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An Adaptive Representational Explanation of COVID-19's Evolution

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Abstract: The outbreak of the SARSCoV-2 (COVID-19) virus in 2019 heralded the beginning of a global epidemic. In the past three years, the virus has mutated significantly at least five times, each time creating new variants that pose unprecedented challenges to human survival and adaptation. Through long-term replication and bidirectional selection founded on the environment, the evolution of the virus strains from Alpha, Beta, Gamma, Delta to Omicron and a series of variants, reflecting their increasing ability of adaption to the environment. Its biological adaptation instinct enables its mutated strains to continuously evade the protection of vaccines in the process of evolution, and the toxicity is gradually weakened, so that the virus can adapt to the physical environment of the host (human or animal) to the greatest extent, and can coexist for a long time. Using adaptive characterization as the explanation method, it is shown that virus is an adaptive agent and its variation is the result of adaptive process. As a basic explanatory framework, adaptive representation reflects the essential operating mechanism of various functional systems.This method can well explain the changes in human immunity and the changes in understanding of the novel coronavirus, and also reflects the interpretation role of adaptive representation in biological variation, conceptual change and theoretical replacement, which can use adaptive representation to better understand the changes in the material structure of the virus and the evolutionary means based on environmental adaptability.

Keywords: COVID-19, Viral Mutation, Environment, Host, Adaptive Representation

1. Introduction

On May 5, 2023, the World Health Organization made the significant pronouncement that the COVID-19 pandemic no longer fell within the realm of a "Public Health Emergency of International Concern". From the initial declaration on the 30th of January in the year 2020, wherein the World Health Organization first labeled COVID-19 as a "Public Health Emergency of International Concern", to this momentous declaration of its conclusion, a span of 1,191 days had elapsed. Official records grimly tallied a death toll nearing 7 million souls, though the actual count might be nearly triple the documented number. A profound query that emerges from this global-scale public health crisis is this: How did the novel coronavirus (referred to as "COVID-19" hereafter) undergo mutation and evolution over these three years? From a biological point of view, the survival and evolution of all living things involve the concept of fitness. As early as 1932, Sewall Wright proposed to express the survival ability of biological mutated genes in the environment as biological fitness, and reflected it with the help of fitness landscape. The fitness of organisms depends on a certain combination of genotypes, and specific phenotypes exhibit optimal adaptability under the action of natural selection [21]. Organisms constantly predict and process and adjust themselves in the uncertain environment, thus forming the adaptive representation ability dependent on the environment [24]. From a scientific perspective, we posit that this inquiry is intricately linked to the adaptive representation of scientific cognition rooted in abduction [1]. Adaptation reflects the history of natural and biological evolution, and evolutionary biology and cognitive science form the basis of adaptive characterization [3]. The root cause of immune escape and rapid spread can be analyzed from the structure of the virus [5-7]. In order to seek long-term survival, viruses and other

microorganisms can coordinate with or fight against the host immune system in various ways such as quorum sensing system or internal signal communication [10-12]. Although viruses do not have consciousness, the adaptive representation method can coordinate the explanation of functionality and the explanation of entity behavior. It can not only explain the internal mechanism of consciousness, but also serve as the explanation framework of micro-entities, which is a possible and feasible solution [25]. Using adaptive representations to explain the correspondence between external causes of the environment and internal causes of biological mutations, the analysis of the evolution of the novel coronavirus also confirms the characteristics of adaptive representations such as potentiality, persistence, complexity, and coordination. Thus, the objective of this discourse is to utilize abductive reasoning as its fundamental premise, employing the methodology of adaptive representation to dissect the intricacies of COVID-19's variation and evolution. This endeavor aspires to furnish a cognitive and methodological foundation, one that can be scientifically applied to comprehend and forestall this virus.

2. COVID-19 Adaptive Evolution

It is well known that the first technical description and definition of adaptation originated in the field of biology. Within the biological context, adaptation delineates the gradual modification of organismal structures, aiming to confer superior efficacy in their ecological niches. Whether it is an intelligent human or a non-cellular viral entity, all living organisms share a common objective: ensuring their own survival and optimizing the proliferation of their progeny. To attain a state of relatively stable progression within an ever-changing environment, organisms necessitate adaptive structural adjustments, responding astutely to alterations in their habitats. These alterations, manifesting intuitively, epitomize the organism's inherent adaptability to its environment.

In the case of COVID-19, the overall trend it shows is: each successive generation of variants exhibits an enhanced transmission capability compared to its predecessor, underscoring the extraordinary transmissibility of these variant viruses over their ancestral strains [2]. Notably, compared to the previous strains, the Omicron variant has demonstrated a relatively equilibrated profile in both transmission and virulence, featuring a substantial augmentation in transmission capability concomitant with a diminishment in virulence. From our perspective, this evolutionary pattern observed in viral strains can be cogently elucidated within the framework of adaptive representation.

