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Culturomics: Taking the cross-scale, interdisciplinary science of culture into the next decade

Siyang Luo^{a,*}, Hang Yuan^a, Yin Wang^b, Michael Harris Bond^c

^a Department of Psychology, Guangdong Provincial Key Laboratory of Social Cognitive Neuroscience and Mental Health, Guangdong Provincial Key Laboratory of Brain Function and Disease, Sun Yat-Sen University, Guangzhou 510006, China

^b State Key Laboratory of Cognitive Neuroscience and Learning, and IDG/McGovern Institute for Brain Research, Beijing Normal University, Beijing, China

^c Department of Management and Marketing, Faculty of Business, Hong Kong Polytechnic University, Hong Kong

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ABSTRACT

Culture is a complex topic involving a comprehensive representation of human institutions, social customs, norms, and lifestyles. Over the past half-century, the methods of cultural studies have improved dramatically in the depth of the research questions posed. However, most contemporary research on cultural issues is conducted from a single perspective, which fails to account for the holistic and extensive nature of culture. The development of culture is influenced by various factors, encompassing not only the humanistic environment but also factors related to the natural environment and socio-economic conditions. Hence, culture involves multiple concepts with associated levels and dimensions, such as genes, molecules, brains, individuals, groups, institutions, societies, and political environments. Therefore, we propose the concept of Culturomics, a cross-level, interdisciplinary science that studies human behavior and cultural representation in high-order space. Under this concept, it is necessary to find new methods to compare multidimensional data from different levels directly. In this paper, we first review past cultural studies, then introduce the concept, research content, and methodology of Culturomics, and discuss future directions for this field.

Culture is a complex topic involving a comprehensive representation of human institutions, social customs, norms, and lifestyles. Over the past half century, the methods of cultural studies have continued to evolve as research questions have expanded and deepened (Bond and Van de Vijver, 2011; Smith and Bond, 2019). However, most current methods focus on interpreting cultural phenomena from a single dimension. This narrow approach ignores culture's holistic and extensive characteristics. This paper first reviews cultural studies over the past 50 years from three levels: external manifestations, internal mechanisms, and genetic basis, and extracts the bottleneck issues currently faced by cultural studies. Then, drawing on the systematic thinking in genomics research, the concept of cultural genomics is introduced, and new research methods, new ideas for solving problems, and future development directions under the framework of cultural genomics research are discussed.

1. Five decades of cultural studies

1.1. Culture and psychology

Culture is a fundamental characteristic of a society and has an important influence on the psychology and behavior of the people who live there. Over the past half century, the relationship between culture and psychology has gradually attracted the attention of researchers and form three main research directions: cross-cultural psychology, cultural psychology, and indigenous psychology. Before the 1970s, under the influence of biological determinism, people devoted their research attention to finding a universal central processing mechanism based on the assumption that humans have a "unified mind". For example, Parsons (2013) studied values as a common symbolic system shared by members of different societies.

In the 1970s and 1980s, researchers began to recognize the link between a person's cultural background and the psychological characteristics of members of that cultural group. Researchers tended to view differences in psychological behavior as the products of cultural

* Correspondence to: Department of Psychology, Sun Yat-sen University, Guangzhou 510006, China.

E-mail addresses: Luosy6@mail.sysu.edu.cn, Ljc520ida@163.com (S. Luo).

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conditioning. They mainly explored behavioral manifestations in relation to broad cultural concepts, usually Collectivism-Individualism. The methodological approach in this stage primarily employed questionnaire surveys and experimental methods. Questionnaire surveys focus on the relationship between culture and the target variables of interest (such as beliefs, values, attitudes, or self-awareness). Experimental methods, such as cultural priming, are employed to temporarily alter individuals' views on a specific cultural value system through explicit (e.g., imagining oneself as a member of another country) or implicit means (e.g., contemplating similarities or differences with one's family and friends). Subsequently, the individual's behavioral performance is measured based on this altered perspective. During this period, the concept of "cultural psychology" in the modern sense began to emerge, namely, the field of study that examines the interplay between individuals, society, and culture.

