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CHAPTER 1

COVID-19: FROM BIOLOGICAL IMAGE TO THE SOCIAL CONSTRUCTION OF A VIRUS **

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Abstract

The 21st century extreme societal situations, such as the global COVID-19 Coronavirus pandemic, represent major upheavals for people and societies. The COVID-19 pandemic breakdown that has been elicited by the invisible virus SARS-CoV-2 has led to the collapse of representations of the common reality and it has shattered many important aspects of people's lives worldwide. Although, SARS-CoV-2 virus which is at the origin of COVID-19 Coronavirus disease remains unseen to people. The invisibility of this virus gives rise to various representations, projections and imaginations which have a preponderant importance within the population because they drive human beings' cognitions, emotions and behaviours. Therefore, a multidisciplinary research approach is necessary to challenge the "invisible" enemy and the related "domino effects" of consequences. The current research aims to offer a thorough multidisciplinary investigation of this enemy that represents SARS-CoV-2 virus, based on innovative collaboration between hard and soft sciences. To create this synergy, the first objective is to deploy methods from the field of physics, computational sciences and nanometric solutions of microscopy that allow to investigate the biological image of SARS-CoV-2 virus which is an enveloped particle of 120 nm in diameter. Then, the second objective is to investigate the socially constructed representation of SARS-CoV-2 virus by the social representations approach. Therefore, this innovative collaboration that has as main goal the construction of a multidisciplinary overview of SARS-CoV-2 virus images contributes irrevocably to an improved multi-level crisis management effectiveness of current and future pandemic breakdowns.

Keywords: COVID-19, SARS-CoV-2 virus, invisibility, biological image, social constructivism, crisis management

“If the COVID-19 virus could talk, it would have said:

I don’t need any weapons to kill a lot of people.”

(Anonymous female, 63 years)

1. INTRODUCTION

The 21st century extraordinary events represent major collective upheavals for people and societies. The COVID-19 Coronavirus pandemic has shattered many aspects of people’s lives globally during an extended period. To date, the worldwide COVID-19 Coronavirus pandemic has caused more than 383 509 779 confirmed cases and 5 693 824 deaths (World Health Organization, February 3, 2022). The global COVID-19 Coronavirus breakdown has led populations, health, social and economic systems into a total or partial lockdowns that have never been encountered before. Such an unprecedented pandemic breakdown has been apprehended as a rupture by many individuals that have been forced into social isolation impacting in a harmful manner various aspect of their lives. The COVID-19 Coronavirus disease is caused by an “invisible” and “intangible” virus SARS-CoV-2 of 120nm in diameter which arouses many assumptions, representations, projections, and imaginations that have turned people’s reality upside down.

1.1. COVID-19: An Unpredictable Threat of Extreme Consequences

The invisible SARS-COV-2 virus represents major large-scale societal threat nowadays whose public comprehension and people’s representations are the results of complex social construction processes. Social construction of reality remains preponderant especially due to the large-scale, unseen, uncertain and intangible nature of the unknown SARS-CoV-2 virus (Pelletier, McLaughlin, Valette, Lefort, & Boespflug, 2021). The COVID-19 Coronavirus pandemic represents irrevocably an emblematic 21st century extreme situation whose nature is inherent to the human condition. Yet, as Giddens (1994) has pointed out, the paradox of our modern societies is that people lead more secure and comfortable lives than ever before, in a world that is plenty of new dangers

and tensions. The extraordinary situations, whatever their origins and consequences, elicit a rupture between the usual configuration of the state of the world and people's common perception of reality. Indeed, major crisis situations are similar to a sudden chaos that could be qualified as a "*cosmology episode*" (Weick, 1993, p. 633) which refers to a profound upheaval in people's universe.

These unprecedented circumstances that invaded people's lives during the COVID-19 Coronavirus pandemic are marked by uncertainty, ambiguity, novelty of the situation, and the feeling of fear that amplifies the perception of an imminent threat that exacerbates the fragility of human existence. Thus, the global COVID-19 Coronavirus pandemic represents an emblematic situation of major collective threat that leads to a loss of usual stable benchmarks (Pyszczyński, Lockett, Greenberg, & Solomon, 2020). Under these extreme circumstances, external and internal conflicts, tend to hamper the understanding and the acceptance of this new reality. Nevertheless, the "*lifting of chaos*" in extreme situations becomes possible, primarily through meaning-making and social construction processes (Jodelet, 2020; Pelletier, 2016) that allow people to overcome the collective trauma (de Jong, Ziegler, & Schippers, 2020; Pelletier & Drozda-Senkowska, 2019a). Specifically, the "invisible" and "intangible" SARS-CoV-2 virus requires the build-up of a concrete representation of this unknown and dangerous virus that has quickly spread across the globe. Although, the lay perception of SARS-CoV-2 virus is irrevocably underpinned by numerous distortions between the biological image of the virus and people's social representations.