On the one hand, COVID-19 exemplifies the essentiality of adaptive representation. Representations, being manifestations of the attributes of different substances, widely permeate in the material world, they reflect the characteristic of substances in terms of generality, fundamentality, and essentiality [3]. Similarly, adaptive representation contains the intrinsic attributes of organisms, showcasing the organism's inherent natural state and its functional prowess in adapting to the environment. Coronaviruses, significant pathogens afflicting both humans and vertebrate animals, possess the capability to infiltrate the host's respiratory, gastrointestinal, liver, and central nervous systems [4]. Despite COVID-19 is a non-cellular life, like other organisms, engages with its environment as an autonomous biological regulator. These entities employ two mechanisms—genetic variation and genetic stability—to modify themselves in response to the environmental. Both of these mechanisms constitute manifestations of organisms augmenting their representational capacity to adeptly adapt to their environment.

As a novel RNA virus, COVID-19 possesses a distinctive attribute: its single-stranded structure, which expedites swift self-replication, significantly heightening the probability of genetic mutations. This attribute stands as one of the primary rationales behind the virus's rapid generation of variants. Unlike other organisms that depend on lengthy natural selection processes for evolution, COVID-19 capitalizes on its uncomplicated RNA structure, during extensive replication within a host, the Spike (S) protein, serving as a highly mutable domain, assumes a pivotal role in determining the trajectory of COVID-19's mutations. This encompasses factors such as virus transmission, pathogenicity, and host range.

Consequently, COVID-19 has evolved numerous different characteristics. Certain variant strains demonstrate heightened adaptability to the host environment during transmission, fostering the proliferation and spread of mutant strains. This phenomenon stands as a primary catalyst for the recurrent outbreaks of COVID-19. The inherent structural characteristics of COVID-19 confer upon it the essential capacity to adapt to a shifting environment. In the normal course of events, when the human immune system is stimulated by the virus, it generates antibodies that "neutralize" the infection. However, the presence of multiple synergetic mutations on the Omicron variant's epitopes results in over 85% of the neutralizing antibodies were escaped [5]. Given that genetic alterations in the variant strains can impact the virus's pathogenicity and transmission capability, coupled with the uncertainty regarding the direction of mutations, the establishment of a fitting representation for inheritance involves yet another facet of COVID-19's adaptive representation: error correction capability. The error correction process corrects the evolutionary course, empowering the virus to more effectively adapt to the host's body environment.

Evidently, the evolution of COVID-19 serves as a testament to the biological instinct of adaptability, implying that the attributes reflected in the virus's intrinsic structural representation are based on interactions with the environment, culminating in adaptive phenotypes. The aforementioned characteristics of COVID-19 provide it with increased opportunities to adeptly conform to its environment. As a microorganism, the virus undergoes alterations in response to the environment while also perpetually shaping the environment itself.

Virologist Wendy Barclay from Imperial College London stated, "I was thoroughly expecting that this new coronavirus would adapt to humans in a meaningful way —and that would probably mean increased transmissibility" [6]. The virus's variability in this context does not stem from "conscious" evolution, given its status as a non-cellular microorganism devoid of the complete life and cognitive attributes necessary for purposeful evolution. It lacks the capacity to conceive "notions" regarding the most advantageous representations for its own development. Instead, the environment operates as an intangible regulatory force, with its core attribute residing in the capacity for "change." Concerning the direction of COVID-19's mutations, the selection criteria should harmonize with the external environment, facilitating the objective of survival smoothly. Consequently, macro-regulation plays a crucial role in COVID-19's mutations.

In this context, the environmental regulatory system's role converges with the virus's survival imperative. The virus, acting as the agent, acclimates itself to the target host (such as the human body) upon which it relies for sustenance. COVID-19's mutations confer upon it the ability to adjust to environmental fluctuations while simultaneously eluding detection by the host's immune system. Consequently, immune evasion capability stands as a facet of the virus's adaptive representation.

On the other hand, by scrutinizing the evolving features of the virus's intrinsic structural, we can anatomize its adaptation to the host's physiological environment, elucidating the structural attributes of its adaptive representation. Much like other substances in the world, viruses, being microorganisms, possess distinctive structural configurations. These unique structures, constituting the material foundation for representation, epitomize the virus's inherent properties. The Omicron variant, for instance, displays as many as 30 mutations in the Spike (S) gene, with half of them occurring in the Receptor-Binding Domain (RBD) of the S protein [7]. This results in a substantial reduction in the human immune system's capacity to identify and combat COVID-19, enabling the virus to evade detection and immune responses effectively.