Since the 1990s, cultural and psychological studies have increasingly emphasized theories that examine the interactions between cultural features and individuals' psychological processes. Researchers began focusing on the relationship between culture and a range of other factors, including behavior and the natural environment (Pedersen, 1998). One line of argument proposed that the generation of culture is influenced by the environment faced by the cultural group in question. For example, "rice theory" proposes that farming types may cause cultural differences, with the rice-dependent southern population in China exhibiting stronger collectivism and a more holistic thinking style (Talhelm et al., 2014). Another study has found that increased environmental threats (such as disease and war) lead to lower relational mobility (Thomson et al., 2018). Human culture also has important effects on objects at different levels, such as the cognition and emotions of individuals, interpersonal relationships within groups, social organization, and even the natural environment. For example, Gelfand et al. (2021) pointed out that countries with tighter cultures have fewer infections and deaths in the face of infectious threats, because tight social norms confer an evolutionary advantage in times of collective threat. This phase of research involves not only traditional psychological research methods, but also new technologies, methods and measures from different disciplines to explore the underlying mechanisms of the interactions between the features of culture and the psychological responses of its members.

1.2. Cultural neuroscience

Cultural neuroscience is a new interdisciplinary discipline that explores the relationship between cultural characteristics and human brain function (Han et al., 2013). It is an emerging discipline that integrates anthropology, cultural psychology, neuroscience, and neurogenetics together with their associated theories and methods. Based on the assumption of human neuroplasticity (Pascual-Leone et al., 2005), group members can produce stable neural activity patterns arising from specific cultural environments through repeated learning, thus forming long-term stable cognitive and behavioral patterns (Kitayama and Park, 2010). Therefore, the neural characteristics of the group may reflect the internal mechanisms of culture.

From this perspective, cultural neuroscience uses fMRI as the primary technical method to investigate how culture shapes brain structure or function (Chiao et al., 2010; Chiao and Ambady, 2007; Luo et al., 2022). Researchers have identified cross-cultural differences in the neural basis of the brain in basic psychological processes, including cognition, emotion, and motivation. For example, Ma et al. (2014) found that individuals from the Danish culture showed stronger activation than Chinese persons in the medial prefrontal cortex (mPFC) when thinking about self-related personality traits, whereas individuals from Chinese culture demonstrated enhanced activation in the temporoparietal junction (TPJ) when considering their social attributes. Furthermore, Han and Ma (2014) conducted a meta-analysis to investigate the cultural differences in brain activity during social and non-social

activities. They showed that the brain activation patterns of East Asians (E) and Westerners (W) exhibited significant differences in their social cognition (e.g., E: TPJ; W: anterior cingulate), social emotion (e.g., E: right dorsal lateral frontal cortex; W: left insula), and non-social processes (e.g., E: left inferior parietal cortex; W: right lingual gyrus).

Another issue cultural neuroscientists investigate is how neurophysiological mechanisms promote the generation and transmission of cultural characteristics. For example, Lumaca et al. (2019) combined auditory and resting-state fMRI with an interactive laboratory model of cultural transmission. Their findings indicated that individual differences in interhemispheric resting-state functional connectivity within frontotemporal auditory networks could predict changes in the music system's cultural transmission and regularization process. This suggests that differences in the lower sensory neurological system may influence the diversity of group cultural characteristics.

In general, cultural neuroscience focuses on interactions between culture, behavior, and the brain. The culture-behavior-brain (CBB) loop (Han and Ma, 2015) highlights the fact that common cultural beliefs enable humans to develop unique behavior patterns. Furthermore, the significant changes in behavior enable the brain to gradually produce structures and functions that adapt to the cultural environment. At the same time, the brain further influences the cultural environment by inducing changes in individual members' behavior.

1.3. The "Genotype" of culture

Culture-gene coevolution theory states that cultural characteristics are the product of human adaptation, similar to the natural selection process of genes, cultural selection, and gene selection interacting with each other (Boyd and Richerson, 1985). Therefore, in addition to exploring the internal mechanisms of culture, researchers have also begun to examine the genetic basis of culture. Previous studies have found that cultural differences can affect differences in gene expression. For example, Kim et al. (2009) investigated how culture and C(-1019)G serotonin 1 A receptor polymorphism (5-HTR1A) gene interact to affect individual thinking patterns. Their findings indicated that the G allele is sensitive to cultural factors, while cultural background can regulate the cognitive tendency of individuals carrying G alleles. The study pointed out that Korean Americans who carry the C/G and G/G alleles tend to have analytical cognition, which is similar to that observed in European Americans but not in Koreans. Kitayama et al. (2014) found that individuals with the same Dopamine D4 Receptor Gene (DRD4) allele showed different social orientations across different cultural contexts. Specifically, European American DRD4 allele carriers were more independent, and Asian-born Asian carriers were more interdependent.

