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1. SUMMARY

In this Final report, we present the research on the acceptance and acceptability of virus-based plant protection products (VB-PPPs) and the main findings so far. In the second section, we shall describe the psycho-sociological problem of virus-based biotechnological innovation starting from the mismatch between common and scientific knowledge. In fact, this kind of agricultural innovation is increasingly urgent to cope with new phytosanitary policies aimed at reducing the use of pesticides, and it clashes with a common sense of the virus as something negatively connoted. Therefore, acceptability can be described in terms of a 'dilemma' between opposing positions and interests, which corresponds to a more general knowledge gap between experts and non-experts. The research was structured to hold together the different points of view explored through different tools and methods. The views of 23 experts were explored through the Delphi method, carried out at three time points: before the Covid-19 outbreak, during the months of the lockdown, and one year later. In strong interaction with the first Delphi, we conducted 5 focus groups that were attended by 35 people. Unfortunately, due to the Covid-19 emergency, it was not possible to conduct the sixth focus group. In the results section we shall expose some framing of the dilemma from the experts' side (Section 4.1), the role of social representations and more generally of risk perception by non-experts (Section 4.2), and finally we shall propose a sense-making model of acceptability as it emerged from the focus groups. In Sections 5 and 6, the main problems will be resumed deepening the more strictly communicative aspects indicating the future challenges both from the side of psycho-social research and, more generally, for the process of innovation of virus-based biotechnologies in agriculture.

2. ACCEPTANCE AND SENSE-MAKING OF VIRUS-BASED BIOTECHNOLOGICAL INNOVATIONS

2.1. VIRUS AS A SOCIOCULTURAL PROCESSUAL-OBJECT

This research on social acceptance of virus-based plant protection products (VB-PPPs) adopted a socio-constructivist approach, i.e., taking a processual point of view that allows to follow the moments of the construction/reconstruction of knowledge validity within social fields that may accelerate or inhibit innovation (Carradore *et al.*, 2020). The pandemic outbreak stimulated global research around the coronavirus object and the constellation of issues related to contagion (Coccia, 2021; Zyoud and Zyoud, 2020). At the same time, as an indirect effect, this hyperobject (Morton, 2013) caused an alteration of flows (not only economic but also symbolic), by re-locating or stopping activities in other areas deemed no longer relevant (Yanow and Good, 2020), and by incentivizing the writing of new research agendas. For these contextual reasons, defining 'what is a virus, beyond the disciplines immediately involved (from virology to immunology, from human to plant biology) implies focusing on a complex of fields, from policymaking to the information system, which contribute to the *signification* and *perception* of the object in question. What we know about viruses depends on detection technologies that, in turn, are based on historically conditioned epistemological and political models (Colella *et al.*, 2019). On the other hand, policy decisions often depend on the scientific knowledge available at a given historical moment. With respect to this double movement, in which the science-society relationship is inscribed, the areas of uncertainty multiply either by facilitating innovation (as elaboration and articulation of new cognitive or applicative hypotheses) and by imposing a governance of complexity (as a reduction of interferences but also as an acceleration of interchanges between societal sectors) (Illynskii, 2009).

2.1.1. A PARADIGM SHIFT IN THE DEFINITION OF VIRUS

Historically the discovery of viruses is dramatically linked to the efforts made by the biological sciences to combat major diseases that are lethal to human beings and, more generally, to the living world. The framework of reference of pathological phenomena has undoubtedly conditioned the very choice of the term 'virus', whose etymon '*vira*' in Latin means 'poison'. However, if we consider the Indo-European root '*vis', the meaning is more neutral, expressing the quality of 'being active', 'operational' and 'aggressive'. This latter accent has actually remained in the background compared to the *negative connotation* of the virus as a biological entity by definition 'harmful' and 'dangerous'. This has undoubtedly allowed the medical research to identify viruses as the main

cause of major diseases and to develop strategies and therapies to counteract them. For decades, the field of virology has been oriented in this direction, also thanks to official awards, such as the Nobel prizes for the discovery of viruses such as HIV and human papilloma virus in 2008 (Weiss, 2008).

A first step aside from this framework was the recognition, alongside pathogenicity, of a plurality of ways in which viruses can be harmful, such as been responsible for the reduction of host fertility or behavioral alterations. Therefore, it seemed more accurate to define viruses as "fitness-reducing entities, most often through their pathogenic effects" (Pradeu, 2016, p. 81). By leveraging the concept of adaptation, this specification turns the focus to immune dynamics. It is noteworthy that even in this case the fundamental frame of reference was initially, and for a long time, based on an interpretation of the immune system as a 'defense system', representing the system-environment interaction as a 'war' between a healthy organism and the pathogens that populate the living context. This warlike and conservative representation, although widely rescaled and challenged – especially by *evolutionary developmental biology* (Minelli, 2009) and *developmental ecology* (Gilbert *et al.*, 2018) – still conditions the directions of scientific inquiry and the destinations of research funding, and especially scientific communication (Semino, 2021; Schnepf and Christmann, 2021; Panzeri *et al.*, 2021).

From the perspective of the sociology of knowledge (Cerroni, 2018), the construction of virus meaning can be described as a circular, mutually reinforcing relationship between the virus and the immune system as follows: if a disease is defined as a threat to the defense system, then its cause is understood and treated as an 'absolute enemy'. The iteration of this epistemological-political syllogism (Esposito, 2011), therefore, tends to transform the negative connotation (which should concern a fraction of the possible: 'that single virus in specific circumstances is the cause of damage to the host organism') in *tout court* denotation: 'every virus is an enemy'. A 'pathological paradigm' in which viruses are understood, prepares the new acquisitions within a framework of stable and publicly recognized assumptions (Silvestri, 2021).

A 'scientific revolution' in the field of virology has occurred over time, thanks to the discovery of phenomena no longer framed or reducible to the two definitions of viruses reported above. Roossinck (2011) examined a set of phenomena that are incompatible with the framework of pathogenicity as is the case for mutualistic symbiosis, a special behavior involving two or more entities that increase the fitness of the host in different ways. Symbiosis in nature is a common situation, both at the macro and micro levels, when two distinct entities live in intimate association. Depending on the specific qualitative and exchange relationship between the parties, three types

of symbiosis can be distinguished: a) antagonism, when one partner benefits at the expense of the other; b) commensalism, where one partner benefits and the other is unaffected; and c) mutualism, when a relationship between the partners not only benefits them both, but also increases their fitness, defined as their ability to reproduce. Within the latter case, it is possible to examine the impact of mutualism on host development, protection, and invasion capacity. As an example of the beneficial effects of a virus on host development, the evolution of the placenta in mammals due to the presence of an endogenous retrovirus may be cited (Pradeu, 2016). Endogenization is interpreted as the result of a process of immunization to an otherwise lethal virus, a life event not only for the individual, but also for the evolution of the species. Symbiotic mutualism is a kind of fusion of two symbiotic entities (such as host and a specific virus) that becomes essential for mitigating the damage caused by other viruses or pathogenic microorganisms. In their ability to kill competitors, viruses help their hosts adapt to threats and environmental changes. The discovery of these processes has incentivized research into the *microbiota* (the population of microorganisms that coexist symbiotically in a host organism) and, within it, the *virobiota* (the community of viruses) and the set of all genes in the virobiota itself (*viroma*). In the last decades, the crucial function of a part of the bacterial population of the human microbiota has been widely recognized by the public opinion, also thanks to the notion of probiotics, defined at the beginning of 2000 by WHO as live microorganisms present in or added to food and that confer a benefit to the host organism (Nerlich and Koteyko, 2008). The food industry, through the lever of healthiness, has certainly facilitated and accelerated this change of perception not only towards bacteria but also towards antibiotics, which are considered increasingly harmful to the mycobiotic balance (Klaenhammer, 2000; Saarela *et al.*, 2000). Moreover, the presence of mutualistic viruses may induce vital functions of mutualistic bacteria living in the host. For example, in the case of the human intestinal microbiome, "we will undoubtedly find that many of the beneficial effects of the microbiome are encoded by viruses" (Roossinck, 2011, p. 106). In addition, metagenomics studies have shown that the virobiota, while specific to each individual, can show similarities in people living together or belonging to the same family; indeed, people in close contact with each other share a fraction of their oral virobiota (Abeles and Pride, 2014). The representation of health as an individual fact would seem to give way to a communitarian conception, in which the immune endowments of individuals are mutually reinforced according to the homeostatic dynamics of a super-organism (Eberl, 2010).

Historically, viruses have been employed as natural weapons, in which adaptation is no longer played out within the organism but in the external environment. A famous case of intentional use of viruses, as a biological control agent, dates back to the 1950s, when the myxomatosis virus was

spread in Australia and the United Kingdom to control the proliferation of wild rabbits (Bartrip, 2008). This strategy mimics the natural attitude of some microorganisms, such as bacteria and yeasts, to counter biological competitors by using viruses. During modernity, epidemics that have affected the indigenous peoples because of their contact with Europeans can be read from the perspective of a biological control of new territories, obtained through the combination of a great variety of the European microbiome (trained by internal migrations and pandemics) and the effectiveness of medical techniques.

Despite the existence of mutualistic viruses has been known since a long time, the persistence of the old paradigm has slowed down alternative orientations. Only in relatively recent times, a full "more general reconceptualization of viruses, at the interface between medical and ecological-evolutionary approaches" (Pradeu, 2016, p. 80) has emerged, implying a new process of signification and sense-making at the level of public opinion. In 2019, the Italian virologist Guido Silvestri wrote a popular essay provocatively entitled *The Good Virus* (re-published under the title *Men and Viruses* in 2021) to promote a more complex perspective of meaning starting from the examination of retroviruses that, as mentioned above, can grant beneficial and in some cases vital functions to the host organism. Currently, it is estimated that "8-10% of the human genome is made up of endogenous retroviral sequences, not necessarily harmful to the health [...], and that another 15 percent is composed of three other mobile units of probable viral origin. [...] We are full of retroviruses, and each of our cells is full of retrovirus. Similarly, retroviruses are full of us, since every retrovirus that reproduces in our body is readily packed in the outer membrane (called envelope) of the newborn particle. If our DNA is full of retroviruses, and if retroviruses are full of our molecules, then where is the line between us and them?" (Silvestri, 2021, p. 53). Raising the question of the limit between human and virus is not only a philosophical-epistemological issue that requires a rethinking of scientific knowledge of an immune system (be it human, animal, or vegetal); it is also predominantly a socio-political issue. Indeed, the legitimization of the social role of scientists (and of scientific knowledge) in Western societies has been consolidated thanks to the successes of a "triple convergence" between science, politics, and society; this is the case for the eradication of smallpox virus through a massive worldwide vaccination campaign conducted from 1958 to 1977. This campaign was rooted on the pathological-essentialist paradigm 'virus = poison'. Therefore, whenever research progresses, critical issues concerning the social acceptability of innovations (theoretical and practical) arise, i.e. the complex of stakes, norms and values in force in specific contingencies and that regulate the relationships and interactions of everyday life.

2.2. THE DILEMMA OF SOCIAL ACCEPTANCE OF VIRUS-BASED BIOTECHNOLOGIES

In the last decades, a paradigm shift has taken place concerning the knowledge of viruses and their ecological role (Witzany, 2012; Crawford, 2002), whose implications in medicine but also in agriculture and environmental contexts have not yet been adequately investigated sociologically in terms of the acceptability of innovation, or the conditions under which an invention can take root in a social context and transform production routines (Rodgers, 1993; Weldon and Laycock, 2009; Bozzini, 2017).

2.2.1. ACCEPTANCE OF VIRUS-BASED PRODUCTS IN MEDICINE

Phage therapy is the most popular and historical example of the use of viruses in human healing (Anomaly, 2020; Dedrick *et al.*, 2019; Fauconnier, 2019). Currently, social acceptance of such therapy is required at the regulatory and institutional level, but only at the level of the physician-patient relationship, in specific circumstances and contexts, including clinical trials on a voluntary basis (Sybesma *et al.*, 2016) or in extreme circumstances. The presence of this topic in the public discussion is also fragmentary. So, it is possible to argue that the successful acceptance of phage therapy in humans is due to a delegation of trust granted by the public to the recognized scientific authority in the medical field (Siegrist, 2000). However, this entails a contradictory framing with respect to the denotation of viruses. If one frames bacteriophage in terms of 'medicalization', as drugs to treat a disease, what about the representation of virus as an 'absolute enemy'? In the communicational framework of phage therapy, a counter-narrative develops, so that the virus, from an 'absolute enemy', becomes a 'lethal weapon' to be used in extreme cases (*extreme ratio*). This frame of reference, promoted in the communication of phage therapy, once again fuels an outdated (and therefore scientifically incorrect) representation of current knowledge around what a virus is and how it functions in ecological dynamics. Furthermore, an acceptance obtained without awareness produces new risky forms of *negative knowledge*, suspicion, and distrust towards scientists (with or without conspiracy drifts). At first glance, the 'unaware acceptance' of phage therapy could be seen as a positive starting point from which to develop a communicative strategy of large-scale social acceptance, i.e., overcoming the barriers of specialized medical knowledge. However, from the expert point of view, the resulting acceptance can be perceived as a threshold between 'passive acceptance' and 'active non-acceptance', between a tame and docile behavior *versus* an oppositional and confrontational behavior. This partly reveals the 'dark side' of expert mindset, the background of strategies aimed at obtaining social acceptance, but also the representations and prejudices that condition not only the relations between science and society

but also between science and the market, and of course the general image of scientific roles and professions. The most revealing example from this point of view is the marketing of virus-based products (in medicine but also in agriculture) through misleading names that do not refer to the etymological field of viruses. These strategies are not necessarily a linguistic deception, as in the legitimate use of the expression 'phage therapy' without explaining that phage is a specific type of virus. Indeed, the term 'phage' is not referable to virus and its imaginary by non-expert citizens (Mbembe, 2008).

2.2.2 ACCEPTANCE OF VIRUS-BASED IN AGRICULTURE

What has been said for phage therapy in human medicine can be taken as a touchstone to reflect on the dynamics of biotechnology acceptance in other contexts (Hesse and Adhya, 2019; Saba *et al.*, 2000; Holtappels *et al.*, 2019). If we move from medicine to agriculture, the dynamics of acceptability impose a relatively independent *problematization* (Weldon and Laycock, 2009). At least two complexity jumps can be envisaged: a) from hospital-administered human therapy to agricultural experiments in a controlled greenhouse and, b) from the latter, to extended use in the open field. For the first jump, the variation of complexity is kept under control thanks to the characteristics of the application context: closed environment, few actors involved, control of unexpected consequences. For the second leap, a plurality of variables intervenes, including the role of experts, the public and institutional actors, regulatory processes, ecological and environmental factors, etc., leading to redefine not only the form of acceptability but also its temporal constraints. This second leap prompts the imagination of terrifying scenarios concerning possible (albeit remote or unlikely) consequences that a 'release of viruses into the environment' might have in terms of ecological balances. Operators, including both researchers and entrepreneurs engaged in the development of VB-PPPs, taking note of this climate of opinion (more assumed than verified), usually adopt communication strategies employed for biopesticides, i.e., the metaphor of 'vaccinating the plants' is used to explain the so-called cross-protection approach. Although not entirely accurate from a scientific point of view, this is considered an effective and useful strategy, as a driver for acceptance (Carradore *et al.*, 2019; Carradore, 2019). However, the topic of vaccination is a major issue in health policies, with wide resonance in European public communication. Despite the worldwide vaccination against COVID-19, the presence and persistence of antivax movements should not be underestimated, moreover for its gender characterization by a strong female component (Rosselli *et al.*, 2006; Napolitano *et al.*, 2018; D'Alessandro *et al.*, 2018). So, it is plausible to assume that such movements, going to affect the acceptability of vaccines in general, may equally negatively affect that of biopesticides, especially

since the image of plant vaccination is massively used in an inappropriate way (Gualano *et al.*, 2018). More generally, in controversies involving the citizenry, it is common to observe a rapid shift from unawareness to critical thinking, which, in the absence of a dialogue with institutions, mediators, and scientists, takes the form of a conspiracy theory. Opposition to vaccines would then be a response to a concern about some poorly known items (the composition and actual functioning of a vaccine) or not very transparent (the relationship between basic scientific research and mass production by multinational drug companies), but perceived as very relevant. As an autoimmune response of the social body, the conspiracy theory, fearing the subordination of free scientific enterprise to the economic interest, reaffirms freedom of choice as a supreme value, by placing in the background (at least in theory) any imposition, including those aimed at public health, by a state perceived as a technocratic one.

2.2.3. FRAMING THE ACCEPTANCE DILEMMA

According to the set of factors examined here, the acceptability of virus-based applications could be described in terms of a dilemma between benefits and representations, between tangible effects and intangible meanings, thus as an 'unsustainable' innovation. While the research side is accelerating the discovery of highly specific and selective therapeutic approaches, with an eye to safeguarding the ecological relationships between the organism and its environment, these benefits (presented as objective) clash with a complex of critical issues at the regulation and public opinion levels. Both these issues are characterized by the persistence of obsolete models of sense-making that undoubtedly include the social memory of traumatic diseases such as smallpox and polio, or, more generally, the plague. The existence of a knowledge gap in answering the question "what is a virus?" should invite us to build occasions of confrontation between science and society, where dissemination of the latest discoveries can easily flow from the scientific field to the rest of the social system.

3. RESEARCH FRAMEWORK

3.1. INTRODUCTION

The medical and environmental implications of the paradigm shift described previously, concerning the knowledge of viruses and their ecological role, have not yet been adequately investigated neither sociologically nor in terms of acceptability. VB-PPPs, but also biotechnological products for human health, well exemplify the ambivalence of a disruptive innovation and the challenge it poses to both science and society as a whole. The current moment is as hot and salient as ever, especially since the research presented here took place during the emergence of Covid-19, when the 'virus' concept took on an exceptional significance. The historical contingency spilled over into the research work prompting us to adopt a *second-order perspective* (Foerster, 1984), that is, to put in the background the problem of measuring standardized parameters of social acceptance of technologies, and to foreground the problem of the meaning that such products or processes take on in contexts of public discussion. Accepting the new is, for the human psyche and for social organization, far from obvious and simple, even in the plural acceleration that characterizes our time (Ceruti, 2018). Measurement implies the possibility of a correction or manipulation of public opinion, making acceptable what initially was not through incentives and concessions. Nevertheless, this argument presupposes the existence of a static, essential, and self-evident meaning that from the innovator descends to the citizenry, which in turn can only react in terms of pandering or opposition. From the point of view of the innovator, the citizenry is perceived as an irrational entity, led by a persistent obsolete or partial worldview.

