires ensuring the privacy of tourists as a prerequisite. Developing technical and institutional measures, such as data anonymization and opt-out mechanisms, is indispensable. Moreover, evaluating tourist satisfaction from data requires combining GPS logs with other behavioral and subjective indicators. Furthermore, a comprehensive discussion that considers a wide range of stakeholders in tourism destination management, including the impact on residents' living environment, is also necessary.

3.47 Reflection on Wang et al.'s research (2022)

This research, which estimated the physical activity levels of the elderly from their smartphone app usage logs and sensor data and explored the relationship with cognitive function, provides important insights for considering a healthy lifestyle in old age. The finding that the use of step-counting apps was associated with cognitive function is interesting. While the direc-

tion of causality is unclear, it is plausible that promoting physical activity contributes to maintaining cognitive function. It suggests the possibility of a behavior change approach through smartphones. The challenge lies in the diversity of participant attributes. This study focused on relatively healthy elderly individuals, but data collection needs to include a wider range of physical and mental conditions. Based on this, it is crucial to consider tailored support strategies that take individual differences into account. Additionally, for evidence-based policy formulation, a careful examination of cognitive function evaluation indicators is indispensable. While assessing the possibilities and limitations of data, we need to proceed cautiously with practical applications in the field.

3.48 Reflection on Lee et al.'s research (2019)

This is a study that examined the relationship between smartphone app usage logs and learning behavior at a university library. Frequent use of learning-related apps was linked to self-regulated learning strategies, while prolonged use of social media apps was associated with shorter learning times. It is significant in empirically capturing patterns of learning in digital environments. The findings could provide insights for designing ICT-enabled learning spaces such as learning commons in university libraries. The challenge lies in the difficulty of identifying causal relationships. Does the way apps are used influence learning behavior, or does the approach to learning influence the choice of apps? An analysis that considers confounding factors is necessary. Moreover, exploring how to promote effective app utilization is also an important research topic.

3.49 Reflection on Chen et al.'s research (2020)

The research on estimating lifestyle habits (smoking and drinking) from smartphone battery consumption and location information opens up new possibilities for preventive medicine. The approach of predicting risk factors from the spatio-temporal patterns of behavior, such as nighttime movements and specific stay locations, is innovative. It is expected to provide insights that can contribute to improving health literacy and intervening early for lifestyle improvements. However,

there are many challenges to overcome, such as ensuring data accuracy, securing representative samples, and protecting privacy. It is necessary to engage in interdisciplinary discussions involving experts like medical professionals, accumulate ethical considerations, and gather evidence of intervention effectiveness. Log data is not a panacea. It is essential to combine it with conventional approaches and utilize it while recognizing its limitations.

3.50 Reflection on Wu et al.'s research (2022)

This research analyzed museum visitors' smartphone operation logs to explore patterns of artwork viewing behavior and their relationship with popular artworks. The finding that photography and sharing apps were used more frequently in front of popular artworks, and dwell times were longer, is interesting. The fact that it also revealed the relationship between viewing artwork explanations on apps and satisfaction levels is commendable. It can be considered an ambitious attempt to depict the immersive experience at art museums from multifaceted data. The gained insights could be applied to optimizing exhibition space layouts and developing smartphone-based viewing guides. However, caution is needed regarding the biased attributes of museum visitors. Accumulating surveys targeting diverse attributes is necessary. Moreover, artistic experiences have aspects such as dialogues with artworks that cannot be captured by operation logs alone. Combining qualitative approaches is indispensable.

3.51 Reflection on Zhang et al.'s research (2021)

This is an ambitious research that attempts to detect the decline in driving ability of elderly drivers through predictive analysis of their smartphone app logs. By linking the findings with cognitive function tests, it identified behavioral indicators that could lead to driving risks, such as slower reaction times and increased operation errors. Ensuring driving safety is highly significant in a super-aged society. By suggesting the possibility of smartphones becoming a preventive monitoring tool, it can be considered a socially impactful finding. However, caution is needed in examining how applicable the results from simulator experiments are to actual driving. Factors other than age must also be considered. Ethical research practices with privacy considerations and careful social implementation are required in this area.

3.52 Reflection on Li et al.'s research (2020)

This research, which analyzed the relationship between tourists' smartphone GPS data and their satisfaction and intention to revisit, provides insights beneficial for destination management. The finding that the choice of sightseeing routes influences satisfaction opens up a new perspective in tourism behavior research. It could lead to enhancing the quality of tourist experiences through smartphone utilization, such as providing information and navigation tailored to the characteristics of visited locations. Simultaneously, efforts are needed to ensure the accuracy of GPS data and address areas without signal coverage, such as indoor facilities. Moreover, there is room to reconsider the appropriateness of measuring tourism evaluation solely through satisfaction. We would like to explore indicators for qualitative experiential values, such as "unexpected discoveries." Above all, an ethical stance that carefully balances the purpose of analysis and the privacy of subjects is required. The symphony of tourism DX and data ethics is expected to hold the key to sustainable tourism.

3.53 Reflection on Wang et al.'s research (2019)

This research, which estimates interpersonal skills from smartphone app usage logs and sensor data, suggests the possibility of a new personality assessment approach using behavioral data. The correlation between the usage time of communication apps and self-rated sociability aligns with intuition. The attempt to measure social skills through non-verbal behavioral indicators can be considered a challenge that pioneers the frontier of psychological assessment. However, there is room to reconsider how interpersonal ability is perceived. Being "good at it" does not necessarily equate to "building positive relationships." Qualitative elements, such as the motivation behind app usage, need to be incorporated. Additionally, there are many challenges to overcome, including ensuring the validity of self-reports, considering behavioral dif-

ferences across situations, and examining privacy protection and appropriate feedback methods. We look forward to the integrative development of diverse approaches that delve into the multifaceted nature of interpersonal skills.

3.54 Reflection on Kim et al.'s research (2021)

This research, which linked children's smartphone usage logs with the quality of parent-child relationships, provides insightful perspectives on understanding family dynamics in the digital age. The finding that parent-child pairs with less communication within the household also had fewer message exchanges via messaging apps reflects the continuity between the real and virtual worlds. It suggests that smartphones could serve as a new yardstick for measuring intimacy, making it a significant finding. At the same time, caution is needed in interpreting the direction of causality. Does a distant relationship lead to less smartphone usage, or does reliance on smartphones neglect face-to-face conversations? Hypothesis testing using more multifaceted indicators is required. Moreover, there is room to reconsider whether qualitative meanings of intimacy can be appropriately measured solely through log data. It is essential to complement the research with qualitative studies that meticulously explore the reality of offline interactions.

3.55 Reflection on Mehrotra et al.'s research (2017)

Through proposing a model to predict the receptivity to smartphone notifications, this research contributes insights towards improving user experience. The empirical demonstration of the importance of optimizing notification timing according to the user's situation is commendable. Notifications often involve a trade-off between convenience and annoyance, but adaptive delivery based on behavioral data could potentially resolve this dilemma. However, a challenge remains in how granularly the user's situation and individual differences can be modeled. Considerations such as contexts beyond location and time (e.g., task importance), situation inference with privacy considerations, and the characteristics of notification content itself (urgency, relevance, etc.) will likely be required. It is expected that the research will evolve towards

comprehensive notification management.

3.56 Reflection on Kokciyan et al.'s research (2021)

The attempt to identify effective behavioral patterns for symptom control through analyzing log data from an asthma management app holds the potential to contribute to treatment optimization and patient empowerment. The identification of behavioral characteristics that are key to self-management, such as medication adherence, is meaningful. Patient involvement is indispensable for the treatment of chronic diseases. This research can be considered as presenting evidence for apps to function as a support tool. However, identifying the causal relationship between app usage and symptom management is not straightforward. Careful examination of the influence of confounding factors is necessary. Considering the substantial individual differences in disease conditions, exploring more personalized intervention approaches is also required. The synergistic effects with factors beyond apps, such as improving the quality of communication with healthcare professionals, should also be considered.

3.57 Reflection on Lee et al.'s research (2020)

The approach of estimating users' political stances from news app browsing histories provides insightful perspectives for understanding the dynamics of public opinion formation. The fact that it delved into the reality of the echo chamber phenomenon is noteworthy. The risks of division and polarization brought about by selective information exposure are crucial issues that concern the foundations of democracy. Log data can serve as a mirror that vividly reflects media consumption patterns. However, caution is required when estimating political stances. Potential risks of privacy infringement and discrimination must be carefully examined. The influence of news content and context also needs attention. By combining log data with qualitative analysis, it is expected that research will delve deeper into the motivations and interpretive frameworks underlying information behavior. To break out of echo chambers, constructive applications such as providing opportunities to encounter diverse opinions should be explored.

3.58 Reflection on Wang et al.'s research (2019)

This research, which identifies behavioral patterns of successful quitters from log data of smoking cessation apps, contributes to the design of evidence-based smoking cessation support. The significance of revealing key behaviors that lead to successful quitting, such as utilizing community functions and frequent diary posting, is considerable. Smoking is a serious public health issue, and optimizing behavior change approaches through apps is an urgent task. However, the success or failure of quitting is complexly intertwined with psychosocial factors. Consideration of influencing factors beyond app usage is indispensable. Comparative evaluation with other smoking cessation methods, such as nicotine replacement therapy, is also required. It is necessary to position app utilization within a multifaceted support scheme tailored to individual circumstances. Simultaneously, we must also address the challenge of how to translate the insights gained from log data into real-world smoking cessation programs.

3.59 Reflection on Chen et al.'s research (2018)

This research, which identified learners' motivation patterns from log data of language learning apps, opens up new possibilities in educational technology. If learners' engagement can be inferred from their behavior on apps, adaptive support can be provided. It can be considered an important step towards realizing technology that accommodates individual differences in learning. The challenge lies in how to optimize interventions to sustain learners' motivation according to their situations. It is necessary to unravel the dynamics of the interaction between the influence of app elements (goal setting, feedback, etc.) and learner factors (outcome expectations, self-efficacy, etc.). Additionally, we must also address the instructional design issue of ensuring continuity between online and offline learning. While grounded in log data, we look forward to an interdisciplinary approach that integrates insights from language education.

3.60 Reflection on Zhang et al.'s research (2021)

This research, which analyzed the relationship between log data from mental health apps and mood changes, suggests the possibility of a new digital technology-enabled mental healthcare approach. If early signs of intervention effectiveness can be captured from app behavior, it could potentially contribute to preventing symptom exacerbation through early intervention. It can be considered a finding that paves the way for continuous well-being monitoring and on-demand support provision based on the monitoring. At the same time, app usage does not necessarily lead to positive effects. The impact may vary depending on the purpose and manner of use, as well as the characteristics of the condition. Careful examination of confounding variables and personalized intervention design that considers individual differences are required. Apps should be positioned as just one component of treatment, complementing care provided by professionals. With ethical considerations in mind, an accumulation of implementation research that integrates the wisdom of the field is anticipated.

3.61 Reflection on Li et al.'s research (2020)

This research, which identified usability issues from operation logs of health management apps for the elderly, highlights the importance of inclusive design in preparation for a super-aged society. The finding that lack of consideration for age-related characteristics, such as font size and navigation issues, became apparent is insightful. Disparities in health literacy could lead to disparities in health outcomes. Improving the UI/UX with consideration for the diversity of the elderly is an urgent task. On the other hand, enhancing the digital skills of the elderly is also necessary. In addition to operational support, multi-faceted literacy education is essential, such as promoting understanding of app usefulness, alleviating anxiety, and more. Furthermore, attention should also be paid to the socioeconomic factors that influence app accessibility. Using the issues identified from data as a starting point, we would like to develop the research through a participatory approach that sincerely listens to the voices of the elderly.

3.62 Reflection on Park et al.'s research (2019)

This research, which tracks changes in eating habits from log data of food diary apps, suggests the potential to contribute to the prevention of lifestyle diseases. If users' behavior change processes can be visualized in data form, it could lead to more personalized interventions. It provides insights into the role that apps could play as nudges to promote healthy behavior improvement. However, ensuring the quality of log data is not straightforward. There are limitations in the comprehensiveness and accuracy of manually entered food diaries. Advancements in data collection methods, such as combining with passive sensing like GPS, are required. Additionally, whether app interventions lead to long-term behavior establishment needs careful examination. Attention should also be paid to the risk of over-reliance on apps. An integrated behavior change strategy with a socio-ecological perspective, such as addressing the food environment, may be necessary.

3.63 Reflection on Wang et al.'s research (2019)

This research, which used log data from an exposure therapy app for social anxiety disorder to evaluate treatment progress and outcomes, represents a pioneering attempt demonstrating the potential of digital mental healthcare. The suggestion that treatment effects could be enhanced by engaging in self-initiated exposure through the app in addition to therapist consultations is significant. Log data can serve as a valuable clue to measure the degree of behavior change in real-life situations. It could also aid therapists in better understanding clients and providing effective feedback. The challenge lies in examining the correspondence between in-app behavioral data and the actual state of social adaptation. From an ecological validity perspective, it is necessary to interpret log data from multiple angles. Furthermore, the clinical discussion on how exposure therapy using apps should be differentiated from and integrated with conventional treatment approaches is also indispensable. Digital technology should not replace but rather support the relationship between therapists and clients.

3.64 Reflection on Chen et al.'s research (2020)

This research, which tracked the development of problem-solving skills from operation logs of a programming education app for children, presents an interesting case demonstrating the potential of app utilization in STEM education. If the degree of acquisition of computational thinking can be inferred from in-app behavior, it could lead to the provision of individually optimized learning support. Early detection of stumbling patterns and adaptive interventions such as providing appropriate hints are expected. At the same time, there are limitations in capturing the overall picture of development from log data alone. Aspects of learning beyond the app, such as the quality of communication in collaborative problem-solving, also need attention. A fundamental discussion on how to position log data in light of the higher educational goal of fostering creativity through programming is also important. It is essential for experts in computer science education and data scientists to collaborate, identify the possibilities and limitations of logs, and explore evidence-based educational practice models.

3.65 Reflection on Zhang et al.'s research (2018)

This research, which explored the possibility of utilizing log data from voice assistant apps to estimate user preferences and habits for personalized recommendations, opens up new horizons in app log utilization. Providing optimal information tailored to the user's context based on their behavioral history could potentially enhance the app's convenience and user satisfaction. At the same time, user profiling is a double-edged sword. Scrutinizing individuals' interests from log data carries no small risk. To strike a balance between privacy protection and data utilization, ensuring transparency and accountability is essential. Clear policies regarding log data acquisition and use should be established, and users' control rights should be fully respected. Additionally, attention must be paid to the issue of bias in recommendation systems. We should strive to minimize the risk of filter bubbles and explore ways to provide information that broadens users' perspectives. While maintaining ethical consid-

erations, we look forward to research that contributes to building a sound relationship between apps and users.

3.66 Reflection on Kim et al.'s research (2021)

This research, which tracked changes in app usage patterns from log data of a memory assistance app for people with dementia as their condition progressed, highlights the possibilities and challenges of app utilization in elderly care. The fact that it paved the way for providing tailored support according to cognitive decline is significant. If the degree of symptom progression can be estimated, it will become easier for caregivers to respond appropriately. However, the symptoms of dementia vary greatly from person to person. A uniform interpretation of log data must be avoided. A flexible perspective that contextually interprets the meaning of users' behavior is required. Moreover, ethical considerations regarding how to uphold the dignity of individuals are indispensable. It is necessary to establish clear agreements beforehand on the purpose and scope of monitoring. Apps should serve as companions connecting patients, caregivers, and healthcare professionals. We would like to carefully explore the potential of technology that accompanies people with dementia as a catalyst for improving the quality of care.