In addition, the expression of specific genes is also culturally specific. For example, Luo et al. (2015) found that oxytocin receptor polymorphism (OXTR) G allele carriers are more sensitive to sociocultural cues, and their empathetic response showed a stronger relationship to interdependent cultural values. Chiao and Blizinsky (2010) analyzed the relationship between collectivist culture and serotonin transporter functional polymorphism (5-HTTLPR) allele frequency in 29 countries from a macro perspective. They found that cultures high in Collectivism are more likely to have members who carry the short (S) allele of the 5-HTTLPR. However, the study's sample lacked representativeness, particularly as it did not include any countries in Africa, thereby limiting the generalizability of its conclusions (Minkov et al., 2015). Nevertheless, the study provides a valuable perspective for examining cultural variations in gene expression.

1.4. Emerging challenges in cultural studies

As research into cultural issues has increased, each discipline has developed its own theoretical perspectives and specific methods for interpreting cultural issues. For example, culture-oriented psychological research describes cultural phenomena at the macro level, referred to as

“culturology” (Minkov et al., 2024); cultural neuroscience compares neural mechanisms at the mesoscopic level; and genetic research explores the genetic mechanisms of culture at the micro level.

The application of a specific disciplinary framework to cultural research allows for a detailed examination of the principal factors that contribute to the emergence of particular cultural phenomena. However, when removed from its specific context, this discipline-specific “key factor” is challenging to comprehend and be accepted by researchers across fields, rendering it less impactful. As early as the last century, Benedict (1935) pointed out that culture should be regarded as an integrated body composed of different value systems. Similarly, Berry’s Eco-Cultural Model (ECM) pointed out that culture is an “organismic” variable that encompasses the multi-level bases of individual biology and psychology, shaped by background factors of ecological and social-political variation (Berry, 2018). Although it is necessary to study certain cultural phenomena in depth within the framework of a specific discipline, this research based on decomposition is not enough to show the complete picture of cultural phenomena.

One problem is that different research levels or disciplines offer unique interpretations of the same cultural issue. For example, psychological research finds that farming type shapes the way individuals think, while genetic research maintains that differences in thinking style may come from different expressions of specific genes. The lack of a unified framework makes it difficult to compare such interdisciplinary findings. Another problem is that due to differences in background knowledge and technical barriers between disciplines, few researchers have been able to link and integrate related research findings at different levels to establish a unified understanding of specific cultural phenomena.

With the cross-integration of disciplines, interdisciplinary research and methods are emerging. The information from different disciplines may confirm or contradict each other and can provide additional evidence or new ideas for research problems. For example, López et al. (2021) used multimodal data to explore the impact of different levels of cultural factors, such as language and religion, and environmental factors, such as geographical distance and altitude, on the genetic structure of Ethiopians. The study found that shared cultural characteristics and geographical proximity jointly promoted the mixing of genes. Lambert et al. (2020) made a horizontal comparison between the evolutionary dynamics of modern cultural artefacts, such as pop music and novels, and organic populations, such as Darwin’s finches and snails. These researchers found that the modern culture evolves at a rate comparable to that of many animal populations, breaking the previous consensus on the rapid evolution of modern culture.

However, current interdisciplinary research remains at a preliminary level. First, such interdisciplinary research tends to focus on the combination of research tools and methods, rather than on the in-depth integration or adjustment of the theoretical foundations underpinning these methods. For example, Svante Pääbo and colleagues used ancient DNA techniques to explore the human evolution process, and by sequencing the DNA of ancient human teeth found in the south corridor of Denisovan Cave, found that the evolutionary history of Denisovan Cave people was very different from that of Neanderthals and modern humans (Reich et al., 2010). Zhang et al. (2019) explored the evolutionary process of languages by combining phylogenetic analysis methods in biology. They found that the Sino-Tibetan language family originated from the Yellow River Basin in northern China.

These studies transfer analytical methods from the biological disciplines and propose groundbreaking solutions to current problems. These applications have transferred the analytical methods of biological disciplines to provide solutions to problems in their own fields, but this cross-over is one-way, rather than cross-disciplinary. Second, research questions are mostly fragmented, and researchers tend to choose superficial issues that are easy to combine at the boundaries of disciplines, lacking in-depth exploration of core issues. Therefore, we propose that contemporary cultural studies should also deeply integrate multi-level,

interdisciplinary research methods and ideas to construct a new approach to cultural studies. To this end, we can draw on the idea of ‘omics’ in the life sciences.