3.1.1. FROM ACCEPTANCE TO ACCEPTABILITY

Posing the problem of meaning means rethinking technology no longer as an object-message transferable from producer to consumer, but as an open, recursive, and reversible process, in which all the actors involved, albeit with different levels of knowledge, power and influence, can shape, denote, and connote, and therefore orient, accelerate and hinder future evolutionary paths. The shift from acceptance to acceptability (Fournis and Fortin, 2017) perspective in our theoretical framework (Carradore *et al.*, 2019) expresses, therefore, the change of focus from *action*, i.e., the decision to accept or not accept, to the *ability* to conduct such action with intentionality and consciousness, i.e., through discussion and comparison of cognitive elements, arguments, and representations. The ability to decide whether to accept or not to accept something is the result of will and experience expressed in intersubjective contexts and is affected by the experience of

others. And it is through such skill that, especially when faced with situations of high uncertainty, a withdrawal or suspension of public acceptance of a technology occurs, as the Chernobyl case has taught (Luhmann, 1993).

3.1.2. MAIN RESEARCH DIMENSIONS

Looking at biotechnological innovation as a social process, in which any agent cooperates in the construction of the meanings and the frame of reference, implies problems of definition of its meaning and role not only within the scientific and technological field, but also in connection with the socio-economic and socio-cultural sphere (Renn and Rohrman, 2000; Mallinson *et al.*, 2018; Bastide *et al.*, 1989). In order to explore these complexities, we have elaborated a multi-methods scientific framework, with a logical priority to qualitative techniques. Exploring how sense-making and acceptability of VB-PPPs work in three different contexts (research operators, stakeholders and general public), we have mainly considered two dimensions of differentiation: gender bias and generation. The first one is a classical topic in risk perception studies, especially within the feminist approach of Science and Technology Studies. Definition of threshold of purity and impurity, as well as the distinction between risk and danger, are not only culturally determined but also characterized within the same social context in relation to the position of man and female in the public arena as well as in the scientific field. For this reason, looking at the process of social acceptability it is important to control and assess the existence of a gender-based different perception, describing it within the wider spectrum of the public opinion. As mentioned in Carradore *et al.* (2019) a peculiar case of distrust in vaccination came from a movement of mothers in Italy.

One of the research objectives was to investigate the role played by the generational variable in the perception and acceptability of biotechnological risk. Innovation challenges societal (economic, cultural, political) frameworks since, by definition, it forces society to confront itself within a new system of coordinates. This implies the development of new control instruments that will have to be accepted, internalized, and implemented by the population. Innovation requires a 'top-down' control by institutions and a 'bottom-up' response by the population, and this response differs according to the belonging to one generation or another. It is therefore of fundamental importance to investigate the nature and consistency of the connective tissue that surrounds the generations and constitutes the means through which the values that guide individual behavior are transmitted. With regard to the topic of innovation, the variables influencing the perception of risk and, consequently, its acceptability, are of particular importance. An innovation will therefore be

acceptable and accepted to the extent that information is transmitted between parents and children in a fluid and undistorted manner. This allows both generations to benefit from a new, 'binocular' and diachronic point of view, a virtuous combination of the two previous ones.

3.2. THEORETICAL FRAMEWORK

The adoption of an interdisciplinary and systemic framework (Luhmann, 1995b, 1995a), inspired this shift in perspective, also allowing for an integration between the conceptual tools of the sociology of knowledge and ignorance (Cerroni, 2003; Gross, 2010; Gross and McGoey, 2015) and those of the psychology of social representations (Moscovici, 2001).

3.2.1. SOCIOLOGY OF IGNORANCE

The sociology of ignorance thematizes the *form* of knowledge in relation to space and time, and what lies beyond the realm of the known. The conceptual tools of 'negative knowledge' (knowledge that is considered dangerous and not worth pursuing) and non-knowledge (the unknowns of which one has knowledge, and that are considered worth to be pursued), have been used to understand the processes of socially constructed ignorance about specific topics (Frickel and Moore, 2006; Gross, 2007). Of particular interest, with regard to the problem of social acceptability of innovation, is the concept of 'undone science' (Hess, 2016; Frickel *et al.*, 2010), which indicates the existence of unexplored and unfunded areas of research for a plurality of reasons. This phenomenon is particularly crucial during an emergency, when the public enters the scientific arena and expresses strong opinions about current scientific policy, both in *problem setting* and *problem solving*, as in the case of olive tree phytopathology related to the *Xylella fastidiosa* bacterium in Italy (Colella *et al.*, 2019). Controversial topics, as well as revolutionary innovations, such as human cloning, can translate negative knowledge into the form of a 'forbidden science', a connotation that is imposed to defend a specific socio-cultural value, such as the uniqueness of the person (Kempner *et al.*, 2011).

3.2.2. PSYCHOLOGY OF SOCIAL REPRESENTATIONS

The theory of social representations (Moscovici, 2001) allows us to observe the dynamics of social co-construction of the collective imaginary in relation to a new scientific concept (Cerroni, 2003; Jovchelovitch, 2007; Wagner *et al.*, 1999). In understanding VB-PPPs, the processes of *anchoring* (the already known and familiar concepts to which the new concept is related) and *objectification* (the images, objects, and people that manage to frame and capture the new concepts) were

examined. Through these lenses it was possible to observe the construction of a constellation of conceptual cores (together with their evaluation) that shape a new common sense.

3.2.3. NEGATIVE CAPACITY

The two perspectives summarized here have allowed the development and contextualization of acceptability in terms of 'negative capacity', the ability to wander and explore the uncertain, not immediately arriving at quick and incomplete explanations (Weick, 1995). The concept, first mentioned by the English poet Keats, was later quoted by Giovan Francesco Lanzara (1999) to analyze the reaction to disruptive events such as earthquakes. In "*Reflections on Technology, Practice and Innovation*", Lanzara (2016) links negative capability to the process of innovation, which is often characterized by a significant amount of uncertainty and ambiguity. The pandemic contingency we are experiencing now, has acted as a generator of negative capability in many ways, channeling the plurality of noises that characterize the settling of innovation toward a path that leads to new opportunities for awareness, knowledge, and understanding. In addition to being an elective tool for researchers to continually adapt and update their work, especially in this research characterized by a high degree of circularity and relevance of contextual happenings, such as the emergence of Covid-19, negative capability has been a cross-sectional lens of analysis on the process of constructing the representation of VB-PPPs that has emerged from the interactions of participants engaged in every phase of the research.

3.3. METHODS AND PHASES OF THE RESEARCH

This research on the social acceptance of virus-based biotechnological innovations was approached methodologically through a triangulation of viewpoints: a) experts, b) non-expert citizens, and c) students. The experts' point of view was addressed through the Delphi method that allows for asynchronous interaction through the administration of short questionnaires to a panel composed of a small group of subjects (6 to 11) who do not know each other and, therefore, cannot interact. We have developed creative focus groups with non-expert citizens, in which interaction was more central than the position expressed by the individual participant. In this case, it was possible to range from the topic of virus-based products in agriculture through the presentation of three examples of applications. Finally, through an exploratory survey (non-representative) it was possible to measure some dynamics that emerged and to thematize the reaction in front of virus-based innovation. After discussing some elements of a methodological nature, the following section will discuss some points that have emerged so far during the analysis.

The three sub-parts of the research were conducted in strong interaction. In particular, Focus group outputs constituted inputs for Delphi #1 and, in the last year of the project, a similar interaction was established between the results coming from the survey and Delphi #3.

3.3.1. DELPHI PANEL OF EXPERTISE

The Delphi method is a pragmatic research method created in the 1950s for use in policy making, organizational decision making, and to inform direct practices. The approach is grounded in the philosophical assumptions of the philosopher and educator John Dewey who believed that social science research should directly relate to and inform real-world practice and decision making (Kirk and Reid, 2002). The Delphi method emphasizes structured anonymous communication between individuals who hold expertise on a certain topic with the goal of arriving at a consensus in the areas of policy, practice, or organizational decision making. The Delphi Panel of experts has been built in order to have a pool of operators (at various level of expertise) selected in the national context by a set of criteria: interest, knowledge (scientists, technicians, journalists) and experience and engagement (environmental NGOs, environmental activists) in agricultural biotechnology innovations. Within Viroplant project, we conducted three Delphi Panels, each of them with 4 rounds of interaction with the panelists (see Annex 1).

During the Delphi #1 (from November 2019 to March 2020), the panel was made by 6 experts: academic professors, consultants, managers for the pharmaceutical sector, secondary school professors. They were selected not only by means of direct knowledge relationship, but also using targeted messages, sent via professional networks (e.g. LinkedIn), with a redemption of about 50%. Although the preliminary contacts were sent paying attention to a gender balancing criterium, the received adhesions, however, made the final composition of the panel unbalanced, having one female member only. Moreover, among the 6 experts, only one did not take part into the project, despite having confirmed the adhesion via email. In parallel with the group of experts, a Focus Group was established. The panel of experts and the focus group of laypeople were put in dialectical relationship in such manner that the answers of one group (output) could give the basis on which the questions for the second group (input) were made: in this way, the two groups made the blocks of a feedback circuit, in order to converge, step by step, on the key issues for the debate by comparing the mutual positions on the subject.

In the Delphi #2 carried out between April and September 2020, the sampling strategy aimed at creating a panel constituted by two interacting groups of experts. The first one was composed by science journalists, agricultural journalists and disseminators, the second was composed by farmers and agricultural entrepreneurs. It worthy of mention that both these groups could be further divided into subgroups, based on the values, the political and social attitudes toward science, technology, and innovation in agriculture (and other fields) expressed by their work, as identified by the researcher prior to the sampling. In the first group of science communicators, disseminators, and journalists, the two subgroups were constituted by journalists and communicators more inclined toward a critical approach to science and technology (for example: concerned about the economic and social aspects of a technology, environmental impacts, etc.) and those more inclined toward an entrepreneurial and technological-driven idea of agricultural activity and productivity. At the same time, the second group could be furtherly divided into two sub-groups, represented by the subgroup of medium and big agricultural entrepreneurs and the subgroup of small farmers (and one technician) that, in addition to the activity of farming, are also involved in activism and agricultural social movements (for example: agroecology, symbiotic agriculture, political activism in general). The reason behind this sampling strategy is the need to better frame the social, political and cultural dimensions of virus-based PPP and agricultural biotechnology among a diverse spectrum of material conditions, attitudes, and worldviews. The age characteristics of the panel sufficiently satisfies a diverse composition, with an age composition that spans from subjects in their 20s to other in their 50s. Unfortunately, from the perspective of gender, the sample did not reach an equilibrium, as the majority of the participants were males and only two female participants were present (one in each group). As a final remark, it must be considered that the Delphi has been conducted during the Covid-19 emergency. It is fair to consider that this uncommon situation had a certain impact on the response rate, which gradually decreased during the unfolding of the emergency and during the months. As shown by the table below this is particularly evident in the case of agricultural entrepreneurs and farmers (arguably for a lack of time to dedicate to our research or the typology of work conducted).

During the Delphi #3, conducted between June and July 2021, the group of experts was once more made by 6 elements, representing both the academic world and the biotech research world. The experts were selected by means of personal relationship and professional networks (LinkedIn). The redemption, slightly less than 50%, led again to an unbalanced group with regard to the gender dimension, but in the opposite direction if compared to the Delphi #1: here, only one male member was present. Similarly to Delphi #1, only one expert, after having confirmed via email, did not attend

to the project and did not send any answer. In this case, for merely organizational issues, it was not been possible to put the group of experts in a feedback mechanism with the focus group of laypeople. Therefore, the questions were adjusted by means of the answers received from the survey submitted within the project. This survey, named "Investigation on nutrition, environment, agriculture", took place simultaneously with Delphi #3 and was deemed to analyze the risk perception among high school students and their parents (see D6.2).

3.3.2. FOCUS GROUPS OF LAYPEOPLE

Our focus group study addressed the complexity of the underlying dynamics of virus-based technologies' representation. This methodology has been already used in similar cases of public perception of biotechnological innovation (Massarani and Moreira, 2005; Ditlevsen *et al.*, 2020) and consists of implementing a group discussion, governed and enriched by a series of stimuli lead by the researchers (conversational or practical), to investigate a specific theme. One of the cardinal aspects of focus groups is the critical role of social interaction, which is explicitly promoted by the methodological configuration: the co-construction of meaning, flowing through the mutual exchange of opinions, can be considered as the main clue for the comprehension and evolution in real time of social representations.

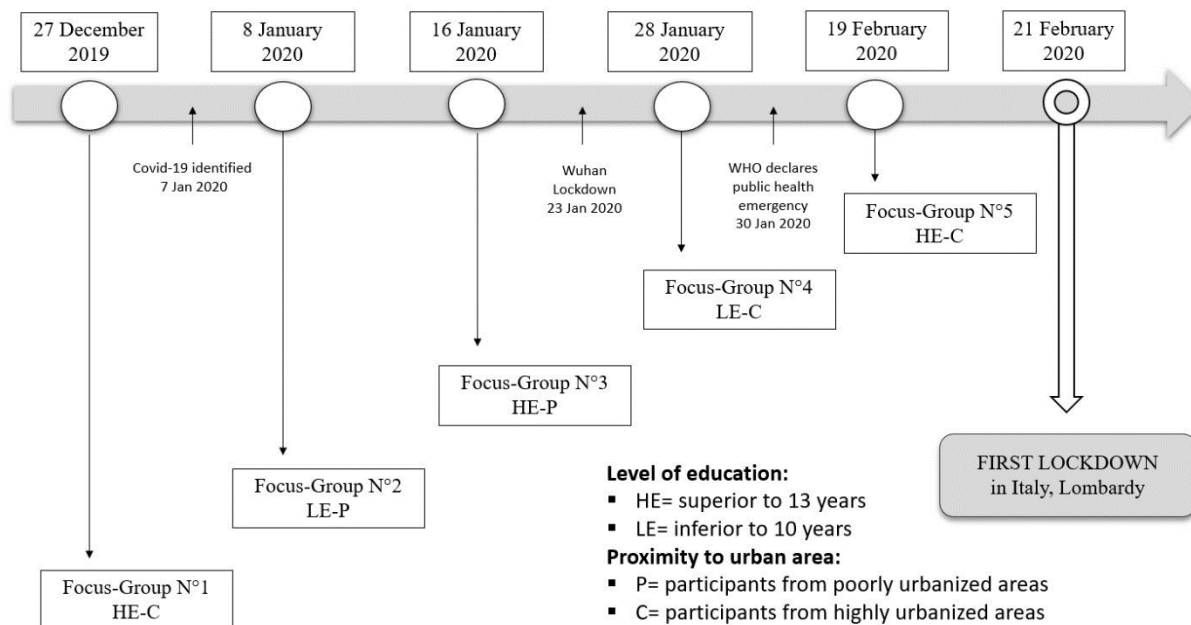


Fig. 3.3.2.1. Timeline of Focus Groups' study

Concretely, we have realized an overall of 5 focus groups of approximately two and a half hours duration each (Fig.3.3.2.1)¹. The mean of participants for group discussion was 7 (min. 6, max. 9). The focus groups were organized between December 2019 and February 2020. More focus groups were programmed for February and March; unfortunately, due to the Covid-19 outbreak in Lombardy (Italy), it was not possible to respect the previously conceived schedule. However, the unintentional matching between the increasing international relevance of Covid-19 and our study allowed us to monitor over time some aspects linked to the social representation of viruses.

SAMPLING

To understand the social representation of virus-based products, 35 participants were selected according to their profiles' characteristics²:

- Gender: participants were 17 males and 18 females, equally distributed among the focus groups.
- Age: 21 participants were under 32 years and 14 older than 40 years (from a minimum of 23 to a maximum of 70 years), equally distributed among the focus groups.
- Level of education: 15 participants had a qualification even or inferior to 10 years of study (low education) and 20 participants even or superior to 13 years of study (high education with University Degree). We decided to design the participation keeping separated these two levels of education in order to facilitate the cooperation and expression of ideas and opinion. It is known that subjects with higher education are commonly perceived with higher social status which could lead to an inferior communication potential of the less educated participants (Fern, 2001).
- Living environment: 15 participants came from poorly urbanized areas (suburban zones far from main urbanized cities). At the opposite, 20 participants came from the main metropolitan city of Lombardy (Milan), or its close suburbs.

Participants were found and selected through snowball sampling (Cohen and Arieli, 2011), involving the network of indirect social contacts of the researchers. During the sampling process, we tried to avoid that the participants of the focus groups already knew each other directly. In some specific cases, particularly for focus groups held in small suburban areas where the links between fellow citizens are more frequent, it happened that some participants already had some connections

¹ Our partner ILVO conducted two focus groups in Belgium with the same structure used in the Italian case. A draft report of the activities is in Annex 2, part 2.

² Subsequently, these characteristics will be mentioned in the form of an abbreviation: F32LEP is a female of 32 years old, low level of education, living in peripheral poorly urbanized area.

between each other; in those circumstances, during the data collection and the analysis, we monitored the possible emerging dynamics with particular attention.

STRUCTURE

Each focus group was divided into three phases (see Annex 2. part 1):

Introduction, rules and icebreaking. To stimulate spontaneous interaction between the participants and promote the fluidity of communications, we opted for an informal introduction, explaining the basic conversation rules and reminding that there were no right or wrong answers to the activity proposed: “the only thing that really matters is your personal opinion about the topics presented”. Subsequently, we took advantage of the participants' common trait for icebreaking. We asked them about living in a poorly urbanized area/living in a metropolitan city (depending on their belonging to one or the other) and the positive and negative aspects of living there. This ploy granted us the possibility to activate a better contextual self-identification and to accustom the participants to the rules of communication previously presented. The introduction had a duration of approximately half an hour.

Three cases activity. One of the first aspects we considered during the arrangement of the focus groups was the complexity of potential applications of virus-based products, which can create diversified answers concerning the usages. To control these complexities, we decided to develop the core activity of the focus group around the submission to the participants of three different cases, each one focused on a particular field of application of virus-based products. During the oral explanation of each case, as a form of support for comprehension, graphic materials were distributed in the form of text-cards and images, containing detailed case information. The discussion of the cases had a duration of approximately one hour and a half.

- Case A. Application of virus-based products in human medicine. This case implied the use of bacteriophages (or phages) as a possible method for the cure of bacterial infections, and therefore a potentially feasible alternative to antibiotics. It was said that these virus-based products could be both natural and bioengineered.
- Case B. Discussion of hypothetical application of virus-based products for agricultural biocontrol. It was explained that the product presented could be utilized as an alternative to chemical pesticides commonly used in agriculture and could decrease the spread of crop pests. It was stressed that this kind of virus was bioengineered.
- Case C. Like the previous one, case C probed an application of virus-based products for agricultural use. The participants were asked to discuss the use of natural brome mosaic virus colonies that, when transferred on rice plants, could improve their resistance to drought.

Unlike the previous cases, no comparison terms were given. It was made clear that the brome mosaic virus had not been artificially manipulated.