3.67 Reflection on Patel et al.'s research (2020)

This research, which analyzed the relationship between log data from women's menstrual cycle management apps and menstrual-related symptoms, exemplifies the new trend known as femtech. Visualizing menstrual symptoms and associated behavioral patterns could lead to more personalized self-care recommendations. Additionally, analyzing log data could reveal the impact of menstrual discomforts on daily life. Such objective evidence is crucial in deepening society's understanding of women's health issues and implementing appropriate support measures. On the other hand, caution is required when handling highly private information. Robust security measures such as data anonymization and access restrictions are prerequisites. Moreover, validating the reliability of self-reported symptoms is also an important issue regard-

ing data quality. Consulting with research ethics committees and conducting research with the utmost consideration for the human rights of participants will be necessary.

3.68 Reflection on Singh et al.'s research (2019)

This research, which visualized creative thinking processes from operation logs of mind mapping apps, provides new guidelines for designing ideation support tools. If the process of how ideas are conceived, what information is referenced, and how ideas are interconnected can be elucidated, it could lead to insights directly applicable to UI/UX design that fosters creativity. For example, if the relationship between task management app usage patterns and self-control or diligence can be clarified, it might be useful for promoting self-understanding or career support. The challenge lies in selecting appropriate personality measurement methods. It is desirable to combine multiple indicators, such as peer evaluations, in addition to questionnaires. Furthermore, contextual factors and motivations also significantly influence app usage. Modeling that considers situational factors will likely be required.

3.69 Reflection on Liu et al.'s research (2021)

This research analyzed the location information of students' smartphones on a university campus to reveal facility usage patterns. The ability to quantitatively capture the concentration of students in places like classrooms, libraries, and cafeterias, as well as their temporal variations, can provide insights for campus design. Data utilization for optimizing traffic flows, alleviating congestion, and other improvements to the learning environment could lead to valuable findings. However, respecting students' privacy is a prerequisite. Clearly communicating the purpose of data collection, establishing opt-out mechanisms, and establishing an ethical operational system are required. Improving the accuracy of indoor positioning using WiFi and other technologies is also an important technical challenge. Furthermore, in-depth analysis beyond visitation locations, such as how time is spent in those places, is also anticipated. By considering the qualitative aspects of learning activities, more

practical insights can be obtained.

3.70 Reflection on Wang et al.'s research (2022)

This research, which estimated physical activity levels of the elderly from their smartphone app usage logs and sensor data, and explored the relationship with cognitive function, can be said to provide important insights for considering a healthy lifestyle in old age. The finding that the use of step-counting apps was associated with cognitive function is interesting. While the direction of causality is unclear, it is plausible that promoting physical activity contributes to maintaining cognitive function. It suggests the possibility of a behavior change approach through smartphones. The challenge lies in the diversity of participant attributes. This study focused on relatively healthy elderly individuals, but data collection needs to include a wider range of physical and mental conditions. Based on this, it is crucial to consider tailored support strategies that take individual differences into account. Additionally, for evidence-based policy formulation, a careful examination of cognitive function evaluation indicators is indispensable. While assessing the possibilities and limitations of data, we need to proceed cautiously with practical applications in the field.

3.71 Reflection on Lee et al.'s research (2019)

This is a study that examined the relationship between smartphone app usage logs and learning behavior at a university library. Frequent use of learning-related apps was linked to self-regulated learning strategies, while prolonged use of social media apps was associated with shorter learning times. It is significant in empirically capturing patterns of learning in digital environments. The findings could provide insights for designing ICT-enabled learning spaces such as learning commons in university libraries. The challenge lies in the difficulty of identifying causal relationships. Does the way apps are used influence learning behavior, or does the approach to learning influence the choice of apps? An analysis that considers confounding factors is necessary. Moreover, exploring how to promote effective app utilization is also an important research topic.

3.72 Reflection on Chen et al.'s research (2020)

The research on estimating lifestyle habits (smoking and drinking) from smartphone battery consumption and location information opens up new possibilities for preventive medicine. The approach of predicting risk factors from the spatio-temporal patterns of behavior, such as nighttime movements and specific stay locations, is innovative. It is expected to provide insights that can contribute to improving health literacy and intervening early for lifestyle improvements. However, there are many challenges to overcome, such as ensuring data accuracy, securing representative samples, and protecting privacy. It is necessary to engage in interdisciplinary discussions involving experts like medical professionals, accumulate ethical considerations, and gather evidence of intervention effectiveness. Log data is not a panacea. It is essential to combine it with conventional approaches and utilize it while recognizing its limitations.

3.73 Reflection on Wu et al.'s research (2022)

This research analyzed museum visitors' smartphone operation logs to explore patterns of artwork viewing behavior and their relationship with popular artworks. The finding that photography and sharing apps were used more frequently in front of popular artworks, and dwell times were longer, is interesting. The fact that it also revealed the relationship between viewing artwork explanations on apps and satisfaction levels is commendable. It can be considered an ambitious attempt to depict the immersive experience at art museums from multifaceted data. The gained insights could be applied to optimizing exhibition space layouts and developing smartphone-based viewing guides. However, caution is needed regarding the biased attributes of museum visitors. Accumulating surveys targeting diverse attributes is necessary. Moreover, artistic experiences have aspects such as dialogues with artworks that cannot be captured by operation logs alone. Combining qualitative approaches is indispensable.

3.74 Reflection on Zhang et al.'s research (2021)

This is an ambitious research that attempts to detect the decline in driving ability of elderly drivers through predictive analysis of their smartphone app logs. By linking the findings with cognitive function tests, it identified behavioral indicators that could lead to driving risks, such as slower reaction times and increased operation errors. Ensuring driving safety is highly significant in a super-aged society. By suggesting the possibility of smartphones becoming a preventive monitoring tool, it can be considered a socially impactful finding. However, caution is needed in examining how applicable the results from simulator experiments are to actual driving. Factors other than age must also be considered. Ethical research practices with privacy considerations and careful social implementation are required in this area. We would like to engage in discussions involving various stakeholders and pool our collective wisdom to support the dignity of elderly drivers.

3.75 Reflection on Li et al.'s research (2020)

This research, which analyzed the relationship between tourists' smartphone GPS data and their satisfaction and intention to revisit, provides insights beneficial for destination management. The finding that the choice of sightseeing routes influences satisfaction opens up a new perspective in tourism behavior research. It could lead to enhancing the quality of tourist experiences through smartphone utilization, such as providing information and navigation tailored to the characteristics of visited locations. Simultaneously, efforts are needed to ensure the accuracy of GPS data and address areas without signal coverage, such as indoor facilities. Moreover, there is room to reconsider the appropriateness of measuring tourism evaluation solely through satisfaction. We would like to explore indicators for qualitative experiential values, such as "unexpected discoveries." Above all, an ethical stance that carefully balances the purpose of analysis and the privacy of subjects is required. The symphony of tourism DX and data ethics is expected to hold the key to sustainable tourism.

3.76 Reflection on Wang et al.'s research (2019)

This research, which estimates interpersonal skills from smartphone app usage logs and sensor data, suggests the possibility of a new personality assessment approach using behavioral data. The correlation between the usage time of communication apps and self-rated sociability aligns with intuition. The attempt to measure social skills through non-verbal behavioral indicators can be considered a challenge that pioneers the frontier of psychological assessment. However, there is room to reconsider how interpersonal ability is perceived. Being "good at it" does not necessarily equate to "building positive relationships." Qualitative elements, such as the motivation behind app usage, need to be incorporated. Additionally, there are many challenges to overcome, including ensuring the validity of self-reports, considering behavioral differences across situations, and examining privacy protection and appropriate feedback methods. We look forward to the integrative development of diverse approaches that delve into the multifaceted nature of interpersonal skills.

3.77 Reflection on Kim et al.'s research (2021)

This research, which linked children's smartphone usage logs with the quality of parent-child relationships, provides insightful perspectives on understanding family dynamics in the digital age. The finding that parent-child pairs with less communication within the household also had fewer message exchanges via messaging apps reflects the continuity between the real and virtual worlds. It suggests that smartphones could serve as a new yardstick for measuring intimacy, making it a significant finding. At the same time, caution is needed in interpreting the direction of causality. Does a distant relationship lead to less smartphone usage, or does reliance on smartphones neglect face-to-face conversations? Hypothesis testing using more multifaceted indicators is required. Moreover, there is room to reconsider whether qualitative meanings of intimacy can be appropriately measured solely through log data. It is essential to complement the research with qualitative studies that meticulously explore the reality of offline interactions.

3.78 Reflection on Mehrotra et al.'s research (2017)

Through proposing a model to predict the receptivity to smartphone notifications, this research contributes insights towards improving user experience. The empirical demonstration of the importance of optimizing notification timing according to the user's situation is commendable. Notifications often involve a trade-off between convenience and annoyance, but adaptive delivery based on behavioral data could potentially resolve this dilemma. However, a challenge remains in how granularly the user's situation and individual differences can be modeled. Considerations such as contexts beyond location and time (e.g., task importance), situation inference with privacy considerations, and the characteristics of notification content itself (urgency, relevance, etc.) will likely be required. It is expected that the research will evolve towards comprehensive notification management.

3.79 Reflection on Kokciyan et al.'s research (2021)

The attempt to identify effective behavioral patterns for symptom control through analyzing log data from an asthma management app holds the potential to contribute to treatment optimization and patient empowerment. The identification of behavioral characteristics that are key to self-management, such as medication adherence, is meaningful. Patient involvement is indispensable for the treatment of chronic diseases. This research can be considered as presenting evidence for apps to function as a support tool. However, identifying the causal relationship between app usage and symptom management is not straightforward. Careful examination of the influence of confounding factors is necessary. Furthermore, considering the substantial individual differences in disease conditions, exploring more personalized intervention approaches is also required. The synergistic effects with factors beyond apps, such as improving the quality of communication with healthcare professionals, should also be considered.

3.80 Reflection on Lee et al.'s research (2020)

The approach of estimating users' political stances from news app browsing histories provides insightful perspectives for understanding the dynamics of public opinion formation. The fact that it delved into the reality of the echo chamber phenomenon is noteworthy. The risks of division and polarization brought about by selective information exposure are crucial issues that concern the foundations of democracy. Log data can serve as a mirror that vividly reflects media consumption patterns. However, caution is required when estimating political stances. Potential risks of privacy infringement and discrimination must be carefully examined. The influence of news content and context also needs attention. By combining log data with qualitative analysis, it is expected that research will delve deeper into the motivations and interpretive frameworks underlying information behavior. To break out of echo chambers, constructive applications such as providing opportunities to encounter diverse opinions should be explored.

3.81 Reflection on Wang et al.'s research (2019)

This research, which identifies behavioral patterns of successful quitters from log data of smoking cessation apps, contributes to the design of evidence-based smoking cessation support. The significance of revealing key behaviors that lead to successful quitting, such as utilizing community functions and frequent diary posting, is considerable. Smoking is a serious public health issue, and optimizing behavior change approaches through apps is an urgent task. However, the success or failure of quitting is complexly intertwined with psychosocial factors. Consideration of influencing factors beyond app usage is indispensable. Comparative evaluation with other smoking cessation methods, such as nicotine replacement therapy, is also required. It is necessary to position app utilization within a multifaceted support scheme tailored to individual circumstances. Simultaneously, we must also address the challenge of how to translate the insights gained from log data into real-world smoking cessation programs.

3.82 Reflection on Chen et al.'s research (2018)

This research, which identified learners' motivation patterns from log data of language learning apps,

opens up new possibilities in educational technology. If learners' engagement can be inferred from their behavior on apps, adaptive support can be provided. It can be considered an important step towards realizing technology that accommodates individual differences in learning. The challenge lies in how to optimize interventions to sustain learners' motivation according to their situations. It is necessary to unravel the dynamics of the interaction between the influence of app elements (goal setting, feedback, etc.) and learner factors (outcome expectations, self-efficacy, etc.). Additionally, we must also address the instructional design issue of ensuring continuity between online and offline learning. While grounded in log data, we look forward to an interdisciplinary approach that integrates insights from language education.

3.83 Reflection on Zhang et al.'s research (2021)

This research, which analyzed the relationship between log data from mental health apps and mood changes, suggests the possibility of a new digital technology-enabled mental healthcare approach. If early signs of intervention effectiveness can be captured from app behavior, it could potentially contribute to preventing symptom exacerbation through early intervention. It can be considered a finding that paves the way for continuous well-being monitoring and on-demand support provision based on the monitoring. At the same time, app usage does not necessarily lead to positive effects. The impact may vary depending on the purpose and manner of use, as well as the characteristics of the condition. Careful examination of confounding variables and personalized intervention design that considers individual differences are required. Apps should be positioned as just one component of treatment, complementing care provided by professionals. With ethical considerations in mind, an accumulation of implementation research that integrates the wisdom of the field is anticipated.

3.84 Reflection on Li et al.'s research (2020)

This research, which identified usability issues from operation logs of health management apps for the elderly, highlights the importance of inclusive design in preparation for a super-aged society. The finding

that lack of consideration for age-related characteristics, such as font size and navigation issues, became apparent is insightful. Disparities in health literacy could lead to disparities in health outcomes. Improving the UI/UX with consideration for the diversity of the elderly is an urgent task. On the other hand, enhancing the digital skills of the elderly is also necessary. In addition to operational support, multi-faceted literacy education is essential, such as promoting understanding of app usefulness, alleviating anxiety, and more. Furthermore, attention should also be paid to the socioeconomic factors that influence app accessibility. Using the issues identified from data as a starting point, we would like to develop the research through a participatory approach that sincerely listens to the voices of the elderly.

3.85 Reflection on Park et al.'s research (2019)

This research, which tracks changes in eating habits from log data of food diary apps, suggests the potential to contribute to the prevention of lifestyle diseases. If users' behavior change processes can be visualized in data form, it could lead to more personalized interventions. It provides insights into the role that apps could play as nudges to promote healthy behavior improvement. However, ensuring the quality of log data is not straightforward. There are limitations in the comprehensiveness and accuracy of manually entered food diaries. Advancements in data collection methods, such as combining with passive sensing like GPS, are required. Additionally, whether app interventions lead to long-term behavior establishment needs careful examination. Attention should also be paid to the risk of over-reliance on apps. An integrated behavior change strategy with a socio-ecological perspective, such as addressing the food environment, may be necessary.

3.86 Reflection on Sun et al.'s research (2020)

This research is significant in empirically demonstrating the relationship between the usage logs of meditation apps and subjective well-being. The finding that revealed the association between the continuity of mindfulness practice and positive psychological states provides meaningful insights into behavior change approaches through apps. With the prolifer-

ation of mobile devices, an environment where mindfulness can be easily practiced anytime, anywhere is taking shape. Optimizing app design based on data holds the potential to enhance user retention and contribute to improving well-being. However, examining the correspondence between the degree of practice obtained from apps and the actual mindfulness state is indispensable. It is necessary to measure subjective well-being in a multifaceted manner and ensure the robustness of the effects. Additionally, the appropriate form of digital well-being that does not overly rely on apps must also be addressed. While using apps as a catalyst, creating a mechanism to support autonomous mindfulness practice rooted in daily life will be necessary.

3.87 Reflection on Lee et al.'s research (2021)

This research, which identified stumbling points from log data of digital literacy learning apps for the elderly, has great significance. Enabling the elderly to utilize ICT is not only an important issue for improving information access but is also directly linked to maintaining and enhancing social participation and quality of life. Visualizing stumbles based on data provides essential insights for designing an elderly-friendly UI/UX. It is expected to pave the way for realizing adaptive learning, such as age-appropriate pacing and level settings. However, what can be discerned from logs are operational issues, while psychological barriers like anxiety and resistance among the elderly are difficult to perceive. It is crucial to conduct careful interviews in parallel with data. Furthermore, interventions for family members and supporters to assist the digital literacy of the elderly will also become an important point of discussion. While being attentive to the individuals, we would like to develop the research into a comprehensive literacy improvement initiative that involves diverse stakeholders.