These observations underscore that COVID-19 exhibits both rapid mutation capabilities and self-correction capabilities, rendering the virus itself a miniature regulatory system. Its straightforward structural composition, coupled with mutation-prone regions, endows COVID-19 with the ability to explore diverse mutation pathways, ensuring the emergence of new strains adapted to the ever-shifting environment. The direction of viral mutations remains uncertain, with the environmental selection of new mutation directions assuming paramount significance. The retention of new mutant representations becomes vital for survival. As the largest single-stranded RNA virus discovered to date, COVID-19 has a relatively low mutation rate compared to other types of viruses. Even coronaviruses, including COVID-19, encompass specific self-correcting mechanisms within their polymerases. All these factors contribute to COVID-19's suitability for transmission and adaptation.

In essence, the evolution of COVID-19 is not solely propelled by its intrinsic mutations; ultimate determination rests with environmental selection. Therefore, the virus must possess the capacity for adaptive mutations. Experimental evidence suggests that although most individuals with compromised immune functions can clear COVID-19 infections, there have been cases that highlight the possibility of persistent infections in immunocompromised states accelerating viral evolution [8]. The virus's progression aligns with both sustained infection and accelerated viral evolution. The environment, acting as a macro-regulator, engages with COVID-19 as a self-regulator, adhering to the adaptation-representation principle. This signifies that the virus's adaptability fluctuates with variations in the external environment, with mutations predisposing COVID-19 towards heightened infectivity and immune evasion capabilities.

3. An Adaptive Optimization Representation of COVID-19's Mutation Process

The preceding discussions elucidate that the intrinsic structural characteristics of COVID-19's mutations manifest adaptive optimization behavior, rooted in three distinct rationales:

Firstly, the process of viral mutation embodies an adaptive optimization mechanism. As a self-regulating system, the interplay between the virus's internal structure and the external environment can be delineated into input and output components: external physical environment as a positive input and internal output resulting from changes in the representation state due to external environmental influences. Such a comprehensive positive feedback loop representation acts as the system operates iteratively. We posit that COVID-19 fundamentally constitutes an adaptive representation microsystem, where adaptation and representation engenders a positive feedback mechanism within input and output facets: the virus's myriad unknown mutations persistently generate selectable entities for the external environment. The environment evaluates the virus based on adaptability criteria. If the intracellular environment following the virus's intrusion proves unsuitable for its replication, the assembly or release of infectious virus particles fails, resulting in an abortive infection that impedes viral replication. Consequently, the virus's capability to perceive external entities is accomplished through adaptive representation, empowering the virus to adjust the overall mutation direction in response to shifts in the external environment, ultimately acclimating to novel environments. This fundamental dynamic also elucidates why conventional human treatment modalities face formidable challenges in combatting viral infections.

In biological evolution models, representation can be expressed through models to characterize the features of the

target organism or system. In the case of COVID-19, an individual's RNA genetic information serves as the system's input, during the reproductive process, RNA mutations and recombination engender genetic information distinct from the original viral strain. These new genetic information embodies varied traits, introducing additional heritable phenotypes within the group. The environment furnishes the substantive groundwork for organisms and determines the successful inheritance of new genetic information. The principle of "survival of the fittest and elimination of the unfit" signifies that the environment actualizes the manifestation of group traits frequencies through genetic screening of individual viruses [9].

COVID-19 mutations may employ mechanisms like genetic material recombination, interactions between gene products, and alterations in nucleotide base sequence to enhance the virus's fitness and augment reproduction rates. As the virus continuously adjusts to shifts in the external environment, the representation structure of the entire system similarly undergoes corresponding alterations, dominant strains commandeer more environmental resources, becoming prevalent within the group due to positive feedback effects. Consequently, the environment's impact on a biological group is immediate and enduring. Under the dual influence of genes and the environment, this phenomenon constitutes the fundamental model of biological evolution.

For us, a significant challenge lies in how to define the strength of the virus's adaptive representation capacity. The simple form of viruses is insufficient to support them in actively engaging with the world as higher organisms do. While they cannot rely on complex functional structures to interact with a broader environment, they can still ensure their survival in the environment and create more opportunities favorable for their reproduction. This feat is accomplished through viruses, functioning as non-cellular microorganisms, employing adaptive optimization representations.

In terms of biological priorities, reproductive imperative surpasses mere survival. The evolution of COVID-19, akin to all biological entities, seeks an expansion of reproduction. Consequently, the virus inevitably preserves the most optimal representation. These representations, contrasted with the original structural morphology, epitomize adaptations to environmental shifts. Organisms, molded by external survival pressures, concurrently adapt to the demands of new environments, leading to the development of adaptive optimization representation structures, exemplified by various coronaviruses.

Viruses, as non-cellular organisms, although devoid of the intricate language expression systems found in higher organisms such as humans, possess their unique form of "language" (genes) for transmitting information and a representation mechanism for their own groups—quorum sensing systems. For example, microbiologists have discovered that phages use small-molecule communication system to coordinate the infection process. Viruses secrete signaling molecules to monitor environmental signals and regulate specific gene expression based on the concentration levels of molecules in the environment. This ultimately synchronizes individual behaviors at the community level [10]. Biology has demonstrated that microorganisms possess an adaptive system to process external information representation and establish interconnections between communities through these representations.