Therefore, the global COVID-19 Coronavirus pandemic requires the collaboration of multiple research disciplines that offer a holistic investigation of the unprecedented situation. The interdisciplinary approach of CoviZion research program, conducted currently in France, is based on innovative collaboration between hard and soft sciences. The aim of this research is to investigate thoroughly various images of SARS-CoV-2 virus that remains the unseen enemy with a thousand faces.

2. COVID-19: BIOLOGICAL IMAGE OF A VIRUS

2.1. Importance to Investigate Biological Images of the Virus

Because of their apparent complexity, scientific research is sometimes misinterpreted by a population informed on these topics only through the prism of mass media that holds incomplete information. This dark side that surround researchers' world and isolate the information for the rest of the population can engender mistrust of the whole research world. This is the case, for example, of genetically modified organisms (Wunderlich & Gatto, 2015) and of certain infectious diseases, that were recently experienced with the COVID-19 Coronavirus. An appropriate way to elicit people's interest for scientific results is by diminishing this informational shadow through simplified experiments combined with explicit and significant results of infectious agents or by any other scientific advances that are debating in society. In this perspective of simplification, we turned to the observation of endogenous fluorescence on the part of the proteins of viral particles of SARS-CoV-2 to provide the best possible information about the new virus and to induce responsible behavior to people through reliable health instructions. Thus, the additional aim of the current investigation is to contribute to restore trust between basic research and the population (Kreps & Kriner, 2020).

On the basis of this reflection about the prevention of the pandemic, it seems relevant to investigate the questions of the population in order to better understand the scientific approaches and the resulting sanitation policies (Pelletier, McLaughlin, Boespflug, Ferrandon, & Lefort, 2021). Information about virus and diseases can be very sensitives and unqualified orator or institution can provide contradictory advices under the guise of scientific council. Thus, making people understand the importance of the scientific work rather than imposing their vision is one of ways to reduce the share of skeptics within the population.

2.2. New Methods to Study 120 nm Objects

Insofar as we want to address the greatest number of people, the presentation of results requires the acquisition of obvious images of the biological mechanisms that researcher aims to explain. However, microscopes are subject to the diffraction limit making these soft solutions difficult to observe objects such as organisms smaller than 200 nm. The SARS-CoV-2 viral particles presenting a diameter 100 thousand times smaller than a human hair (around 120 nm) is therefore necessary to go beyond the diffraction barrier. Several solutions have been affordable since the emergence of super-resolution technologies. The purpose of these techniques is to reduce the impact of the Airy profile at the image through the complete knowledge of the point spread function (PSF) of the system (Lefort, Chouzenoux, Magnol, Massias, & Pesquet, 2020), induced when the sample is excited by a light source. The reduction of this information overflow emitted by the sample will make it possible to refine the signal source that comes from the sample and thus improve the resolution of the image or the ability to discriminate two points side by side on the image.

Recently, many different super-resolution microscopy techniques have appeared (Hell et al., 2015), and below are some examples. PALM microscopy seeks to activate the fluorescence of fluorophores randomly to have only one PSF per fluorophore and then reconstruct a final image combining a multitude of sample images. This technique requires labeling with fluorophores able of extinguishing and activating depending on the given light signal. Light sheet microscopy (Wan, McDole, & Keller, 2019) will collect the light signal emitted by the sample perpendicular to the sample excitation signal, improving resolution especially in the optical axis, and enabling 3D acquisitions. STED-type microscopes will use a de-excitation beam around the excitation beam, reducing the PSF around the fluorophore and thereby improving resolution. Adding spinning disk to a confocal microscope also improves contrast and resolution, requiring a posteriori reconstruction of the final image. The drawbacks for some of the techniques mentioned above is that the sample must be marked and / or fixed to obtain quality images. In this way is not possible to acquire in depth images quickly without damaging the living sample.