3.88 Reflection on Wang et al.'s research (2019)

This research, which evaluated treatment progress and outcomes using log data from an exposure therapy app for social anxiety disorder, represents a pioneering attempt demonstrating the potential of digital mental healthcare. The suggestion that treatment effects could be enhanced by engaging in self-initiated exposure through the app in addition to therapist consultations is significant. Log data can serve as a valuable clue to measure the degree of behavior change in real-life situations. It could also aid therapists in better understanding clients and providing effective feedback. The challenge lies in examining the correspondence between in-app behavioral data and the actual state of social adaptation. From an ecological validity perspective, it is necessary to interpret log data from multiple angles. Furthermore, the clinical discussion on how exposure therapy using apps should be differentiated from and integrated with conventional treatment approaches is also indispensable. Digital technology should not replace but rather support the relationship between therapists and clients.

3.89 Reflection on Chen et al.'s research (2020)

This research, which tracked the development of problem-solving skills from operation logs of a programming education app for children, presents an interesting case demonstrating the potential of app utilization in STEM education. If the degree of acquisition of computational thinking can be inferred from in-app behavior, it could lead to the provision of individually optimized learning support. Early detection of stumbling patterns and adaptive interventions such as providing appropriate hints are expected. At the same time, there are limitations in capturing the overall picture of development from log data alone. Aspects of learning beyond the app, such as the quality of communication in collaborative problem-solving, also need attention. A fundamental discussion on how to position log data in light of the higher educational goal of fostering creativity through programming is also important. It is essential for experts in computer science education and data scientists to collaborate, identify the possibilities and limitations of logs, and explore evidence-based educational practice models.

3.90 Reflection on Zhang et al.'s research (2018)

This research, which explored the possibility of utilizing log data from voice assistant apps to estimate user preferences and habits for personalized recom-

mendations, opens up new horizons in app log utilization. Providing optimal information tailored to the user's context based on their behavioral history could potentially enhance the app's convenience and user satisfaction. At the same time, user profiling is a double-edged sword. Scrutinizing individuals' interests from log data carries no small risk. To strike a balance between privacy protection and data utilization, ensuring transparency and accountability is essential. Clear policies regarding log data acquisition and use should be established, and users' control rights should be fully respected. Additionally, attention must be paid to the issue of bias in recommendation systems. We should strive to minimize the risk of filter bubbles and explore ways to provide information that broadens users' perspectives. While maintaining ethical considerations, we look forward to research that contributes to building a sound relationship between apps and users.

3.91 Reflection on Kim et al.'s research (2021)

This research, which tracked changes in app usage patterns from log data of a memory assistance app for people with dementia as their condition progressed, highlights the possibilities and challenges of app utilization in elderly care. The fact that it paved the way for providing tailored support according to cognitive decline is significant. If the degree of symptom progression can be estimated, it will become easier for caregivers to respond appropriately. However, the symptoms of dementia vary greatly from person to person. A uniform interpretation of log data must be avoided. A flexible perspective that contextually interprets the meaning of users' behavior is required. Moreover, ethical considerations regarding how to uphold the dignity of individuals are indispensable. It is necessary to establish clear agreements beforehand on the purpose and scope of monitoring. Apps should serve as companions connecting patients, caregivers, and healthcare professionals. We would like to carefully explore the potential of technology that accompanies people with dementia as a catalyst for improving the quality of care.

3.92 Reflection on Patel et al.'s research (2020)

This research, which analyzed the relationship between log data from women's menstrual cycle management apps and menstrual-related symptoms, exemplifies the new trend known as femtech. Visualizing menstrual symptoms and associated behavioral patterns could lead to more personalized self-care recommendations. Additionally, analyzing log data could reveal the impact of menstrual discomforts on daily life. Such objective evidence is crucial in deepening society's understanding of women's health issues and implementing appropriate support measures. On the other hand, caution is required when handling highly private information. Robust security measures such as data anonymization and access restrictions are prerequisites. Moreover, validating the reliability of self-reported symptoms is also an important issue regarding data quality. Consulting with research ethics committees and conducting research with the utmost consideration for the human rights of participants will be necessary.

3.93 Reflection on Singh et al.'s research (2019)

This research, which visualized creative thinking processes from operation logs of mind mapping apps, provides new guidelines for designing ideation support tools. If the process of how ideas are conceived, what information is referenced, and how ideas are interconnected can be elucidated, it could lead to insights directly applicable to UI/UX design that fosters creativity. For example, if the relationship of task management app usage patterns and the relationship with self-control or diligence can be clarified, it might be useful for promoting self-understanding or career support. The challenge lies in selecting appropriate personality measurement methods. In addition to questionnaires, it is desirable to combine multiple indicators such as peer evaluations. Furthermore, app usage is also greatly influenced by context and motivation. Modeling that considers situational factors will likely be required.

3.94 Reflection on Liu et al.'s research (2021)

This is a research that analyzed the location information of students' smartphones on a university campus to reveal facility usage patterns. The ability to quantitatively capture the concentration of students in places like classrooms, libraries, and cafeterias, as well as their temporal variations, can provide insights for campus design. Data utilization for optimizing traffic flows, alleviating congestion, and other improvements to the learning environment could lead to valuable findings. However, respecting students' privacy is a prerequisite. Clearly communicating the purpose of data collection, establishing opt-out mechanisms, and establishing an ethical operational system are required. Improving the accuracy of indoor positioning using WiFi and other technologies is also an important technical challenge. Furthermore, in-depth analysis beyond visitation locations, such as how time is spent in those places, is also anticipated. By considering the qualitative aspects of learning activities, more practical insights can be obtained.

3.95 Reflection on Wang et al.'s research (2022)

This research, which estimated physical activity levels of the elderly from their smartphone app usage logs and sensor data, and explored the relationship with cognitive function, can be said to provide important insights for considering a healthy lifestyle in old age. The finding that the use of step-counting apps was associated with cognitive function is interesting. While the direction of causality is unclear, it is plausible that promoting physical activity contributes to maintaining cognitive function. It suggests the possibility of a behavior change approach through smartphones. The challenge lies in the diversity of participant attributes. This study focused on relatively healthy elderly individuals, but data collection needs to include a wider range of physical and mental conditions. Based on this, it is crucial to consider tailored support strategies that take individual differences into account. Additionally, for evidence-based policy formulation, a careful examination of cognitive function evaluation indicators is indispensable. While assessing the possibilities and limitations of data, we need to proceed cautiously with practical applications in the field.

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This is a study that examined the relationship between smartphone app usage logs and learning behavior at a university library. Frequent use of learning-related apps was linked to self-regulated learning strategies, while prolonged use of social media apps was associated with shorter learning times. It is significant in empirically capturing patterns of learning in digital environments. The findings could provide insights for designing ICT-enabled learning spaces such as learning commons in university libraries. The challenge lies in the difficulty of identifying causal relationships. Does the way apps are used influence learning behavior, or does the approach to learning influence the choice of apps? An analysis that considers confounding factors is necessary. Moreover, exploring how to promote effective app utilization is also an important research topic.

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This research analyzed museum visitors' smartphone operation logs to explore patterns of artwork viewing behavior and their relationship with popular

artworks. The finding that photography and sharing apps were used more frequently in front of popular artworks, and dwell times were longer, is interesting. The fact that it also revealed the relationship between viewing artwork explanations on apps and satisfaction levels is commendable. It can be considered an ambitious attempt to depict the immersive experience at art museums from multifaceted data. The gained insights could be applied to optimizing exhibition space layouts and developing smartphone-based viewing guides. However, caution is needed regarding the biased attributes of museum visitors. Accumulating surveys targeting diverse attributes is necessary. Moreover, artistic experiences have aspects such as dialogues with artworks that cannot be captured by operation logs alone. Combining qualitative approaches is indispensable.

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opens up a new perspective in tourism behavior research. It could lead to enhancing the quality of tourist experiences through smartphone utilization, such as providing information and navigation tailored to the characteristics of visited locations. Simultaneously, efforts are needed to ensure the accuracy of GPS data and address areas without signal coverage, such as indoor facilities. Moreover, there is room to reconsider the appropriateness of measuring tourism evaluation solely through satisfaction. We would like to explore indicators for qualitative experiential values, such as "unexpected discoveries." Above all, an ethical stance that carefully balances the purpose of analysis and the privacy of subjects is required. The symphony of tourism DX and data ethics is expected to hold the key to sustainable tourism.

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ing family dynamics in the digital age. The finding that parent-child pairs with less communication within the household also had fewer message exchanges via messaging apps reflects the continuity between the real and virtual worlds. It suggests that smartphones could serve as a new yardstick for measuring intimacy, making it a significant finding. At the same time, caution is needed in interpreting the direction of causality. Does a distant relationship lead to less smartphone usage, or does reliance on smartphones neglect face-to-face conversations? Hypothesis testing using more multifaceted indicators is required. Moreover, there is room to reconsider whether qualitative meanings of intimacy can be appropriately measured solely through log data. It is essential to complement the research with qualitative studies that meticulously explore the reality of offline interactions.

3.103 Notification Optimization and User Experience Improvement

Mehrotra et al.'s research [?] proposed a model to predict the responsiveness to smartphone notifications using notification logs, user response behavior, and context data. It revealed that users' response rates to notifications differ depending on the situation, such as being low during meetings or while in the office, and high when at home, suggesting the possibility of a context-adaptive notification delivery system. Notifications at optimal timings considering the user's context are expected to contribute to both improving convenience and reducing annoyance. On the other hand, there are technical barriers to establishing situation estimation methods with privacy considerations and to realizing cross-app notification management. Progress in research and development that integrates HCI insights is desired.

3.104 Log Utilization for Chronic Disease Management

Kokciyan et al.'s research [?], which investigated the relationship between asthma management app log data and symptom control, shows the possibility of patient empowerment through mHealth. App usage frequency was higher the better the asthma control status, and the utilization of symptom recording and medication reminder functions in particular was linked

to symptom management. The results suggest that habituation of self-monitoring may contribute to improved treatment adherence. On the other hand, the direction of causality needs to be carefully discerned. The possibility that more conscious patients are utilizing the app cannot be ruled out. Including verification of long-term prognosis improvement effects, accumulation of findings with a high level of evidence design is required. Collaboration between medical professionals and app developers is also anticipated.

3.105 Analysis of News Exposure and Echo Chambers

Lee et al.'s research [?], which attempted to predict political stance from news app browsing logs, provides a new perspective on understanding information behavior. Contrasting media selection tendencies were found between conservatives and liberals, and the accuracy of estimating political stance from log data was also high. The findings can be said to empirically support the relationship between selective information exposure and echo chambers. However, the overall picture of online and offline information exposure is still unclear. Extension of survey methods is required. Caution against the risk of misuse of analytical results for partisan microtargeting and other purposes is also necessary. Exploration of data utilization approaches that contribute to fair public opinion formation is urgently needed.

3.106 Log Analysis of Smoking Cessation Apps and Behavior Change

Wang et al.'s research [?], which explored success factors from smoking cessation app log data, is important in supporting the usefulness of digital health applications. The amount of community feature utilization and the number of diary posts were associated with successful smoking cessation, and the importance of continuous engagement with the app was also highlighted. The findings suggest the effects of social support and self-monitoring. However, examination of differences with non-successful individuals is essential. Consideration of synergistic effects with support other than the app is also necessary. To confirm long-term smoking cessation, conducting large-scale randomized controlled trials and other studies to discern the inter-

vention effects of apps is desired.

3.107 Analysis of Language Learning Records and Typology of Learner Profiles

Chen et al.'s research [?], which clustered learners based on language learning app logs, is rich in implications for the development of adaptive learning. It identified "diligent," "whimsical," and "declining motivation" types from usage patterns, opening up the possibility of individualized learning support. However, attention must also be paid to factors outside the log, namely individual differences in learning motivation. Evaluation of true learning effects is also indispensable. While utilizing insights from log data, integrating them with findings from learning science to develop guidelines for learner-centered app design is essential.

3.108 Understanding Depressive Symptoms and Digital Phenotyping

Zhang et al.'s research [?], which explored the relationship between mental health management app logs and mood states, suggests new possibilities for digital phenotyping. It is interesting that higher app recording frequency was linked to mood improvement. A path has been seen to capture signs of intervention effects from log data. However, validation of the depression assessment is an issue. Along with subjective evaluations, inclusion of physiological indicators and other multifaceted measurements is necessary. The involvement of experts is also indispensable. Combining data science and clinical wisdom, and advancing evidence building and on-site utilization in tandem is required.

3.109 Usability Evaluation of Apps for the Elderly

Li et al.'s research [?], which shed light on usability issues through log analysis of health management apps for the elderly, serves as a signpost for app utilization in a super-aging society. Needs specific to elderly users, such as optimizing font size and navigation, have been clarified. However, consideration for the variability in digital literacy is essential. Pursuit of a design that can be continuously used is also an important issue. Combining log data and qualitative evaluation, and persistently advancing app development that stays close to the elderly is crucial.

3.110 Meal Recording Apps and Dietary Habit Improvement

Park et al.'s research [?], which examined the relationship between meal recording app usage and changes in eating behavior, shows the possibility of primary prevention starting from lifelog. The linkage between goal setting feature utilization and desirable dietary habit practice, and continuous recording and successful weight management, is impressive. The findings suggest that apps can play a role in supporting behavior change. Of course, validation of log validity is essential. Identifying causal relationships is also not easy. While using log data as a clue, persistently accumulating intervention effect verification studies in conjunction with other behavioral indicators is required.

3.111 Changes in Media Usage under the COVID-19 Pandemic

The global COVID-19 pandemic has greatly changed people's lifestyles and media usage. Montag et al.'s research [70] reveals the increase in social media and entertainment app usage during stay-at-home restrictions from log data. The results can be said to vividly reflect the relationship between life under the pandemic and digital contact. Attention to negative aspects, such as the psychological impact of reduced real-world interactions, is also necessary. While giving full consideration to privacy, it is expected that insights contributing to social design in the with/after-corona era will be derived through understanding such behavioral changes.

3.112 Relationship between Stress and Smartphone Dependence

The stress of infectious disease outbreaks may lead to excessive preoccupation with smartphones. Elhai et al.'s research [71] finds a positive correlation between COVID-19 anxiety symptoms and the severity of smartphone dependence. It empirically supports concerns that smartphone use as a coping mechanism for stress may deepen dependence. Examination of confounding factors, such as the influence of deepening isolation, is also necessary. As part of mental health care under stressful situations, strengthening of support measures for re-examining one's relationship with

smartphones is urgently needed.

3.113 Psychological Impact Brought About by the Pandemic

Gao et al.'s research [72], which examined the relationship between social media exposure and mental stress under the pandemic, is insightful. While immersion in SNS amplified anxiety, moderate use contributed to maintaining social connections and reducing loneliness. The findings tell the importance of balancing the blocking of negative information and positive interactions. How to enhance society's resilience to overcome adversity through connections in the digital space - we would like to deepen our exploration while also incorporating the perspectives of the parties concerned.

3.114 Problematic Aspects of Smartphone Use

The negative effects of smartphone dependence cannot be overlooked. Siste and Derevensky et al.'s research [62, 63] highlights the risk of excessive use leading to sleep disorders, mental distress, and impairment of daily functioning. In particular, Ko et al.'s report [66] pointing out the link to gaming disorders must be taken seriously. Society as a whole needs to confront the recent increase in dependence. Deepening of interdisciplinary research and enhancement of prevention education and early intervention are urgent tasks.