In this intricate process, the collaborative nature of representations takes center stage, allocating scarce resources through information exchange at the community level. This cooperative trait underscores the functions of biological entities, fulfilling the ultimate objective of system-level survival. Adaptive representations serve as a collaborative feedback mechanism, facilitating the interaction between viruses and their environment. Amidst these shifts, both viral and environmental systems can undergo disruptions, leading to alterations in either domain. The emerging system might reconfigure, diminish, or augment existing elements. This regulation embodies the subject's adaptation to its environment, preserving a dynamic equilibrium between itself and the external environment to achieve synchronization and harmony between the internal and external realms.

In summary, adaptive representation is not only applicable to the study of mechanisms in biological evolution or human cognitive activities but also applicable to explaining the evolution of semi-living entities like COVID-19 or even non-carbon-based structures (artificial intelligences). Viruses as non-intelligent semi-living entities, manifest a distinctive form of adaptive representation in their mutation process, epitomizing the evolving direction and behavioral significance of their intrinsic structural characteristics.

Secondly, the dynamic interplay between viruses and their environment epitomizes adaptive optimization representation. How does evolution engender organisms better suited to highly uncertain environments? This entails the self-optimization of individual organisms, preserving a relative equilibrium with the broader environment amidst intricate and fluctuating surroundings. Bergson's theory of creative evolution asserts, "Adaptation involves not just the elimination of the unfit. External conditions actively influence an organism, enabling it to adapt to the external environment and sculpt its unique form" [11]. Opportunistic pathogens like pseudomonas aeruginosa actively sense alterations in host immune function, showcasing activities like enhancing virulence phenotypes, research has elucidated the mechanisms through which prokaryotes emit signals directly, triggering responses in the immunity of their eukaryotic hosts [12]. Given the volatility of the environment, organisms cannot endure in a stable state for prolonged periods. To mitigate the impact of uncertainty, organisms must preemptively devise multiple alternative strategies, ensuring optimal outcomes. This enables them to respond adeptly to environmental signals, minimizing the harm wrought by external changes, and preserving fundamental stability.

Why does COVID-19 overall show a trend of increased infectivity and decreased lethality? We conducted an abductive analysis based on the evolution of COVID-19 and found that adaptive representation plays an intrinsic role in it,

the dynamic nature of the human host's environment has a significant impact on the virus's evolution-the dynamic nature of human environmental change makes the dominant representation of virus adaptive. Notably, the spike protein of COVID-19 does not undergo random mutations but rather gravitates towards either high infectivity plus low immune resistance or low infectivity plus high immune resistance [13]. In such cases, humans often use the term "cunning" to describe the virus's mutational capability". Cunning" is actually a metaphorical description of the virus's adaptation to the environment, signifying its strong escape ability. The life force of organisms has a primal desire for reproduction, and the external material environment serves as an external driving force for biological evolution and a stimulus for generating mutations. In the ongoing struggle between organisms and their environment, the myriad options organisms generate and adapt are meticulously screened, seeking the most suitable ones for the prevailing environment. This process propels biological evolution toward optimal adaptability. Environmental selection on viruses transcends mere elimination of those ill-suited to the environment. Through the constraints of external environmental conditions, organic life forms receive feedback and develop morphological manifestations that align with environmental demands.

Another factor contributing to the trend of increased infectivity and decreased lethality in COVID-19 can be attributed to the changing state of the human host as an external environment. As the number of infected and vaccinated individuals in the human population rises, herd immunity mechanisms develop, enhancing the body's adaptability to the virus. This adaptation occurs gradually in the ongoing "war" with the virus. When viruses evolve to evade immune surveillance, their adaptability and infectivity may decrease but COVID-19 still maintains a high level of infectivity [14]. Compared to highly infectious viruses, weakly infectious viruses are more stable than highly infectious strains, weakly infectious viruses are limited in their spread because they are recognized by the immune system, which confines their transmission to a smaller range. Similarly, if a highly infectious virus also has high lethality, it may not easily lead to widespread transmission. Consider the well-known Ebola virus; its rapid fatality limits the time available for contact with others, significantly restricting its outward spread. Viruses lack consciousness and cognitive abilities, yet they exhibit adaptive mutations and representational capabilities. It is precisely this adaptability in representation that makes them appear to spread and infect other organisms prolifically. Therefore, adaptive representation stands as the inherent mechanism and survival strategy guiding viruses toward their evolutionary objectives.

