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Signs of Risk: Materiality, History, and Meaning in Cold War Controversies over Nuclear Contamination

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The reality of ideological phenomena is the objective reality of social signs.
———V. N. Vološinov, 1929

INTRODUCTION

Starting in the 1960s, the increasing presence of Soviet vessels in the Mediterranean Sea pushed the U.S. Navy to reconsider its strategy in the region. As reported by *Time Magazine* in June 1971, the "Soviet Thrust in the Mediterranean" made the middle sea "no longer an American lake."[1] Naval strategists decided to increase the surveillance of "choke points" with new bases.[2] At the beginning of the 1970s, the U.S. administration and the Italian government undersigned a secret bilateral agreement to allow the installation of a U.S. Navy nuclear submarines base in the Archipelago of La Maddalena, offshore of the northeastern corner of the island of Sardinia (Italy).[3] Against the early attempts of the Italian government and military

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[1] "Soviet Thrust in the Mediterranean," *Time Magazine* 97, 26 (28 June 1971): 27–28.

[2] "Choke points" are bottlenecks, points of access into a naval area for both surface and underwater navigation.

[3] Located amidst the Tyrrenian Sea, the archipelago had been a strategic maritime fortress of the Italian Navy since the nineteenth century. Because of its geographic position and the local

authorities to silence safety concerns related to the presence of nuclear submarines, Italian civilian experts and environmental activists from outside La Maddalena argued that in the archipelago radiological safety protocols should be applied in analogy with Italian regulations for in-land nuclear power plants.[4] After two years of intense expert and public debates, in 1974 the Ministry of Health instructed the Radiation Laboratory of the National Institute of Health (ISS) and the Radioprotection Division of the National Committee for Nuclear Energy (CNEN) to design an environmental monitoring program in the archipelago. In order to assess risk, Italian experts requested technical information about the reactors propelling the submarines stationed at La Maddalena and planned a series of radioecological campaigns to acquire knowledge of the archipelago's environment, including cross-seasonal atmospheric conditions, to elaborate models of radioactive materials dispersion in case of accidents. For security reasons, both the U.S. Navy and the Italian Ministry of Defense denied access to classified information about the submarines. At the same time, organizational obstacles and a lack of resources prevented ISS and CNEN experts from completing the planned ecological surveys in a timely manner.

During the six years following the installation of the base (1972–1978), incomplete data prevented expert agencies from providing a concrete definition of the risks that long-term residents were facing. In addition, lack of previous experiences with radioactivity hazards left many Maddalenini wondering what might go wrong (accidental and routine discharges of radioactive material), the likelihood of an odd event taking place, and the possible consequences of accidental releases of radioactive substances.

Through the lens of historical ethnography, I will here examine how citizens without knowledge of radiation hazards tried to understand what risks were involved in these U.S. Navy operations and how they interpreted changes and continuities in the surrounding environment, as well as allegedly unprecedented events, such as birth defects, as evidence of nuclear contamination, or a lack thereof.

community's long experience living in the vicinity of military personnel, U.S. and Italian defense strategists decided that La Maddalena was the perfect location for the base. They did not expect local opposition.

[4] Two months after the base was installed, at the request of the Italian Ministry of Defense, the Center for the Military Applications of Nuclear Energy (CAMEN) and the president of CNEN issued two reports reassuring people that radiological risks in the archipelago were slight. No special safety protocols were necessary, they said, given the reliability of the U.S. reactor technology. The personnel of CNEN's radioprotection division protested that the report was written at the personal initiative of CNEN's president, Ezio Clementel, and was not based on scientific evidence.

I will provide a conceptual and methodological contribution to enduring debates concerning risk, knowledge formation, citizen science, and sociotechnical controversies over environmental pollution. In particular, I address two important questions that, in my view, have been examined unsatisfactorily within the STS field: (1) How do non-experts make sense of technological risk in the absence of knowledge about its manifestation and consequences? (2) How do objectifications of risk change and stabilize within a community over time?

To explain how residents of La Maddalena, experts, and local political authorities interpreted or ignored potential signs of risk, I draw on anthropologist Webb Keane's concept of "semiotic ideologies": "basic assumptions about what signs are and how they function in the world."[5] I argue that in order to make invisible risks (such as radiation) visible, non-experts and experts alike rely on interpretations of environmental and bodily signs to provide practical evidence through which they can objectify and represent risk in tangible ways.[6] The question both experts and non-experts need answer is "risk of what?"

While experts in charge of monitoring the levels of radioactivity relied on their knowledge of radioactive materials and relative patterns of dispersion into the environment, local residents tried to understand what kinds of risk they were dealing with by paying attention to changes and continuities in the surrounding environment and on their bodies. Both expert and non-expert interpretations of environmental signs were not fixed; they reflected the mutable conditions of the environment as well as controversies about unprecedented events, particularly a spike in birth defects. Thus, my second argument is that meanings of risk change over time as signs of risk become available for interpretation.