2. Culturomics from the system science perspective

2.1. Development history of “omics”

Omics usually refers to the systematic study of a collection of various research objects in biology, such as genes, proteins, and metabolites (Vailati-Riboni et al., 2017). Traditional biomedical research is dedicated to exploring the function of a specific type of biological molecule within a living system. However, with advances in science and technology, researchers have discovered that biological problems often arise from complex interactions between genes, proteins, and other molecules. In biological processes, multiple stages—from DNA encoding proteins to producing active metabolites—involve key steps like transcription, translation, and transport. Focusing on just one step can miss important information, such as how different steps complement or influence each other (Sun and Hu, 2016). To capture this complexity, scientists began to study biology in a more integrated way, which led to the development of “omics.” The earliest one is genomics, which systematically explores the structure, function, and interrelationship of the genomes of different organisms (Hieter and Boguski, 1997). Following the completion of the Human Genome Project (HGP), the omics of Proteomics, Glycomics, and RNomics have advanced dramatically. So far, this line of omics research has produced several transformative results, such as the HGP leading to a clearer understanding of genes and their regulatory elements, significantly improving the identification of drug targets (Gates et al., 2021).

Another important branch of omics is Brain Connectomics, which originated from fMRI technology and was promoted by mathematical tools, such as graph theory (Sadaghiani et al., 2022). The adult human brain contains approximately 100 billion neurons, each of which can grow 2000 to tens of thousands of dendrites. These interconnected neurons form small networks with specific functions, known as “brain regions.” When different brain regions interact, they create large-scale networks that drive complex behaviors. As a result, Brain Connectomics studies these neural structures at multiple levels—ranging from the microscopic to the macroscopic—enabling a deeper understanding of the brain’s higher-level functions. For example, Malik--Moraleta et al. (2022) used functional connection analysis to study the fronto-temporo-parietal language network across 45 languages and explored the topography and key functional properties of the network. Brain Connectomics has also been applied to treating neurological diseases or neurological defects, such as schizophrenia (Li et al., 2020), obsessive-compulsive disorder (Goodman et al., 2021), and depression (Gong and He, 2015).

In general, Omics research embodies the principles of systems theory. By using high-throughput, systematic methods, it views the research subject as a complete system, focusing on the relationships between its components. This enables scientists to observe and analyze complex biological processes more comprehensively. As a result, the rise of omics research has significantly advanced our understanding and application of medical care and biotechnology. It is particularly useful in identifying disease risks and discovering biomarkers. This broader approach encourages us to uncover new insights that emerge from the interactions between various components and levels, offering a deeper understanding of the research focus.

2.2. Recommit culturomics

It is challenging to understand the nature of culture by studying a single variable from a particular dimension alone. In light of the systematic view of omics, we bring forward the concept of “Culturomics”, originally proposed by Michel et al. (2011). They treated each word in

centuries-old publications as a cultural unit and analyzed the frequency of these words over time to uncover trends in human cultural evolution. They referred this as ‘‘Culturomics’’, a method that studies human behavior and cultural trends through the quantitative analysis of digitized texts. However, the above concept of ‘‘Culturomics’’ mainly borrowed methods of data analysis from genomics to uncover cultural patterns and changes through collecting, storing, and analyzing large amounts of cultural data. The work of Michel et al. (2011), although innovative in its approach, was limited in its scope as it focused on a single level of culture, namely textual analysis, without considering the multi-layered nature of culture.

Thus, we propose to reframe Culturomics as a cross-level and interdisciplinary science, ranging from the micro to the macro levels, to investigate human behavior and cultural representations in multi-dimensional spaces. (Fig. 1) We believe that this multi-level analysis offers a promising approach to addressing global problems, such as climate warming, population aging, epidemics, and so forth. Although there are currently no representative examples, we can envision its application by considering the COVID-19 pandemic. (Fig. 2)

The development and spread of COVID-19 have been influenced by multiple factors (Fangerau and Labisch, 2022), such as the strain variation at the micro level (Li et al., 2023), mental health at the mesoscopic level, and epidemic prevention policies and societal culture at the macro level. These levels are all important components of Culturomics. At the

same time, interactions occur within and across these levels. For instance, individual trust levels can influence adherence to public health policies, ultimately affecting the rate of virus transmission (Yuan et al., 2022). Therefore, a comprehensive understanding of pandemic events requires the integration of diverse disciplines and methodologies, utilizing an omics perspective to capture the full complexity of these phenomena.

Under the conceptual framework of Culturomics, a key question worth exploring is the biological basis of culture. Current cultural research predominantly focuses on phenotypic aspects, studying the macro-level and external characteristics of culture. For example, anthropologists focus on the living habits of human communities, and historians are concerned with the historical materials related to the development of human civilizations.