Another image analysis technique rests on the implementation of specific computational strategies for the image analysis and the extraction of information lost in blur and noise. The Figure 1 highlights the effect of the instrument on the image deformation for object dimensions in the same range of the resolution (Lefort, Chouzenoux, Magnol, Massias, & Pesquet, 2020). The distortion of the object on the image can be corrected by image processing algorithms to reduce image convolution and render it closer to the original object. In this study, fluorescent microspheres similar in size to viral particles were used to calibrate the image processing software. It is in this context that the microscopy images obtained from the viruses were processed by the FAMOUS deconvolution system (Lefort et al., 2021), developed by the Digital Vision Center (CVN) from CentraleSupélec (Paris-Saclay University, France) in collaboration with Xlim Research Institute (University of Limoges, France), starting from an image recorded in multiphoton microscopy.

The technology inherent in multiphoton microscopy (Larson, 2011) uses a pulsed beam that allows the emission of photons in a region localized at the optical plan, removing in this way the parasite light that is usually produced in more standard solutions of optical microscopy (bright field or confocal for example). This optical solution reduces the damage inflicted on the sample during the acquisition and refine the emission of the signal from the sample by targeting a single focal plane. It was with these parameters that we acquired the images of viral particles and calibrated the parameters used for deconvolution by the FAMOUS system.

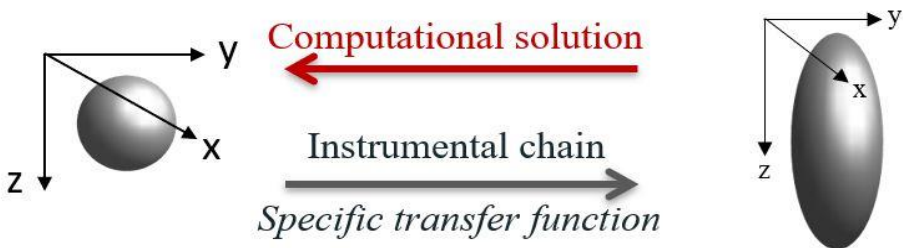


Figure 1. Impact of optical microscope on the image and correction by a computational solution resting on a deconvolution process (red arrow).

2.3. Study of Biological Images of SARS-CoV-2 Virus

To obtain endogenous fluorescence image acquisitions of viral particles and reduce the impact of parasitic fluorescence under a multiphoton microscope it was necessary to purify the sample as much as possible from cell debris and culture medium. This purification took place in three stages. First, the supernatant from infected cell culture media was clarified to remove cell debris and passed under UV beam for 1min to inactivate the viral particles by breaking DNA or RNA bonds in their genetic material. The medium was filtered by centrifugation in Amicon 4mL tubes for 10min at 5000g to keep only virus-sized particles. Finally, the filtrate was taken and transferred to 2mL Eppendorf tubes, diluted by half in PBS and filtered by 40 μ L beads on a magnetic rack after 30min of incubation. This protocol was realized in a biosafety level 3 laboratory (BSL3) specialized in virus treatment. Free inactivated cytomegalovirus and SARS-CoV-2 label-free virions were used for these acquisitions. The same preparations were analyzed with a multiphoton microscope and an environmental scanning electron microscope (ESEM) to have a different view of the surface of the viral particles at higher magnification. The ESEM images presented in Figure 2 were acquired with FEI ESEM Quanta 450 FEG.

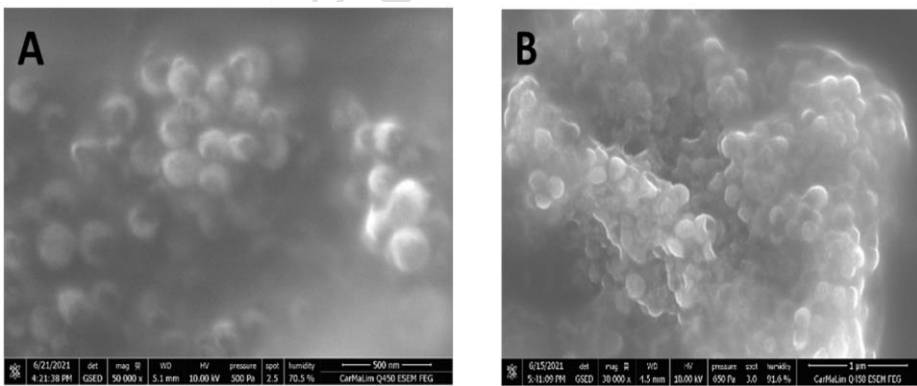


Figure 2. Images acquired at the environmental SEM of samples of CMV coupled to magnetic beads (A) and of SARS-CoV-2 coupled to magnetic beads (B).