Finally, adaptive representation stands as an intrinsic mechanism and propelling force driving the evolution of viruses. According to Piaget's epistemology, cognition can be approached through biology, explaining biology in terms of the interaction between biological internal factors and external environmental factors, and subsequently elucidating the close relationship between the subject and object of cognition. Cognition, inherently adaptive, constitutes a specialized instance of organisms adjusting to their environment, with the criterion for adaptation being the success of adaptation. Adaptation acts as a yardstick indicating how effectively a virus adjusts to biological and environmental conditions for survival. It allows the virus to seize opportunities for increased reproduction and to expand its territory for survival through the screening process of the external environment, which is a manifestation of success.

4. Human Adaptive Representation to COVID-19

Humans are undoubtedly adaptive subjects, reshaping their living environment when faced with external factors, including viruses. In comparison to other organisms, humans possess consciousness and constitute a sophisticated self-regulating system, allowing them to adapt more flexibly to shifting environments. Their adaptation to any environment can be perceived as a form of creative activity. Bergson astutely noted that the essence of cognition lies deep within the evolutionary process of creative vitality, which continuously manifests itself in novel forms. Consequently, human cognition can be envisioned as an ongoing adjustment of knowledge content and form, rooted in existing structures, be it in response to external environmental changes or internal adaptations. Both external environmental shifts and corresponding internal adjustments serve as foundations for constructing new structures atop existing ones.

The natural environment's role in human cognitive representation is evident in its integration into human thought and its extension into the world. Representation, as an efficacious means, unveils the intricate relationship between the subject's internal state and the external environment, participating in a feedback loop that influences development and change. In this way, adaptive representation aids in our seamless integration into evolving environments, enhances our understanding of internal structures, and updates our perceptions of the external world.

As an example, we amalgamate experiential knowledge of a particular object with our existing experiences. This fresh content becomes the material supporting modifications to our theories, which are subsequently consolidated into new structures, such as scientific theories.

Certainly, human cognition of viruses constitutes an exploratory process intertwined with the ever-changing environment. This evolutionary epistemology goes beyond merely applying biological evolution to the realm of epistemology. A direct amalgamation of the two would create a disjunction between knowledge in the domains of evolution and epistemology, preventing them from forming a cohesive whole. To address this, it's crucial to first clarify our comprehension of cognitive functions, recognizing that these functions change in tandem with evolution. In other words, our cognition of things dynamically shapes itself as these

things evolve. During the process of exploration, cognition becomes entwined with the surrounding environment in which the object resides, it exhibits dynamic developmental traits in response to environmental shifts. Adaptation forms the bedrock for the reciprocal transformation of experience and cognition, serving as the bridge connecting concepts and representations. Within the realm of human representations, we endeavor to categorize the ideas within our minds, organizing and processing information from the external world, organisms seek to explore the essence of matter and selectively create representations of ideas to approach the truth itself. Cognition and representation exist as states of co-evolution; as the environment changes, representations dynamically adjust. This is when adaptive representation becomes particularly important.

In the practice of combating COVID-19, the evolution of people's cognition of the virus and their concepts of personal health exemplify a process of adaptive representation. In the process of developing cognitive knowledge about objective phenomena, we categorize and organize interactions between the subject and object. This leads to an enhancement of representational capacity, rendering adaptive representation as a fundamental categorization ability.

In the initial stages of the COVID-19 outbreak, limited knowledge and understanding prevailed among people regarding the virus. As the virus spread into its mid-phase, the heightened pathogenicity of the novel coronavirus triggered the innate vigilance and fear of the unknown, this realization catalyzed a rapid surge in comprehending the virus. However, due to various constraints, numerous misconceptions persisted. As the risk posed by variant viruses diminished and global research on COVID-19 intensified, the public acquired a more profound understanding of the virus's property, pathogenic mechanisms, prevention, and treatment measures. Consequently, people's perceptions of COVID-19 underwent subtle shifts.

This deepening knowledge empowered individuals to gain fresh insights into COVID-19, motivating them to invest greater efforts in bolstering their immune defenses and virus prevention. Continuous monitoring of COVID-19's dynamic changes, coupled with up-to-date information on its infectivity and pathogenicity, led to the realization that the virus would coexist with humans for an extended period. The realization that the virus would coexist with humans for an extended period led people to adopt an approach to prevention and treatment similar to other infectious diseases of the same level. This adaptation to the post-COVID era's normalization of life is rooted in the evolving understanding of the virus and the changing psychological states of individuals. Consequently, individuals gradually acclimate to shifts in the external environment and proactively regulate their mental and physical well-being.

The adaptive representation changes are notably evident in the conceptual adjustments related to COVID-19. Older concepts might carry biases in their representation of the target object due to limitations in experience or technology, changes in newer concepts signify progress in people's cognition of things. These conceptual adjustments can vary significantly, some completely overturn the old concepts in terms of both name and meaning, this is one aspect. In another aspect, certain concepts undergo extensions or reductions while retaining their essential core. In these cases, the original definition or expression is adjusted based on new evidence over time. In other words, both subjects and target objects make adaptive adjustments based on real-time circumstances. Scientific concepts are not static, their representations inevitably evolve in tandem with humanity's ongoing exploration and understanding.