The stakeholder activity. The third section of the focus group investigated the opinions of the participants about the stakeholders usually involved in the process of communication with the public. The exercise required participants to position a series of cards, representing professional figures commonly involved in the process of communication of new technologies, along a continuum representing perceived grade of stakeholder involvement. More precisely, for encouraging group discussion, we asked to put towards the “plus” side of the continuum, stakeholders that the participants considered more suitable to manage the communication with the public about virus-based technologies. In reverse, towards the “minus” side we asked to put the stakeholders perceived as less suitable for an effective relationship with the public. It was also demanded if there were stakeholders not listed among the proposed ones. The original list included: farmers, politicians, journalists, university professors, doctors of private/public sector, pharmacists, influencers, and scientific communication experts. The stakeholder activity had a duration of approximately half an hour.

The data collected was organized through N-Vivo, software for qualitative research. For the analysis of the information gained, we decided to use the method of Thematic Analysis (Braun and Clarke, 2006).

3.3.3 SURVEY

In the third year of VIROPLANT, we have applied the preliminary results of Delphi and Focus Groups in designing a survey on intergenerational perception of VB-PPPs³. The target of this part of the research were students in high-schools and their parents. The pandemic impacted this part of the research both thematically and logistically. For the first aspect, it was decided not to ask questions about the coronavirus and Covid-19, but to possibly let comments emerge spontaneously in the open-ended questions of the questionnaire. Social distancing and distance learning made data collection complicated. Principal goals of this quantitative task are to control the gender variable and the transmission of values, drivers, and resistances about biotechnological innovation. Indeed, the school system is a socializing place of acquisition of competences, skills, and values.

³ The Section 3.3.3. is taken from D6.2 which is entirely dedicated to the Survey part of WP6 on social acceptance of VB-PPPs.

Nevertheless, school is also a place for social differentiation, where conflict and negotiation of the traditional and stereotypical thinking can emerge. Differently from our initial aim -to evaluate how the imaginary about virus works- the survey has been designed to gain the interrelation of three analytical levels implied around VB-PPPs, which emerged significantly in Delphi and Focus Groups: food safety, environment and agriculture. For logistical reasons, data collection was done through the Google Form platform, sharing a link with teachers engaged by the CNR-IPSP team as gatekeepers. The questionnaire was anonymous, all data have been collected without any tracking of any personal information.

SAMPLING

In the design phase, we decided to focus attention on the last two classes of high school (both from technical and professional schools, and also from scientific and classical -ancient languages-based curricula- high school) and to involve students aged 18 and older for two reasons: a) fourth and fifth grade students have science subjects in their curricula that allow them to understand some technical aspects of the questions in the questionnaire; b) since they are citizens of age, we wanted to explore the degree of participation in public life through some questions in which they were asked to express a decision or to hypothesize a social behavior. In order to assess the intergenerational dimension, we asked the students to share the questionnaire's link with one of their parents or legal guardians. We deliberately did not specify of sharing with the father or mother, since the aggregate figure of the majority presence of one figure or the other is significant for us to assess the direction and degree of intergenerational communication. In other words, the degree of transmission of the questionnaire between students and parents/legal guardians gives us a measure, however spurious, of the degree of transmission of knowledge and activation in participation in a public undertaking such as scientific research. With respect to the purely exploratory purposes of the survey in question, it has allowed us to grasp a datum that is interesting in its own way.

	<i>Technical and Professional school (N=97)</i>	<i>Scientific and Classical high school (N=52)</i>	<i>Secondary school (N=6)</i>	<i>High school diploma (N=13)</i>	<i>Bachelor's and Master's degree (N=8)</i>
<i>Students (N=149)</i>	29.9% female 70.1% male	67.3% female 32.7% male			
<i>Parents/Legal guardians (N=27)</i>			33.3% female 66.7% male	69.2% female 30.8% male	100% female 0% male

Tab. 3.3.3.1 Students' school and Parents/Legal guardians' education level

The total number of respondents is 176: 84.7% students and only 15.3% were parents. This means that only 18.12% of students were able to actively involve their parents in filling out the questionnaire.

This disproportion may be caused by a complexity of factors inherent in intra-family dynamics, however, being the gap wide, suggests caution in the interpretation of the knowledge gap that may thus arise. Because the questionnaires were anonymous, it is not possible to have any indication about which subgroup of students did not have their parents/legal guardians complete them. Of the 27 parents/legal guardians alone, the gender distribution is 70.4% female and 29.6% male; while for the students it is 47.2% female and 52.8% male. Although we cannot speak of significant numbers, it is interesting to note that mothers are involved more than twice as much as fathers. The geographical-residential context is distributed as follow: 29% provincial towns, 26% city 25% countryside; 18% suburbs; 1,1% mountain (see Tab.2).

Residence context		Subjects		Totale
		Parent/Legal guardian	Student	
Countryside	counts	3	41	44
	% in Residence context	6,8%	93,2%	100,0%
City	counts	9	37	46
	% in Residence context	19,6%	80,4%	100,0%
Mountain	counts	1	1	2
	% in Residence context	50,0%	50,0%	100,0%
Provincial town	counts	9	42	51
	% in Residence context	17,6%	82,4%	100,0%
Suburbs	counts	5	28	33
	% in Residence context	15,2%	84,8%	100,0%
Total	counts	27	149	176
	% in Residence context	15,3%	84,7%	100,0%

Tab. 3.3.3.2 Contingency chart: Residence context - Respondents (N=176)

Regarding the residential context and the relationship between the two categories of subjects, it is possible to observe that the intergenerational transmission of the questionnaire is easier in urbanized contexts (city, suburbs and provincial towns) than in rural contexts in which, out of 41 students, only 3 have had their parent/legal guardian complete the questionnaire. Data collected do not allow to draw a statistically robust profile; however, it is possible to advance the hypothesis that intra-household dialogue on issues of food health, environment, and agriculture is relatively easier in contexts that are more central to the circulation of knowledge and innovation, although these issues may be more sensitive and understood in the rural context.

QUESTIONNAIRE

The questionnaire is structured into four sections and three macro areas (food safety, environment, agriculture) of inquiry with some questions that cut across the different areas (see Annex 3).

The first section is biographical (Q1-Q8) in which the status of the respondent (student or parent/legal guardian), type of school (for students) and educational qualification and profession (for parents/legal guardians), gender and context of residence were asked.

Food safety is the main topic of the second section of the questionnaire (Q9-Q19) and includes questions about the degree of subjective relevance in the absence of specific elements in a food recipe (Q9-Q15), availability of food safety information (Q15), and personal consumption of information and sources used (Q16-Q17). Finally, one question addresses the case of palm oil and reactions following the case that struck a chord with the public a few years ago (Q18-Q19).

The environment is the area investigated in the third area (Q20-Q25). Here the first three questions about virus-based products for plant care are asked, without specifying the agricultural area (Q20-Q22), in the form of a referendum promoted by a committee of scientists. They are asked to express a position and to indicate a prediction about the outcome of the fictitious referendum, giving reasons for the outcome. Subsequent questions address the availability of information on environmental issues, consumption, and sources of information used (Q23-Q25).

The fourth section includes a list of seven questions about the perceived risk to humans and environmental health of as many objects or processes (Q26-Q32). We asked a question about trust in science to improve quality of life (Q33) before introducing the fifth section on agriculture. In five questions we ask to express the degree of concern and therefore perception of risk regarding the introduction of an object-process near one's home (Q34-Q38). The last questions of the questionnaire deal again with the perception of risk of GMO ingredients for food safety (Q39-Q40). The last two questions deal with a second fictitious referendum similar to the previous one, but this time about the introduction of a therapy for the treatment of diseases in humans (Q41-Q42). In closing, we asked a follow-up question about the respondents' daily life context (Q43) and a final open-ended research feedback question.

4. FINDINGS

The material collected during the project through the methods described above is vast and rich. At the time of writing this final report, we will present the preliminary results that emerged from each part of the research. Themes, issues, meanings, and rhetoric have represented the raw material both for a quantitative measurement in the survey, and for a preliminary synthesis in a model of sensemaking of acceptability, as starting point and perimeter within which to elaborate communicative strategies in the triple relationship between science-politics-civil society. Three main points emerged in the analysis will be described here below: 1) the experts' view of social acceptance; 2) risk perception and social representation of VB-PPPs; 3) social acceptability of virus-based biotechnological innovations. In Section 4.4, a sensemaking model of acceptability of VB-PPPS will be proposed and discussed.

4.1. EXPERTS' PERCEPTION OF SOCIAL ACCEPTANCE OF VB-PPPS

We will try in this section to highlight some of the many themes that emerged from the three Delphi studies carried out, focusing on the role of communication, safety, education and trust, without presuming to resolve the subject matter in either width or depth. It is noticeable among experts a rather frequent use of expressions such as "I do not know if it is correct", "I could be wrong", "maybe I am not up to it", based on two assumptions:

- 1) there are 'right' answers, and therefore that the questions asked are 'trivial' (in von Foerster's sense) questions, for which the correct answer is known a priori.
- 2) the survey is trying to test knowledge, scoring it despite what has been told before.

4.1.1. COMMUNICATION

Positions taken go from varied positions on attitudes towards science, but not extreme ones (Delphi#1), portraying science as 'the voice of one crying out in the wilderness' about a year later, when the vaccination campaign is well underway and the mortality and infectiousness curves reverse in a stable manner. Social media, which in Delphi#1 (pre-pandemic) are acknowledged to have increased "natural exposure even to news of scientific interest" [1.5.1.1]⁴, in Delphi#3 assume the role of generators of a "gargantuan amount of information" [3.2.4.2] from which citizens defend

⁴ Quotes from experts will be given in the format [Delphi#.Expert#.Block#.Question#]. See Annex 1.

themselves by creating "social bubbles" of survival, i.e. "spaces (...) composed of relational networks sharing the same cultural perimeter" [1.5.1.2]. They thus find themselves filtering out only information that acts as a reinforcement of their initial beliefs, and not as a feedback check on the reasonableness of their initial assumptions.

There is an awareness that we are experiencing an *infodemia* (or the infodemic, inflationary growth character of communication), which the pandemic has made even more evident. Faced with this informational 'white noise', what is needed above all is the ability to select information, restoring the centrality of communicative coherence. Moreover, at a time when 'we are all opinion makers' [3.2.3.3] there is a clear lack of cultural mediation through the recovery of prepared agents that characterised scientific communication in the past: within the household, the generational 'leading edge' figure who assumes the role of 'repeater' for the signals guarded by memory (including the successes achieved by scientific research); outside the family unit, the figure of the scientific communicator, who stands as an authoritative figure with strong skills to ensure an effective communication.

In fact, the media (whose role in the communication of the pandemic is only now beginning to take central importance in the eyes of academics) today too often produce manipulative communication (e.g. through the use of logical fallacies used as premises, or journalistic techniques, see for example the distorted use of 'balancing' in a rhetoric of objectivity). In this context, the recovery of authoritative communication also involves the adoption of differentiated strategies of scientific communication. For example, through the creation of the figure of the scientific influencer, capable of adopting 'hybrid' communication strategies (marketing, viral communication, diversified use of available social media) which, grafted onto solid basic scientific knowledge, become an enzyme for shaping public opinion. The aim is to provide shared solid foundations, through a 'simple explained applied science' [3.5.3.3], which will provide the ground for debate, avoiding the temptation to level society towards a more malleable single thought. An important role is played, as a 'generational glue', by the ability to organise scientific events (possibly free of charge) that make up for the lack of a 'leading edge generation', which has led not so much to a disconnect as to a decrease in the density of the medium through which information is disseminated between parents and children. It is therefore necessary to be able to 'create moments of sharing knowledge at various levels with research centres, universities, schools but also, and above all, territorial orders' [3.1.3.2]. In the presence of a 'low-density fog' that hinders intergenerational communication, such events would constitute an 'artificial thickener' capable of improving the efficiency of memory propagation.

4.1.2. CERTAINTY

There is a fundamental misunderstanding of the role of science, which is communicated (or claimed) by some as being safe and perceived by others as providing certainty: "scientists are required to be absolutely certain (even when faced with an evolving situation about which solid data are still lacking)". [2-3-1-1]; "Our society not only rejects risk (if the doctor does not cure me it means he is not a capable one) but distorts it", [3.1.3.3]. "Certainty" is in fact a close relative of truth, for which, if it exists, the necessary words to express it are lacking by definition. We also note a (further) paradox that characterises the public debate on scientific risk: if we expect certainty from science, the same is not required of other visions of the world (denialism, conspiracies...) that characterise a large part of public opinion. There is therefore a distortion of the purpose of science, which should be to instil 'well-founded doubt': "Trying to explain that science is not perfect and that it can make mistakes" [3.3.3] then becomes one of the challenges of scientific communication. There is thus a rejection, even at institutional level, of the concept of RISK (see, for example, the Civil Protection campaign website <https://iononrischio.protezionecivile.it>, in which the Italian "io non rischio" literally means "I do not take risks". This gives rise to a legitimate lack of responsibility on the part of the public, in the name of which the probabilistic nature inherent in the concept of risk is not accepted and, as a result, innovation is rejected as the natural bearer of a degree of uncertainty. There is an enormous communicative, linguistic and semantic component in the perception of risk in times of pandemic, which produces a twofold effect: among the experts, the nonchalance in using an oxymoron such as 'zero risk' in relation to the innovation they are communicating; among the public, the refusal to accept the innovation because, in the absence of communication from the experts, they are unable to independently estimate the percentage of risk it contains.

4.1.3. EDUCATION

Experts use the terms 'schooling' (in Italian: "formazione", from the Latin forma, "shape") 'information' (in Italian: "informazione", from the same latin root) and "instruction" (in Italian: "istruzione", from the Latin verb instrūere, "to order", "to arrange", "to prepare") in an almost undifferentiated and synonymous manner to refer to the condition necessary for the formation of the capability to understand a problem in all its complexity. A "higher level of instruction" is therefore called for as a means of "perceiving and seeking out correct information and/or news (being critically curious)". (3.2.3.1); or, for the same purpose, an "improvement of the educational (must be literally read as formational) pathway" in first and second grade schools [3.4.3.3]. Thus, a

tripartite model of education seems to emerge, a sort of vector space, or "three-legged stool" that rests on schooling, information and instruction in the following meanings:

SCHOOLING: ideas, criteria for thinking (knowledge of the validity of the scientific method, the ability to recognise logical argumentative fallacies, etc.), which are currently lacking due to a 'teaching method which, over the years, has continually 'simplified' to the point of rendering the theoretical foundations of many disciplines useless' [3.1.3.1]

INFORMATION: what fills the 'form' of ideas. It is the notions that constitute a 'dynamic', unstable capital, to be checked periodically, extended, replaced when necessary.

INSTRUCTION: using an analogy borrowed from IT, the set of 'rules' on how to use training and information, enabling them to talk to each other.

In this way education (from Latin verb educĕre, "to pull out"), the vector resulting from the combination of the three above, is the force that 'pulls' one out of the infodemic 'dark age'. Tripartite education makes it possible to overcome the obstacles between the individual and, for example, the ability to estimate as correctly as possible the risk contained in a specific biotechnological innovation. The hypertrophy of one of the components (e.g. the information component, which led to the coining of the term 'infodemia') or the hypotrophy of another may perhaps help to understand certain attitudes of rejection of science that are widespread among the scientific community itself and among people with high cultural capital. An education in which the three components are balanced provides the tools for evaluation so as not to place indiscriminately and uncritically "environmental movements, ecologists, "nostalgists", conspiracy theorists, or (...) celebrities" [2.11.1.2] on the same level, opposite to that of "science", in a balance that is at the very least precarious and almost impossible to achieve.

4.1.4. CONFIDENCE AND TRUST

Confidence and trust are closely linked to the theme of communication, both verbal and paraverbal. If, immediately before the pandemic, confidence in science could still be said to be sufficiently solid ("Misinformation and some excesses have diminished confidence. Most are, however, still confident in scientific progress" [1.1.1]), the same cannot be said in the acute phase of the pandemic, in which the inflationary growth in the amount of information undermines scientists' credibility (too much information creates confusion and one no longer knows whom to trust" [3.3.1]). The amount of trust placed in an expert has a significant influence on the quality of

information flowing between those involved. We can say, in the case of biotechnological communication, that trust plays a fundamental role in maximising the effectiveness of a message along the communication channel linking expert and public, activating, in order to achieve Public Engagement ("The good disseminator is the one who manages to create a relationship of trust between him and the public" [1.2.2]), a process regulated by a feedback mechanism and influenced by numerous factors. In recent months, for example, the 'experts' called upon by the media to give their views on biotechnological issues (and grouped in the increasingly large media category of 'virologists') have been competing to win the initial confidence of the public, which in most cases is 'passive confidence' [1.4.3.1] or 'resigned confidence' [1.4.3.2]. This can be achieved through a combination of elements, among which we can point out:

- A television declination of Thomas' theorem, as a result of which whoever is presented as a virologist acquires ipso facto authority;
- The role played by the white coat as an identifying element of the 'authorised spokesperson' who speaks in the name of science;
- The use of terminology that is often difficult to understand, but which 'resonates' in a manner consistent with the interpretative framework defined by the previous two points;
- The authoritarian rather than authoritative attitude, that "academics approach even when they enter the world of communication (referring also unintentionally to the deficit model (PUS) that was so much in vogue in the 80s of the last century: I teach you - you understand - you agree with me - if you don't: you are an ass)" [1.5.2.1]

The resulting image is that of an "authority (...) uncritically idolised, (for which) trust is more akin to faith" [2.1.1]. This fragile form of trust can, however, be subjected to a more or less radical retro-performative revision if a breach of trust appears, whether at public or private level. The expert, therefore, associated by synecdoche with the science for which he is the authorised spokesperson, will experience a loss of the trust placed firstly in the person, and then, à rebours, in the category ('Trust in scientists has been lost' [3.4.3.3]) and finally in science itself.

4.2. RISK PERCEPTION AND SOCIAL REPRESENTATION OF VB-PPPS (FG)

The collective construction of meaning is, therefore, a propaedeutic moment in the elaboration of a shared collective representation. The latter can be understood as the outcome of a recursive

process, open and cautious, in which an element of knowledge expressed by a particular point of view enters the debate as an ingredient, immediately losing its original denotation, subjectively determined, to take on connotations (positive or negative, convergent or divergent, etc.) that are linked to the other elements of previous knowledge. Observing the interaction with this perspective, we can understand the cognitive drivers of the participants involved, further deepening a series of specific thematic cores particularly relevant within the discussion.