As observed in this figure the viral particles have a dark marking on their envelope and a smooth surface. The shape of the viral particles and their

size seem to correspond to the expected scales and the prolonged zooms at high pressure induced their destruction in a few seconds. These images allowed a better understanding of the observations of multiphoton microscopy in the distribution of the viral particles around the magnetic sphere.

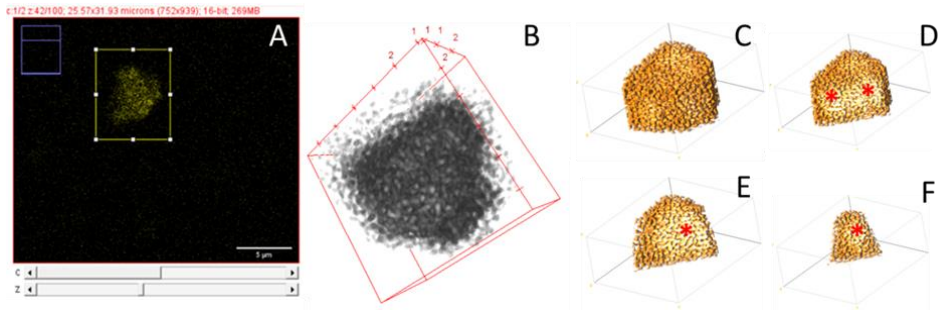


Figure 3. 2D (A) and 3D images of the agglomerate of labeled virions around the magnetic sphere, wavelength: 770nm, emission filter 495-540nm, average power at the sample stage: 5mW, PSF estimated by FIGARO of 275 nm in diameter. C to F. 3D image of the agglomerate of a cluster of labeled virions coupled to the magnetic sphere (red stars) at different resected plans.

In this way, the viral particles coupled to the magnetic sphere could be observed under a multiphoton microscope and reconstructed in 3D and are presented in Figure 3. The images obtained under a multiphoton microscope show us the presence of spherical elements grouped in clusters in PBS between slide and coverslip, with a scale between 0.5 and 1 μm. After digital processing of the 3D stacks images of the area of interest by the FIGARO algorithm, we could obtain a more resolute stack visible under 3Dviewer in ImageJ. From a 3D image digitally processed by FAMOUS, it is also possible to visualize the reconstruction of the image according to different slices, allowing to observe the magnetic spheres inside the cluster of viral particles.

In summary, the acquisition of ESEM images allowed us to better understand the data acquired with a multiphoton microscope, especially in terms of the distribution of virions around the magnetic spheres and the quantity of potential clusters present at the end of the preparation. The presence of darker

areas on the surface of the viral particles in the ESEM images may be the result of the pressure inside the microscope chamber, causing the virion envelope to burst. Although the resolution is better with this technique, we can only observe the surface of the clusters while multiphoton microscopy allows us to observe the sample in all its depth. Observation of viral particles, although they are very small, is therefore possible under a multiphoton microscope. However, it is thanks to deconvolution that we can have such a 3D rendering. We must keep in mind that this are preliminary results, and we need to take a step back about our observations and conclusions. By improving the efficiency of the image processing software, in the future, the acquisition of such images, will provide concrete support for medical biology on the possibilities of observing cells undergoing infection without labeling. Such images are also an asset for the social sciences in explaining and preventing the COVID-19 Coronavirus.

The results of the current research offer interesting perspectives: the observation of the endogenous fluorescence of viruses in a cell during infection appears particularly interesting for understanding the precise infection strategy. Additionally, these findings are relevant to different research disciplines such as medical biology, image processing, artificial intelligence and also social sciences.

3. COVID-19: SOCIAL CONSTRUCTION OF A VIRUS

3.1. Importance to Investigate Social Representations of the Virus

The invisible SARS-CoV-2 virus that is at the origin of the COVID-19 pandemic has shattered various aspects of people's lives and societies worldwide. Therefore, the invisible SARS-CoV-2 virus of 120 nm in diameter represents one of the major current large-scale societal threats. Such a major collective upheaval causes the rupture of continuity between individual's common perception of reality and new circumstances brought by this pandemic. Therefore, the collapse of representations elicited by the unpredictable and uncertain large-scale societal threat requires the reconstruction of meaning of the situation that allows people to cope with these extraordinary circumstances (de Jong, Ziegler, & Schippers, 2020; Pelletier &

Drozda-Senkowska, 2019a). Indeed, as other large-scale societal threats, there are numerous discrepancies between the real threat that represents the biological contamination by SARS-CoV-2 virus and the perceived threat that is based on people's social representations of the virus. Thus, social sciences have a primordial role in investigating social representations of SARS-CoV-2 virus and related consequences of the COVID-19 Coronavirus pandemic on the population.