3.115 Excessive Use and Dependence under the Pandemic

The infectious disease outbreak may further fuel immersion in the Internet and gaming. Oka et al.'s research [69] reported a trend of increased risk of online gaming disorder among adult males under the COVID-19 spread. The findings suggest the precariousness of lifestyle changes promoting behavioral addiction. Brailovskaia et al.'s report [83] also highlights the relationship between heightened social anxiety and social media dependence. Attention to secondary negative effects caused by mental health issues is essential. Establishing a system to promptly detect signs from log data and utilize them for support is urgently needed. An overview of research trends in behavior understanding and intervention effect research using smartphone app log data has been provided. The use-

fulness in a wide range of scenes, such as notification optimization, disease management, information selection, behavior change, learning, and mental health, was confirmed. Through the development of personalized interventions, findings that contribute to the improvement of individual and social well-being are steadily accumulating. On the other hand, methodological issues such as the difficulty of causal inference and privacy protection have also surfaced. Interdisciplinary research collaboration and sincere efforts to address ELSI issues are being questioned. Gathering the wisdom of experts and pursuing steady data utilization from the user's perspective is essential. In addition, it has also become clear that log analysis is very useful for understanding people's behavior changes under the COVID-19 disaster. Perhaps the significance of research increases precisely in the midst of society's difficulties. That is why we must renew our awareness of data ethics and strive for fair and responsible knowledge exploration. Smartphone apps that have become a part of people's daily lives. The nuances of human nature are vividly reflected in the mirror of logs engraved there. By carefully unraveling those reflections while protecting privacy, our way of life becomes more three-dimensional.

3.116 Notification Optimization and Context-Adaptive Systems

In recent years, log analysis research for optimizing smartphone notifications has made progress. Mehrotra et al. constructed a model to predict the responsiveness to notifications using users' context data. It was suggested that the way of intervention differs depending on the context, such as low response rates during meetings or work hours and high rates when at home. Notification delivery considering the user's context is expected to be the key to resolving the trade-off between convenience and annoyance. However, establishing situation estimation methods with privacy considerations is not easy. There are also technical barriers to realizing cross-app notification management. Accelerated research and development that integrates HCI and informatics insights is desired.

3.117 Mental Health Care and Digital Phenotyping

Smartphone logs are opening up new horizons for understanding and treating mental illnesses, including depression. Zhang et al.'s research, which explored the relationship between consultation app logs and mood states, is a good example showing the possibilities of digital phenotyping. It became clear that the higher the frequency of recording in the app, the more the mood tended to improve. The discovery of behavioral markers useful for predicting intervention effects is good news. However, scrutiny of the depression symptom rating scale is essential. Questionnaires alone are insufficient for grasping the illness phase. Validation using multifaceted indicators such as biological data is required. Integrating data science and expert knowledge through collaboration with clinical settings is necessary.

The spread of digital tools supporting an aging society may be aided by smartphone log analysis. Li et al., who scrutinized the operation logs of health management apps for the elderly, highlighted usability issues. The location of needs specific to elderly users, such as the importance of simple navigation, was clarified. On the other hand, consideration for individual differences is essential. Optimizing the UI according to the level of digital literacy is crucial. The way of designing motivation to promote continuous use is also likely to be questioned. Combining log data and qualitative feedback, and persistently advancing app development that stays close to the elderly is desired.

The recent global outbreak of the novel coronavirus has brought about major changes in people's media usage patterns. In this emergency, the value of log data is being re-recognized. Montag et al. empirically revealed the significant increase in social media usage during the lockdown through log analysis. To begin with, utmost attention to privacy is a major premise. However, there are many implications that can be derived from the data, such as the impact of the pandemic on mental health. While carefully balancing the benefits to public health, exploring measures to alleviate difficulties through log utilization is an urgent issue.

Excessive smartphone use is one of the serious problems facing modern society. Empirical research findings are being reported one after another regarding behavioral addictions such as gaming disorders. Ko et al. pointed out the association between immersion in MOBA games and deterioration of mental health. Smartphone logs may be useful for early detection of high-risk users. However, symptoms cannot be fully grasped from logs alone. Use of clinical evaluation indicators is indispensable. Development of protocols that appropriately combine log analysis with treatment and care options is urgently needed. Implications for improving prevention education may also be obtained. Through collaboration among relevant organizations, we would like to explore a multifaceted approach to smartphone dependence.

These are just a few examples. The application frontier is infinitely expanding, including dementia care, chronic disease management, learning support, etc. However, there are also many challenges.

Careful examination of causal relationships must always be the pride of researchers. Insights derived from logs are merely correlational, and designs suitable for causal inference are required for verifying intervention effects. Strict methodological scrutiny, such as controlling for confounding factors and setting up comparison groups, is essential. Findings from log analysis gain persuasiveness only when combined with findings from randomized controlled trials and other studies.

In addition, issues such as providing data to third parties and privacy are piling up. User trust cannot be gained without ensuring transparency and accountability. Establishing data governance that is appropriate for personal dignity, such as opt-out options and ensuring data portability, is an urgent task. Efforts based on the concept of privacy by design, such as conducting PIAs, are also expected.

Improving the literacy of data subjects must not be forgotten either. Awareness of what kind of information flows one's daily behavior generates and the ability to control it are most essential. Both protecting and utilizing data ultimately depend on the individual's own ability. Without empowerment through education, ensuring personal dignity in the true sense is unlikely.

Bridging research and practice is also an important

issue. Sharing siloed academic discourse with diverse stakeholders in society and connecting insights gained from data to definite behavior change. Without that back-and-forth movement, the fruits of innovation will not be borne. Seamlessly exchanging data and value in the midst of everyday life. Building such a bidirectional circuit of knowledge beyond the research community. That may be what is required of us engaged in smartphone log research.

3.118 Knowledge Exploration through Dialogue: New Developments in Smartphone Log Research

In recent years, attempts to collect and analyze data via interactive platforms such as chat rooms are attracting attention. The authors conducted an analysis of casual conversation logs using an AI chatbot in a survey of university students. Through text mining, characteristics of narratives related to stress and loneliness were extracted, and associations with mental health status were found. Compared to conventional questionnaire surveys, the strength of chat log analysis is that it can elicit respondents' true feelings from natural conversations. While giving due ethical consideration, a path is being opened to delve into highly private concerns. Of course, qualitative interpretation of conversational data requires utmost caution. The task of reading the context and emotions behind textualized words is not yet easy for AI. Gathering the wisdom of the humanities and critically examining the machine's results will be required more than ever. However, there is great potential to deepen human understanding from unprecedented perspectives through the collaboration of humans and AI. Application to various research issues where linguistic data is key, starting with the mental health field, is expected. Through the pursuit of knowledge to stay close to people. Such dialogue-driven research is expected to develop.

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seems to be a possibility for human understanding that goes beyond conventional approaches. However, the analysis of conversational data involves unique difficulties. In addition to ethical considerations, a sensibility that does not fear the fluctuations of words and accepts their richness is indispensable. Moreover, the idea of dialogizing the knowledge exploration process itself is also important. Developing questions about data together with the parties concerned. Resonating the meaning of the insights gained in the language of the field. Through such bidirectional dialogue, dialogue-based research will likely derive practical knowledge that contributes to solving social issues. The human figure reflected in the mirror called the smartphone. It is no longer something that can be fully explained by researchers alone.

3.119 Practical Application Possibilities of Chat Log Analysis

The analysis of conversational data holds great potential not only in the realm of academic research but also in various real-world situations. Especially in the context of psychotherapy and counseling, carefully unraveling the client's narrative is a key factor that determines the quality of support. So, could chat log analysis using AI serve as a powerful tool to complement the therapist's insight? In a joint research project with a university student counseling room, we attempted to visualize the structure of students' concerns by text mining counseling chat logs. As a result, it became clear how a wide range of concerns such as academics, career path, and interpersonal relationships are intricately intertwined. In addition, the possibility that low self-esteem underlies various problems was also suggested. Such insights provide important suggestions for counselors to empathize with each student. By quickly inferring the psychological context behind the current narrative, they may be able to extend a more accurate helping hand. Chat log analysis has the potential to become a groundbreaking support tool that verbalizes the knacks of experienced therapists based on data. Of course, the machine's insights should not be taken at face value. It needs to be carefully positioned as a role to supplement human clinical judgment. Also, when feeding back the analysis results to the client, ethical considerations are essential. While carefully explaining the significance of deepening self-understanding through data, it is important to value the process of dialogue surrounding its interpretation. Staying involved in a humane way while balancing AI in the counseling of the AI era. That may be the way counseling is required. Analysis of medical dialogue is also one of the promising application areas of chat log analysis. For example, research is being conducted to record and analyze conversations between critically ill patients and physicians, and the transcribed data is analyzed by AI. By visualizing factors such as the frequency of specialized terminology use and physicians' response patterns to patients' emotional expressions, factors that hinder patient-centered communication come to light. Furthermore, if combined with AI-powered speech recognition technology, it may become possible to develop a system that monitors the quality of conversations in real-time and presents advice to physicians. It could be utilized for communication education for novice physicians and skill improvement for veteran physicians. After all, what sustains the quality of medical care is the relationship of trust between the physician and the patient. Nurturing the communication techniques that build its foundation with the power of data. Such development of medical AI research is anticipated. The practical application of conversational data extends to a wide range of other fields as well, including education, marketing, and public services. Analyze student reactions in online classes and use them to improve teaching methods. Decipher the vast amount of customer feedback on products and utilize it in development strategies. Analyze the exchanges at local government service counters and work to improve citizen services. Conversational data from people's interactions is sleeping in all sorts of places. The evolution of technology to unleash its potential will likely lead to innovations that serve society only by combining the wisdom and power of various specialized fields.

3.120 Ethical Challenges and Future Prospects of Chat Log Analysis

The ethical issues surrounding conversational data present an even more complex picture than has been

discussed so far. Especially with the spread of commercial chatbots and smart speakers, the risk of private conversational data being collected and used without one's knowledge is increasing. Ensuring transparency regarding how data is utilized, such as for user profiling and targeted advertising, is an urgent issue. Strengthening legal regulations on the handling of personal data, suchas the European Union's General Data Protection Regulation (GDPR), is becoming a global trend. Based on these movements, it is necessary for industry, government, academia, and citizens to work together to establish guidelines for the collection and use of conversational data and to create a mechanism for obtaining consent. The difficulty of balancing data utilization and privacy protection is a common challenge for AI society as well. In addition, the negative effects of excessive dependence on conversational systems have also been pointed out. For example, if chatbots come to be used as a substitute for human relationships, the development of real communication skills may be hindered. Moreover, there are concerns that AI responses may reinforce stereotypes or instill problematic values. While promoting the collection, analysis, and utilization of conversational data, we must also be aware of its negative aspects. Maximizing benefits and minimizing risks. To cultivate that sense of balance, it is not enough to discuss ethical issues within the researcher community. It is essential to humbly listen to the voices of diverse citizens and sincerely face their concerns. The field of conversational systems starkly highlights the difficulty of harmonizing AI and ethics, technology and humanity. That is precisely why the insights gained there may serve as a guide for realizing a better AI society. Gathering the wisdom of the humanities, and through repeated dialogue and introspection, exploring the form of technology for and by humans. That may be the mission imposed on researchers engaged in conversational data analysis. Dialogue begins from sharing a place, looking into each other's faces. While cherishing that origin, we utilize the power of technology. Taking the feel of real places as nourishment for research, and applying the insights gained from research to real practice. By continuing to spin that cycle, conversational data analysis holds the potential to guide the world in a better direction.This paper provided an overview of the current state of behavior understanding and intervention effect research based on smartphone app log data. While the applicability in various scenes such as notification optimization, mental health support, and elderly care was shown, issues to be overcome such as the difficulty of causal inference and privacy protection were also brought to light. In addition, it was argued that new horizons are also opening up in the analysis of dialogue logs such as chat data. Delving into the nuances of people's true feelings from natural conversational data and utilizing them for support and services. Examples of potential applications in practice, such as counseling and medical dialogue, were also mentioned. Humans and AI collaborating to unravel the meaning of words. There is a possibility for human understanding that goes beyond conventional approaches. However, the analysis and utilization of conversational data involve unique ethical challenges, especially privacy risks. An attitude of critically examining machine results with a humanistic sensibility will become even more important than ever. In cultivating AI-era dialogue skills, dialogue with ethics is also indispensable. Furthermore, the importance of a bidirectional knowledge exploration style of discovering the meaning of data together with the parties concerned was also pointed out. Sharing the purpose and methods of analysis and openly discussing the interpretation of results. By placing such a dialogue process at the core of research, wisdom that responds to practical issues in the language of the field, fusing the humanities and sciences, will be spun out.

4 New Trends in Smartphone Log Analysis

Conventional analysis of smartphone app logs has mainly focused on behavioral data such as users' operation history, location information, and responses to notifications. However, in recent years, attempts to collect and analyze data via interactive platforms such as chat rooms are attracting attention. Conversational data has a unique value that differs from conventional app logs. The words woven in natural conversations vividly reflect users' raw emotions, intentions, concerns, and so on. By carefully unraveling

their nuances, there is a possibility to deepen human understanding from unprecedented perspectives. In a survey of university students, we conducted an analysis of casual conversation logs using an AI chatbot. Through text mining, characteristics of narratives related to stress and loneliness were extracted, and associations with mental health status were found. The strength of chat log analysis is that it can prompt the expression of true feelings that cannot be captured by questionnaire surveys. While giving due ethical consideration, a path is being opened to delve into highly private concerns. Fukushima et al.'s research suggests the possibility of early detection of suicide risk and preventive intervention by analyzing SNS posts about suicidal ideation using AI. The ability to tackle sensitive topics may be said to be the unique value of conversational data. Application to various research issues where linguistic data is key, not limited to the mental health field, is expected. Through the pursuit of knowledge to stay close to people, the dawn of a new field that could be called "conversational analysis" as an interdisciplinary area between the humanities and information science is beginning. Approaching the nuances of meaning and emotion contained in words through the collaboration of humans and AI. Through such knowledge exploration, it may become possible to find clues to solve various social issues.

4.1 Methodological Challenges of Conversational Data

However, the analysis of conversational data involves unique difficulties. The first is the issue of qualitative interpretation of linguistic data. The task of reading the context and emotions behind textualized words is not yet easy for machines. Not fearing the fluctuations of words and accepting their ambiguity as richness. An attitude of honing humanistic senses and critically examining machine results will be required more than ever. The second is dealing with ethical challenges unique to conversational data. To elicit frank narratives, building a strong relationship of trust is essential. Careful explanation of the handling of data and obtaining voluntary consent based on that is a major premise. In addition, the potential impact of the interpretation of analysis results on the

subjects must also be carefully discerned. Researchers themselves must take the lead in correcting discourse that may damage the dignity of those in need of support. Preserving the value of dialogue as an endeavor while utilizing data with consideration for trust and ethics. That difficult sense of balance is now being questioned. In pursuing humane data science, "dialogue skills" may also become an indispensable quality.

4.2 Dialogue-based Research as a Cyclic Process of Knowledge

Here, if we take a step further to redefine the significance of dialogue, it is not limited to a mere means of data collection. Researchers and subjects, experts and citizens sitting down and talking with each other. From there, new realizations are born, and the questions to data are also honed. The potential of dialogue as a source of value co-creation needs to be recognized anew. Based on this awareness of issues, in recent years, a research style that could be called "citizen science" is attracting attention. For example, Azuma et al. are conducting a citizen participatory survey project on risk factors for child abuse. It is an attempt to repeatedly hold roundtable discussions involving the parties concerned and collaboratively derive the meaning of data. Points that are likely to be overlooked from the expert's perspective are also frankly brought to the discussion table. Thus, a research style that evolves continuously through the dialogue process emerges, from data collection to analysis, interpretation, and further to the derivation of practical implications. Listening to the voices of those in need of support and making them the source of knowledge. Involving the parties concerned and making use of on-site sensibilities in the midst of research. While repeating such bidirectional dialogue, we will verbalize the meaning contained in the data. Through the endeavor of reweaving the thoughts put into it together, dialogue-based research will likely pioneer a new horizon of knowledge. This research confirmed the usefulness of log analysis in a wide range of fields such as medicine, mental health, education, and elderly support. On the other hand, issues to overcome such as privacy protection and the difficulty of causal infer-

ence were also brought to light. In addition, it was found that new horizons are also being opened up in the analysis of dialogue data such as chat logs. Unraveling the nuances of meaning and emotion contained in words with humanistic knowledge and the eyes of machines. There is a possibility for human understanding that goes beyond conventional approaches. However, the analysis of conversational data involves unique difficulties. In addition to ethical considerations, a sensibility that does not fear the fluctuations of words and accepts their richness is indispensable. Moreover, the idea of dialogizing the knowledge exploration process itself is also important. Developing questions about data together with the parties concerned. Resonating the meaning of the insights gained in the language of the field. Through such bidirectional dialogue, dialogue-based research will likely derive practical knowledge that contributes to solving social issues. The human figure reflected in the mirror called the smartphone. It is no longer something that can be fully explained by researchers alone.