These phenotype-level studies lack a unified understanding of the internal mechanism of culture. As a characteristic shared by individuals in cognition, emotion, and behavior, culture has its corresponding neurobiological basis. Genetic studies have demonstrated the mutual influence between culture and genes, such as the advantage of the lactose tolerance gene in dairy cultures. Neuroscience research has further shown that the formation and transmission of culture relies on brain functions such as learning, memory, and imitation. Therefore, Culturomics research should integrate these fragmented findings to provide a comprehensive biological perspective on the origin and

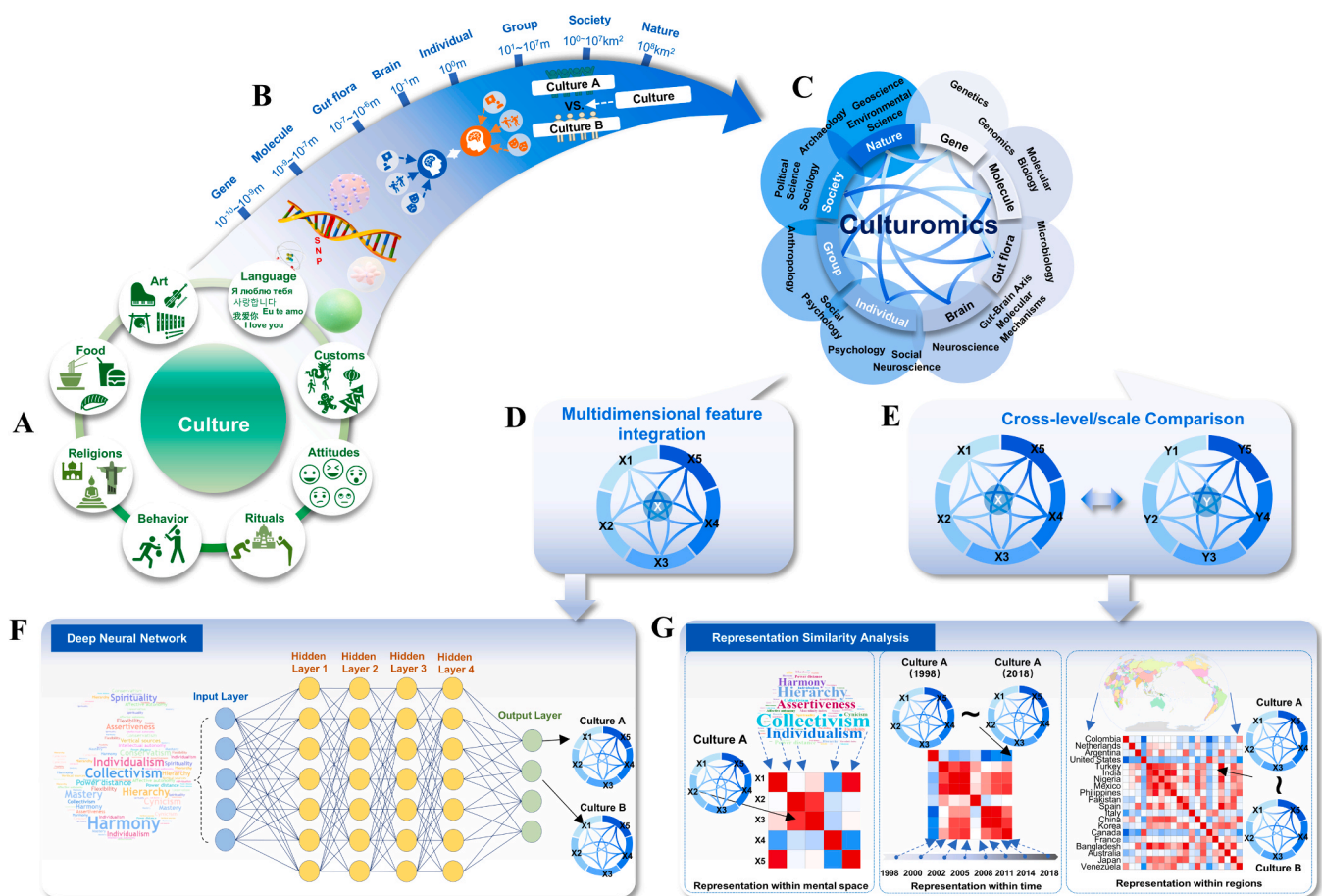


Fig. 1. The research framework of the current research. (A) Culture is a complex topic involving a comprehensive representation of human institutions, social customs, norms, and lifestyles. (B) The study of culture over the past 50 years has involved micro, mesoscopic and macro scales. (C) We propose to reframe Culturomics as a cross-level and interdisciplinary science, ranging from the micro to the macro levels, to investigate human behavior and cultural representations in multi-dimensional spaces. There are two challenges to be faced within the framework of culturomics , (D) cultural studies must adopt a holistic approach that focuses on the interaction of multiple variables, extracting cultural profiles from higher-order space; (E) cultural studies should integrate data of different levels and scales. Based on this, new methods to study cultural issues is proposed: (F) DNN algorithm could be used to cluster and extract multi-dimensional cultural features to obtain higher-level, abstract cultural features.(G) RSA makes it possible to compare cultural phenomena on different levels.