The categorization of concepts constitutes a process guided by adaptive optimization, shaping human cognitive thinking. This process naturally involves absorbing, communicating, integrating, and reproducing new forms of knowledge. The changes in people's understanding of the COVID-19 concept exemplify the ongoing process of adaptive representation adjustment and optimization. The assessment of the virus's also influences the nomenclature of the virus and necessitates adjustments on different time scales, crucial for determining research priorities in virology and public health fields [15].

In the initial stages of the pandemic, the World Health Organization named the virus "Corona Virus Disease 2019 (COVID-19)" primarily due to the prevalence of pneumonia symptoms in infected individuals [16]. This naming was a reasonable representation based on the disease's characteristics. Subsequently, "novel coronavirus pneumonia" was redesignated as "novel coronavirus infection" and its classification was downgrade from Class A prevention and treatment to Class B prevention and treatment [17]. These changes in terminology clearly resulted from an enhanced cognition of the virus, grounded in adaptive representation built upon evolving facts and iterative reasoning. Consequently, it can be asserted that adaptive representation reflects that the cognitive process unfolds through conceptual or symbolic representation and embodies a typical categorization adaptation ability [18].

In conclusion, over the several generations of COVID-19 evolution, there has been a general decrease in overall infectivity and pathogenicity. The theoretical definitions of COVID-19 that were valid in the past are no longer adequate for the current situation. China has undergone a nationwide epidemic, and immunity levels have reached a relatively high point [19]. The revisions in the new definitions stem from long-term epidemic monitoring and a comprehensive evaluation of the situation, serving as a direct reflection of people's evolving cognition of virus variation. The virus's mutations have led to dynamic adjustments in how people represent it, aligning with the current developments of both the subject and the target object. These adjustments in representation are adaptive responses to changes in external real-world conditions.

5. Adaptive Representational Characteristics of the Evolution of COVID-19

The analysis above highlights that adaptive representations

in the evolution of COVID-19 exhibit characteristics of potentiality, persistence, complexity, and coordination.

Potentiality stands out as the most prominent characteristic of adaptive representations in the evolution of COVID-19. This implies that the virus harbors potentiality in the subject-object relationship. Representations, as intermediary objects, carry the content or meaning of referential relationships. Changes in their attributes, structures, features, etc., are inherently bound by the environment. These potential changes in the adaptive subject are subtle, not easily discernible, yet profoundly influence the representations. The potentiality demonstrated by the virus's representations propels objects toward higher levels of development. These potential changes don't bypass the adaptation-representation mechanism but lie dormant within the system, surfacing later. Whether these are minor shifts within the system itself or external factors (such as fluctuations in the external environment, alterations in resource allocation, and internal physiological differences), they amalgamate to form a comprehensive "adaptation" before manifesting as changes within the intricate adaptive system. Consequently, adaptive systems employ internal representation models to anticipate the future, guiding current actions based on anticipated outcomes without the necessity to actualize these changes in reality.

In tandem with the potentiality of adaptive representation systems is their persistence. The persistence of adaptive representations within the virus manifests in two aspects: firstly, the potentiality of adaptive representations requires time for changes in the environment and subject adaptation; secondly, the role of adaptive representations are continuous. On the one hand, representations themselves exhibit dynamic adaptability, continually evolving and improving with changes in external conditions. For instance, the highly transmissible Omicron variant continues to mutate rapidly, posing challenges for antibody drugs that require frequent updates [20]. Changes in external conditions do not occur overnight, environmental shifts mostly unfold over extended periods, gradual and persistent in nature. In response to these slowly evolving environmental conditions, the impact on representation subjects permeates gradually, prompting the subject to adjust itself in response. On the other hand, the complexity of environmental changes necessitates representations to rely on the external environment, leading to the development of the characteristic of long-term adjustment in harmony with environmental changes. This feature of long-term adjustment constitutes the fundamental reason for the persistence of adaptive representations within the virus.

Under normal circumstances, the adaptability of most subjects to their natural environment is a gradual process, occasionally punctuated by mutations. Gradual changes imply that subtle alterations at each stage must be promptly detected and responded to by organisms. A delayed response can lead to the gradual accumulation of changes, resulting in a qualitative transformation that threatens the subsequent survival of the organism. Therefore, as long as changes in external environmental conditions persist, the changes within organisms will continue to iterate to maintain relative synchrony. The role of adaptive representation within this process will also endure, ensuring the organism's adaptation to the evolving environment.

The persistence of adaptive representation results in its complexity, permeating various aspects. Inorganic non-living entities and organisms constitute an inseparable ecosystem, and the adaptability of this multifaceted ecosystem thrives on the genetic diversity of organisms. This genetic diversity lies at the heart of natural selection's effectiveness and the mechanism of natural learning. With shifts in the environment, new ecological niches demand biological functions capable of sustaining stability, and the complex combinations of biological genetics provide a continuous source of new combinations for natural selection.