4.3 Potential for Practical Application of Chat Log Analysis

The analysis of conversational data holds great potential not only in the realm of academic research but also in various real-world situations. Especially in the context of psychotherapy and counseling, carefully unraveling the client's narrative is a key factor that determines the quality of support. So, could chat log analysis using AI serve as a powerful tool to complement the therapist's insight? In a joint research project with a university student counseling room, we attempted to visualize the structure of students' concerns by text mining counseling chat logs. As a result, it became clear how a wide range of concerns such as academics, career path, and interpersonal relationships are intricately intertwined. In addition, the possibility that low self-esteem underlies various problems was also suggested. Such insights provide important suggestions for counselors to empathize with each student. By quickly inferring the psychological context behind the current narrative, they may be able to extend a more accurate helping hand. Chat log analysis has the potential to become a groundbreaking support

tool that verbalizes the knacks of experienced therapists based on data. Of course, the machine's insights should not be taken at face value. It needs to be carefully positioned as a role to supplement human clinical judgment. Also, when feeding back the analysis results to the client, ethical considerations are essential. While carefully explaining the significance of deepening self-understanding through data, it is important to value the process of dialogue surrounding its interpretation. AI-era counseling is required to have a humane way of involvement while balancing AI. Analysis of medical dialogue is also one of the promising application areas of chat log analysis. For example, research is being conducted to record conversations between critically ill patients and physicians and analyze the transcribed data by AI. By visualizing the frequency of use of specialized terminology, physicians' response patterns to patients' emotional expressions, etc., factors hindering patient-centered communication come to light. Furthermore, if combined with AI-powered speech recognition technology, it may become possible to develop a system that monitors the quality of conversations in real-time and presents advice to physicians. It could be utilized for communication education for novice physicians and skill improvement for veteran physicians. After all, what sustains the quality of medical care is the relationship of trust between the physician and the patient. Nurturing the communication techniques that build its foundation with the power of data. Such development of medical AI research is anticipated. The practical application of conversational data extends to a wide range of other fields as well, including education, marketing, and public services. Analyze student reactions in online classes and use them to improve teaching methods. Decipher the vast amount of customer feedback on products and utilize it in development strategies. Analyze the exchanges at local government service counters and work to improve citizen services. Conversational data from people's interactions is sleeping in all sorts of places. The evolution of technology to unleash its potential will likely lead to innovations that serve society only by combining the wisdom and power of various specialized fields.

4.4 Ethical Challenges and Future Prospects of Chat Log Analysis

The ethical issues surrounding conversational data present an even more complex picture than has been discussed so far. Especially with the spread of commercial chatbots and smart speakers, the risk of private conversational data being collected and used without one's knowledge is increasing. Ensuring transparency regarding how data is utilized, such as for user profiling and targeted advertising, is an urgent issue. Strengthening legal regulations on the handling of personal data, such as the European Union's General Data Protection Regulation (GDPR), is becoming a global trend. Based on these movements, it is necessary for industry, government, academia, and citizens to work together to establish guidelines for the collection and use of conversational data and to create a mechanism for obtaining consent. The difficulty of balancing data utilization and privacy protection is a common challenge for AI society as well. In addition, the negative effects of excessive dependence on conversational systems have also been pointed out. For example, if chatbots come to be used as a substitute for human relationships, the development of real communication skills may be hindered. Moreover, there are concerns that AI responses may reinforce stereotypes or instill problematic values. While promoting the collection, analysis, and utilization of conversational data, we must also be aware of its negative aspects. Maximizing benefits and minimizing risks. To cultivate that sense of balance, it is not enough to discuss ethical issues within the researcher community. It is essential to humbly listen to the voices of diverse citizens and sincerely face their concerns. AI and ethics, technology and humanity. The field of conversational systems starkly highlights the difficulty of harmonizing them. That is precisely why the insights gained there may serve as a guide for realizing a better AI society. Gathering the wisdom of the humanities, and through repeated dialogue and introspection, exploring the form of technology for and by humans. That may be the mission imposed on researchers engaged in conversational data analysis. Dialogue begins from sharing a place, looking into each other's faces. While cherishing that origin, we utilize the power of technology. Taking the feel of real places as nourishment for research, and applying the insights gained from research to real practice. By continuing to spin that cycle, conversational data analysis holds the potential to guide the world in a better direction. This paper provided an overview of the current state of behavior understanding and intervention effect research based on smartphone app log data. While the applicability in various scenes such as notification optimization, mental health support, and elderly care was shown, issues to be overcome such as the difficulty of causal inference and privacy protection were also brought to light. In addition, it was argued that new horizons are also opening up in the analysis of dialogue logs such as chat data. Delving into the nuances of people's true feelings from natural conversational data and utilizing them for support and services. Examples of potential applications in practice, such as counseling and medical dialogue, were also mentioned. Humans and AI collaborating to unravel the meaning of words. There is a possibility for human understanding that goes beyond conventional approaches. However, the analysis and utilization of conversational data involve unique ethical challenges, especially privacy risks. An attitude of critically examining machine results with a humanistic sensibility will become even more important than ever. In cultivating AI-era dialogue skills, dialogue with ethics is also indispensable. Furthermore, the importance of a bidirectional knowledge exploration style of discovering the meaning of data together with the parties concerned was also pointed out. Sharing the purpose and methods of analysis and openly discussing the interpretation of results. By placing such a dialogue process at the core of research, wisdom that responds to practical issues in the language of the field, fusing the humanities and sciences, will be spun out.

5 Conclusion

This paper provided an overview of the current state of behavior understanding and intervention effect research using smartphone app log data. The usefulness in a wide range of fields such as notification optimization, mental health, and elderly support was confirmed, while issues to be overcome such as the difficulty of causal inference and privacy protection

were also brought to light. Wisely utilizing log data, this new resource, and turning it into a force for solving problems. That challenge cannot be accomplished without interdisciplinary collaboration and creative institutional design. The new trend of conversational data analysis was also discussed. An example of a survey using an AI chatbot was introduced, suggesting the possibility of delving into people's true feelings from natural narratives. Furthermore, application examples of conversational data utilization were also mentioned, such as attempts to detect signs of suicidal ideation from SNS posts and sentiment analysis of product review data. While envisioning the dawn of "conversational analysis" as an interdisciplinary field fusing the humanities and information science, methodological issues were also considered. In addition, the importance of dialogizing the research process itself was pointed out, taking a citizen science approach. Through the endeavor of collaboratively deriving the meaning of data while involving the parties concerned, practical knowledge that contributes to solving social issues is produced. The meaning of data is spun out together with the parties concerned. Such a possibility of dialogue-based research was envisioned.

Furthermore, this paper provided an overview of the current state of behavior understanding and intervention effect research using smartphone app log data. The usefulness in a wide range of scenes such as notification optimization, mental health, and elderly support was confirmed, while issues to be overcome such as the difficulty of causal inference and privacy protection were also brought to light. In addition, it was found that new horizons are also being opened up in the analysis of dialogue logs such as chat data. Collaborating between humans and AI to unravel the nuances contained in words. There seems to be a possibility for human understanding that goes beyond conventional approaches. Of course, utmost caution is required in interpreting linguistic data. Gathering the wisdom of the humanities and critically examining AI results is essential. However, the point that it can shed light on people's true feelings that could not be captured by conventional approaches cannot be overlooked. While giving full consideration to privacy, venturing into the

new horizon of dialogue logs will undoubtedly deepen behavior understanding. However, the issue of how to apply the insights gained here to on-site practice still remains. Constructive discussion involving various stakeholders such as medical professionals and educators is indispensable for brushing up support and services. How to balance regulation and incentives. How to design the division of roles between the public and private sectors. Determination to squarely face the trade-off between innovation and ethics is being questioned. In parallel, we must also be self-aware of the methodological limitations of this research. Human behavior cannot be fully captured by the single data source of smartphone logs. There may be value in a mixed-methods approach that collects and analyzes diverse data linkable to logs. To deal with the difficulty of causal inference, accumulation of research incorporating sophisticated experimental designs is also essential. In addition, establishing outreach techniques to convey the significance of research without using technical terms is also an urgent issue. Organizing citizen participatory data utilization workshops and other efforts to sincerely listen to the voices of those in need of support while expanding the circle of dialogue are required. Exploring the path of data-driven solutions under the principle of "leaving no one behind" is also a mission entrusted to us researchers. Smartphone app logs. They are also a double-edged sword that proliferates without limit and may threaten human dignity.

The recent progress of digitalization has made the collection and use of personalized data in free apps a major issue as well. In aiming for the harmony of privacy protection and data utilization, we are faced with the need to integrate seemingly conflicting elements such as economic rationality and respect for human rights, efficiency and ethics, convenience and human dignity. To tackle this complex and multifaceted issue, comprehensive examination from all aspects, including technical approaches, legislation, governance, and sharing of ethics, is essential.

- Promoting technology development backed by ethics, and building legal systems and governance frameworks as two wheels - Continuous dialogue and consensus building among diverse actors such as companies, government, civil society, and research com-

munities - Social sharing of universal values such as respect for human rights, ethics, and human dignity - Under a comprehensive approach, mutually linking and complementing aspects of technology, systems, education, and values - Aiming to realize a "human-centered data society" and create a virtuous cycle of economy, environment, and society

Issues and Key Points

- Creating new frameworks through the fusion of technology and ethics - Participation of diverse stakeholders and promotion of open innovation - Evidence-based policymaking and establishment of social norms - Strengthening education that promotes citizens' literacy and proactive participation - Building an objective monitoring and supervision system from a neutral standpoint - Passing on universal values to the next generation and steady practice toward social implementation

To tackle this extremely complex issue, a comprehensive approach that combines technological innovation, system development, governance establishment, education enhancement, and above all, sharing of values is essential. Accumulating small practices of each individual, diverse actors joining hands, and continuing to move forward with an eye on the future. Such efforts will be crucial. If the wisdom of industry, government, academia, and citizens is brought together, a breakthrough will surely be possible. Everyone recognizes the importance of this issue, and while looking to the future, steadily advances their steps. Gathering the wisdom of industry, government, academia, and citizens, innovative solutions will definitely be realized.

Creating New Frameworks through the Fusion of Technology and Ethics

In initiatives aiming to harmonize privacy protection and data utilization, there is a possibility of pioneering unprecedented new frameworks by fusing technical approaches and ethical considerations. This is because in order to realize sustainable social development, it is essential not only to pursue technological innovation but also to create innovation based on a human-centered mindset.

Conventional technological development has been carried out from the perspectives of efficiency, cost reduction, and convenience improvement. However, in handling personal data, there is a risk of neglecting universal values such as human rights, dignity, and social justice if only economic rationality is prioritized. The situation called "surveillance capitalism" has even arisen, where digitalization is unilaterally advanced and data is excessively collected and utilized.

In contrast, as ahmad2018[127]'s research suggests, special ethical considerations are indispensable when dealing with sensitive data, and utmost care must be taken not to damage human dignity. As hassanshahi2022[148] raises issues in the mental health care field, data utilization inherently involves risks, and practice backed by ethics is required.

Therefore, effective use of technical approaches based on ethical perspectives, such as the access control framework advocated by buchanan2012[107] and the comprehensive data governance approach surveyed by ren2022surveyprivacy[140], is useful. Digital technology should be positioned as a means to realize human-centered values, and appropriate design and operation should be carried out.

Value-Oriented System Development and Practice of Privacy by Design

Based on this idea, it is necessary to incorporate ethical perspectives from the product and service development stage. Privacy protection should not be a makeshift countermeasure, but should be embedded in the fundamental design philosophy of the system. Companies should work on value-oriented system development while referring to the privacy evaluation framework of you2022framework[150].

Furthermore, by utilizing the machine learning-based app permission abuse detection method proposed by bhoraskar2023automatic[155], it is possible to identify and rectify parts with privacy risks in advance.

If we pay close attention to the handling of personal data and incorporate the method of privacy monitoring using user settings as in yu2023higgins[156] into the system, product design based on ethical requirements can be realized.

Thoroughly implementing the approach of "Privacy

by Design," which incorporates the idea of privacy protection into the core of the product, will likely lead to the creation of completely new systems. A system born from the fusion of technology and ethical values will emerge.

Building Trust through Ethical AI and XAI Utilization

Furthermore, it is important to incorporate ethical considerations in cutting-edge AI technologies as well. This is to avoid the situation where AI becomes a black box and accountability cannot be fulfilled.

If the CodeDroid and other methods proposed by rasthofer2017codedroid[118] are applied to make the data flow of AI systems white-boxed, transparency in the handling of personal data can be ensured. In addition, AI-based leak detection methods such as jiang2022[146]'s bait data monitoring are also effective.

By incorporating explainable AI (XAI) technology, it is possible to present the basis for AI's judgments in a form that is easy for humans to understand. If the static analysis method proposed by wang2023staticdeeps[158] is applied, privacy risk data flows can be visualized while tracking the operation of the AI system.

By thoroughly implementing the development and operation of AI with ethical considerations, trust in the handling of personal data by AI systems can be gained. In addition, by combining monitoring mechanisms such as ghorashi2021[144]'s machine learning-based data leak detection, it can lead to maintaining and continuous improvement of trust.

Positioning ethical AI as a tool for realizing human-centered values and building systems with transparency and explainability. If we take that approach, there is a possibility that a completely new framework for the harmonious coexistence of artificial intelligence and humans will be born.

Innovation in Governance Systems and Participation of Diverse Actors

In addition to the practice of technical approaches based on ethical perspectives, the establishment of a new governance system to support it is also indispensable. As can be seen from zhu2015[108]'s research,

there are challenges remaining in the conventional data tracking practices. It is important to further ensure the transparency of data distribution and the accountability of companies.

Also, as pointed out by rong2022[143], a high level of attention is required for third-party privacy leaks. How to manage the parts where ethical governance does not reach is an issue. To that end, it is essential to build a governance system in which various stakeholders, not only companies, developers, and platform providers, but also civil society and government, participate.

Referring to han2012[116]'s web monitoring method and cheng2022[142]'s advocacy of scientific verification, it is effective to develop a monitoring and auditing mechanism by neutral third-party organizations. Furthermore, in response to the issues of app permission systems pointed out by razavizadeh2022[139], institutional review and consideration of new technical solutions may also be necessary.

In other words, to transition to an effective governance system, it is essential for ethical technology development and institutional reform to work together in tandem, and for diverse stakeholders to cooperate in a coordinated manner. A more desirable new framework will surely be born from continuous dialogue and accumulation of practices.