4.2.1. MEDICINE AND AGRICULTURE

A first conceptual core, related to the possible medical application of virus-based products, was that of 'health remedies'. In fact, participants often inferred the functioning of virus-based products for medical purposes through analogies drawn from commonly known health remedies or of which they had direct experience. The most frequently used images were those of vaccines, radiotherapy and chemotherapy, antibiotics, homeopathic medicines, and more generally the concept of a drug. "I trivially compare it a bit to chemotherapy. Something that's potentially harmful, that's difficult to dispose of-re, but it's also the only viable solution...in my mind" (M20LEC). The analogy expressed in this case refers to the idea of the extreme remedy to be used as a last resort, in the face of an otherwise insurmountable evil and a good - human life - whose value is considered absolute. Similar analogies have frequently given rise to opposing and coexisting hypotheses or assumptions. References to potential collateral effects and potential negative repercussions that virus-based products may have on organisms and human health proceeded alongside arguments emphasizing the positive role that these products might have for human and technological progress, "as when vaccines were invented to defeat certain diseases, so using these products perhaps it will be possible..." (F60HEP). The material in Case A highlighted the progressive loss of effectiveness of antibiotics and the need to find alternative solutions; consequently, participants may have perceived a higher level of personal risk (perceived threat to their own health or that of their loved ones) and consequently considered the need for an effective solution despite possible risks. "If it's something that's very much about my health then yes. That is, if I absolutely have to take something to cure myself otherwise, I'm doomed, I have no alternative. I do". (F45HEC)

Moving from the medical to the agricultural frame of reference, the rap-presentations change dramatically. The most frequently used analogies are those related to the agri-food context (GMOs, pesticides, palm oil, DDT, etc.) and to other industrial products (plastics and bioplastics, asbestos, etc.). "I am reminded of the example of GMOs... that is, GMOs have been presented mainly as something positive because they allowed plants to be strengthened without affecting people, so

as to feed the ever-increasing population. However, in people's perception, many people had a negative opinion, against GMOs... so... I associate it a little bit with that" (M54HEC). In this thematic context, the similarities resulted in predominantly negative comments and statements related to potential health and ecosystem damage, both short and long term. One factor that may have contributed to the creation of such polarized representations could be the historically consolidated image of chemical pesticides, which, thanks to the actions of environmental movements in the second half of the twentieth century, are considered destructive, harmful, and generally dangerous. Although in the presentation of Case B virus-based products were presented as a possible alternative to chemical pesticides, the latter were often used as the prevailing analogy within the discussion, serving as the main anchor also in reference to further analogies that emerged. Participants from highly urbanized areas and, to a greater extent, those from sparsely urbanized areas expressed personal experiences with the harms of chemical pesticides and, in analogy, the potential harms of virus-based technologies. Some of the older participants exhibited some temporal considerations about promoting technologies that later proved harmful. "My mom when there were flies in the house in 1950 used DDT. DDT they took it out because it made everyone die...not just the flies" (F60LEC).

4.2.2. NATURAL AND ARTIFICIAL

"You know it's a genetically engineered thing...it can be good, and it can be bad" (F26HEC). Another key distinction that guided the representation of virus products, particularly in the agricultural use setting, is the contrast between natural and artificial. Most participants made extensive use of this distinction as a discriminating reference point. "So, do viruses in nature...have the same benefits as those produced in the lab? Sure...with those in nature we feel a little safer..." (F62LEP). The concept of 'natural' is usually associated with lower risks, and when natural remedies or solutions are considered, they are perceived as something that possesses a lower efficacy of action. In addition, natural technologies are often perceived as having a greater ecological balance, dedicated to environmental sustainability, and commonly described as being in greater harmony with the environment and living organisms. In general, participants affirmed a positive and universal vision of the value of naturalness, configured as a preferred alternative, capable of ensuring a more sustainable, clean and healthy future. Among participants' representations, the oppositional distinction between natural and artificial seemed to play a prominent rhetorical role even when not specifically elicited. Predilection toward the use of technologies perceived as "natural" was used as a form of defense, as a necessary alternative to counteract the potential negative effects of using artificial technologies. "So here we'd really better get out of the country

in a hurry because...I mean, I don't know. You know? Honestly, both of those options are very perplexing to me and would be vastly outweighed by something more... healthy... natural. The most environmentally friendly way..." (F45HEC).

Turning to the concept of 'artificial', the data show a recognized effectiveness of man-made health and agricultural products that has hardly ever been questioned: the results are always guaranteed. However, this absolute efficacy is perceived as closely linked to possible harmful or unknown effects, a consequence of the need to obtain certain results. Harmful effects are often understood as repercussions on the environment (death of crops and animals) or on people (development of tumors or other diseases potentially harmful in the medium-long term). With respect to potential unknown risks, the arguments revolve around the concept of unpredictability and uncontrollability: artificial elements are perceived as capable of subverting the "natural order of things", to break the complicated balance of our ecosystem. "You know it's a chemical thing, it's never good for you. That much is clear, whether it's food or viruses.... And yet, they continued to use these products... but why? Why wasn't there another way or anything else?" (M50HEP). Furthermore, the conceptualization of the artificial was often accompanied by reflections on the economic exploitation associated with it. Products included in analogies referring to the theme of the artificial, such as pesticides, were implicitly linked to images of business, industry, and economic profit at the expense of consumer health. Participants constantly alluded to the possible presence of third-party interests, which were generally considered to be unspecified management figures whose interests revolved exclusively around profit at "any cost". The discussion often focused on the "lack of ethics" perpetrated with the aim of obtaining a net economic advantage, without regard to any criteria of social relevance. "Do you know what the problem is? People's greed. Sometimes they use logics that are not always those of improving health. So, I really don't know who to trust" (M27LEC). The relationship between business and innovation, although negatively characterized with respect to the public interest, was overall perceived as an inevitable process enrolled in the structure of our society. This made even more evident and, at the same time, controversial, the need for trust in economic and institutional actors, which, in turn, is the resource circulating in the process of acceptability of innovation.

4.3. GENDER AND GENERATIONAL BIASES IN SOCIAL ACCEPTANCE OF VB-PPPS

4.3.1. PERCEPTION: REACTING TO THE UNEXPECTED

The introduction of an innovation can occur with or without the involvement of the population and a negotiation with institutions and experts. In the second questionnaire (Annex 3), we posed a series of questions (Q34-Q38) in which we ask to express the reaction to an unexpected event related to agricultural practices.

- “Imagine that in the field bordering your house you begin using one of the products listed below. What would be your first reaction to the use of...?”

From the synoptic table (Table 4.3.1) it is possible to observe the five responses as many ways of positioning oneself with regard to the unexpected. Acceptance is often understood in passive terms, "I do nothing because I suppose everything is in order", which implies a trust in science and regulatory institutions, as well as - in this case - in neighborhood behavior. From this extreme, two modes of "unacceptance" can be distinguished: a passive one, as a discontent that does not translate into any external behavior; and an active one as a bottom-up mobilization towards institutions. Compared to these strong and polarizing reactions, other reactions that are more moderate and open to the construction of meanings are also possible. The first can be defined as a type of acceptability oriented towards otherness: in fact, "I ask the owner of the field for clarification" indicates a willingness to know the meaning and context of something perceived as unexpected. The second one, "I inform myself", is more oriented towards the individual acquisition of information without this resulting in a social relationship. We call these last two options within the label of acceptability as momentary suspension of judgment on acceptance since they set in motion the subjective ability to arrive at a conscious and reasoned judgment.

Data show that VB-PPPs are "passively accepted" in 21% of respondents compared to GMOs (31.3%) and pesticides (26.1%). "Passive unaccepted" in the three cases are essentially at the same level: pesticides outnumber VB-PPPs and GMOs by 1.1%; while active unacceptance is more pronounced than in the other cases (11.9%). Overall acceptability is high (59.6%), more directed at the self than at comparison with the other. If we look at the other cases, it is interesting to observe that for GMOs there seems to be an "unacceptance" (15.4%) that is lower than acceptance (31.3%) and above all also lower than acceptability (53.4%), even though it is more directed towards self-learning than towards comparison with others.

Reactions	<i>Passive acceptance</i>	<i>Passive unacceptance</i>	<i>Active unacceptance</i>	<i>Other-oriented acceptability</i>	<i>Self-oriented acceptability</i>

	"I do nothing because I suppose everything is in order"	"I get scared, but I do nothing"	"I get scared, and I mobilize with the neighbors and the Municipality"	"I ask the owner of the field for clarification"	"I inform myself"
Pesticides	26.1%	8.5%	10.2%	28.4%	26.7%
GMOs	31.3%	7.4%	8%	22.2%	31.2%
Virus-based PPPs	21%	7.4%	11.9%	26.1%	33.5%
Manure and compost	79%	1.7%	0.6%	5.1%	13.6%
Bees and pollinating insects	73.9%	1.1%	3.4%	%	17.6%

Tab. 4.3.1. Reactions toward the unexpected in terms of acceptance and acceptability. "Imagine that in the field bordering your house a farmer begins using one of the products listed below. What would be your first reaction to the use of" (Q34-Q38) [N=176]

With respect to this general outline, it is possible to refine the analysis at the level of gender distinction. In the case of VB-PPPs there are no relevant differences (>4%) with the exception of the response "I get scared but I do nothing" (12% female and 3.2% male).

	Gender		Totale
	Female	Male	
I ask the owner of the field for clarification	24,1%	28,0%	26,1%
I inform myself	33,7%	33,3%	33,5%
I get scared and I mobilize with the neighbors and the Municipality	10,8%	12,9%	11,9%
I get scared but I do nothing	12,0%	3,2%	7,4%
I do nothing because I suppose everything is in order	19,3%	22,6%	21,0%
	100,0%	100,0%	100,0%

In the case of pesticides (Tab. 4.3.3.) we can observe a greater gender polarization on "passive acceptance", with a difference of 15.2% (18.1% female and 33.3% male), and on "passive unacceptance" with a difference of 13.5% (15.7% female, 2.2% male). The answer "other-oriented acceptability" is more frequent in females (31.3%) than in males (25.8%).

	Gender		Totale
	Female	Male	
I ask the owner of the field for clarification	31,3%	25,8%	28,4%
I inform myself	26,5%	26,9%	26,7%
I get scared and I mobilize with the neighbors and the Municipality	8,4%	11,8%	10,2%
I get scared but I do nothing	15,7%	2,2%	8,5%
I do nothing because I suppose everything is in order	18,1%	33,3%	26,1%

	Gender		Totale
	Female	Male	
I ask the owner of the field for clarification	25,3%	19,4%	22,2%
I inform myself	27,7%	34,4%	31,3%
I get scared and I mobilize with the neighbors and the Municipality	10,8%	5,4%	8,0%
I get scared but I do nothing	12,0%	3,2%	7,4%
I do nothing because I suppose everything is in order	24,1%	37,6%	31,3%
	100,0%	100,0%	100,0%

Even in the GMOs case (Tab. 4.3.4.) there is a polarization on "passive acceptance": greater in males (37.6%) than in females (24.1%). Similarly to the case of VB-PPPs, a second prevailing attitude in males is "self-oriented acceptability" (34.4%), decidedly higher than "other-oriented acceptability". Females, on the other hand, tend to express forms of unacceptance (active and passive) for 22.8% versus 8.6% of males.

Tab. 4.3.4. Q35. "Image that in the field bordering your house, a farmer begins using GMOs. What would be your first reaction?" (N=176)

PUBLIC DECISIONS ON THE INNOVATION

In some circumstances, the introduction of a new technology which is particularly controversial from an ethical point of view is submitted to the attention of citizens through the form of a referendum. In the questionnaire, we formulated two fictitious referenda for the authorization of the use of VB-PPPs in agriculture and phage therapy in medicine. The questions openly take the assumption that these referendums are supported by a committee of scientists, in order to be able to measure the degree of trust accorded to them by citizens. The general picture that emerges from Q20 (Tab. 4.3.5.) on VB-PPPs is characterized by a strong component of subjects who, before deciding, wish to acquire more information (63% in adults; 73.2% in students). This attitude, using the terminology introduced earlier, expresses a "self-oriented acceptability". It is more marked in female students than in male students. In adults this value is substantially indifferent with respect to gender. Abstentionism is three times greater in adults (more in males, 25%, than in females, 15.8%) than in

students. Positive acceptance is greater in students (especially males, 18.4%) than in adult females (10.5%) while there are no adult males in favor. Unacceptance is greater in adults than in students with no significant variation according to gender.

Respondent			Gender		Totale
			Female	Male	
Parent/Legal guardian	20. In some countries of the world is underway an experiment that sees the use of viruses to fight some plant diseases. In the hypothesis that in Italy a committee of scientists promotes a referendum to authorize this technique, what would be your positio	I abstain	15,8%	25,0%	18,5%
		before deciding I want to inform myself better	63,2%	62,5%	63,0%
		I am against it even though I trust scientists	10,5%	12,5%	11,1%
		I am in favor because I trust scientists	10,5%		7,4%
		Tot.	100,0%	100,0%	100,0%
Student	20. In some countries of the world is underway an experiment that sees the use of viruses to fight some plant diseases. In the hypothesis that in Italy a committee of scientists promotes a referendum to authorize this technique, what would be your positio	I abstain	1,6%	9,4%	6,0%
		before deciding I want to inform myself better	81,3%	67,1%	73,2%
		I am against it even though I trust scientists	3,1%	4,7%	4,0%
		I am in favor because I trust scientists	14,1%	18,8%	16,8%
		Tot.	100,0%	100,0%	100,0%
Tot.	20. In some countries of the world is underway an experiment that sees the use of viruses to fight some plant diseases. In the hypothesis that in Italy a committee of scientists promotes a referendum to authorize this technique, what would be your positio	I abstain	4,8%	10,8%	8,0%
		before deciding I want to inform myself better	77,1%	66,7%	71,6%
		I am against it even though I trust scientists	4,8%	5,4%	5,1%
		I am in favor because I trust scientists	13,3%	17,2%	15,3%
		Tot.	100,0%	100,0%	100,0%

Tab. 4.3.1. Q20. Parents/Legal guardians and Student positions on VB-PPPs authorization (N=176)

Asking in the survey about the expected outcome of the referenda, we intend to assess the individual respondent's perception of the climate of opinion around an issue that is then objectified in the outcome of the referendum. It is therefore a question from which we can obtain a representation of the "imagined majority"." (Noelle-Neumann, 1984).

From the point of view of adults, it is considered more probable that the referendum will not reach a quorum (66.7%) with a strong distinction based on gender: 57.9% females and 87.5% males; for students instead, the percentage is much lower: 28.1% females and 21.2% males. "Not approved" is considered probable by 40.9% of students (with no relevant gender distinction), by 26.3% of

females and only 12.5% of males. It is noteworthy that male students consider approval more likely than females by a 9.1% gap.

Respondent			Gender		Totale
			Female	Male	
Parent/Legal guardian	21. Regardless of your position, what do you think the outcome of the referendum set forth in the previous question might be?	Approved	15,8%		11,1%
		Not approved	26,3%	12,5%	22,2%
		Quorum not reached due to abstention	57,9%	87,5%	66,7%
		Tot.	100,0%	100,0%	100,0%
Student	21. Regardless of your position, what do you think the outcome of the referendum set forth in the previous question might be?	Approved	29,7%	38,8%	34,9%
		Not approved	42,2%	40,0%	40,9%
		Quorum not reached due to abstention	28,1%	21,2%	24,2%
		Tot.	100,0%	100,0%	100,0%
Tot.	21. Regardless of your position, what do you think the outcome of the referendum set forth in the previous question might be?	Approved	26,5%	35,5%	31,3%
		Not approved	38,6%	37,6%	38,1%
		Quorum not reached due to abstention	34,9%	26,9%	30,7%
		Tot.	100,0%	100,0%	100,0%

Tab. 4.3.6. Q21. Expected outcome of the referendum on VB-PPPs authorization (N=176)

The second fictitious referendum on the use of bacteriophages (Tab. 4.3.7.) in medicine presents a general picture of prevalence of "self-oriented acceptability" (59.1%), which is higher in adults (77.8%), especially in females (84.2%) than in males (62.5%). In students there is a gender gap of only 1% and this option collects 55.7% of responses. Acceptance related to trust in scientists is about three times higher in students (more in females, 34.4%, than in males, 28.2%) than in adults. The no-vote option is not significantly different between adults and students.

Respondent			Gender		Totale
			Female	Male	
Parent/Legal guardian	41. Therapy based on the use of bacteriophages (a type of virus that feeds on harmful bacteria) is being tested in combating some sometimes lethal infectious diseases, such as cholera and dysentery, with promising results. Scientists anticipate similar (v	I abstain	5,3%	12,5%	7,4%
		before deciding I want to inform myself better	84,2%	62,5%	77,8%
		I am against it even though I trust scientists		12,5%	3,7%
		I am in favor because I trust the scientists	10,5%	12,5%	11,1%
		Tot.	100,0%	100,0%	100,0%
Student	41. Therapy based on the use of bacteriophages (a type of virus that feeds on harmful bacteria) is being tested in combating some sometimes lethal infectious diseases, such as cholera and dysentery, with promising results. Scientists anticipate similar (v	I abstain	7,8%	8,2%	8,1%
		before deciding I want to inform myself better	56,3%	55,3%	55,7%
		I am against it even though I trust scientists	1,6%	8,2%	5,4%
		I am in favor because I trust the scientists	34,4%	28,2%	30,9%
		Tot.	100,0%	100,0%	100,0%
Tot.	41. Therapy based on the use of bacteriophages (a type of virus that feeds on harmful bacteria) is being tested in combating some sometimes lethal infectious diseases, such as cholera and dysentery, with promising results. Scientists anticipate similar (v	I abstain	7,2%	8,6%	8,0%
		before deciding I want to inform myself better	62,7%	55,9%	59,1%
		I am against it even though I trust scientists	1,2%	8,6%	5,1%
		I am in favor because I trust the scientists	28,9%	26,9%	27,8%
		Tot.	100,0%	100,0%	100,0%

Tab. 4.3.7. Q41. Parents/Legal guardians and Student positions on phage therapy authorization (N=176)

The expected outcome of the referendum (Tab. 4.3.8.), in this case, shows a different perception between parents/legal guardians and students: respectively 25.9% and 47.7% predict approval. For adult females the most probable outcome is "not approved" (42.1%), while for adult males "quorum not reached due to no-vote" (62.5%). With regard to students, the gender dimension has a marked effect (>8%) on the "approved": 53.1% female and 43.5% male.

Respondent			Gender		Totale
			Female	Male	
Parent/Legal guardian	42. Regardless of your position, what do you think would be the outcome of the referendum set forth in the previous question?	Approved	21,1%	37,5%	25,9%
		Not approved	42,1%		29,6%
		Quorum not reached due to abstention	36,8%	62,5%	44,4%
		Tot.	100,0%	100,0%	100,0%
Student	42. Regardless of your position, what do you think would be the outcome of the referendum set forth in the previous question?	Approved	53,1%	43,5%	47,7%
		Not approved	25,0%	32,9%	29,5%
		Quorum not reached due to abstention	21,9%	23,5%	22,8%
		Tot.	100,0%	100,0%	100,0%
Tot.	42. Regardless of your position, what do you think would be the outcome of the referendum set forth in the previous question?	Approved	45,8%	43,0%	44,3%
		Not approved	28,9%	30,1%	29,5%
		Quorum not reached due to abstention	25,3%	26,9%	26,1%
		Tot.	100,0%	100,0%	100,0%

Tab. 4.3.8. Q42. Expected outcome of the referendum on phage therapy authorization (N=176)

From the comparison between the two referenda (Tab. 4.3.9), it is possible to observe a preponderant tendency towards information seeking ("self-oriented acceptability") especially in the case of VB-PPPs. Regarding acceptance, the result is higher in the case of medicine (27.8%); while unacceptance is identical.