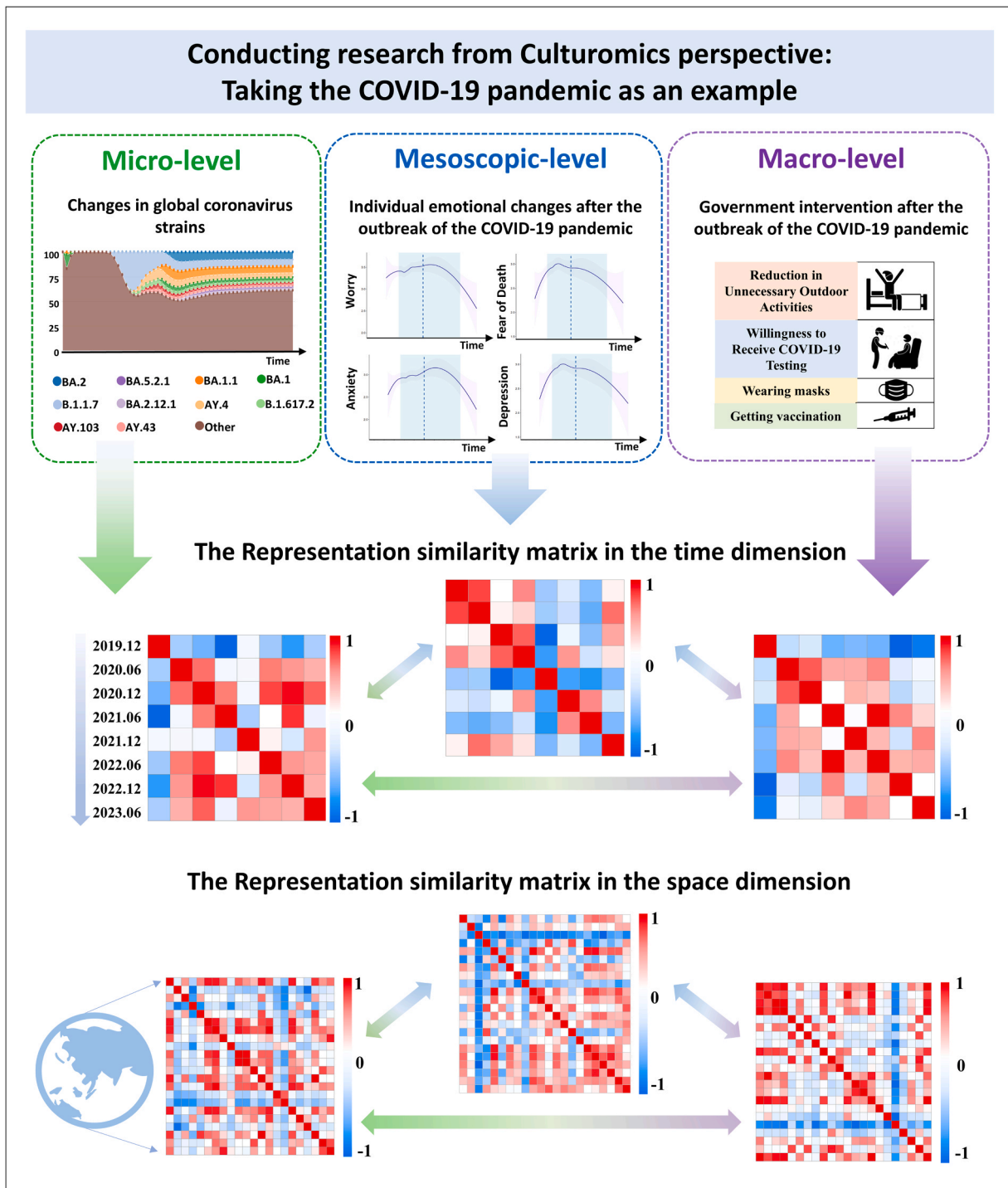


Fig. 2. Conducting research from the Culturomics perspective. The development and spread of COVID-19 have been influenced by multiple factors, such as the strain variation at the micro level (Li et al., 2023), mental health at the mesoscopic level, and epidemic prevention policies and societal culture at the macro level. The interactions occur within and across these levels. Therefore, multidisciplinary methods should be combined to conduct research, such as using RSA analysis to extract high-order patterns of data at different levels, making comparisons between data across dimensions possible.

development of culture. Such a holistic understanding will open new directions for future cultural research and deepen our understanding of human behavior and societal development.