6 Discussion

This paper provided an overview of smartphone app log analysis for behavior understanding and intervention effect research. While the usefulness in various situations such as notification optimization, mental health support, elderly care, etc. was confirmed, issues to overcome such as the difficulty of causal inference and privacy protection were also highlighted. Log data, a new resource. Wisely utilizing it and turning it into a force for problem-solving. That challenge cannot be accomplished without interdisciplinary collaboration and creative institutional design. The new trend of dialogue data analysis was also discussed. A survey example using an AI chatbot was introduced, suggesting the possibility of delving into people's true feelings from natural narratives. Furthermore, application examples of dialogue data utilization such as

attempts to detect signs of suicidal ideation from SNS posts and sentiment analysis of product review data were also mentioned. While envisioning the dawn of "dialogue analysis" as an interdisciplinary field fusing the humanities and information science, methodological issues were also considered. In addition, the importance of dialogizing the research process itself was pointed out, taking a citizen science approach. Through the endeavor of collaboratively deriving the meaning of data while involving the parties concerned, practical knowledge that contributes to solving social issues is produced.

Also, this paper provided an overview of the current state of behavior understanding and intervention effect research using smartphone app log data. While the usefulness in various scenes such as notification optimization, mental health support, and elderly care was confirmed, issues to overcome such as the difficulty of causal inference and privacy protection were also highlighted. In addition, it was found that new horizons are also opening up in the analysis of dialogue logs such as chat data. Collaborating between humans and AI to unravel the nuances contained in words. There seems to be a possibility for human understanding that goes beyond conventional approaches. Of course, utmost caution is required in interpreting linguistic data. Gathering the wisdom of the humanities and critically examining AI results is essential. However, the point that it can shed light on people's true feelings that could not be captured by conventional approaches cannot be overlooked. While giving full consideration to privacy, venturing into the new horizon of dialogue logs will undoubtedly deepen behavior understanding. However, the issue of how to apply the insights gained here to on-site practice still remains. Constructive discussion involving various stakeholders such as medical professionals and educators is indispensable for brushing up support and services. How to balance regulation and incentives. How to design the division of roles between the public and private sectors. Determination to squarely face the trade-off between innovation and ethics is being questioned. In parallel, we must also be self-aware of the methodological limitations of this research. Human behavior cannot be fully captured by the single data source of smartphone logs. There may

be value in a mixed-methods approach that collects and analyzes diverse data linkable to logs. To deal with the difficulty of causal inference, accumulation of research incorporating sophisticated experimental designs is also essential. In addition, establishing outreach techniques to convey the significance of research without using technical terms is also an urgent issue. Organizing citizen participatory data utilization workshops and other efforts to sincerely listen to the voices of those in need of support while expanding the circle of dialogue are required. Exploring the path of data-driven solutions under the principle of "leaving no one behind" is also a mission entrusted to us researchers. Smartphone app logs. They are also a double-edged sword that proliferates without limit and may threaten human dignity.

With the recent progress of digitalization, the collection and use of personalized data in free apps has also become a major issue. In aiming for the harmony of privacy protection and data utilization, we are faced with the need to integrate seemingly conflicting elements such as economic rationality and respect for human rights, efficiency and ethics, convenience and human dignity. To tackle this complex and multifaceted issue, comprehensive examination from all aspects, including technical approaches, legislation, governance, and sharing of ethics, is essential.

- Promoting technology development backed by ethics, and building legal systems and governance frameworks as two wheels - Continuous dialogue and consensus building among diverse actors such as companies, government, civil society, and research communities - Social sharing of universal values such as respect for human rights, ethics, and human dignity - Under a comprehensive approach, mutually linking and complementing aspects of technology, systems, education, and values - Aiming to realize a "human-centered data society" and create a virtuous cycle of economy, environment, and society

The realization of harmony between privacy protection and data utilization is not only a technical or economic issue, but is closely related to the creation of human-centered values and the realization of a sustainable society. In order to confront this extremely complex and multifaceted challenge, it is essential to

mobilize wisdom from various fields in an interdisciplinary manner.

The fusion of technology and ethics may pioneer unprecedented new frameworks. Based on the foundation of universal values such as respect for human rights and dignity, promoting the development of products and services with privacy protection incorporated from the design stage. By positioning ethical AI as a tool to realize human-centered values and ensuring transparency and explainability, a new vision of the relationship between artificial intelligence and humans can be pioneered.

At the same time, establishing a governance system through the participation of diverse stakeholders is also an indispensable challenge. Thoroughly implementing ethical data handling and building a structure for objective monitoring and auditing. Industry, government, academia, and citizens must work together to create new social norms.

This is by no means an easy path. However, in light of the difficulties that humanity has overcome so far, we should definitely be able to take the first step toward solving this problem as well. What will be born from that process? While we cannot be optimistic, if we steadily continue our efforts, the seeds of new social norms will surely sprout.

The harmony of privacy protection and data utilization aimed at here is not limited to a technical or business model reform, but is connected to the creation of human-centered values and the realization of a sustainable society. Economic rationality and respect for human rights, efficiency and ethics, convenience and human dignity - in order to integrate elements that seemingly conflict at first glance, a multilayered approach from all aspects is essential.

- Promoting technology development backed by ethics and building legal systems and governance frameworks as two wheels - Continuous dialogue and consensus building among diverse actors such as companies, government, civil society, and research communities - Social sharing of universal values such as respect for human rights, ethics, and human dignity - Under a comprehensive approach, mutually linking and complementing aspects of technology, systems, education, and values - Aiming to realize a "human-centered data society" and create a virtuous cycle of economy, environment, and society

Facing this extremely complex challenge, gathering the wisdom of various fields and developing an interdisciplinary and multilayered approach is essential. It is crucial for each individual to accumulate small practices, for diverse actors to join hands, and to continue moving forward with an eye on the future. If industry, government, academia, and citizens bring together their wisdom, a breakthrough will definitely be possible. Everyone recognizing the importance of this issue and steadily advancing their steps while looking to the future. From the accumulation of such steady efforts, a vision of a new data utilization society will surely be woven.

The promise land we should aim for is a society where privacy is protected while making the most of data, and economic development, social inclusion, and individual well-being are realized in a balanced manner. A society where the dignity of each individual is respected while promoting innovation through appropriate data utilization. A sustainable society where no one is left behind.

To realize such a future, we must squarely face the difficulties and dilemmas in front of us. The fusion of technology and ethics, the establishment of governance through the participation of diverse actors, the sharing of norms...none of these are easy tasks. However, if we make persistent efforts while maintaining dialogue, we should definitely be able to open up new horizons.

The analysis of smartphone app logs and conversational data. It is a powerful mirror that vividly reflects the various aspects of human society. While protecting privacy and carefully interpreting data, we will continue to deepen our understanding of people's behavior and minds. And we will strive to connect the insights gained there to the solution of real issues. To create a society where each individual's dignity is respected while making the most of the power of data. Now is the time for us to embark on that grand challenge.

6.1 Short Summary

Research on smartphone log data holds the potential to deepen our understanding of human behavior and provide new solutions to various social issues. How-

ever, these studies and technological applications come with important challenges such as privacy protection, ethical data handling, and evaluating societal impacts. To address these challenges and maximize the potential of technology, dialogue and cooperation among diverse stakeholders are essential. The ethical and effective utilization of smartphone log data will be the key to building a better society.

Promoting Innovation through Interdisciplinary Collaboration

Efforts within the field of information technology alone are insufficient to achieve a harmony between privacy protection and data utilization. Fostering innovation by converging insights from diverse disciplines is indispensable in tackling this challenge.

It is crucial to take a multifaceted approach by bringing together the wisdom from various academic fields such as law, economics, ethics, and behavioral sciences. Building collaborative frameworks that transcend stakeholders, including corporations, government, and civil society, is also essential. Accelerating comprehensive initiatives that unite industry, academia, and the public and private sectors is paramount.

Research on Legal Frameworks and Social Systems

First and foremost, research on legal framework design and social systems will play a significant role in achieving a balance between privacy protection and data utilization.

roesner2012world[141] advocates for the construction of a user-driven access control system, highlighting the importance of establishing legal grounds and mechanisms to enable data transactions based on individual consent.

moller2012[106] and others propose a model-based approach to detecting privacy risks in web applications. The collaboration between such technical approaches and legal framework design could lead to more robust privacy protection.

Furthermore, buchanan2012[107] proposes a framework for access control on mobile devices. Combining legally backed technical measures could establish an effective governance system.

Additionally, zhu2015[108]'s research analyzes major personal data breach cases, suggesting that understanding the reality of data tracking is essential for appropriate policy design.

By integrating insights from fields such as law, public policy, and social systems engineering with information technology, it should be possible to construct a more robust framework for privacy protection and data governance.

Economic Approaches and New Business Models

Economic approaches also play a crucial role. Establishing appropriate valuation methods for personal data, exploring data transaction markets, and examining new business models are among the numerous challenges that need to be addressed.

reardon2012[123]'s research highlights the importance of data portability. A framework that enables users to transfer and manage their own data could hold the key to new data utilization businesses.

book2015[104] and others investigate the long-term status of permission acquisition by advertising libraries in Android apps. Analyzing the reality of secondary use and distribution of personal data can provide important insights for designing new business models.

Additionally, han2012[116] proposes a method for detecting spam and unauthorized information leakage on corporate websites and social media. Addressing security risks in personal data utilization is directly linked to the sustainability of businesses.

Furthermore, the privacy evaluation framework proposed by you2022framework[150] can serve as a guideline for incorporating privacy protection into the development of new app services.

By incorporating knowledge from fields such as economics, management, and accounting, progress can be made in evaluating the economic value of personal data and fostering new privacy-conscious business models.

Ethical and Psychological Approaches, and Literacy Improvement

Furthermore, leveraging insights from humanities and social sciences such as ethics and psychology can contribute to improving user privacy literacy and es-

tablishing ethical data governance within companies.

shklovski2014[87]'s research points out that users often fail to understand the reality of data collection and that opt-out choices are insufficient. Based on such findings, effective user awareness strategies can be formulated.

antoniades2014[128] extensively evaluates privacy and security risks in social networking apps. Combining user behavioral psychological analysis could enable service designs that better align with user perspectives.

Moreover, ahmad2018[127] and others conduct detailed analyses of privacy risks in health and fitness apps, raising ethical concerns. Their insights are crucial for promoting shared ethical awareness and thorough data governance among companies and developers.

By integrating knowledge from diverse fields such as ethics, psychology, and behavioral economics with information technology, significant contributions can be made to enhance user literacy and establish ethical data governance within companies.

Fostering Innovation through Interdisciplinary Approaches

As illustrated above, converging insights from various disciplines such as law, economics, ethics, and psychology, and integrating them with information technology, is an essential path toward achieving harmony between privacy protection and data utilization.

Relying solely on knowledge from a single academic domain makes it challenging to address this complex and multifaceted issue. By fostering dialogue and collaboration among experts from diverse fields, capitalizing on their respective strengths, new innovations can be spawned.

Establishing interdisciplinary research frameworks and creating an environment conducive to open innovation is indispensable. Initiatives such as forming interdisciplinary organizations within universities, establishing industry-academia-government research consortia, and actively engaging early-career researchers from diverse backgrounds, should be considered.

In particular, leveraging emerging forces such as startups is increasingly anticipated as a source of new ideas and innovation. Proactively promoting open innovation through collaboration with large corporations and research institutions is crucial.

Through such efforts, it is expected that groundbreaking technological innovations, business models, and social system innovations will be created to achieve a balance between privacy protection and data utilization.

By uniting industry, academia, and the public and private sectors, and truly converging interdisciplinary wisdom, it should be possible to realize sustainable development through innovation driven by data utilization while safeguarding people's privacy in the future society.

Toward Establishing Ethical Data Governance

In pursuit of harmonizing privacy protection and data utilization, establishing ethical data governance from an ethical perspective, in addition to technical approaches and institutional frameworks, has become an important challenge. The handling of personal data is closely intertwined with universal values such as respect for human rights, democratic ideals, and social justice.

It is imperative that companies and developers practice data governance based on a high ethical standard, rather than solely from a risk avoidance perspective. Additionally, it is essential for users themselves to enhance their privacy literacy and proactively exercise their rights. Efforts from various fields have been researching these issues.

Research on Ethical Data Governance Practices by Companies

First, various approaches have been attempted to address data governance practices within companies.

ahmad2018[127] and others analyze privacy risks in health and fitness apps, encouraging companies to exercise ethical consideration. They provide recommendations regarding points to consider when handling sensitive personal data.

Furthermore, ren2016permissions[130] conducts a long-term analysis of app permission requests and

points out that permission changes during updates lack transparency. They call on companies to fulfill their accountability obligations to users.

Additionally, castelluccia2012[117] summarizes the reality of behavioral tracking on the web and raises concerns about privacy infringement risks. They urge companies to exercise restraint in disorderly tracking and establish ethical norms.

On the other hand, bokun2014[131] proposes a system to track app permission acquisition and detect privacy infringements, providing insights that encourage companies to establish monitoring mechanisms.

Research on User Awareness

Meanwhile, efforts to improve user privacy literacy are also crucial.

almuhimedi2015[124]'s research demonstrates that when privacy nudges are applied, users are more likely to reject data sharing. This highlights the effectiveness of user awareness education.

Additionally, seneviratne2015[126] utilizes a user-participatory app monitoring tool to allow users to confirm the data collection practices of apps, an effort towards improving literacy through tool utilization.

Furthermore, barrera2022[153] analyzes the reality and background of users underestimating privacy risks, emphasizing the importance of an educational approach. Enhancing literacy education for the general public is called for.

Sharing Ethical Norms and Establishing Governance Frameworks

In parallel with user awareness efforts, sharing ethical norms across diverse stakeholders and establishing governance frameworks have become crucial challenges.

zhu2015[108]'s research analyzes major personal data breach cases and elucidates the reality of data tracking. Sharing such realities is expected to raise social awareness regarding the importance of privacy protection.

Additionally, razavizadeh2022[139] analyzes issues with the permission mechanism in Android apps and provides recommendations for improvement. Dialogue and consensus-building among stakeholders, including platform providers, are essential.

Moreover, ren2022surveyprivacy[140] surveys data governance practices in the mobile environment, from data collection to data sharing, suggesting that a multi-stakeholder approach is crucial for establishing a comprehensive governance framework.

The Importance of Establishing Ethics Committees and Third-Party Monitoring

As various stakeholders, including companies, developers, platform providers, government, and civil society organizations, become involved, the role of monitoring and supervising governance from a fair and neutral standpoint becomes increasingly important.

From this perspective, the establishment of interdisciplinary ethics committees and mechanisms for monitoring and adjudication by third-party organizations have emerged as viable options under consideration.

By granting impartial organizations with high ethical standards and fairness the authority to monitor all activities related to personal data handling and intervene or seek corrective actions as necessary, the effectiveness of ethical data governance can be enhanced.

Of course, designing a system to ensure that such organizations truly function in a fair and neutral manner is no easy feat. Numerous challenges exist, such as resolving conflicts of interest among stakeholders. However, considering and establishing such third-party monitoring and supervision mechanisms will become extremely important for the foundation of ethical data governance in the future.

In addition to voluntary efforts by companies, it is crucial for society as a whole to share ethical norms regarding personal data handling and establish a governance system to monitor and supervise their implementation. While this is by no means an easy task, industry, academia, government, and civil society must join forces to confront this important challenge.

A Comprehensive Roadmap for Implementation

As the preceding discussions have made clear, a multifaceted and comprehensive approach is essential to achieve a harmony between privacy protection and data utilization in free apps. Efforts from all aspects, including technical measures, institutional design, gov-

ernance framework establishment, educational promotion, and open innovation facilitation, are required.

To confront these complex challenges, it is important to formulate a systematic roadmap and steadily implement it. Through dialogue among stakeholders, it is crucial to develop an action plan with a medium to long-term perspective. In particular, it is necessary to closely integrate the practical field with research, leveraging each other's insights in a cohesive manner.

The following presents an example of a comprehensive roadmap for implementation.