Indeed, human beings' cognitions, emotions and behaviors are driven primarily by subjective comprehension of the pandemic reality. Therefore, social sciences that emerged in the 17th century during the Age of Enlightenment in Europe have as a primary aim the rational study of various social relationships that underpin our societies. Social sciences that encompass a range of disciplines such as sociology, anthropology, history, economy, social psychology, human geography, management and political sciences focus specifically on the investigation of complex societal issues within given context by multiple methodologies (Backhouse & Fontaine, 2010). Indeed, the perception of the biological COVID-19 threat is irrevocably anchored in a historical and social context. Consequently, individuals' perception of the large-scale societal threat is the result of complex social construction processes encompassing various projections, imaginations, and situations experienced at the individual and collective levels (Jodelet, 2017). Further, the perception of the biological threat elicited by an invisible virus is distorted by mass media, political and institutional communications that tend to amplify or attenuate the characteristics and consequences of this real biological threat (Kasperson, Kasperson, Pidgeon, & Slovic, 2010; Pelletier & Drozda-Senkowska, 2019b).

3.2. Social Representations Theory: The Construction of Common Reality

Social sciences offer a unique opportunity for conceptual and methodological bridge-building that allow to seize the complexity of extreme societal issues related to the current COVID-19 pandemic reality (Pelletier, 2021). The fundamental work of the sociologist Emile Durkheim (1895/1988)

mentions the concept of “*collective representations*” which are collective mental products that allow individuals to construct a representation of an abstract object. This central idea brought in the field of social psychology by the theory of social representations (Moscovici, 1961/1976) postulates that “*social representations*” are aggregations of individual’s beliefs and values which are collectively shared and tend to primarily emerge during daily interpersonal conversations. Social representations are a kind of “theories” that express a common knowledge about a social object with words that are loaded with affects and meanings. Thus, social representations are a form of knowledge which is socially created and shared with others and enable the population to construct a vision of a common reality (Jodelet, 1989/2007, p. 53). In addition, social representations also have a practical aim because as a system for interpreting reality, social representations allow individuals to organize and direct behaviors and interpersonal communication.

Further, it is important to emphasize that the theory of social representations is deeply rooted in the logic of symbolic interactionism that postulates that social interaction processes have a preponderant role in the construction of reality (Mead, 1934/2015). Thus, language tends to be seen as a central tool for the social construction of reality that allows individuals to share a common meaning of abstract objects and situations (Berger & Luckmann, 1966). The social representations that are transmitted and shared through interpersonal communication carry specific cognitive and affective elements that allow the appropriation and internalization of reality. In addition, interpersonal communication allows the dissemination and transformation of social representations. Therefore, the interpersonal communication is a main process that underlies the construction of common COVID-19 pandemic reality.

The COVID-19 pandemic, as any other new and extraordinary situation, obliges people to reconsider their ideas and their usual way of thinking in order to adapt to the new situation which is becoming a part of the 21st century history. According to the “ternary” psychosocial reading proposed by Moscovici (1984), our interpretation of facts and relations, such as the unprecedented COVID-19 pandemic, are the result of complex social construction processes, represented in Figure 4. These social construction processes are the sum of the interaction between “**Ego**” which refers to an individual, a social

group, an institution or a mass media and “Alter” which represents another individual, another social group, another institution or another mass media. According to the theory of social representations (Moscovici, 1961/1976), two different human thinking processes operate simultaneously allowing individuals to construct and to appropriate the representation of an abstract or new object, such as the COVID-19 Coronavirus pandemic.

These two human thinking processes are the anchoring process and the process of objectification that tend to emerge in language and interpersonal communication. Specifically, anchoring process refers to human thinking by analogy which enables individuals to understand the event, assimilate it into their pre-existing thinking system and related beliefs and values. Therefore, the anchoring process necessarily relies on individual and collective memories of a similar object or a situation. Further, the process of objectification allows selecting new information, wherein solely the information consistent with individual’s previous beliefs is retained and transmitted to others. In addition, the process of objectification tends to transform an abstract or unknown object into a more familiar and tangible purpose. Additionally, that is through the processes of anchoring and objectification that common ideological consensus is constructed about an object or a situation. Therefore, the individuals’ common social representation is driven by a subjective logic that is the result of complex individual and collective social construction processes.