Another important direction is the development of cultural profiles, particularly the study of co-occurrence patterns of multidimensional cultural traits. In current research, researchers have recognized that culture has multiple dimensions. For example, Hofstede (2001) proposed that cultural value has five dimensions, including

Individualism/Collectivism, Power Distance, Uncertainty Avoidance, Masculinity, and Long-term Orientation. However, previous studies have tended to focus on single variables within specific dimensions, such as exploring a country's Individualism/Collectivism orientation by measuring the frequency of first-person pronouns (I, we) used by its members (Kashima and Kashima, 1998). Such traditional psychological approaches struggle to capture the macro-cultural representation composed of all dimensions.

Berry (2018) has consistently argued that culture is a complex system consisting of social norms, national customs, societal institutions, ideologies, and other multi-dimensional features. It should be possible to identify multi-dimensional patterns that combine multi-dimensional cultural traits to obtain the corresponding cultural profiles characteristic of particular ecological backgrounds. Thus, we can examine the spatial changes (the differences in cultural profiles in different regions), the temporal changes (the change in cultural profiles in different historical periods), and the mental-space differences (the change in cultural profiles with different psychological characteristics) associated with these different cultural profiles.

2.3. The challenge of culturomics

Two challenges will be faced in addressing the critical issues of Culturomics. First, there is a need to transform traditional, univariate research into a higher-order representation of multiple variables. Second, it is necessary to move from traditional, single-level research to cross-level comparison and integration.

2.3.1. From univariate to higher order representation

From the methodological perspective, cultural studies must adopt a holistic approach that focuses on the interaction of multiple variables, extracting cultural profiles from higher-order spaces and achieve the transition from stimulus space to representation space. At present, new cultural dimensions are constantly emerging. For example, in cross-cultural studies, cultural dimensions can be divided into Individualism-Collectivism according to the degree of dependence of individuals on the proximal group (Hofstede, 2001) or Tight-Loose culture according to the strength of social norms (Gelfand et al., 2011). In addition, there are multiple dimensions, such as Conservatism (Schwartz, 1994), Power Distance (House et al., 2004), Societal Cynicism (Leung and Bond, 2004), and the recent Monumentalism-Fluxumility of Minkov and Kaasa (2021). The cultural dimensions proposed by different theories are unique, yet there is some overlap between them. Therefore, when constructing cultural profiles, it is necessary to effectively integrate multi-dimensional data while retaining the distinctive features of each cultural dimension.

In addition, the multi-dimensional structure of culture may exhibit different characteristics at the same or different levels of analysis. For example, after conducting a long-term field survey on different primitive tribes, Benedict (2019) found that Zuni culture showed the characteristics of obedience, moderation, and mildness, while Dobu culture showed the characteristics of jealousy, suspicion, and competition. Similarly, Cheng et al. (2023) used two different tasks—dimensional surveys and relational word categorization—to examine individuals' cognitive frameworks regarding social relationship terms. The dimensional survey identified three key dimensions in human relationships: hostile, public, and private. In contrast, the categorization task extracted six major dimensions: hostile, familial, romantic, affiliative, power, and transactional. Therefore, when constructing cultural profiles under different backgrounds, it is necessary to ensure the comparability of this high-level data form, that is, to achieve objective quantification of the characteristics and changes of cultural archives to help us more accurately compare the characteristics and changes of cultural profiles arising from different ecological-cultural heritages (see e.g., Sánchez-Rodríguez et al., 2023).

2.3.2. From single level to cross-level

The biological basis of culture has three characteristics: distributed, networked, and topological. Distributed means that cultural phenomena have corresponding manifestations at different levels of analysis (e.g., neural circuits, gray matter volumes, or SNPs). Networked means that these manifestations are not independent but instead involve cross-level interactions. Topological refers to the higher-dimensional patterns of manifestations that may be similar or consistent at different levels.

Limited by research methods, most previous studies were conducted based on distributed characteristics, carrying out cultural research at a specific level. For example, at the macro level, researchers have analyzed the frequencies of genes such as 5-HTTLPR in populations, discovering the co-evolution of genes and cultural values shaping societal emotional characteristics. At the individual level, researchers have examined cross-cultural differences in the neural activity of specific brain regions, e.g., mPFC, to understand the cross-cultural variations in the neural basis of culture. In addition, cultural studies extend beyond humans, as researchers have identified cultural differences in other species, such as distinct dance languages among bee colonies. These studies at different levels only reflect a specific dimension of culture and are thus incapable of providing cross-level comparative and integrative conclusions to construct a holistic model of culture. Therefore, it is necessary to find corresponding methods to compare and integrate data from different levels simultaneously in the same study.