	VB-PPPs	Phage Therapy in human medicine
Before deciding I want to inform myself better	71.6%	59%
Abstention	8%	8%
I am favor because I trust in scientists	15.3%	27.8%
I am against it even though I trust in scientists	5.1%	5.1%
I am against it because I distrust in scientists	0%	0%
Approved	31.3%	44.3%
Not approved	38.1%	29.5%
Quorum not reached due to no-vote	30.7%	26.1%

Tab. 4.4.9 Referendum for the introduction of virus-based products in medicine and in plant protection (Q20,21,22,41,42) [N=176]

It is noteworthy that in both cases there are no "I am against it because I distrust in scientists" responses. The aversion as reflected in some responses to question Q22 relates to the lack of popular participation and the suspicion that beyond the work of the researchers, the implementation of such an innovation may not be done in an efficient, safe and controlled manner:

- Especially after the pandemic I don't think people would approve of using viruses
- Because it would be too dangerous in a time of crisis like now.
- Because it would certainly bring economic benefits and often the economy is benefited at the expense of the welfare of citizens
- Because the idea that man has of viruses (covid-19) would probably induce him to reject this project. This is because of misinformation/disinterest and fear of going against something irreversible/uncontrollable.
- The population is opposed but disinterested in food issues
- There would be the fear of dangerous mutations of viruses (since in some people there is the doubt that the covid was born from laboratory errors) also harmful to plants. This pandemic has made us more careful and afraid of viruses.

From these answers we can say that the non-acceptance of innovation is not strictly linked to the work or reputation of scientists, but to the role played by all the actors involved in the innovation process: from experts and end-users to communicators and policymakers.

4.4. SENSEMAKING MODEL OF ACCEPTABILITY OF VIRUS-BASED BIOTECHNOLOGIES

The representations discussed so far, showing traits of uncertainty and absence of perceived control and intrinsic complexity, may lead to the hypothesis that the acceptability towards virus-based PPPs would somehow be compromised and controversial. We found many factors that came into play and exerted direct or indirect influence associated with participants' demographic profile. Data collected on acceptability negotiation suggested the regular emergence of spontaneous group dynamics that we represented in a multi-component model, whose elements, in relation to each other, have different impacts on the acceptance, but also on participants' engagement (Fig.4.4.1).

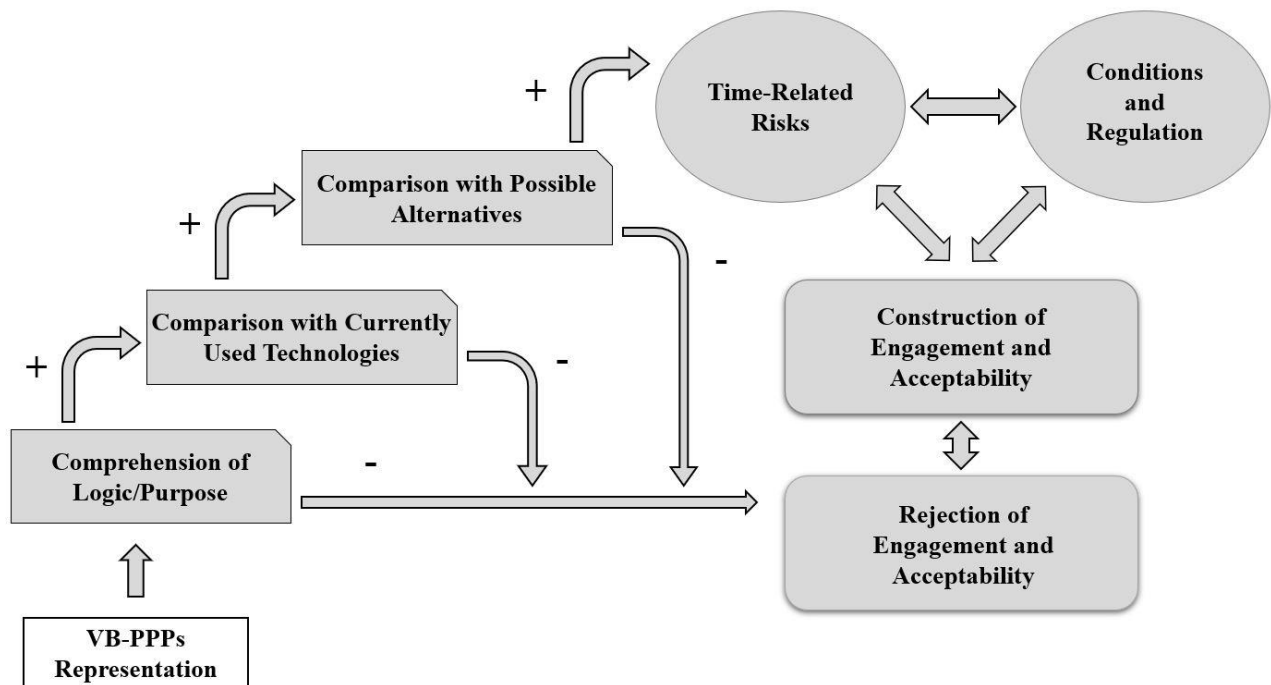


Fig. 4.4.1. Sensemaking model of acceptability of VB-PPP

A) COMPREHENSION OF LOGIC/PURPOSE

One of the main points of discussion involving the participants within the focus groups was the attempt to understand the rationale of functioning of the proposed technology. Despite the materials distributed during the focus groups describing the cause-effect connections underlying the use of virus-based PPPs, some participants showed a tendency to hastily deconstruct these arguments in terms of negative knowledge (and eventually of forbidden science), elaborating new

alternative interpretations: "I don't understand. We can survive without corn. Humanity has always adapted according to how the planet changes. So, I do not understand why we should use this [virus-based PPP] to save the corn if we can survive by growing something else. Maybe that's what someone's making money off" (M21LEC). We were also able to observe a cautious attitude towards the uncertainty stemming from the new technologies presented. Some participants, indeed, avoided an impulsive judgement, requesting and discussing more elements to deepen their understanding of the logic. This kind of reaction stimulated by disruptive innovations represent a good example of negative capability, carving the path leading from the unknown to an engaging non-knowledge: "I want to know more about that" (F62LEC).

B) COMPARISON WITH CURRENTLY USED TECHNOLOGIES

Subsequently, both the objective and symbolic value of the technologies currently in use appeared to be a determining factor in the construction of acceptability. The education level variable appeared as crucial: participants with lower education more often expressed negative opinions about currently used PPPs technologies, especially pesticides, described as harmful *a priori*. On the other hand, participants with higher education profiles generally considered the effectiveness and benefits of pesticide use, while also recognizing their negative implications in environmental and health damage: "I'm in favor of this technology because I absolutely hate pesticides" (M26LEP). "We have arrived at a level where the controls and legislation on food safety has progressed, so the products have adapted... in my opinion. I think that the pesticides used today compared to those used 50 years ago are, all in all, acceptable" (F48HEC).

C) COMPARISON WITH POSSIBLE ALTERNATIVES

One of the reflections mainly brought up by participants from poorly urbanized areas was the opportunity of using alternative methodologies instead of virus-based PPPs, which were perceived as potentially too dangerous. The alternatives proposed were not always concrete (and sometimes only supposed) and often based on the concepts of *bio*, natural and low environmental impact: "I'd rather feed the ladybugs and control them than throw pounds of chemicals on the crops" (M27HEP).

D) TIME-RELATED RISKS

One of the recurrent concerns was the overall perception of possible loss of control and potential negative long-term consequences. Virus-based PPPs were perceived as not static, yet as dynamic

entities, playing potentially disruptive roles in their interaction with the (eco)system; they were considered as complex objects whose characteristics partially overlapped with those of general viruses, and consequently were perceived as autopoietic and subjected to mutations, and therefore dangerous: "It scares me, because you can't predict how this technology could be integrated... maybe well, it strengthens... or maybe it strengthens those hideous beasts" (F25HEC).

E) CONDITIONS AND REGULATION

Participants, especially those with higher education, showed a general aversion to the immediate acceptance of the technology proposed. Indeed, they used to indicate conditions of acceptability, asking for regulation and supervision by experts and institutions in conformity to ethical principles. On the contrary, participants with lower education seemed to accept the proposed technology more easily, making it clear that constant monitoring methods would be necessary. The main arguments for acceptability revolved around the need for innovation and sustainability to cope with possible global emergencies: The risk-taking propensity, supported by laypeople, had to be accompanied by the assumption of responsibility of all actors involved in the innovation process: "I mean I think the most important things for people to understand are side effects... costs... safety... experimentation... expert opinions..." (M40HEC). "At my own risk, I would be in favor of these new products" (M23LEC).

5. COMMUNICATION ISSUES

Along with this report the problem of communication has been widely described and analyzed. In this section we take up two more aspects of the communication process related to the process of social acceptability of a breakthrough biotechnological innovation as a starting point for the discussion of the most relevant aspects that emerged during the subsequent phases of the research with respect to the topic of communicating virus-based biotechnological innovation. In particular, the following two aspects that impact on the process of acceptability will be focused on: 1) the setting of the public engagement in the innovation process as a co-constructor of meanings; 2) the characteristics of “good communicator”. The combination of these two lines of inquiry could indicate some general indications on which to build effective communication strategies in the future.

5.1. FOCUS GROUP AS LABORATORY FOR PUBLIC ENGAGEMENT

In the focus group part of WP6, we have explored the construction of representations on an unknown and potentially disruptive innovation in agriculture. Focusing on the science-society relationship, we have investigated the construction of the acceptability of virus-based innovation through three theoretical lenses, in a triangulation perspective. We highlighted what links the unknown with the already known in terms of social representations, anchoring and objectification. This epistemological level is the precondition for value-orientations between what is/is not worthy of being known and investigated. This last distinction depends not only on individuals' knowledge and direct and indirect experience, but also on the state of common sense (diffuse and local knowledge). In particular, the innovation process is perceived as profoundly opaque and subject to collusion with private interests that go against the public good/interest. Initially, many participants have expressed a negative attitude towards the conductors (perceived as “latent promoter”: *you want to sell us something!*). During the activities and after the conclusion of the focus-group, the most frequent sentiments expressed by the participants were trust and gratitude for the opportunity to participate to the research, asking for more information and knowledge about the topic.

This reaction led us to the following considerations. Firstly, after the end of this experience, a constellation of representations (not only on the virus theme but also on the processes of innovation) remained in the participants. We assume that these residuals constituted an imaginative resource to deal with the Covid-19 emergency that would have followed later. Secondly, the structure of our focus groups turned out to be a *place of empowerment of the imaginary*, increasing citizens'

awareness of an object absent in their daily life, but also their negative capability with respect to new objects and problems emerging at local and global levels. Our study on the imaginary in a focus group setting revealed research-action potential, especially from a Citizen Science perspective by involving citizens not as receivers or consumers, but as active agents of the construction of common sense about the known and the unknown.

5.2. STAKEHOLDERS IN THE COMMUNICATION PROCESS

As we have been able to learn from the Covid-19 pandemic experience, taking care of the communication processes between institutions and the public is of fundamental importance to ensure safety, transparency and control of operational practices involving the entire population. Especially during the emergency phase, but also in reference to the promotion of technologies not yet known and disruptive from the point of view of transformative potential. The need to receive coherent information through communication practices perceived as correct, as previously discussed, are among the most important criteria that the population considers indispensable to guarantee that fiduciary delegation, a prerequisite for the acceptance of virus-based technologies. This circularity in the relationship between knowledge and citizenship leads us to conceive communication with the public as a dynamic phenomenon, co-constructed by the interaction between all stakeholders. The information practices through which the population interactively negotiates the representations of a given technology are in fact conveyed by a wide range of professionals who, albeit in different ways in relation to their status and social role, contribute to the creation of a shared social imaginary of the technologies presented. Investigating the opinions of citizenship with respect to the professions that interface, directly or indirectly, with it, has allowed numerous considerations to emerge that help us understand how best to manage the communication process in a functional and useful way.

In concrete terms, within the focus groups, with particular reference to the activity of phase three, a tendency that consistently characterized the participants was that of explicitly negotiating, during the discussion, parameters that would serve as a reference point for the placement of the players presented. Among the parameters used, the ones that most frequently emerged were the following.

5.4.1. SCIENTIFIC KNOWLEDGE

The players were evaluated according to their specific scientific knowledge on the subject. In concrete terms, those considered to be competent, i.e., with sufficient scientific knowledge to

understand the technologies considered, were evaluated positively. The characters considered most competent are university professors, scientific communicators and professionals working in the public and private sectors. These players obtain public recognition thanks to their title, which acts as a guarantee. The scientific credibility of these figures was never questioned among the participants. "You have to admit that if we take knowledge into consideration, then professors go first" (M45HEP). At the same time, there was no unified opinion in terms of knowledge with respect to the other professionals presented. Within the categories of journalists, influencers, pharmacists, and farmers, different degrees and levels of scientific expertise were recognized. Obviously, journalists and pharmacists were recognized as having at least a degree potentially or partially inherent to the subject matter, whereas it was pointed out that politicians, farmers, and influencers may not have any kind of theoretical expertise. In support of intra-professional variability, completely opposite examples were also reported: "But farmers are no longer the old farmers we are used to thinking about. I have a peer who is studying to be an agricultural scientist...so we're not talking about 80-year-old people, we're talking about young guys who are studying these things. They are the new farmers" (F24LEP).

5.4.2. PRACTICAL COMPETENCES

Professionals were evaluated according to their practical competence (actual or potential) in the use or interaction with the presented technologies. This aspect was significantly associated with pharmacists and farmers recognized as front-line operators who can directly verify or monitor the effects of the virus-based products used (respectively to their fields of expertise). "So, for me towards the positive pole we should put pharmacists because they are the ones who deal with the most people... who go to the pharmacy for a wide variety of reasons..." (F20LEC) This form of experience in the relationship with the product was considered as a positive factor that led the participants to emphasize the need to involve these figures in the relationship with the public. "Farmers first of all are on the ground... and second, they have an impact within the average Italian family which is still the majority of the population... Farmers have the knowledge on the ground" (M26HEC)

5.4.3. COMMUNICATION SKILLS

The ability to reach and influence the public was one of the most discussed parameters within the focus groups as it was often subject to conflicting opinions. This is a topic that proved to be articulated and complex, and it was necessary to make an internal distinction within the parameter through the concepts of "effectiveness" and "reach". The first was conceived as the ability to express

content in a simple, clear, precise and understandable way, and is unanimously recognized as a determining factor in communicating with the public. "It depends on how, though, i.e., the college professor might be a little technical...i.e., difficult to understand. It's usually not a popular communication" (F56HEC). Professional figures such as science communicators and journalists who possess a mastery of communicating with the public are valued positively, while figures such as university professors, experts, and technicians in the public or private sector who are not able to manage the communication process are considered less suitable despite their high symbolic and knowledge capital.

Regarding reach, this expresses the ability to reach and influence a large number of people. Although it has been described as a resource often used in the interests of the person who possesses it (i.e. as a means of further increasing their visibility and popularity), it is also recognized as useful in activating the interest of large portions of the population that would otherwise be difficult to reach. Figures associated with great communication reach are influencers and politicians. "If the goal is for people to speak to inform, the influencer is already at a higher level. We're talking about using influencers based on what skills they have. I see the influencer here as being able to communicate to a large segment of the population, maybe a young one..." (M54HEP)

5.7.4. PROFESSIONAL ETHICS

In a complex society, the ethical dimension connotes every professional figure, since it strongly expresses the social mandate and thus the fiduciary delegation on which prestige and power are based. Professional figures have been evaluated on the basis of the ethical principles associated with their professional activity. This parameter is particularly important because it is considered one of the fundamental criteria for trustworthiness. Figures such as public sector professionals and university professors are usually perceived as experts who dedicate their lives to a "cause" and have positive ethical principles to which they are deeply committed. On the other hand, private sector professionals, journalists, influencers, and politicians (as well as pharmacists and farmers, albeit to a lesser extent) are often judged on their lack of ethical principles, i.e. supporting one cause over another based on personal gain or that of the entity they represent: "It is often believed that influencers are the ones who manipulate the masses, but in reality they act without real expertise. They are also paid by brands to present their products... and so they sell themselves a bit to anyone..." (F30HEC)

5.7.5. PUBLIC OPINION

The parameters presented allow us to understand quite clearly how the participants in the focus groups negotiated with each other the placement of the professional figures involved. Stopping at a superficial analysis, it could be said that the actors who, on the whole, were positively placed on multiple continuums defined by the parameters were also those considered most suitable for the process of communicating with the public. However, during the course of the focus groups, it became evident that the largest portion of the discourse was always dedicated to the discussion of the professional figures considered most ambiguous, i.e., those figures who simultaneously possessed parameters with positive and negative valence. For example, politicians and influencers are judged positively in terms of reach but negatively with respect to the possession of scientific and practical knowledge. Compared to other professionals, they received significant attention time. This predominance in discourse can be explained with reference to the natural tendency of participants to possess already established opinions. If figures such as journalists, public and private sector professionals, and university professors' opinions were expressed in a simple and unarticulated way, for influencers and politicians there was a wide critical opinionated interaction. This suggests a strong presence of these figures within public opinion which, for better or worse, considers them as integral parts and primary interlocutors within the process of communication with the public.

In conclusion, it was possible to observe a further phenomenon within the discussion: in all the focus groups, frequent reference was made to the concept of 'mass audience', understood as fickle, susceptible to manipulation, to making instinctive and erroneous choices. This phenomenon occurred without consistent variation and involved almost all participants. The main reflections on the topic displayed a self-assessment of their own reach, which was considered limited with respect to the main actors of communication. The other components of the citizenship, conceived as a 'mass', would have conflicting opinions and would always prevail. Powerlessness in the face of the irrational and manipulable choices of the 'mass' gave rise to comments that reflected negative feelings about one's social identification, with frequent references to resignation as a state of mind. This process of disidentification from the citizenship as a whole, this deviation of the participant from the representation of the average citizen and the citizenship-mass as a whole, taking place within the setting of the focus group constituted an important moment of self-awareness not only on an individual level but also as a group of strangers gathered to discuss a topic of public relevance. In this sense, the focus group represented a space for the verbalization of this state of mind, but also for its potential overcoming.