In the realm of cognitive representation, complexity also arises during the construction process. When the subject describes the object empirically, they must navigate the intricate web of relationships between the representing subject, the target object, and the mediating object to find an appropriate form of representation. If genetic diversity forms the cornerstone of natural selection, adaptability stands at the core of representation. It refines and modifies the core of experiential content using suitable representational tools, ensuring that all facets of the representation are aptly reflected.

Complexity confers a significant advantage on adaptive representation: higher coordination. Adaptive representation enables evolution to explore the space of phenotypes by selecting the most suitable set of genotypic parameters [21]. Elements within representation exhibit a high degree of correlation, whether between the subject and the object or between the mediating object and the subject-object. All these elements share the same environment within a specific region. Each subsystem within this region is part of the overall system and establishes connections with others.

Similar to natural organisms, where healthy cells adopt effective reproductive strategies to avoid excessive reproduction that could disrupt the living environment, the elements within adaptive representation coordinate to maintain harmony.

However, the question of whether the evolutionary capacity of organisms can follow organic evolution is a topic of considerable debate. Some argue that natural selection cannot directly influence species evolution but achieves it indirectly through adaptability. A recent study published in Science suggests that adaptability and natural selection can coexist, and strong natural selection on the phenotype of organisms leads to the rapid fixation of new functions arising from mutations [22]. This demonstrates that natural selection can drive adaptability in the Darwinian evolution and enhance evolvability.

Adaptability and natural selection are not in conflict; instead, they cooperate in the process of organic evolution. Natural selection tends to cluster genes that make up balanced systems, the process of genes working harmoniously together in the gene pool is referred to as "integration" or

"coadaptation". The result of this selection is called "internal balance". Each gene tends to select the genetic background that contributes the most to fitness, and the adaptability of genes depends on and is controlled by the overall genetic background [23].

In summary, adaptive representations establish connections between organisms and the natural environment, forming a set of selection mechanisms that result in the natural representation thus presented is also coordinated in many ways. These adaptive representations are highly dependent on the conditions of the represented entities, and the intricate intertwining of the real situations of the represented entities becomes one of the factors affecting representation establishment. Representations at different levels involve placing the target within a contextual framework. This necessitates managing changes in experience within a dynamic environment while also coordinating appropriate representation forms. A successful representation form must always be adapted to the target entity, a commonality shared by representations in various fields.

6. Conclusion

Adaptive representations originate from the adaptability of organisms to changing environments during biological evolution. Looking back at the history of the evolution of COVID-19, we can see that adaptive representations played a central role in shaping its overall trends. Adaptive representations, with their essentiality, structural, and coordination, contribute to the dynamic coordination of the virus's characteristics. They reflect the mutual verification of biological adaptation to the environment and the environment's selection of advantageous biological functions. This implies that organisms are adaptive representation systems, and even semi-living entities like viruses are no exception. From a scientific perspective, we can trace the evolutionary mechanisms of COVID-19 through adaptive representations. Therefore, adaptive representations can be used not only to explain the evolution of scientific theories but also to interpret the evolution of complete organisms, semi-living entities, and even self-organizing physical systems in non-living entities. As human cognition deepens with the continuous variation of the virus, the categorization classification of the concept of COVID-19 reflects people's ability to obtain suitable representations in a progressive adaptive process. Representations are no longer abstract descriptions isolated from the perception of the subject but are dynamic presentations and expressions that integrate the subject with the object, the environment with experience, in an adaptive manner. Thus, adaptive representations provide a reasonable framework for a deeper cognition of the evolution of viruses.

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Conflicts of Interest

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References

[1] 魏屹东. (2020). 溯因推理与科学认知的适应性表征. 南京社会科学, (7): 34-43+67. [Wei Yidong. (2020). Abductive Reasoning and Adaptive Representation of Scientific Cognition. Nanjing Journal of Social Sciences, (7): 34-43+67.]

[2] Dai Hui, Zhao Bin. (2023). Association between the infection probability of COVID-19 and ventilation rates: An update for SARS-CoV-2 variants. Building simulation, 16(1): 3-12.

[3] 魏屹东. (2022). 认知的适应性表征: 机制、特征与功能. 南京社会科学, (05): 17-25. [Wei Yidong. (2022). Adaptive Representations of Cognition: Mechanisms, Features and Functions. Nanjing Journal of Social Sciences, (05): 17-25.]

[4] Chen Yu, Liu Qianyun, Guo Deyin. (2020). Emerging coronaviruses: genome structure, replication, and pathogenesis. Journal of medical virology, 92(4): 418-423.

[5] Cao Yunlong, Wang Jing, Jia Fanchong, et al. (2022). Omicron escapes the majority of existing SARS-CoV-2 neutralizing antibodies. Nature, 602(7898): 657-663.