2.4. The advanced methods of culturomics

The traditional, single-discipline framework cannot effectively solve the bottleneck problems faced by Culturomics research, so it is urgent to carry out method or paradigm changes from the perspective of interdisciplinary science. Among them, Deep Neural Network (DNN) and Representation Similarity Analysis (RSA), common methods in neuroscience, can help to tease apart the complex structure of culture and provide bridges to connect or compare findings at different levels.

2.4.1. Deep neural network (DNN)

DNN is an Artificial Neural Network (ANN) with multiple hidden layers between the input and output layers. Like ANN, DNN can model complex non-linear relationships (Sze et al., 2017). DNN has recently become the standard tool for solving various computer vision problems. In Culturomics studies, besides applying DNN to data generation, prediction, and causal analysis, it is more important that the nature of the DNN algorithm be used to cluster and extract multi-dimensional cultural features to obtain higher-level, abstract cultural features.

DNN has already been applied in cultural studies. For example, Cowen et al. (2021) used DNN to extract 16 facial expressions from 6 million video clips from 144 countries and found that about 70 % of the expressions had cross-cultural universality. DNN can excavate the higher-level dimensional features hidden under complex cultural representations to help us construct cultural structures more accurately and comprehensively. However, DNN has limitations in interpretability, as there is a "black box" between its input and output information, making it challenging to understand each layer of the network. Therefore, future research should focus on developing interpretable models and generalizable methods to explore the fundamental cultural attributes when using DNNs. Currently, a range of large language models (LLMs) based on DNNs, such as ChatGPT, BERT, and ERNIE, have gained public attention, contributing to the possibility of doing Culturomics research. For instance, the BERT (Bidirectional Encoder Representations from Transformers) can perform cross-linguistic semantic analysis and cultural sentiment analysis, facilitating the integration of various levels of cultural data, e.g., language, symbols, behavioral patterns, and revealing the complex structures of cultural phenomena.

2.4.2. Representation similarity analysis (RSA)

RSA is a multivariate pattern analysis method that compares units pairwise to reveal their representation in higher-order space (Haxby et al., 2014). RSA is widely used in neuroscience to correlate various patterns of neural data and behavioral measures to reveal how information is encoded in the brain. It can extract higher-order pattern features of original data to realize cross-level data comparison. Researchers have used RSA to explore the correlation between cross-species, cross-spatial levels, and cross-dimensional data (Popal et al., 2019; Yuan and Luo, 2024; Luo et al., 2022).

Some researchers have introduced RSA analysis into studies of cross-cultural psychology. For example, Huang et al. (2022) constructed the representation similarity matrix of indicators such as the level of Individualism, the total number of deaths, and mortality in 73 countries during the COVID-19 epidemic. The results of correlation analysis showed that the representation similarity of Individualism, as defined by Hofstede's cultural dimension theory among different countries could significantly predict the similarity pattern of death-related indicators among different countries.

Two other studies explored the relationship between economic freedom, trust, and COVID-19 epidemic indicators in different countries from the perspective of representation similarity and found that both the level of economic freedom and interpersonal trust showed significantly similar representation patterns with the speed of epidemic control (Huang et al., 2022; Yuan et al., 2022). In general, RSA makes it possible to compare cultural phenomena on different levels within the same study.

3. Future direction of Culturomics studies

Under the framework of Culturomics, future research can not only determine the antecedents or outcome variables of a specific cultural feature, but can also study the material basis, internal structure, evolution process, and interaction with other cultural features. In addition, future Culturomics research should also try to answer key social questions, such as how sociocultural factors can contain the spread of COVID-19 and subsequent epidemics. Are differences in the epidemiology, patient characteristics, and clinical treatment of malignant diseases, e.g., breast cancer, between Asian and Western countries mediated by material features of their cultural context, especially dietary patterns (see e.g., Akaliyski et al., 2022)? How does the co-evolution of nature and culture affect climate change? What cultural features will drive regional development in the process of economic recovery? Finding answers to these questions is crucial to understanding the nature and meaning of culture. Social science needs this understanding to address 21st century issues of existential concern.

Author contributions

YH and LSY designed the study; YH and LSY conducted the review; YH, LSY, WY and MHB wrote the manuscript.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

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