6. FUTURE CHALLENGES AND FINAL REMARKS

The term virus is negatively connoted as a result of a knowledge gap between the research world and other sectors of economic and social life. Our research on social acceptance of virus-based biotechnologies involved: the world of biotechnological research, scientists and academics, operators in the agricultural and public communication sectors. Through questionnaires and focus groups we then collected the views of non-experts. The main theme that emerged concerns the communication of innovation. From laypeople's perspective, innovation needs to be understood and publicly discussed before widespread application.

6.1. CHALLENGES

We now see what challenges lie ahead both from the perspective of psychosocial research and in understanding the dynamics of acceptance and acceptability of virus-based biotechnological innovation.

6.1.1. COMMUNICATION AS EDUCATIONAL CHALLENGE

Therefore, it is necessary for all stakeholders to communicate effectively on three levels that are often confusing: **a) learning as the acquisition of logical tools; b) information as the acquisition of knowledge; and c) instruction as practical problem-solving procedures.** Communicating on these three levels in a balanced way means building education, a necessary condition to avoid simple solutions or irrational reactions, generating a culture of risk to deal with uncertainty from a participatory perspective that minimizes the damage resulting from a potential social conflict. To do this, communication must be shared by identifying channels and opportunities for dialogue between generations, mending the social distrust in the scientific progress that emerged and was exasperated during the pandemic.

6.1.2. PANDEMIC AND INNOVATION

Our analysis shows that the pandemic has made the term virus taboo to a different and greater extent than before. Scientists reflecting on the climate of opinion generated in this period may be induced to give up investigating lines of research that employ the use of "good viruses" (Roossinck, 2011) so as not to incur opposition and ostracization from the public and institutions (Kempner *et al.*, 2011). However, alongside this negative perception, we have noted the possibility of constructing contexts of positive dialogue with citizens, i.e., the focus group, as a place of meaning-

making and education. The impact of the pandemic constitutes a singularity which possesses a high density of information and which, therefore, opens up previously unseen and unimaginable spaces for social and scientific innovation. A necessary condition to operate a change of perspective is the possession of appropriate theoretical tools that place "prepared minds" (Carradore *et al.*, 2020) on the other side of the crisis and see a perhaps unrepeatability opportunity in the explosion of information complexity resulting from the pandemic.

On the medical research side, the pandemic has been an exceptional stimulus for clinical virology, as evidenced by the realization of vaccines. Although there is opposition in a minority of the citizenry regarding the administration of coronavirus vaccines, scientists have enjoyed unquestioned visibility and credit from institutions and the media. The social construction of the *symbolic capital* collected by the experts therefore becomes valuable material for psycho-social analysis aimed at designing communication and policy interventions to minimize social conflict.

Regarding the social acceptability of virus-based innovations in agriculture, we observed an attitude not of *preclusion*, but of *caution*. Public trust in the actors involved in the innovation process has a reduced fideistic component, but it needs to be built and supported by timely, non-contradictory information.

The communication challenge facing researchers but also all stakeholders involved in the testing and implementation of VB-PPPs is to overcome the effects of Covid-19 related infodemia without falling into preemptive self-censorship ("If I had to present a project on virus-based products today, I wouldn't do it"), but by implementing ethical and consistent communication and commercial strategies. This is possible, e.g., by leveraging the ecological role of viruses that can combine synergistically with the broader and more complex issue of climate change and impact on ecosystems. Again, psychosocial research can play a role in mediating between the knowledge gaps of stakeholders by identifying the biases and systematic errors that have characterized the opposition of the use of VB-PPPs by non-experts.

6.1.3. INTERGENERATIONAL DIALOGUE

From the survey there is little dialogue between students and parents which is itself a symptom of poor communicability of biotech innovation issues. Young people are an increasingly stimulated subject to respond to the global movement to cope with the effects of climate change. However, compared to the adult world, there seem to be differences in the perception of risk and acceptability of innovation. On the other hand, as emerged during Delphi, these differences are

diagnosed starting from a different or even opposite attitude towards viral therapies by young people and adults. The latter, by virtue of the memory linked to dramatic moments that have been sedimented in a positive vision of the science-society relationship, in which the former is at the disinterested service of the latter, are not able to achieve a sharp transmission of memory. However, in a model of transmission of memory, the so-called generational hairpin bends play a fundamental role, generational figures intermediate between parents and children, i.e. older children, cousins, etc. generational fractions that act as repeaters of the experience. These figures, leading edge generation, have been replaced by the mass-media that emit contradictory messages, interfering with the coherence of meaning that is transmitted from generation to generation. This coherence would make it possible to define the contours of the common sense and therefore of a shared risk culture: a shared perception of risk means that when faced with uncertainty one can respond in an efficient and more coordinated manner. From the point of view of the subjects participating in the process of biotechnological innovation, this intergenerational challenge is placed both at the level of educational paths, but also at the level of professional training, making it necessary to develop a communicative sensitivity even on the part of those subjects who, by virtue of a status recognized at the institutional level, could avoid a direct confrontation with both adults and the new generations.

6.2. FINAL REMARKS

The acceptability process of VB-PPPs has been described in terms of a dilemma between benefits and representations, between tangible effects and intangible meanings, thus as an unsustainable innovation. If from the research side the evidence collected is accelerating highly specific and selective therapeutic approaches capable of safeguarding the ecological relationships between the organism and its environment, on the other hand these benefits (presented as objective) clash with a complex of critical issues at the level of regulation and public opinion. Both are characterized by the persistence of obsolete models of sensemaking that undoubtedly include the social memory of the traumas of diseases such as smallpox and polio, or more generally of the plague. The existence of a knowledge gap in answering the question "what is a virus?" should invite us to build places for encounters between science and society, in which the transmission of the latest discoveries can easily flow from the scientific field to the rest of the social fabric. However, this cannot happen easily insofar as the fiduciary pact is compromised and the expert is accused of betraying the social mandate and of orienting his public conduct on the principle of maintaining a position of prestige. If, as it has been said by the Italian virologist Roberto Burioni, "science is not democratic", it should not be forgotten that public opinion in some particular circumstances can

act as a handbrake on the processes of innovation with techno-scientific traction (Habermas, 1992). Counting the damage caused and the outrage suffered by abrupt braking and slowing down is a matter of risk analysis. From such knowledge (often painfully acquired) may arise a much more solid and widespread awareness of the inescapable role of public opinion in determining the trajectories of scientific and social innovation, and therefore of the importance of a dialogue as symmetrical as possible, not improvised at the time of a crisis. Inevitably, the drama of the pandemic and the controversy surrounding the vaccination campaign will provide the new framework for the future challenges of virus-based biotechnological innovation. **What will be the attitude of scientists toward the frontiers of virus research and how the social acceptability of viral therapies will evolve, it is not easy to say.** However, once the survival of the social systems affected by coronavirus is assured, in the reconstruction of a new normality, in order to reinforce the fiduciary mandate, it will be crucial to govern complexity by mitigating the mutual suspicion between experts and the public, and structuring a *mutualistic symbiotic relationship*, similar to the one discovered between organisms and viruses.

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ANNEX 1: DELPHI QUESTIONNAIRES

Delphi #1. November 2019 - March 2020

	Name	Expertise	Gender	R 1	R 2	R 3	R 4
1	Matilde Ferretto	University professor	F	X		X	
2	Massimo Gulisano	University professor	M				
3	Giulio Cesare Pacenti	Consultant (Pharmaceutics)	M	X	X	X	
4	Davide Ederle	Manager (Biotech)	M	X	X		
5	Santo Barreca	Manager (Pharmaceutics)	M	X	X	X	X
6	Paolo Filotico	High school professor	M	X	X	X	X

Round 1. 26.11.2019

- 1) How would you describe the most common general attitude towards science among Italians?
- 2) In your opinion, what are the macro-factors that most influence the attitude you described in the previous question?
- 3) Can you tell us how many scientific dissemination/communication events you have attended (both as speaker and auditor) in the last year?

Round 2. 13.01.2020

During the first focus groups, as expected, a polarization of opinions emerged on the basis of educational level. In particular, two opposing evaluative frames materialized: the one characterized by the *fallacia ab auctoritate* (the need to trust authoritative communicators on the part of those with low education, delegating to them the elaboration of information) and that of "paralysis by analysis" (the need to have access to a plurality of information on the part of those with high education, with the risk of not being able to converge on their own opinion). There also emerges a confusion between the concepts of risk and danger, used as synonyms (confusion that transfers to the definition of "safety") and a contradiction between the need for less human intervention (desire for something "more natural") and the need for more control (implying human intervention).

From this we derived the following two questions:

1) Among the professional figures indicated as best suited to the task of communicating biotechnological innovation is that of the university professor, who combines authority and passion with respect to his or her topic of study. However, this same figure is often judged to be lacking in communication skills. What do you think? Can you briefly describe, based on the characteristics highlighted above (authority, passion, communication skills), your significant experience (positive or negative) as a speaker and your experience as an auditor?

2) Participants in focus groups express concern about a possible loss of control of virus behavior. This leads them to suggest alternative solutions characterized by the following attributes: naturalness, lower environmental impact, greater control. Based on your experience in dealing with innovations in biotechnology/agriculture, have you encountered needs expressed through these same attributes? In light of recent biotechnological innovations, how would you define the concept of "nature" (and "natural") taking into account the inevitability of human intervention?

Round 3. 05.02.2020

From the last two focus groups have emerged significant issues from which we have developed the following questions on which we ask you to reflect and give us your point of view.

1) In recent weeks the Coronavirus issue has essentially monopolized the media and political agenda, both locally and internationally, with important repercussions on the macroeconomic scenario. Moreover, in the construction of strategies to cope with the emergency, communication between experts and the public is playing a decisive role.

To what extent can the media case around the Coronavirus issue, in your opinion, influence the attitude of non-experts regarding the use of viruses in the medical and phytosanitary field?

2) One of the variables that we are keeping under control in the focus groups is the level of education. We are seeing a general tendency among those with low education to accept relatively passively communication from those recognized as authoritative and possessing institutional legitimacy.

If experts address the public by imagining the latter not as an interlocutor but as passive, then the tendency of the less educated portion of the public is to develop a fatalistic attitude. "If they're going to cheat us, they're going to cheat us anyway," using the words of one focus group

participant. What are your thoughts on this? Have you encountered such an attitude in your public contact experiences? How can you avoid developing such an attitude in your audience?

Round 4. 07.03.2020

I invite you to express some free considerations on your participation in our panel of experts and on the epidemic that has involved us and that has grafted itself with dramatic timeliness in the current project.

Delphi #2. April 2020- July 2020

	Name	Expertise	Gender	R 1	R 2	R 3	R 4
1	Stefano Dalla Casa	Freelance Science Communicator	M	X	X	X	X
2	Massimo Sandal	Freelance Science Communicator	M	X	X	X	X
3	Annarita Longo	Science Communicator	F	X	X	X	X
4	Mimmo Pelagalli	Science Communicator	M	X			
5	Franco Brazzabeni	Science Communicator	M	X	X	X	X
6	Gianluigi Cesari	Farmer	M	X			
7	Roberto Polo	Farmer	M	X			
8	Federico Polinelli	Farmer	M	X	X	X	
9	Giovanni Melcarne	Farmer	M	X			
10	Ivano Gioffreda	Farmer	M	X	X	X	
11	Renata Boeri	Farmer	F	X	X	X	

Round 1. 16.04.2020

- 1) How would you describe the attitude of Italians towards Science and Technology?
- 2) What could be the factors that in your opinion influence the attitude you described in the previous question?

Round 2. 08.05.2020

In the previous and preliminary round of questions we asked some generic questions about attitudes towards science and technology and the factors that can influence those attitudes. From the answers provided by the panel some very interesting points emerged that I want to propose here. First, a focus on the political dimension of scientific research emerged. Emphasis was given to scientific research as an institution, an institution that can influence or, on the contrary, be influenced by political and/or economic dynamics.

1) Instead, going into the specifics, in the field of agriculture, how do you think scientific research in agriculture can be influenced by political-economic dynamics? And how could it influence political decision-making?

Another aspect that emerged is that of the usefulness of scientific research; research that "improves lives" or that could be (at least in some cases) a vehicle for uncalculated risks.

2) Still remaining in the fields of agriculture, what should be the primary purpose of agricultural research? and what could be the risks of such activity?

Now we introduce a new question. Please feel free to answer it also by linking it to the previous questions. Let's talk now about biotechnology. The Encyclopedia Treccani defines biotechnology as "technologies that control and modify the biological activities of living beings in order to obtain industrial and scientific products".

3) What biotechnologies currently used in agriculture come to mind? How do you assess the relationship between agricultural practices and biotechnology products?

Round 3. 03.06.2020

In the past rounds the panel has shown to be particularly attentive to the political components inherent in scientific research and innovation, as social activities they are never neutral, as they say ... "science and innovation never happen in a vacuum". But as you reminded us, being aware of this does not mean not recognizing the "liberating" potential of research activity and technical-scientific innovation. Especially with regard to productive efficiency and agricultural work. Another interesting issue that has emerged will now help us to finally introduce the main reason why you have been asked: the so-called Virus-Based Plant Protection Products. Viruses can be used in agriculture in order to protect plants from harmful insects, bacterial or fungal infections. The use of

these biotechnologies could reduce dependence on agrochemicals. In this way, viruses could be the answer to the concerns about the environmental sustainability of phytoiatric practices raised in our previous contacts. On the other hand, however, environmental sustainability has been directly linked to structural issues, concerning the modes of agricultural production and consumption on a global scale, sustainability is therefore a process, not achievable only through a single product, a single innovation, a "magic wand". Based on these two keys of interpretation you provided, I would ask you this.

- 1) How do you evaluate the prospect of using biotechnology for virus-based plant protection?
- 2) (For those who practice) Would you use them? (e.g. for biological control of a pathogenic organism, to maximize crop yield, etc.)

As we told you at the beginning, this research project was born a couple of years ago. Certainly we could not imagine what would happen from the beginning of 2020, and how "the Virus" would soon become the protagonist of policies, laws, of our daily lives. On an intuitive level we can say that they are not enjoying a good reputation lately. Although, as you know, viruses and bacteria are an integral part of us, of plants and of the soils from which plants emerge.

- 3) How do you think the Covid-19 event may affect perceptions and representations of Viruses and its uses, even when beneficial?

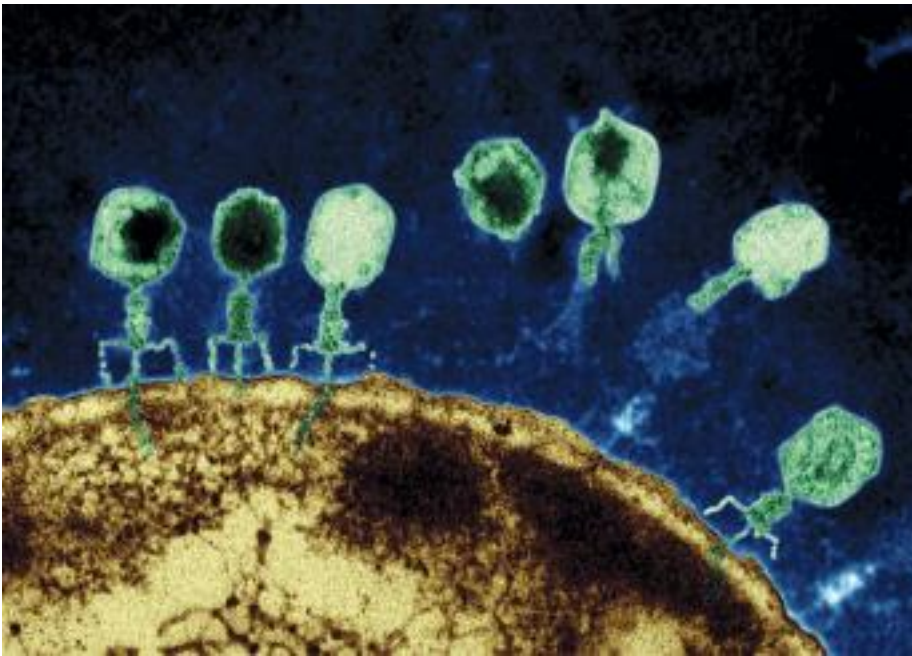
Round 4. 07.07.2020

In the previous round of questions, we finally introduced "Virus", a word that since the beginning of this 2020 we have all heard (or pronounced) at least once a day. As is normal, the coronavirus emergency that we are all experiencing inside and outside our bodies has had a strong impact on the perception of viruses. In fact, we would like to take this opportunity to ask your opinion on two aspects.

- 1) How do you evaluate the management of the emergency by the Italian institutions?
- 2) How do you evaluate the communication of the emergency and scientific communication (intermediate or disintermediate) in the case of Covid-19 in Italy?

Turning back to the plants, Virus is also part of the name of our project. Viroplant, as mentioned, aims to study alternative ways to fight against plant pathogens such as bacteria, fungi and insects.

As you have well noticed, for every new biochemical or biotechnological product whose use is being evaluated, for every nascent innovation, a new area of ignorance and 'yet to be known' is associated with it. In short, in trying to solve one problem, new ones may arise. Think of DDT, a chemical compound that was certainly useful in eradicating malaria in Europe and North America, but that over time we have discovered to be harmful to the environment, animals and humans. Many, in fact, are the products widely used in agriculture that follow the same logic: to solve a specific problem, often creating a new one. Let's think about pathogenic bacteria, for years one of the main antibacterial and antiparasitic agents used in agriculture has been Copper. However, Copper is a heavy metal that besides depositing in the soil and ending up in groundwater, generates antibiotic resistance, which means more efficient pathogens and less and less effective solutions. This time, instead of talking about viruses, we will talk about "bacteriophages"



A bacteriophage is a virus that infects only a particular bacterium. In agriculture, phage therapy could be used as a form of biocontrol against pathogens. The use of phages could meet the two problems described above, the deposition of heavy metals in the soil and the increasing antibiotic resistance.

3) Trying to keep in mind what we have said in these months, about the politics of scientific research, the problems regarding environmental sustainability in agronomic practices, productivity and labor. Which aspects we have talked about do you think are more relevant in trying to frame this new (potential) biotechnology?

4) In this Delphi (this series of questions), taking the issue of Virus-based plant protection products very broadly, we also tried to understand what your idea of agriculture is. What is the relationship that as 'humans' we intend to establish with 'nature', which in this case could be said to act both as a means of production and as a labor force. In this final and concluding question, we ask you to freely express how you understand this relationship.

We thank you for the time you have dedicated to us and for your interesting observations.

Delphi #3. 01.06.2021-26.07.2021

	Name	Expertise	Gender	R 1	R 2	R 3	R 4
1	Matilde Ferretto	University professor	F		X	X	X
2	Valeria Iovino	Biotech Researcher	F	X	X	X	X
3	Maria Carla Cravero	Biotech Researcher	F	X	X	X	X
4	Luca Nerva	Biotech Researcher	M	X	X	X	X
5	Elisa Angelini	Biotech Researcher	F	X	X	X	
6	Cecilia Manzo	University Professor	M				

Round 1. 01.06-2021

1) From your professional experience, do you believe that acceptance of biotechnological innovation is a function of belonging to a generation? Why? Could you give us an example that is significant for you to support your point of view?