[6] Callaway Ewen. (2021). Beyond Omicron: what's next for COVID's viral evolution.Nature, 600(7888): 204-207.

[7] Gao Bo, He Liheng., Bao Yujie, et al. (2023). Repeated vaccination of inactivated SARS-CoV-2 Vaccine dampens neutralizing antibodies against Omicron variants in breakthrough infection. Cell Research, 33(Jan.): 258-261.

[8] Bina Choi, Manish C. Choudhary, James Regan, et al. (2020). Persistence and evolution of SARS-CoV-2 in an immunocompromised host. New England Journal of Medicine, 383(23): 2291-2293.

[9] 樊巍. (2023). 新型冠状病毒变异株会如何进化. 环球时报, 2023-01-07(004).[Fan Wei. (2023). How Does the COVID-19 Variant Evolve. Global Times, 2023-01-07(004).]

[10] Erez Zohar, Steinberger-Levy Ida, Shamir Maya, et al. (2017). Communication between viruses guides lysis-lysogeny decisions. Nature, 541(7638): 488-493.

[11] 魏屹东. (2022). 论适应性表征及其方法论意义. 山西大学学报 (哲学社会科学版), 45(01): 21-31. [Wei Yidong. (2022). On Adaptive Representation and Its Methodological Significance. Journal of Shanxi University (Philosophy and Social Sciences), 45(01): 21-31.]

[12] Wu Licheng, Estrada Oscar, Zaborina Olga, et al. (2005). Recognition of host immune activation by Pseudomonas aeruginosa. Science, 309(5735): 774-777.

[13] Zhao Yongliang, Ni Wenjia, Liang Simeng, et al. (2023). Vaccination with Span, an antigen guided by SARS-CoV-2 S protein evolution, protects against challenge with viral variants in mice. Science Translational Medicine, 15(677): eabo3332.

[14] Shang Jia, Wan Yushun, Luo Chuming, et al. (2020). Cell entry mechanisms of SARS-CoV-2. Proceedings of the National Academy of Sciences, 117(21): 11727-11734.

[15] Gorbalenys A. E., Baker S. C., Baric R.S, et al. (2020). The species Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. Nature microbiology, 5(4): 536-544.

[16] World Health Organization. (2020). Novel Coronavirus (2019-nCoV): situation report, 22. World Health Organization. https://iris.who.int/handle/10665/330991. [Accessed 6 May 2023].

[17] National Health Commission of the People's Republic of China. (2023).关于新型冠状病毒肺炎更名为新型冠状病毒感染的公告 公告 2022 年第 7 号.中国医药, (01), 5. [National Health Commission of the People's Republic of China. (2023). Notice on renaming coronavirus disease 2019 to novel coronavirus infection Notice No. 7, 2022. China Medicine, (01), 5.]

[18] 魏屹东. (2019). 适应性表征: 架构自然认知与人工认知的统一范畴. 哲学研究, (09): 114-124. [Wei Yidong. (2019). Adaptive Representation: A Unified Category of Natural Cognition and Artificial Cognition. Philosophical Research, (09): 114-124.]

[19] 韩辉, 伍波, 张瑾等. (2023). 2023 年 1 月全球传染病疫情概要. 疾病监测, 38(02): 132-134. [Han Hui, Wu Bo, Zhang Jin, et al. (2023). Summary of global surveillance data of infectious diseases in January 2023. Disease Surveillance, 38(02): 132-134.]

[20] 鞠斌, 周兵, 张政. (2022). 抗新型冠状病毒中和抗体研究现状及展望. 中国科学基金, 36(04): 624-629. [Ju Bin, Zhou Bing, Zhang Zheng. (2022). Current Status and Prospect of Anti-SARS-CoV-2 Neutralizing Antibodies. Bulletin of National Natural Science Foundation of China, 36(04): 624-629.]

[21] Reisinger Joseph, Miikkulainen Risto. (2007). Acquiring evolvability through adaptive representations. Proceedings of the 9th annual conference on Genetic and evolutionary computation.pp. : 1045-1052.

[22] Zheng Jia, Guo Ning, Wagner Andreas. (2020). Selection enhances protein evolvability by increasing mutational robustness and foldability.Science, 370(6521): 59-62.

[23] Mayr Ernst. (1963). Animal species and evolution. Harvard University Press.

[24] 魏屹东. (2024). 认知系统: 结构、功能与特征. 系统科学学报, (04), 40-48. [Wei Yidong. (2024).Cognitive Systems: Structure, Function and Features. Chinese Journal of Systems Science, (04), 40-48.]

[25] 魏屹东. (2023). 适应性表征:意识生成的内在机制和解释框架. 科学·经济·社会, (05), 32-49. [Wei Yidong. (2023). Adaptive Representation: An Intrinsic Mechanism and Explanatory Framework for Emergence of Consciousness. Science Economy Society, (05), 32-49.]