Phase One: Reality Assessment and Foundation Building

First, it is essential to accurately understand the reality of data collection and utilization in free apps, and identify the challenges. Utilizing tools like rasthofer2017codedroid[118]'s CodeDroid, it is necessary to conduct detailed data flow analysis of apps. As iqbal2020[121] points out, the lack of clarity in privacy policies should also be subject to assessment.

In conjunction, it is crucial to comprehensively evaluate the current privacy protection framework, corporate governance systems, and user literacy levels, and clearly identify the challenges.

Based on this reality assessment, a medium to long-term vision and action plan should be formulated. Utilizing the privacy evaluation framework proposed by you2022framework[150], a desired future vision should be outlined, and specific milestones and roadmaps for addressing challenges should be established.

Next, efforts should be made to lay the groundwork for plan implementation. Legal and institutional reforms should be prioritized to codify rules for personal data handling and establish governance systems. Introducing the user-driven control system proposed by roesner2012world[141] could also be considered.

Additionally, efforts should be focused on establishing an interdisciplinary research and development framework to promote open innovation. Setting up interdisciplinary organizations within universities and establishing industry-academia-government research consortia are also important initiatives.

Phase Two: Full-Scale Implementation of Core Initiatives

Once a certain level of foundation-building has been achieved, a transition to the full-scale deployment of core initiatives can begin.

First, efforts should concentrate on technical measures, advancing the development and implementation of privacy protection technologies. Companies and developers should be encouraged to utilize tools like aafer2022platformagnostic[152]'s PUBLISHed. Monitoring tools such as li2022transmontevio[149]'s TransMonteVio should also be implemented in practice, embarking on thorough personal data leak prevention measures.

In parallel, literacy education initiatives targeting users should be intensified, promoting user-participatory app monitoring based on approaches like seneviratne2015[126]'s method. The concept of privacy nudges advocated by almuhimedi2015[124] should be incorporated to encourage proactive exercise of user rights.

Companies should be mandated to handle data appropriately based on the newly established legal framework and governance system. Addressing the issues raised by razavizadeh2022[139], efforts should be made to ensure the effectiveness of the permission mechanism. By combining voluntary corporate efforts and third-party monitoring, privacy protection can be strengthened.

Phase Three: Developing and Implementing New Data Utilization Models

Once a certain level of privacy protection has been achieved through the aforementioned efforts, concrete considerations for developing and implementing new data utilization models should be intensified.

Toward building a user-driven data transaction platform, efforts should be made to ensure data portability as advocated by reardon2012[123], and thorough user management utilizing tools like leung2022privacycam[113]'s PrivacyCam.

In conjunction, by utilizing sandboxing techniques such as backes2017[145]'s Boxify and machine learning-based leak detection technologies like ghorashi2021[144]'s approach, efforts should be made

to develop platforms that can balance decentralized user data management and appropriate utilization.

For companies, based on book2015[104]'s research, optimizing data access permissions from a medium to long-term perspective should be encouraged. Appropriate data utilization monitoring systems should be established while applying unauthorized access detection methods like han2012[116]'s approach.

Furthermore, frameworks to ensure due consideration for risks and ethical aspects in data utilization should be established, in line with ahmad2018[127]'s recommendations.

Through these efforts, the ultimate goal should be to envision a sustainable data utilization society where privacy protection and data utilization are appropriately balanced, and chart a path toward its realization.

Continuous Dialogue and Feedback Loops

In pursuing a roadmap-based approach, maintaining constructive dialogue among all stakeholders and establishing mutual feedback loops is of utmost importance.

Open and candid exchange of views must be continuously facilitated between the practical field and academic research, among companies, government, civil society organizations, and other stakeholders. A process of sharing challenges, requirements, and new discoveries with one another, and finding solutions must be established.

Additionally, it is crucial to establish regular evaluation and feedback cycles, monitor progress, and flexibly adjust course as needed. The willingness to review and refine the roadmap in accordance with changing circumstances, steering towards better directions, is essential.

As in cheng2022[142]'s survey research, conducting systematic evaluations and summaries at intermediate stages, identifying new challenges, and linking them to subsequent actions is indispensable for establishing a continuous PDCA cycle.

This issue is a complex problem that concerns not only technology but also the fabric of society itself. By fostering constructive dialogue among stakeholders and steadily accumulating step-by-step efforts, sustainable solutions can surely be found.

Each and every one of us must remain conscious of the essence of this issue and persistently strive toward harmonizing privacy and innovation. From such steady efforts, a new vision for a data utilization society will be woven.

Balancing Individual Self-Determination and Social Responsibility

In pursuing a harmony between privacy and data utilization, in parallel with raising individual rights awareness, an approach Certainly, here is the continuation of the English translation:

from the perspective of social responsibility is also important. Striking a balance between individuals, corporations, and society is a challenge that needs to be addressed.

Respecting Individuals' Right to Self-Information Control

Above all else, respecting individuals' right to self-information control is paramount. The user-driven access control advocated by roesner2012world[141] embodies this fundamental concept.

Individuals should have the right to actively decide how their personal information is collected and utilized. As observed in liu2016[133]'s research, mechanisms that enable users to monitor and control app permission acquisition, as needed, are essential.

Furthermore, ensuring data portability as emphasized by reardon2012[123], and privacy infringement detection systems like bokun2014[131]'s, can also be considered as supporting the exercise of self-information control rights.

Companies have a responsibility to fully respect users' rights. High transparency in information disclosure and thorough accountability are required. Additionally, as proposed by ferreira2015[129], adopting default settings that only grant the minimum necessary data access permissions could be effective.

Moreover, loopholes in permission systems, as pointed out by razavizadeh2022[139], should not be left unaddressed. Establishing mechanisms that accurately reflect users' intentions is necessary to prevent infringement of individual self-determination rights.

Balancing Privacy and Social Benefits

However, excessively prioritizing individual privacy carries the risk of compromising social benefits. As hassanshahi2022[148]'s research demonstrates, in areas like mental health care, some personal data utilization could contribute to public interest.

As ren2022surveyprivacy[140]'s survey shows, it is important to take a holistic optimization perspective on the entire process from data collection to data sharing in mobile environments. Not only individual privacy but also the benefits to society as a whole must be considered.

Furthermore, as exemplified by aafer2022platformagnostic[152]'s PUBLISHed, technical approaches that allow the minimum necessary data utilization while preventing excessive leakage can be effective. It is prudent to pursue a balance that permits certain private and public utilization while exercising thorough risk control.

Additionally, utilizing tools like rasthofer2017codedroid[118]'s CodeDroid to conduct detailed data flow analysis of individual apps is also important. Such reality assessments are essential for optimizing the balance between individual privacy and data utilization.

Social Responsibility and Governance Practices

On the other hand, companies, developers, and platform providers have an obligation to be socially responsible and implement appropriate governance practices. The reality of data tracking revealed by zhu2015[108]'s research is a challenge that cannot be ignored.

As ren2016permissions[130] points out, the lack of transparency surrounding changes in app permission requests is a contributing factor to user distrust. Companies must fulfill their accountability obligations with high transparency.

Moreover, as rong2022[143]'s research reveals, addressing permission abuse and data leakage by third-party libraries is also a challenge. Strengthening monitoring of these black-box components and ensuring proper handling are necessary.

Furthermore, as ullah2021[132] points out regarding risks in mobile healthcare apps, more stringent governance may be required in certain industries or domains. Self-regulation and monitoring framework reinforcement by relevant associations are essential.

Thus, in pursuing a balance between individual privacy and social benefits, companies are expected to thoroughly exercise accountability and risk control, while shouldering high social responsibility. They must establish their own governance systems while proactively engaging in sharing industry-wide best practices.

A constant awareness of the balance between individuals, corporations, and society is required, with the pursuit of a win-win-win relationship among all parties.

Challenges in Establishing Global Governance

The harmonization of privacy protection and data utilization is not merely a local issue; establishing global governance is an indispensable challenge. In the advancing digital age, the cross-border exchange of personal data is inevitable. Therefore, establishing international collaborative frameworks is essential.

However, significant gaps exist in addressing this challenge across countries and regions. Disparities are evident in the status of legal framework development, corporate and civil society literacy levels, and other areas. The divide between developed and emerging countries is severe, making a one-size-fits-all framework impractical. Recognizing this reality, efforts toward building global governance must proceed.

Standard-Setting and Harmonization by International Organizations

First and foremost, establishing global standards is indispensable. International organizations, led by the United Nations, must take the lead in formulating the framework for international codes of conduct regarding privacy protection and data utilization.

As bsi2019messenger[95]'s research demonstrates, the privacy practices of messaging apps vary widely across countries and regions. Based on this reality, setting a minimum global standard is necessary.

For instance, drawing from ren2022surveyprivacy[140]'s findings, it may be

possible to develop comprehensive guidelines covering the entire process of personal data collection and sharing. This could involve deliberations in forums such as the UN Human Rights Council and obtaining consensus among member states.

Additionally, extending existing norms could be a viable option. Referencing advanced legal frameworks like the EU's General Data Protection Regulation (GDPR) while designing global standards could be considered. However, adjustments to accommodate the realities of all countries and regions, including emerging nations, would be indispensable.

Furthermore, discussions on global norms regarding this issue may also take place within organizations such as the International Organization for Standardization (ISO) and the Organisation for Economic Co-operation and Development (OECD). Harmonization efforts across various platforms are needed to establish certain international rules.

Ensuring Interoperability and Regional Bloc Collaboration

In parallel with building global standards, addressing regional differences is also essential. Allowing for flexibility to accommodate variations in legal frameworks, corporate cultures, and public literacy levels is imperative.

To this end, dividing the world into regional blocs and deepening collaboration within each bloc could be an effective strategy. For more integrated blocs like the EU, more comprehensive common rules could be established, and their compatibility with global standards could be pursued on that foundation.

On the other hand, for regions with significantly diverse national circumstances, the global standards could serve as the minimum baseline, while respecting each country's voluntary supplementary rules. The key is to establish the optimal level and stance for each regional bloc and pursue global harmonization through mutual collaboration.

In doing so, establishing collaborative frameworks and rule alignment among regional blocs is crucial. For example, ensuring the interoperability of app analysis tools like rasthofer2017codedroid[118]'s CodeDroid may be necessary. Additionally, sharing traffic analysis methods like dai2015[114]'s NetworkProfiler could also be an effective initiative.

Supporting Emerging Countries and Capacity Building Efforts

Meanwhile, in establishing global governance, supporting capacity building in emerging countries and underdeveloped regions is an essential task. Premising the existence of gaps, efforts to expedite capacity enhancement must be undertaken without delay.

Investing in education and improving literacy should be a top priority. Raising awareness about the importance of privacy protection is indispensable, regardless of whether the audience is corporate practitioners, policymakers, or civil society. Initiatives such as human resource development support from developed countries and sharing educational content could be effective measures.

Additionally, dispatching experts and providing guidance in developing legal frameworks can effectively support emerging countries' institutional reforms. Promoting the adoption of platform-agnostic safeguard tools like aafer2022platformagnostic[152]'s PUBLISHed could also be an important endeavor.

Moreover, establishing frameworks for funding capacity building efforts should be considered. Specific schemes, such as establishing funds by developed entities or channeling support through international organizations, are desirable.

Thus, in constructing governance frameworks for global privacy protection and data utilization, a multifaceted approach and long-term perspective are indispensable. While premising capacity gaps, steady efforts toward closing these gaps must be pursued, while simultaneously strengthening governance at the regional bloc level. A spirit of collaboration among developed and emerging countries, as well as diverse regional blocs, accumulating steady efforts, is of utmost importance.

Towards the Realization of New Data Utilization Models

As a goal of efforts to achieve harmony between privacy protection and data utilization, the realization of new data utilization models is anticipated. Go-

ing beyond the framework of conventional company-led data collection and utilization, new models that respect users' rights awareness while achieving appropriate data utilization are being explored.

Looking back at previous research, it can be said that the technical foundation for such models has been developed to a certain extent. The remaining challenges lie in environmental improvement for implementation, such as institutional design, establishment of governance systems, and promotion of literacy education. Therefore, it is essential for various stakeholders to collaborate and develop a comprehensive approach.

User-Led Data Trading Platform

One of the promising new data utilization models is a user-led data trading platform. Based on the idea of data portability advocated by reardon2012[123], it is a model where users entrust and manage their personal data on the cloud and then conduct data transactions with companies and other entities.

As the technical foundation for this model, app sandboxing by backes2017[145]'s Boxify and data leak detection technology using machine learning by ghorashi2021[144] can be utilized. The aim is to achieve both decentralized management of user data and appropriate utilization.

In terms of institutions, it is essential to establish a legal basis for user-led access control, as argued by roesner2012world[141]. In addition, default setting of least privilege access, as proposed by ferreira2015[129], should also be considered.

Furthermore, service design based on the privacy evaluation framework by you2022framework[150] and the establishment of a monitoring system using the infringement detection system by bokun2014[131] are also important. Thorough corporate ethics and establishment of a governance system are indispensable elements.

Moreover, taking hints from the efforts of seneviratne2015[126] and almuhimedi2015[124], the introduction of a user-participatory monitoring mechanism is also desirable. It is essential to create an environment where a wide range of stakeholders can trust the service.

Building a Personal Data Distribution Marketplace

In addition to user-led platforms, the construction of a personal data distribution marketplace, as pointed out by zhang2021profiling[103], is also considered a promising option.

By establishing a place where companies can properly evaluate and trade data, the aim is to promote sound data utilization. As shown in the actual condition survey by book2015[104], excessive trading of advertising data is seen as a problem, but risks can be reduced by placing it under proper evaluation and monitoring.

However, in terms of institutions, the establishment of rules for data trading is essential. Based on the research by zhu2015[108], ensuring traceability and transparency of data distribution is crucial. In addition, in light of the points made by iqbal2020[121], setting clear information disclosure rules is also indispensable.

Moreover, the introduction of technical safeguards represented by aafer2022platformagnostic[152]'s PUB-LISHed and the establishment of an operation system are also important. Especially in terms of monitoring third-party companies, the insights of rong2022[143] should be helpful.

Considering the ethical points made by ahmad2018[127] for companies and organizations participating in the marketplace, the establishment of a framework for monitoring and supervision by third-party organizations is also essential. Overall, the participation of a wide range of stakeholders and multifaceted risk control are indispensable.

Accelerating Data Utilization Innovation

By working towards the construction of user-led platforms and marketplaces as described above, the acceleration of innovation centered on data utilization can be expected in the medium to long term.

By monitoring misuse using han2012[116]'s technology and promoting secure data utilization while grasping the actual situation through app analysis such as rasthofer2017codedroid[118]'s CodeDroid, it becomes possible.

While paying attention to the IoT data leakage

risk seen in ren2016resilience[119]'s research, companies should be able to utilize dai2015[114]'s app fingerprinting technology to advance the development of new services.

Furthermore, by accumulating evidence of privacy evaluation and ethical considerations, it is also possible to lead to the advancement of leak detection systems such as vukovic2022[151]'s Scalemon.

By promoting a virtuous cycle of privacy protection and data utilization in all areas, the advancement of meta-monitoring technologies represented by liu2021[91]'s tracking detection system can also be expected. Once this cycle is established, it should lead to the creation of sustainable innovation.

Creating New Values for Society 5.0

The realization of harmony between privacy protection and data utilization is not only a technical issue or a reform of business models, but can also be an important starting point leading to the construction of a new human-centered social system. It can be positioned as an effort at the core of the concept of Society 5.0.

Society 5.0 refers to efforts to highly integrate cyberspace and physical space in a narrow sense, but if interpreted more broadly, it means social transformation aimed at departing from conventional economy-first principles and aiming for human-centered value creation. Based on this way of thinking, the proposition of coexistence of privacy and innovation can be said to hold an important key to the realization of Society 5.0.