The COVID-19 pandemic is elicited by unseen biological contaminations through SARS-CoV-2 virus that people tend to anchor in their daily lives by various projections, representations and imaginations. Thus, the unprecedented COVID-19 pandemic situation requires that people construct social representations of the “invisible” SARS-CoV-2 virus, related modes of transmission, and the overall consequences of the COVID-19 breakdown, including the attribution of responsibility for this global pandemic (Apostolidis, Santos, & Kalampalikis, 2020).

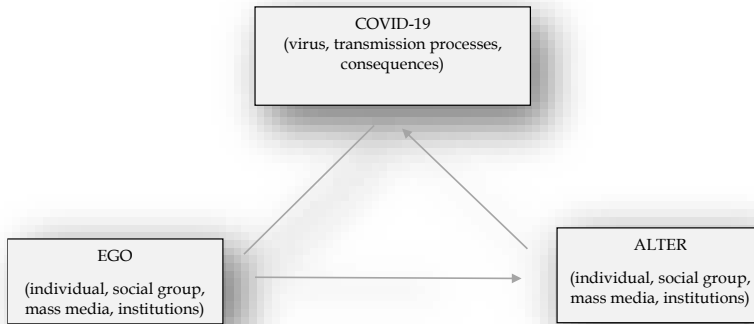


Figure 4. The “ternary” psychosocial reading that underpins the construction of the social representation of COVID-19 pandemic (adapted from Moscovici, 1984).

3.3. Social Constructionist Pathways of SARS-CoV-2 Virus

The SARS-CoV-2 virus causing the Coronavirus COVID-19 disease remains unseen to people, therefore this “*invisible enemy*” requires a proper investigation within given context. The data from this research were collected by an anonymous and strictly confidential questionnaire administered online during the COVID-19 pandemic breakdown on a representative sample of inhabitants of the Nouvelle-Aquitaine region in France. The sample of participants ($N = 928$), aged from 18 to 84 years ($M = 45.41$, $SD = 3.99$). The sample was composed of 52.60% females and 47.40% males. Further, 60.80% of participants declared that their family members or friends have been infected by the COVID-19 Coronavirus disease.

The general objective of this questionnaire was to investigate the social representations of the COVID-19 virus related to the emotional and behavioral reactions of the population. The questionnaire contained a free association task without any constraint of production that aimed to seize participants’ perceptions of the unknown COVID-19 virus. Thus, participants were asked to write spontaneously their most important ideas and feelings while thinking about the COVID-19 virus during the pandemic lockdown in France.

The automatized qualitative data analyses were conducted with the software IRaMuTeQ version 0.7 alpha 2 (Ratinaud, 2014, 2009), and completed with semiotic analyses. The software IRaMuTeQ is an interface of software R version 4.1.0. for Windows, that was designed specifically for

multidimensional analyses of text datasets on the basis of social network analyses principles (Wasserman & Faust, 2009). The main results represented in Figure 5. demonstrated that the initial 13 048 text forms are structured in 10 main discourse clusters, wherein the main cluster, represented in the light green color is centered around the noun “Containment” (*confinement*).