2) In the field of biotechnological risk in Italy, what do you think could be today divisive issues and issues of convergence of opinion between individuals belonging to different generations?

3) We have submitted a questionnaire related to the Viroplant project to high school students (4-5 years) and their parents. In it, we included some questions that we think may bring out a generational gap in the approach to biotech risk. I include two of them below as examples [See Annex 3, Q9-Q14 and Q26-Q32] I'm not asking you to answer these questions, but I am asking you: how do you think students' answers differ from those of their parents? How do you think belonging to different generations might condition responses?

Round 2. 28.06.2021

1) From your professional experience, do you think there may be a gender gap in the acceptance of biotechnology innovation? Why? Could you give us an example that is significant for you to support your point of view?

2) In the questionnaire administered to students and parents in the context of Viroplant there were two questions, which I report below [see Annex 3]:

[Q20] In some countries of the world is underway an experiment that sees the use of viruses to fight some plant diseases. In the hypothesis that in Italy a committee of scientists promotes a referendum to authorize this technique, what would be your position? *

- before deciding I want to inform myself better (Pass to question 23)
- I abstain (Pass question 23)
- I am in favor because I trust the scientists (Pass to question 23)
- I am against it even though I trust scientists (Pass question 22)
- I am opposed because I do not trust scientists (Pass question 23)

[Q41] Therapy based on the use of bacteriophages (a type of virus that feeds on harmful bacteria) is being tested in combating some sometimes lethal infectious diseases, such as cholera and dysentery, with promising results. Scientists anticipate similar (virus-based) therapies to combat more common diseases such as pharyngitis in the future. Assuming that in Italy a committee of scientists promotes a referendum to authorize this technique, what would be your position? *

- before deciding I want to inform myself better
- I abstain
- I am in favor because I trust the scientists
- I am against it even if I trust scientists
- I am against it because I do not trust scientists

I am not asking you to answer the two questions A and B of the questionnaire, but to share with me your thoughts on the possible results that will emerge. In particular, do you think there will be differences related to the gender of respondents? Why?

Round 3. 08.07.2021

1) From the focus groups conducted with non-expert citizens, there emerges a need to be informed about biotechnological innovation in order to make decisions about its acceptability. Similarly, from the panel of experts to which you belong, a similar need to inform the public about scientific innovation issues that impact daily life emerges.

In a society where access to information is increasingly facilitated by new technologies at the service of communication, what is hindering the learning process on the part of citizens, who perceive themselves as "uninformed"?

2) Without prejudice to the right of citizens not to be informed and to make up for it through the trust granted to the so-called "experts", in a controversial communication such as the one related to the use of viruses in plant protection, I ask you to indicate three things to do and three things to avoid in communicating biotechnological innovation to citizens in order to reassure them.

3) A member of the Delphi panel [Responding to Question 2 of the previous round, she] pointed out that trust in the competence of scientists can be linked to the memory, still alive among the elderly, of the successes of science in eradicating certain diseases (e.g., tuberculosis and polio). On the other hand, we see many episodes of mistrust, for example towards vaccination campaigns against Covid 19. What do you think has interrupted the intergenerational transmission of trust in scientists? What could be done to recover it?

Round 4. 26.07.2021

1) What is your overall assessment of your participation in this project based on the Delphi method? Can you indicate some positive and negative aspects of this experience?

2) As some of the responses showed, training can represent a filter against excessive information, allowing a selection to be made on the basis of the source, the quality of the message and the absence of contradictions. But training interventions for children and adolescents, even if they were immediately feasible, would produce their effects in the medium term. What interventions would need to be made here and now? How could adults already out of school be trained?

Focus Group Viroplant H2020 Project

Sampling and recruitment

6/8 focus groups will be organized to research about the conditions of social acceptability regarding the use of new virus-based biotechnologies in agriculture. The participants in the focus groups must be non-experts in the topic. Being an expert in the sector is an exclusion criterion from research focus groups, in particular: having studied or dealing with biotechnology, especially food or agriculture or having a degree in sectors such as medicine, biology or others, evaluated from time to time in recruiting phase. Each group must be formed by 6/8 people and has to be balanced as much as possible by gender and age.

The groups must be divided on the basis of the educational level of the participants: half of the groups must be made up of people with a medium / low level of education (middle school diploma or high vocational schools diploma), half must be made up of people with a high level of education (high school diploma, bachelor's or master's degree, etc.).

Furthermore, based on what emerged from a discussion in the Italian WP6 research group, from the scientific literature and from Eurobarometer 2019, half of the focus groups has to be organized with people residing in the city for more than 5 years (densely populated areas) and half with people residing for more than 5 years in suburban countries, far from large urban conglomerates.

To facilitate the recruitment of the participants, each of them will receive a voucher for a store of books and music, which can be spent online or in the store, worth € 20. Those who host the focus group will receive a 40 € voucher.

Before the start of each focus: informed consent and questionnaire

Before the start of each focus group, while all participants arrive at the set place, each participant must fill in the informed consent form and a short questionnaire for the collection of some socio-personal data of interest (**format attached at the end of this document**).

Schedule

The following list contains indications on the phases, objectives and methods / tools adopted. In addition, some general indications and further suggestions have been included. For the conduction, it is recommended the presence of two people trained in the focus group methodology: one will mainly have the function of conducting, the other mainly that of observation. The conductor or presenter will present each activity, making sure that all participants understand the task. Furthermore, he or she will stimulate the discussion in case the group struggles to proceed and will ask stimulus questions if he or she will find it interesting to deepen one or more aspects related to the discussion in progress. To maximize the generative scope of the focus, even the observer, in agreement with the conductor, is free to intervene with his or her own stimuli and questions. The focus should have a maximum duration of 2 hours. It is good that both people leading the focus group keep time in mind and regulate the duration of the activities.

1) Introduction and rules (max 5 minutes)

- a. *Aim*: to introduce the conductor, the observer and the meeting; to establish the rules of the discussion.
- b. *Method*: enthusiastic and informal opening comprehending:
 - i. Greetings, introductions (simple and informal) of the conductors and the research
 - ii. Rules (duration, freedom of expression, respect of speaking turns, audio recording)

2) Warm-up: activity 1 (max 15 minutes)

- a. *Aim*: Ice breaking between the participants, get them used to the discussion and to the setting.
- b. *Method*: discussion on the place where the participants live: a theme that unites all participants, but that does not directly deal with the theme of research.
 - i. Example of introduction to the activity: "First of all we would like you to discuss about how it is to live [in this country / in this city / in this context (suburb or city)], talking about what, in your opinion, are the positive and negative aspects of living in this place. "
 - ii. Other phrases that can be used, at the opening or to stimulate the discussion: "You are all different people, but you are united by the fact that you have lived in these places, even for many years" - "You are experts in living in these areas, and who better than you can tell us what it's like to live here?" - "What would you change if you were given the chance to?" - "What do you like and what could you not give up about the place you live in?"

3) Activity 2 (ma 60 minutes)

- a. *Aim*: to bring out social representations of virus-based biotechnologies (both based on natural and bioengineered viruses), with particular attention to the dimensions of risk, acceptability and morality of the application of these technologies.
- b. *Method*: consequential presentation of 3 cases (**see below**): 1 - antibiotic resistance and phage therapy, 2 - chemical pesticides vs pest control with bioengineered viruses, 3 - resistance to drought induced through the application of natural viruses. At the end of each case, the participants are required to indicate on a special anonymous sheet (**see below**) their being in favor or not in favor about the introduction of what has been discussed and to indicate the main reason for their choice.
 - i. Case introduction example: "You will now be asked to discuss together. We would like to know your points of view regarding the case we have presented to you, highlighting which positive and negative aspects concern the use of this biotechnology. After discussing for a while, we will ask you to express if you are in favor or against the use of this technology in [add place], writing on a special sheet (**format attached at the end of this document**) which is the main reason that led you to decide that way."
 - ii. It is advisable to deepen, in each case, the issues of **risk, morality** and **acceptability**, above all by asking to argue, or by asking questions for further study, when one of these issues emerges superficially.
 - iii. Voting can be used to appropriately manage the timing of the discussion.

4) Activity 3 (max 30 minutes)

- a. *Aim*: to understand the perception of trust towards some professional figures who could deal with communication and information regarding virus-based biotechnologies discussed in the previous activity.
- b. *Method*: some tags (**format attached at the end of the document**) containing some different social actors usually or potentially implicated in the process of communicating with the public will be presented, extracting randomly two at a time and putting them on the table. The participants will be asked to put them in order, on the table, distributing them on a continuum that goes from "who should absolutely take care of", to "who should not absolutely take care of" the communication regarding virus-based biotechnology discussed in the previous activity.
 - i. Example of introduction to the activity: "(after distributing the first two cards on the table) Now we would like to ask you to discuss who should deal with communicating with you about these types of biotechnology based on the use of viruses. We also ask you to order the following cards by placing at the top who should be more involved in the communication process, while at the bottom who should not be involved."
 - ii. It is advisable that, when one of the cards is moved on the table by a participant, he or she explains the reasons for the new positioning discussing with the other participants.

- iii. At this stage it is good to remind the participants to respect the word turns, as it is easier for them to overlap.
- iv. Other hints: you can use "Who should have more say in communicating / explaining you about these virus-based biotechnologies? Whose voice is to be heard? Who would you like to receive information from? "
- v. In this phase or in the following one it is interesting to deepen the knowledge (or lack of knowledge), by the participants, of the figure of the scientific communicator, asking what characteristics, in their opinion, they should have.

5) Closing (20 minutes max)

- a. *Aim*: to close the meeting and gather final observations on the topic of virus-based agricultural biotechnology and the figures who should take care of communicating them to the public.
- b. *Method*: general restitution on the communication process and on the main issues raised, collection of feedback through some specific questions.
 - i. Example: "Have you already heard of this type of use of viruses? In your opinion, what impact could the introduction of these technologies have on Italians? How do you think your relatives, friends, people around you would consider the introduction of these technologies?"
 - ii. See above about the figure of the scientific communicator.

Activity 2 cases

Format for the voting at the end of each case:

I am favorable against
 because.....

Case 1

In recent years, some types of bacteria have developed increasing resistance to the most commonly used antibiotics. Because of this resistance to antibiotics, some diseases brought on by

bacteria are becoming increasingly difficult to treat: the number of infections caused by antibiotic-resistant bacteria is constantly raising, and it is increasingly difficult to develop new antibiotics to combat them.

To address this situation, potential alternatives to antibiotics are being sought. Among these alternatives, the use of "Phage Therapy" is being tested. Phage Therapy is based on the use of a particular type of virus, called "Phages", which attack bacteria. The viruses used can be either natural (spontaneously found in nature), or bioengineered (artificially modified in the laboratory to attack specific bacteria).

1) In the first image, "Phage" viruses are on the surface of a bacterium.



2) In the second image, "Phage" viruses attack the bacterium: they use its genetic code to multiply and, in doing so, destroy it.



Case 2

The insects that parasitize corn plants are numerous and widespread. These insects feed on the maize and the sap of the plant, causing serious damage to entire plantations.

Chemical pesticides have been the most used method for many years to control the spread of harmful insects and limit the damage to maize plantations. To reduce the use of chemical pesticides, the use of bioengineered viruses is being experimented as an alternative. These viruses are modified in the laboratory in order to attack insects that damage corn plantations.

1) The first image shows the damage caused by insects to maize plantations.



2) The second image shows the effect that bioengineered viruses cause to a corn parasite.



Case 3

Rice plants need a lot of water to grow. In case of drought, the rice plants are seriously damaged, and the harvest is very limited.

To manage this problem, it has been proposed to use the properties of some natural virus species. These viruses, thanks to their characteristics, allow the host plants to better resist drought. In particular, "Brome Mosaic" virus colonies, which occur spontaneously in nature, can be transplanted onto rice plants. The presence of these viruses on plants is able to improve the plants' resistance to drought.

- 1) In the first image, the plant not infected with viruses was left without water for six days. As you can see from the image the leaves are not very luxuriant and the plant seems weakened;
- 2) In the second image, the plant was infected with the "Brome Mosaic" viruses and, despite being left without water for six days, it is still quite lush.



Activity 3

- 1) Scientific communicators (for example the ones working on television)
- 2) Professional scientists working in private field
- 3) Pharmacists
- 4) General practitioners
- 5) Specialized doctors working into hospitals
- 6) Professors and academic researchers
- 7) Influencers

8) Politicians

9) Journalists

10) Farmers

11) Other?

Dear participant,

Thank you for participating to this study. You will be asked to answer some questions, they will help us better understanding some aspects of the discussion you are about to do. We also remind you that the information you give us will be ANONYMOUS and will not be used in any way other than research purposes.

Age:

Gender:

Educational qualification:

Residence (Place and how many years have you lived there):

Civil Status (e.g. single, married, cohabiting partner, other):

Family Composition (e.g. I live with my mother and father, I don't live with anyone, I live with my son, etc.)

Professional area (In which sector do you work? Eg textile industry, agriculture, IT etc.)

How do you usually keep updated and informed?

- Newspapers
- Online newspapers
- Social media (Facebook, Twitter, ecc.)
- Newscast
- Information magazine
- Other:

Do you have special dietary needs? (allergies, intolerances, diets, personal choices etc.)

Do you have special interests or passions? (sports, music, reading, etc.)

BELGIAN FOCUS GROUPS (ILVO)

1. METHODOLOGY

The organization of four Belgian focus groups was planned for this project. Participants would be assigned to groups (6 to 8 individuals) based on education level and residence. The gender and age variables are intended to be as balanced as possible within the focus groups. Participants were recruited through the social and professional networks of the research team. Direct contacts of the researchers never participated in the focus groups themselves but were requested to search for as many participants as possible in their own networks, always ensuring at least one order of separation between the researchers and participants. Potential participants received a short informational text, explaining what they would be participating in. If interested they could follow a link to an online form where they could provide their contact information and the details required for focus group construction. A 20 euro voucher at a national electronics, media, and entertainment store was provided as compensation to each participant that joined the focus groups. Based on the information provided participants were divided into groups (table 1). In total 37 people were recruited. However, only 5 of them had a low education level. Due to this limitation, the 2 planned low education groups could not be organized. The high education

individuals were further split into urban and rural groups. Additionally, some individuals lived in different regions of the country and could practically join focus groups organized in another region. The remaining participants were contacted through email and a time and place were agreed upon. The initial recruiting phase concluded in June 2021. Due to the unavailability of many participants during the summer holidays, the focus groups were conducted at the end of September 2021. The participants in each group can be seen in Table 1. The focus groups were organized in the home of 1 of the participants. Both focus groups had a duration of roughly 2 hours and followed the same structure as Italian Focus Groups.

Focus group sessions were recorded digitally and transcribed for further analysis. The transcribed data was organized through Taguette, software for qualitative research. The organization and analysis were performed using the method of Thematic Analysis (Braun and Clarke, 2006). Based on the results of the focus groups conducted in Italy, 3 central themes were used as a starting point for the analysis of the case activity, “Natural & Artificial”, “Biological & Biotechnological”, and “Risk perception & Conditions of Acceptance”.

Table 1. Anonymized list of recruited participants

Age	Sex	Education	Residence	Region	Group	Participated
48	F	high	urban	A	1	yes
24	F	high	urban	A	1	yes
25	M	high	urban	A	1	yes
28	F	high	urban	A	1	yes
58	F	high	urban	A	1	yes
66	M	high	urban	A	1	yes
67	M	high	urban	A	1	no
64	M	high	urban	A	1	no
37	M	high	urban	A	1	no
28	M	high	urban	A	1	no
50	F	high	urban	A	1	no
25	M	high	urban	A	1	no
26	F	high	urban	A	1	no
30	F	high	urban	A	1	no
25	M	high	rural	A	2	yes
26	M	high	rural	A	2	yes
27	M	high	rural	A	2	yes
32	F	high	rural	A	2	yes
26	M	high	rural	A	2	yes
24	F	high	rural	A	2	yes
22	F	high	rural	A	2	no
58	F	high	rural	A	2	no

43	F	high	rural	A	2	no
28	F	high	rural	A	2	no
73	F	high	rural	C	na	no
71	M	high	rural	C	na	no
55	M	high	rural	C	na	no
35	F	high	rural	D	na	no
24	M	high	rural	D	na	no
26	M	high	rural	E	na	no
65	M	high	rural	E	na	no
65	F	high	urban	B	na	no
52	F	low	rural	A	na	no
21	F	low	rural	B	na	no
53	F	low	rural	B	na	no
22	F	low	urban	A	na	no
18	F	low	urban	D	na	no

2. RESULTS

NATURAL & ARTIFICIAL

The distinction between natural and artificial products was a frequent topic in all three cases for both focus groups. Interestingly there was a large range of opinions regarding the distinction between natural and artificial products.

The majority in both groups agreed that whenever a product was perceived as natural, this was better than when it was artificial.

“Since it [the phage] also occurs in nature it does give me a better feeling”

“I am generally suspicious about what humans think to be able to invent without any consequences”

Some noted that this wasn’t really a meaningful distinction. However, they did acknowledge that the label gave them a better feeling about the product.

“There are also bad substances in nature, it’s not because it’s natural that it’s safe”

“Rationally speaking I don’t have a problem with it [the phage] but emotionally I immediately think that it’s safer if it comes from nature. But rationally I put my trust in the clinical studies”

Others mentioned how next to the emotional value, there was also a rational argument for preferring natural products.

“What matters to me is that it [insect virus] is new”

“I really don’t see a problem in doing it [raising drought resistance] with a virus. Plant viruses have been around for millions of years”

A few participants associated the label ‘natural’ with other product categories that they perceived as ineffective. In our groups, this opinion was only held by some of the young males.

“If it’s natural, does that mean it’s homeopathy?”

“The term [natural] makes me think of essential oils”

Finally, both groups reached the consensus that it was an advantage for a product to be natural but that they were not against the use of artificial products either.

“I just want to stress that if it’s not natural, I wouldn’t immediately be against it but if I had the choice I’d pick the natural option.”

The perception of the virus as natural depended on the degree of genetic modification. Specifically, the second case (where the virus was genetically modified) was perceived as less natural than the others. This will be discussed in more detail in the next section.

BIOLOGICAL & BIOTECHNOLOGICAL

The brunt of this discussion happened in the second case (where the virus was definitely modified) and less in the first or third case (where it could or couldn’t, and never be modified respectively). The general perception of non genetically modified viruses was that they were natural in both groups.

“But that means these viruses are natural. They occur in nature”

Both groups quickly reached the consensus that the genetic modification of the virus, made a product less natural.

“I do think that if it’s a GMO [the insect virus] that it’s not natural anymore.”