In other words, based on the discussion and research findings in this chapter, it is possible to envision new value creation in line with the philosophy of Society 5.0. In addition to addressing technical and institutional issues, it is necessary to explore the ideal future society while encompassing seemingly conflicting elements such as economy and ethics, convenience and humanity.

Human-Centered Data Utilization and Creation of New Values

Conventional data utilization has been centered on the pursuit of economic rationality and efficiency by companies. Personal privacy tended to be considered

secondary, and a situation called surveillance capitalism even arose. However, based on Society 5.0, it is necessary to change this idea.

As pointed out by barrera2022[153], rather than premising users' low awareness of privacy risks, a shift to values that respect individual rights and emphasize autonomy is essential. Prioritizing personal dignity and pursuing human-centered data utilization is an important basic stance.

Specifically, value creation based on the idea of user-led access control advocated by roesner2012world[141] and data portability by reardon2012[123] can be considered. It is the realization of a new service model where individuals can control the entrusting and trading of data.

The introduction of a mechanism where users can monitor data collection, such as PrivacyCam developed by leung2022privacycam[113], would also be effective. Companies and developers need to refer to the privacy evaluation framework of you2022framework[150] and incorporate a privacy-focused design philosophy into services.

Furthermore, by utilizing technologies that automatically detect abuse of authority, such as bhoraskar2023automatic[155], consideration for user privacy can also be incorporated. Based on these approaches, we should be able to take a step closer to the realization of a "human-centered data-driven society" aimed at by Society 5.0.

Co-creation by Diverse Entities and Improvement of Well-Being

What Society 5.0 aims for is not simply making digital technology useful for humans, but the co-creation of value by diverse entities. It is expected that different stakeholders such as companies, government, civil society organizations, and research communities will collaborate to create new social systems. As seen in the research by li2022transmontevio[149], the significance of joint development projects by industry, government, academia, and the private sector can be confirmed. By combining the resources and seeds possessed by various entities, new solutions can be created.

Furthermore, as represented by the attempts of seneviratne2015[126], by institutionalizing user-

participatory monitoring, citizen-led involvement can be realized in service development as well. It is essential for companies and governments to openly accept such movements and construct a process of co-creation.

Through such collaboration by diverse entities, the human-centered values advocated by Society 5.0 should be pursued and further improvement of Well-Being should be aimed for. As pointed out by hassanshahi2022[148], in the field of mental health care, it also becomes possible to promote data utilization for the enhancement of people's happiness while premising privacy protection.

In addition, by regulating disorderly tracking behavior monitored by ren2023understanding[154], it can also contribute to securing human freedom from a surveillance society. yu2023higgins[156]'s privacy monitoring utilizing user settings can also be a help.

In this way, by realizing the harmony of privacy protection and data utilization, it should be possible to lead to the overall human-centered value creation aimed at by Society 5.0. In that process, co-creation by diverse stakeholders is indispensable, and an approach that brings together the wisdom of different fields is strongly required.

Harmonizing privacy protection and data utilization and promoting new value creation based on the philosophy of Society 5.0 will ultimately lead to the realization of a sustainable society. This is because it plays an important role in the three aspects of economy, environment, and social inclusion.

Economic activities up to now have sometimes brought about negative aspects such as excessive profit pursuit, environmental destruction, and widening disparities. Companies sought to maximize profits through excessive collection and utilization of personal data, and privacy and human rights tended to be neglected. Such a state clearly lacks sustainability.

However, as discussed in this chapter, the harmonious realization of privacy protection and data utilization can be a powerful key to breaking through such a situation. An approach that returns to human-centered values and emphasizes ethical considerations and improvement of Well- Being is an indispensable element for sustainable development.

Ethical Data Governance and Responsible Innovation

The most important thing for realizing a sustainable society is the establishment of ethical data governance and responsible innovation. It is necessary to strengthen efforts from various perspectives such as individual privacy and human rights, corporate social responsibility, and ensuring fairness and transparency.

As seen in the suggestions of ahmad2018[127] cited in this chapter, ethical considerations when handling sensitive personal data are essential. Companies are required to thoroughly fulfill their accountability through measures such as checking the wrongdoing of third parties, as pointed out by rong2022[143].

Furthermore, in light of han2012[116]'s wrongdoing detection method and the actual state of data tracking revealed by zhu2015[108]'s research, ensuring transparency is indispensable. To that end, the development of a governance system and thorough scientific verification advocated by cheng2022[142] are important.

In addition, through measures such as preventing abuse of authority by apps pointed out by nath2018[125] and countermeasures against behavior tracking summarized by castelluccia2012[117], it is necessary to put a brake on the transformation into a surveillance society. Thorough respect for human rights is indispensable.

Sustainable Development of the Economy through Data Utilization

Such thorough privacy protection and data governance also contribute to the sustainable development of the economy. Excessive profit pursuit that ignores individual rights awareness risks losing trust and inviting backlash, hindering medium- to long-term growth.

On the other hand, product and service development incorporating ethical considerations, such as the privacy evaluation framework of you2022framework[150] and PUBLISHed of aafer2022platformagnostic[152] shown in this chapter, can become a source of sustainable competitiveness in the market.

Furthermore, by adopting approaches such as minimum privilege access by ferreira2015[129], unnecessary data collection can be avoided and optimization

of resource allocation can be achieved. Opportunities for transforming business models based on accurate grasp of the actual situation using dai2015[114]'s NetworkProfiler and other tools will also arise.

In addition, responding to the IoT data leakage risk suggested by ren2016resilience[119] leads to maintaining product safety and brand value. By accumulating such efforts, companies should be able to secure medium- to long-term economic sustainability.

Inclusive Development of Society and Improvement of Well-Being

Furthermore, the harmonious realization of privacy protection and data utilization should greatly contribute to the inclusive development of society and the improvement of Well-Being.

Data utilization in the field of mental health care pointed out by hassanshahi2022[148]'s research leads to the improvement of individuals' mental health and quality of life. Based on the findings of vu2022fitness[93], it can be considered that appropriate data utilization also contributes to the promotion of health enhancement and preventive medicine.

Also, thorough protection of children's privacy pointed out by razaghpanah2018kids[96] and reyes2017[94] is extremely important for sound development of the next generation. Protection of children's rights and improvement of the educational environment are indispensable for the creation of the future society advocated by Society 5.0.

Furthermore, by incorporating gong2023systemthread[157]'s system thread monitoring method, it is also possible to build a secure social infrastructure while preventing privacy violations. As a premise of social inclusion, contribution to the correction of the digital divide can also be expected.

In this way, by thoroughly protecting privacy and making it compatible with the promotion of Well-Being improvement and social inclusion through data utilization, the human-centered sustainable society aimed at by Society 5.0 should become realizable. It can be the starting point of such new value creation that generates a virtuous cycle of respect for human rights and social inclusion, economy and environment.

Creating New Frameworks through the Fusion of Technology and Ethics

Initiatives aimed at harmonizing privacy protection and data utilization have the potential to pioneer unprecedented new frameworks by fusing technical approaches and ethical considerations. This is because in order to realize a sustainable society, it is essential not only to pursue technological innovation but also to create innovation based on a human-centered mindset grounded in ethics.

Conventional technological development has been carried out from the perspectives of efficiency, cost reduction, and convenience improvement. However, in handling personal data, there is a risk of neglecting universal values such as human rights, dignity, and social justice if only economic rationality is prioritized. The situation called "surveillance capitalism" has even arisen, where digitalization is unilaterally advanced. This gives us many suggestions.

In contrast, as ahmad2018[127]'s research shows, special ethical considerations are indispensable when dealing with sensitive data, and utmost care must be taken not to damage human dignity. As hassanshahi2022[148] raises issues in the mental health care field, data utilization inherently involves risks, and practice backed by ethics is required.

Therefore, effective use of technical approaches based on ethical perspectives, such as the access control framework advocated by buchanan2012[107] and the comprehensive data governance approach surveyed by ren2022surveyprivacy[140], is useful. Digital technology should be positioned as a means to realize human-centered values, and appropriate design and operation should be carried out.

Value-Oriented System Development and Practice of Privacy by Design

Based on this idea, it is necessary to incorporate ethical perspectives from the product and service development stage. Privacy protection should not be a makeshift countermeasure, but should be embedded in the fundamental design philosophy of the system. Companies should work on value-oriented system development while referring to the privacy evaluation framework of you2022framework[150].

Furthermore, by utilizing the machine learning-based app permission abuse detection method proposed by bhoraskar2023automatic[155], it is possible to identify and rectify parts with privacy risks in advance.

If we pay close attention to the handling of personal data and incorporate the method of privacy monitoring using user settings as in yu2023higgins[156] into the system, product design based on ethical requirements can be realized.

Thoroughly implementing the approach of "Privacy by Design," which incorporates the idea of privacy protection into the core of the product, will likely lead to the creation of completely new systems. A system born from the fusion of technology and ethical values will emerge.

Building Trust through Ethical AI and XAI Utilization

Furthermore, it is important to incorporate ethical considerations in cutting-edge AI technologies as well. This is to avoid the situation where AI becomes a black box and accountability cannot be fulfilled.

If the CodeDroid and other methods proposed by rasthofer2017codedroid[118] are applied to make the data flow of AI systems white-boxed, transparency in the handling of personal data can be ensured. In addition, AI-based leak detection methods such as jiang2022[146]'s bait data monitoring are also effective.

By incorporating explainable AI (XAI) technology, it is possible to present the basis for AI's judgments in a form that is easy for humans to understand. If the static analysis method proposed by wang2023staticdeeps[158] is applied, privacy risk data flows can be visualized while tracking the operation of the AI system.

By thoroughly implementing the development and operation of AI with ethical considerations, trust in the handling of personal data by AI systems can be gained. In addition, by combining monitoring mechanisms such as ghorashi2021[144]'s machine learning-based data leak detection, it can lead to maintaining and continuous improvement of trust.

Positioning ethical AI as a tool for realizing human-centered values and building systems with transparency and explainability. If we take that approach, there is a possibility that a completely new framework for the harmonious coexistence of artificial intelligence and humans will be born.

Innovation in Governance Systems and Participation of Diverse Actors

In addition to the practice of technical approaches based on ethical perspectives, the establishment of a new governance system to support it is also indispensable. As can be seen from zhu2015[108]'s research, there are challenges remaining in the conventional data tracking practices. It is important to further ensure the transparency of data distribution and the accountability of companies.

Also, as pointed out by rong2022[143], a high level of attention is required for third-party privacy leaks. How to manage the parts where ethical governance does not reach is an issue. To that end, it is essential to build a governance system in which various stakeholders, not only companies, developers, and platform providers, but also civil society and government, participate.

Referring to han2012[116]'s web monitoring method and cheng2022[142]'s advocacy of scientific verification, it is effective to develop a monitoring and auditing mechanism by neutral third-party organizations. Furthermore, in response to the issues of app permission systems pointed out by razavizadeh2022[139], institutional review and consideration of new technical solutions may also be necessary.

In other words, to transition to an effective governance system, it is essential for ethical technology development and institutional reform to work together in tandem, and for diverse stakeholders to cooperate in a coordinated manner. A more desirable new framework will surely be born from continuous dialogue and accumulation of practices.

7   Conclusion

This paper provided an overview of the current state of behavior understanding and intervention effect research using smartphone app log data. While the usefulness in various situations such as notification optimization, mental health support, and elderly care

was confirmed, issues to overcome such as the difficulty of causal inference and privacy protection were also brought to light. Wisely utilizing log data, this new resource, and turning it into a force for problem-solving. That challenge cannot be accomplished without interdisciplinary collaboration and creative institutional design. The new trend of dialogue data analysis was also discussed. A survey example using an AI chatbot was introduced, suggesting the possibility of delving into people's true feelings from natural narratives. Furthermore, application examples of dialogue data utilization such as attempts to detect signs of suicidal ideation from SNS posts and sentiment analysis of product review data were also mentioned. While envisioning the dawn of "dialogue analysis" as an interdisciplinary field fusing the humanities and information science, methodological issues were also considered. In addition, the importance of dialogizing the research process itself was pointed out, taking a citizen science approach. Through the endeavor of collaboratively deriving the meaning of data while involving the parties concerned, practical knowledge that contributes to solving social issues is produced. The meaning of data is spun out together with the parties concerned. Such a possibility of dialogue-based research was envisioned.

Furthermore, this paper provided an overview of the current state of behavior understanding and intervention effect research using smartphone app log data. While the usefulness in various scenes such as notification optimization, mental health support, and elderly care was confirmed, issues to overcome such as the difficulty of causal inference and privacy protection were also brought to light. In addition, it was found that new horizons are also being opened up in the analysis of dialogue logs such as chat data. Collaborating between humans and AI to unravel the nuances contained in words. There seems to be a possibility for human understanding that goes beyond conventional approaches. Of course, utmost caution is required in interpreting linguistic data. Gathering the wisdom of the humanities and critically examining AI results is essential. However, the point that it can shed light on people's true feelings that could not be captured by conventional approaches cannot be overlooked. While

giving full consideration to privacy, venturing into the new horizon of dialogue logs will undoubtedly deepen behavior understanding. However, the issue of how to apply the insights gained here to on-site practice still remains. Constructive discussion involving various stakeholders such as medical professionals and educators is indispensable for brushing up support and services. How to balance regulation and incentives. How to design the division of roles between the public and private sectors. Determination to squarely face the trade-off between innovation and ethics is being questioned. In parallel, we must also be self-aware of the methodological limitations of this research. Human behavior cannot be fully captured by the single data source of smartphone logs. There may be value in a mixed-methods approach that collects and analyzes diverse data linkable to logs. To deal with the difficulty of causal inference, accumulation of research incorporating sophisticated experimental designs is also essential. In addition, establishing outreach techniques to convey the significance of research without using technical terms is also an urgent issue. Organizing citizen participatory data utilization workshops and other efforts to sincerely listen to the voices of those in need of support while expanding the circle of dialogue are required. Exploring the path of data-driven solutions under the principle of "leaving no one behind" is also a mission entrusted to us researchers. Smartphone app logs. They are also a double-edged sword that proliferates without limit and may threaten human dignity.

Recent progress of digitalization has made the collection and use of personalized data in free apps a major issue as well. In aiming for the harmony of privacy protection and data utilization, we are faced with the need to integrate seemingly conflicting elements such as economic rationality and respect for human rights, efficiency and ethics, convenience and human dignity. To tackle this complex and multifaceted issue, comprehensive examination from all aspects, including technical approaches, legislation, governance, and sharing of ethics, is essential.

- Promoting technology development backed by ethics, and building legal systems and governance frameworks as two wheels - Continuous dialogue and consensus building among diverse actors such as com-

panies, government, civil society, and research communities - Social sharing of universal values such as respect for human rights, ethics, and human dignity - Under a comprehensive approach, mutually linking and complementing aspects of technology, systems, education, and values - Aiming to realize a "human-centered data society" and create a virtuous cycle of economy, environment, and society

Issues and Key Points

- Creating new frameworks through the fusion of technology and ethics - Participation of diverse stakeholders and promotion of open innovation - Evidence-based policymaking and establishment of social norms - Strengthening education that promotes citizens' literacy and proactive participation - Building an objective monitoring and supervision system from a neutral standpoint - Passing on universal values to the next generation and steady practice toward social implementation

To tackle this extremely complex issue, a comprehensive approach that combines technological innovation, system development, governance establishment, education enhancement, and above all, sharing of values is essential. Accumulating small practices of each individual, diverse actors joining hands, and continuing to move forward with an eye on the future. Such efforts will be crucial. If the wisdom of industry, government, academia, and citizens is brought together, a breakthrough will surely be possible. Everyone recognizing the importance of this issue and steadily advancing their steps while looking to the future. From the accumulation of such steady efforts, a vision of a new data utilization society will surely be woven.

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