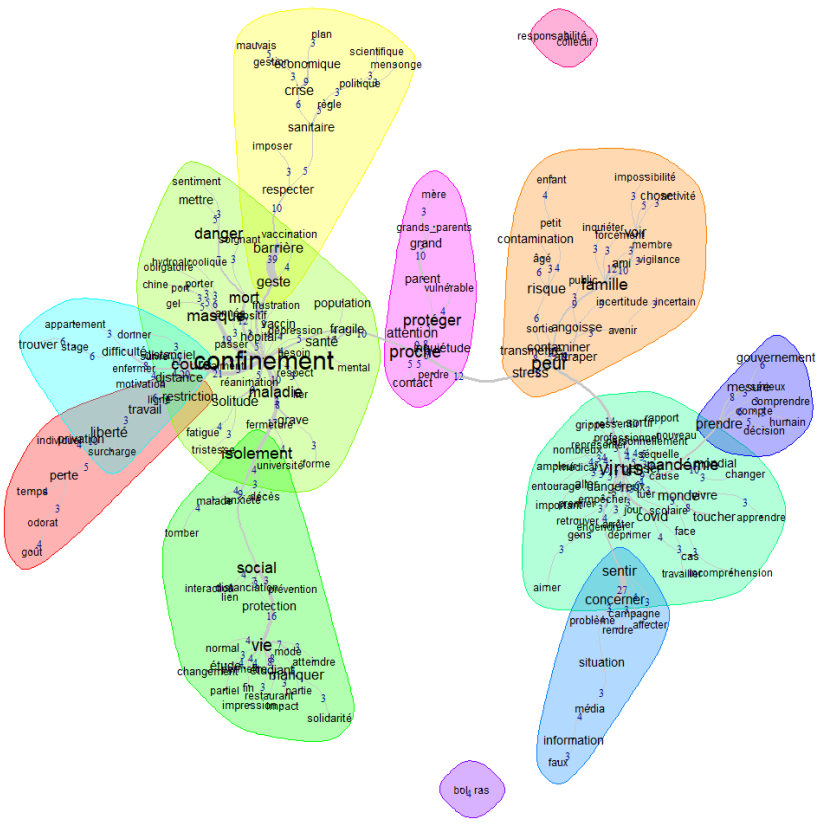


Figure 5. Graph of similarity analysis with the size of verbatims proportional to their frequency and the size of vertices proportional to the co-occurrence of verbatims.

Participants have apprehended the COVID-19 sanitary containment during the pandemic lockdown in France as a sanitation policy that protects

them against the COVID-19 Coronavirus “disease” (*maladie*) that represents a “danger” (*danger*) of “death” (*mort*). The containment (*confinement*) and other related COVID-19 sanitation policies, such as « masques » (*masques*), “hydroalcoholic gel” (*gel hydroalcoolique*), “barrier gestures” (*gestes barrières*) or “vaccination” (*vaccination*) that protects “fragile populations” (*population fragile*). Although, the COVID-19 sanitation policies tend to elicit negative issues such as “loneliness” (*solitude*), “tiredness” (*fatigue*), “sadness” (*tristesse*), “depression” (*depression*) and “isolation” (*isolement*) that impede usual “social life” (*vie sociale*), represented below in the middle green cluster.

Participants expressed their “worries” (*inquiétude*) and willingness to “protect” (*protéger*) their family members, such as “children” (*enfants*), “parents” (*parents*) and “grandparents” (*grand-parents*), represented in the pink cluster. Further, participants expressed their ambivalence related to the fact that might be simultaneously a vector of the virus and that they might “transmit” (*transmettre*) and “contaminate” (*contaminer*) their loved ones (e.g., “parents” and “grandchildren”), but also “catch the virus” (*attraper le virus*). The awareness of the transmissibility of the virus elicits aversive feelings and emotions, such as “fear” (*peur*), “stress” (*stress*), “anxiety” (*anxiété*) and “uncertainty” (*incertitude*), represented in the brown cluster.

Furthermore, the participants represent the “virus” (*virus*) in the dark green cluster, as “dangerous” (*dangeroux*) and “worldwide” (*mondiale*) “killing” (*tuer*) virus that is at the origin of the “pandemic” (*pandémie*) of “global magnitude” (*ampleur mondiale*). The “new” (*nouveau*) virus that can be transmitted by a “touch” (*toucher*) such as a “flu” (*grippe*) causes important “sequels” (*séquelles*) and impediments with regard to “see our loved ones” (*retrouver les gens qu'on aime*) and usual daily activities, such as “work” (*travail*) and “university courses” (*vie scolaire*). The representation of the virus is underpinned by “mass media” (*média*) that convey “information” (*information*) to make people to “feel concerned” (*sentir concerné*) about the “sanitation campaign” (*campagne*), represented in the blue cluster; and by political communication elicited by the “government” (*gouvernement*) that “makes decisions” (*prendre décisions*) about “sanitation policies” (*mesures sanitaires*), represented in the purple cluster.

These results have been confirmed and refined by the multivariate technique of factorial correspondence analyses represented in Figure 6. The

results demonstrated three main discourse categories based on the corpus of text dataset. Thus, participants' representations of the invisible virus refer mainly to (Class 1) the worldwide spreading and dangerous virus that elicits aversive reactions and fear (46.24%), *virus*, $\chi^2(88, N = 84) = 92.61, p < .001$; (Class 2) the consequences of sanitary containment and policies during the COVID-19 pandemic lockdown and related difficulties experienced primarily due to the social isolation (32.23%), *containment*, $\chi^2(140, N = 88) = 73.75, p < .001$; and (Class 3) the fear of death that elicits the feeling of anxiety and other aversive reactions, including stress, sadness and anger (21.53%), *death*, $\chi^2(46, N = 36) = 93.28, p < .001$.