“If it’s more natural [virus compared to pesticides] then it’s going towards organic. But it’s a GMO so it’s like semi-organic”

A subgroup of the young males also briefly linked the virus-based technology to the development of bioweapons (in both groups) and the theory that the coronavirus escaped from a lab (rural group only).

“Maybe the initial idea of viruses is good but who’s to say that there won’t be viruses developed to kill people”

“This [adopting the virus-based technology] would mean we need a lot of labs to produce it. Then you get human error just like some claim happened with the coronavirus”

A minority of the participants mentioned how the use of genetic modification was more of a positive for them.

“I think that it’s a good thing [Genetic modification of the virus], you just get what you want that way.”

RISK PERCEPTION & CONDITIONS OF ACCEPTANCE

In the first two cases where the virus-based technology was characterized as an alternative to another product, the virus was initially perceived as equivalent to the product it would replace. Since antibiotics and pesticides were both perceived rather negatively, this was initially also the case for their virus-based replacements.

“I’m always suspicious about medication [the phage] because I think it’s never a good thing for your body, but not more or less than with antibiotics.”

“If I’m not for pesticides then why would I be for this virus. It also has consequences we won’t know in the beginning.”

This initial stance transitioned towards a more nuanced one over the course of the conversation.

“I’m more against both [pesticide and virus] but we have to do something or our fields will die. In that case, I prefer something more targeted that doesn’t harm the groundwater compared to those chemical insecticides.”

Resistance to antibiotics quickly became a topic of conversation in the first case. This was perceived as the major reason why an alternative to antibiotics was needed and both groups started speculating whether the virus-based alternative would have the same problem or not.

“If resistance to it [the phage] could also arise than you think, is it really that much better?”

This topic was also briefly touched on in the latter two cases by participants in the rural group.

“Can’t those plants also become resistant to the virus”

In the agricultural cases, the female participants mentioned that pesticides residues were a downside of the current products and saw the virus-based products as a potential solution.

“I’m inclined towards choosing the viruses. Because insecticides will always leave behind something on the crops“

On the other hand, a subset of participants in the rural group expressed a strong disagreement with the problem and solution framing from the agricultural cases. They noted that in both cases the real problems (industrial agriculture damaging the environment and global warming respectively) were not being addressed by the virus-based products. They concluded the entire system had to change.

“My argument is that the reason why we need those pesticides is because we are stuck in a monoculture. But if we go more towards permaculture, for example, we will need much less of those insecticides.”

“Just take on the problem of climate change. To me, this [the virus] is complete besides the issue“

Others in the group expressed their doubts about this suggested system change and no consensus was reached on the topic.

“I’m not against it per se [permaculture] but will that be enough to feed our population?“

In both groups, a recurring topic was the specificity of the viruses discussed. There was little certainty in the groups on how specific these viruses would be to their target audiences. However, participants continued to think through hypothetical scenarios with a certain specificity in mind. They consistently concluded that this would be a large determinant of whether they found the products acceptable or not.

“Probably those phages will work on multiple bacteria and they could work on our beneficial bacteria as well.”

“Insecticides kill everything, including the bees. If that virus is more specific then that’s a good thing.”

“I don’t think a virus that works on insects will work on humans as well.”

When discussing the potential for risk of the virus-based products, both groups mentioned the possibility of unintended consequences that only appear after years of use. Both concluded that the containment of the virus to the area of use was an important factor. Participants were mainly concerned with the initial years of use, where the probability of unexpected consequences was perceived as higher. Some form of containment was perceived as a possible solution.

“It takes a long time before you’ve investigated all the possibilities. Until that time I’d rather have it contained. Not even in a greenhouse but really quarantined. We’re talking about public health after all.”

“You could start in greenhouses. Maybe you could do measurements outside of the greenhouse. Then after a few yours, you can continue.”

Some of the younger males in both groups tried to put this into perspective, noting that the perceived need for complete certainty about the safety of a product may not be necessary.

“If chemicals are the only alternative then you don’t need a 100% certainty, 95% is enough already.”

This topic mainly came up during the discussion of the second case. However, it was also mentioned more briefly in the other two cases. In the first case, the image of an uncontrollable virus was associated with covid-19 by participants in the urban group.

“You have to know what you’re dealing with before you do it. We know what happens when a virus can’t be controlled.”

In the third case, the virus could be found in nature already but even here our possible inability to contain it was a reason for concern for the rural group.

“As long as it’s in a field it’s ok but if it gets into a nature reserve it can be detrimental if only one plant gets the advantage [drought resistance].”

In tandem with the containment discussion, participants also wondered how long the viruses would remain in the environment once released and whether it was possible to remove them. A quickly disappearing product and the ability to remove it were perceived as positive. This addition to the containment topic was always brought up by the males of the group.

“Can we take it away again or fight it?”

“With many pesticides that’s a real problem, that they remain present. So if those viruses could degrade faster that would be a positive.”

For both groups, a significant difference between the naturally occurring viruses and their use in these cases was the quantity in which they would be applied. This was a reason for concern in all three cases.

“Could there become too many phages”

“I’m already less suspicious if it occurs in nature but you would be applying it in a much greater number than how it naturally occurs.”

The possibility for the virus to mutate was raised in both groups. This was attached to the other topics discussed above. It was noted as a reason why containment may be necessary.

“You spray it [insect virus] and you lose control, that’s nature. You lost it. How will it react, will it mutate and move in different hosts?”

The large quantity used in agricultural applications was perceived as a factor that could raise the risk of mutation.

“The more you spread it, the greater the risk of mutation and other effects.”

However, not all participants had the same concern about mutation.

“I don’t think a [insect] virus will ever mutate so it will suddenly make humans sick.”

Throughout the sessions, participants brought up the fact that they only had limited information about virus-based technologies. Both groups concluded that in the end they would and had to trust the relevant experts to decide on whether the technology should be adopted or not. Researchers, government, and doctors were all mentioned as trusted decision-makers by both groups.

“As an individual, you can’t know everything so you need to have trust. Or, yeah, you can have trust in it”

“Yeah if a reputable institution comes up with this, I’ll quickly be behind it”

“The people that develop this can experiment and see how far they can go.”

While in the two agricultural cases only some individuals formulated a clear statement of trust. This position was unanimously held by all participants.

“Yes, you simply have faith in your doctor”

A minority in the rural group also expressed this trust in the case of genetically modified viruses.

“I would prefer it if this natural product [phage] would be changed by science to make it even better. They’ll do enough research to check and test it.”

This trust was not bestowed upon all stakeholders equally, however. Commercial companies were mentioned as an exception to the trust bestowed upon others. The fact that these are motivated by profit is perceived as a cause for distrust.

“It depends if it’s made with the right intentions. If it’s made for profit then it’s less trustworthy.”

“With some things, I do think there are lobbies that hide a lot. Especially with the pharmaceutical industry, like tobacco for a long time and like’s still the case with hormonal birth control pills.”

Both groups concluded that companies are limited by regulations, making the end product trustworthy after all.

“In Belgium, I have enough faith in the government to say whether something is good for society or not. With a private company, that’s less.

“That’s with everything. They do research, bring something new to the market, that gets tested by a neutral authority and they give permission.”

In both focus groups, a less vocal minority was present that expressed explicit disinterest in the technology used in the cases discussed.

“If it works it works, what the precise principle is doesn’t matter if it does the same thing. Those chemicals can have just as many side effects [compared to the insect virus].”

“I honestly really don’t care what they use.”

Some clarified that this disinterest in the type of technology comes back to the same trust described above.

“I think it’s good that the government forces us to only buy good products. I will just buy what looks good and the government will have to make sure it’s safe and adjust to any long-term effects.

This conversation led to the rural group making the distinction between their behavior as consumers and citizens.

“I’m hypocritical in this. In a conversation like this, I’ll want it to be natural and stuff like that but if I’m at the store I’ll just buy the best looking thing.”

OTHER

Both groups used other topics as an analogy to the ones at hand. Prominent in this were the coronavirus and the associated vaccination campaign. But other analogies were used as well. The urban group also used flu vaccines. The rural one used the history of asbestos. Meanwhile, both also used PFOS as an analogy (a recent chemical contamination scandal in Belgium) (Hope, 2021).

“Covid is also a virus and that has also had many negative effects. So I imagine can that be the case here as well.”

“If you wait until the insect plague is there you’ll be too late. So you’ll have to spray preventatively. So it’s like the flu vaccine, you have to predict what variant you have to put in your vaccine.”

“Years ago asbestos was also a wonder substance, that has changed as well because we didn’t know any better back then.

In the rural group, someone mentioned that the small scale of viruses made them feel different and more dangerous.

“I wonder if people aren’t starting to play god if you’re working on such a small scale. You can’t see it, you can’t feel it, that’s scary.

Another participant noted that this didn’t make any difference for them. No further discussion emerged and the group moved on to other points.

“I see no difference with birds or predatory insects, it’s just a different size.”

The last case initially received a much better response. After these starting remarks, the group still moved naturally to a discussion of possible risks, as described above.

“This really can’t do any harm this little virus, it could only do good. In comparison to the other cases, it looks so simple.”

“It’s almost too good to be true.”

REFERENCES

Hope, A. (2021). *Revealed: Flemish government knew about PFOS problem in 2017.* <https://www.brusselstimes.com/news/belgium-all-news/174208/revealed-flemish-government-knew-about-pfos-problem-in-2017/>

ANNEX 3: SURVEY QUESTIONNAIRE

Survey on Food, Environment and Agriculture - Project H2020 VIROPLANT - University of Milan-Bicocca

Dear Participant

You have been invited to participate in a survey of students in grades IV and V and their parents coordinated by the MaCSIS Interuniversity Center of the University of Milan-Bicocca.

Before deciding whether you would like to take part in the study, please read the information below carefully.

What is the purpose of the study?

The general purpose of this study is to investigate attitudes towards some issues related to food health, environmental health and agriculture.

How long does the questionnaire take to complete?

The estimated duration of completion is approximately 15 minutes.

Why do we suggest you participate?

The study is part of the European Research Project H2020 VIROPLANT. We propose you to participate because we are interested in the differences between adolescents and adults regarding biotechnological innovation.

Are you obliged to participate?

Your participation is completely free. Furthermore, if you change your mind and wish to withdraw, you are free to do so at any time without explanation.

What are the steps required to participate in the study?

Participation in the study is subject to detailed information about the characteristics, risks and benefits of the study (see below). After this information has been provided, you may consent to participate in the study. Only after you have given your consent will you be able to actively participate in the proposed study.

What will you be asked to do?

The study will be conducted online. You will be asked to answer a series of questions about the three areas of inquiry. There are no right or wrong answers, so you are free to express your thoughts.

What are the benefits?

The study will increase knowledge about the attitudes of citizens of different age groups to issues of great public importance. This knowledge will help in the implementation of more inclusive policies at European level.

What are the risks, side effects, discomforts?

This research does not contain sensitive questions related to the sphere of intimacy. However, if you feel uncomfortable answering a question, please note that you can stop filling out the questionnaire at any time. Your data will be saved and sent to the collection center only after you have completed the questionnaire.

How is the confidentiality of the information guaranteed?

The questionnaire is completely anonymous and the data collected will be used exclusively within the VIROPLANT Project in aggregate form, so that the data and identity of individuals cannot be traced. At the end of the research, the collected data will be deleted and will no longer be accessible.

Other important information

Please note that the study will be conducted in accordance with the ethical principles set forth in the Declaration of Helsinki and the Convention on Human Rights and Biomedicine (Oviedo Convention).

Questions?

For further information and communications during the study, please write to:

Roberto Carradore (roberto.carradore@unimib.it)

Matteo Tonoli (m.tonoli3@campus.unimib.it)

<https://www.viroplant.eu>

*Mandatory field

1. Consent to participate in the study THE UNDERWRITER in light of the information provided: *

- I AGREE
- DO NOT AGREE Go to section 18 (Thank you!).

Master data

1. Respondent *
 - Student/StudentPass to question 3.
 - Parent/Legal GuardianPasses to question 4.

Student

2. School Address *
 - Classical High School
 - Scientific High School
 - Other High School
 - Technical Institute
 - Professional Institute
 - Other:

Skip to question 6.

Parent

3. Educational Title *
 - Elementary school certificate
 - Secondary school certificate
 - High school diploma
 - Bachelor's degree
 - Master's Degree/Single Cycle Degree
 - PhD

4. Job/Profession *

Skip to question 6.

Master Data

5. Age *

6. Gender *

- F
- M
- Other

7. Residence context *

- Urban center
- Urban periphery
- Provincial town
- Agricultural countryside
- Other:

Food safety

8. How important is it to you that a food is "GMO-free"? *

not at all / not very important - very important / essential [1-5]

9. How important is it to you that a food be "preservative-free"? *

not at all / not very important - very important / essential [1-5]

10. How important is it to you that a food be "dye-free"? *

not at all / not very important - very important / essential [1-5]

11. How important is it to you that a food be "gluten-free"? *

not at all / not very important - very important / essential [1-5]

12. How important is it to you that a food be "palm oil free"? *

not at all / not very important - very important / essential [1-5]

13. How important is it to you that a food be "sugar free" *.

not at all / not very important - very important / essential [1-5]

14. In your opinion, in general, the availability of health food information is: *

very poor – great [1-5]

15. How often do you inquire about health food issues *.

never/almost never – daily [1-5]

16. Where do you document yourself regarding food issues? You may indicate more than one option *

Select all applicable items.

- Social Networks/Social Media
- Radio/TV
- Newspapers, weeklies or generalist websites
- Books, journals, or scientific or educational websites
- Friends and acquaintances
- Family
- School
- Other: _____

17. A few years ago, the palm oil food case broke out. As a result of this incident, have you changed your food choices? *

- Yes (Please skip to question 19)
- No (Please skip to question 19)
- Don't remember

18. Why? * _____

Environment

19. In some countries of the world is underway an experiment that sees the use of viruses to fight some plant diseases. In the hypothesis that in Italy a committee of scientists promotes a referendum to authorize this technique, what would be your position? *

- before deciding I want to inform myself better (Pass to question 23)
- I abstain (Pass question 23)
- I am in favor because I trust the scientists (Pass to question 23)
- I am against it even though I trust scientists (Pass question 22)
- I am opposed because I do not trust scientists (Pass question 23)

20. Regardless of your position, what do you think the outcome of the referendum set forth in the previous question might be? *

- Approval
- Not approved
- Quorum not reached due to abstention

Move on to question 23.

21. Why? * _____

22. In your opinion, in general, the availability of information about the environment is: *

very poor – great [1-5]

23. How often do you inquire about environmental issues? *

never/almost never – daily [1-5]

24. Where do you document yourself on environmental issues? You may indicate more than one option *

Select all applicable items.

- Social Networks/Social Media
- Radio/TV

- o Newspapers, weeklies or generalist websites
- o Books, journals, or scientific or educational websites
- o Friends and acquaintances
- o Family
- o School
- o Other:

Human and environmental health

25. In your opinion, how harmful to human and environmental health is the use of pesticides? *
- o not at all harmful
 - o slight harm
 - o moderate damage
 - o high damage
 - o not know how to evaluate it
26. In your opinion, how harmful to human and environmental health is the use of genetically modified products? *
- o not at all harmful
 - o slight harm
 - o moderate damage
 - o high damage
 - o not know how to evaluate it
27. In your opinion, how harmful to human and environmental health is deforestation? *
- o not harmful at all
 - o slight harm
 - o moderate damage
 - o high damage
 - o not know how to evaluate it
28. In your opinion, how harmful to human and environmental health is water pollution? *
- o not at all harmful
 - o slight damage
 - o moderate damage
 - o high damage
 - o not know how to evaluate it
29. In your opinion, how harmful to human and environmental health is air pollution? *
- o not at all harmful
 - o slight damage
 - o moderate damage
 - o high damage
 - o not know how to evaluate it
30. In your opinion, how harmful to human and environmental health are electromagnetic fields? *
- o not at all harmful
 - o slight damage
 - o moderate damage
 - o high damage
 - o not know how to evaluate it
31. In your opinion, how harmful to human and environmental health is overbuilding? *
- o not at all harmful
 - o slight damage
 - o moderate damage
 - o high damage
 - o I can not evaluate it

Scientific research

32. Do you think scientific research in environmental and food science can improve the quality of our future lives? *

- Yes
- No
- I Don't know

Agriculture

Imagine that in the field bordering your house you begin using one of the products listed below. What would be your first reaction to the use of:

- 33. Pesticides *.
 - I get scared but do nothing
 - I get scared and mobilize with the neighbors and the municipality
 - I do nothing because I suppose everything is in order
 - I inform myself
 - I ask the owner of the field for clarification
- 34. GMO *.
 - It marks only an oval
 - I get scared but I do nothing
 - I get scared and I mobilize with the neighbors and the Municipality
 - I do nothing because I suppose everything is in order
 - I inform myself
 - I ask for clarification to the owner of the field
- 35. Virus-based plant protection products*.
 - I get scared but do nothing
 - I get scared and I mobilize with the neighbors and the Municipality
 - I do nothing because I suppose everything is in order
 - I inform myself
 - I ask for clarification to the owner of the field
- 36. manure and compost *.
 - It only marks an oval.
 - I get scared but do nothing
 - I get scared and I mobilize with the neighbors and the Municipality
 - I do nothing because I suppose everything is in order
 - I inform myself
 - I ask for clarification to the owner of the field
- 37. bees and pollinating insects *.
 - I get scared but I do nothing
 - I get scared and I mobilize with the neighbors and the Municipality
 - I do nothing because I suppose everything is in order
 - I inform myself
 - I ask the owner of the field for clarification

- 38. Imagine that the manufacturer of your favorite food introduces a genetically modified ingredient that allows for a 20% price reduction. What would be your reaction? *.
 - I give up on the product (Go to question 40)
 - Before deciding to purchase I inquire about
 - I continue to buy the product (Go to question 40)

Skip to question 41.

- 39. Why? * _____

Innovative therapies

- 40. Therapy based on the use of bacteriophages (a type of virus that feeds on harmful bacteria) is being tested in combating some sometimes lethal infectious diseases, such as cholera and dysentery, with promising results. Scientists anticipate similar (virus-based) therapies to combat more common diseases such as

pharyngitis in the future. Assuming that in Italy a committee of scientists promotes a referendum to authorize this technique, what would be your position? *

- before deciding I want to inform myself better
 - I abstain
 - I am in favor because I trust the scientists
 - I am against it even if I trust scientists
 - I am against it because I do not trust scientists
41. Regardless of your position, what do you think would be the outcome of the referendum set forth in the previous question? *
- Mark only one oval.
 - Approval
 - Not approved
 - Quorum not reached due to abstention

42. This is the last question and we would like to know how often you see a tractor on your commute to school/work? *
- never
 - rarely/sometimes
 - often/every day

44. Thank you for your cooperation. If you want you can add a comment or a brief reflection on the topics covered in the questionnaire.

Thank you! For further information or questions you can contact us at the following addresses:

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