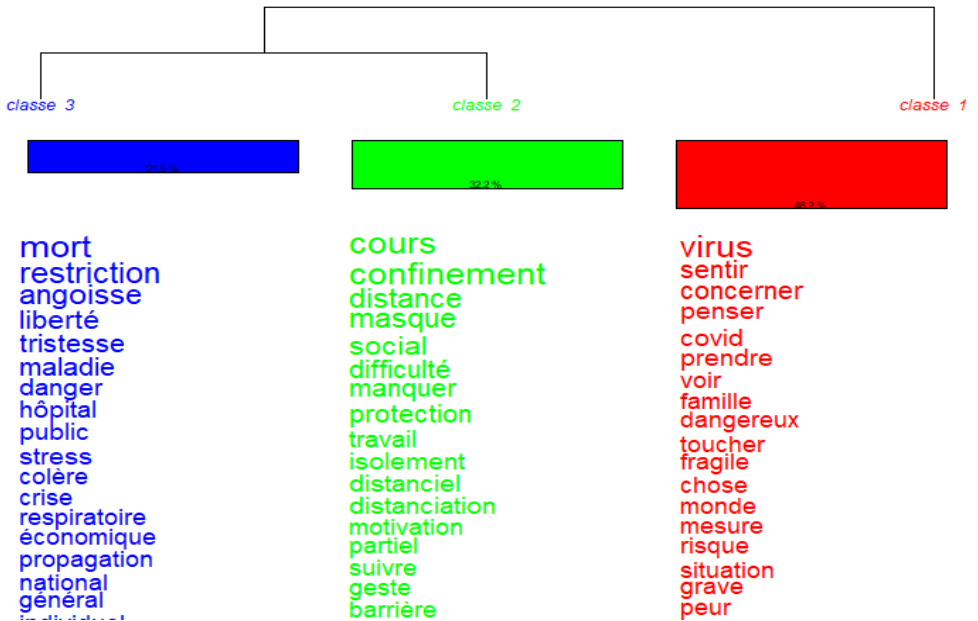


Figure 6. Graph of multivariate technique of factorial correspondence analyses for the three main discourse categories.

These results demonstrate the importance of people's narratives in the construction of social representations of the invisible SARS-CoV-2 virus. The

“war metaphor” largely conveyed by the mass media and political communications testifies the universal human reflex to narrate, to tell stories, in an attempt to understand and to construct meaning of the unprecedented COVID-19 pandemic (McLaughlin, Pelletier, & Boespflug, 2022). Moreover, people’s narratives place the virus in the role of an enemy to demolish and the COVID-19 narratives tend to divide civilians into distinct armies: those who are on the front line to act, those who must stay at home to protect themselves and others, those who are the most important "vectors" of the virus, and those who are the first victims of COVID-19 Coronavirus disease.

4. CONCLUSION

The current research offers a thorough multidisciplinary investigation of the invisible enemy that represents SARS-CoV-2 virus, based on innovative collaboration between hard and soft sciences. Specifically, the biological image of SARS-CoV-2 virus has been investigated by methods from the field of physics, computational sciences and nanometric solutions of microscopy. Further, the socially constructed representation of SARS-CoV-2 virus has been investigated by the social representations approach and completed with semiotic analyses. Therefore, the current research that offers a multidisciplinary overview of different images of the invisible and intangible SARS-CoV-2 virus aims to construct relevant knowledge that irrevocably contributes to an improved multi-level crisis management effectiveness of current and future pandemic breakdowns.

In particular, the current research highlights discrepancies between the biological image and the socially constructed image of SARS-CoV-2 virus. The gap between the biological microscopy image of SARS-CoV-2 virus and the complex socially constructed image is therefore significant. These main results indicate a difficulty in apprehending the biological microscopy image within the population that attempts to appropriate the unseen and unknown virus rather by socially constructed representations elicited primarily by mass media and

his or her own living experience. Indeed, the current research demonstrates the primary influence of mass media and political communications that underpin the construction of social representations of SARS-CoV-2 virus. Therefore, an efficient crisis communication, that contributes to the overall crisis management effectiveness, should focus also on the diffusion of the biological microscopy image of SARS-CoV-2 virus in order to limit various fake news and conspiracy theories related to the possible non-existence or misrepresentations of SARS-CoV-2 virus and related COVID-19 Coronavirus disease.

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