This dynamic approach to risk problematizes assumptions that experts and non-experts possess radically different forms of knowledge and static accounts of these two categories of actors as politically and culturally homogeneous and free from internal conflicts. In what follows, I show that internal hierarchies and power dynamics influence how meanings of risk are socially regimented: their emergence or silencing depends on the context of power relations in place in a given community. In the case of La Maddalena, I examine how local intellectuals and political activists who opposed the U.S. Navy presence policed, rationalized, and sometimes silenced risk hypotheses within their community when they thought they lacked credibility and therefore would be easily dismissed by expert and military authorities. For this reason,

[5] Webb Keane, "Semiotics and the Social Analysis of Material Things," *Language and Communication* 23, 2–3 (2003): 409–25.

[6] By "material signs" I indicate that signs have material embodiments and characteristics that allow their perceivers to interpret them in various ways.

anti-base activists deployed a range of communicative strategies to assemble "scientized" arguments that could lend credibility to their cause. In this sense, interpretations of signs as possible instantiations of nuclear contamination were socially regimented and controlled. I call the set of practices aimed at establishing normative constraints on the interpretation of risk signs "the politics of coherence."[7]

I propose a semiotic approach to risk that attends to material processes of signification by looking closely at the ways in which communities of experts and non-experts in La Maddalena defined or challenged meanings of risk over time. The semiotic approach to risk is based on the following theoretical and methodological propositions:

(1) Both experts and non-experts use material signs to make invisible risks like radiation visible.
(2) Understandings of risks change and are highly contingent on local power dynamics. Objectifications and representations of risks change and stabilize over time as signs of risk become available for interpretation (e.g., environmental changes, unprecedented events, health effects).
(3) "Experts" and "non-experts" are not bounded or homogenous groups. Especially in situations of uncertainty, when knowledge about risk is not yet established, experts and non-experts epistemic and communicative strategies emerge out of contradictions and conflicts, and influence one another, at times through active collaborations.
(4) When experts and non-experts elaborate arguments in public controversies, members of both groups engage in activities meant to reduce internal conflicts and contradictions that might undermine their credibility. This is the set of activities I call "the politics of coherence."

In the next section I will briefly illustrate how STS scholars have analyzed public risk perception and lay/expert controversies over risk assessment and highlight some of what I see to be limitations in the literature. Next, I will suggest how recent "object-oriented" approaches to public participation can help us overcome these limitations. Finally, I will use archival and ethnographic data to illustrate how a semiotic approach to risk controversies focused on material processes of signification can offer analytical tools that are applicable across culturally and historically specific case studies.

[7] For a discussion of the methodological approaches to analyzing semiotic regimentation, see Richard Parmentier, "The Semiotic Regimentation of Social Life," *Semiotica* 95, 3–4 (1993): 357–95.

RELATIONAL RISKS BEYOND ISSUE FRAMING: BRINGING MATERIALITY BACK

In a now classic piece on Cumbrian shepherds' controversies with British scientific authorities, Bryan Wynne argued that understandings of risk are "relational," for they depend heavily on laypeople's perceptions of expert agencies' competence and intentions, and of experts' attitudes toward local communities' concerns and whether or not they consider non-experts' vernacular knowledge.[8] As a consequence, according to Wynne, the real point of contention in expert-lay controversies is not just information and the status of knowledge about "disputed" facts, but the very definitions and framings of technoscientific problems that reflect contrasting cultural identities and life-worlds, which are sometimes irreconcilable, at least in the situations he explored.[9]

Despite Wynne's warnings about the risks of generalizing and simplifying the implications of his "relational" and "anti-foundational" approach, within the field of STS many have interpreted his case study as paradigmatic of the dichotomy and incompatibility between scientific knowledge production and other forms of experiential knowledge.[10] In my view, there have been two major causes of this overly schematic representation.[11] First, STS scholarship on lay/expert controversies is based almost exclusively on case studies. The local scale of analysis often leads researchers to observe a level of social cohesion, cultural identity, and "ways of life," and allegedly local ways of knowing, which is assumed to exist in every context. But as soon as we zoom out of the exclusive, local dimension of sociotechnical controversies

[8] Brian Wynne, "Misunderstood Misunderstandings: Social Identities and Public Uptake of Science," *Public Understandings of Science* 1 (1992): 281–304.

[9] Brian Wynne, "Public Understanding of Science Research: New Horizons or Hall of Mirrors?" *Public Understandings of Science* 1 (1992): 37–43; Brian Wynne, "May the Sheep Safely Graze? A Reflexive View of the Expert-Lay Knowledge Divide," in Scott Lash, Bronislaw Szerszynski, and Brian Wynne, eds., *Risk, Environment and Modernity: Towards a New Ecology* (London: SAGE, 1996), 44–83. See also Sheila Jasanoff, "The Political Science of Risk Perception," *Reliability Engineering & System Safety* 59, 1 (1998): 91–99; and "The Songlines of Risk," *Environmental Values* 8, 2 (1999): 135–52.

[10] Brian Wynne's alerts about the perils of overstretching his original argument are illuminating. See, for example, "May the Sheep Safely Graze"; and his reply to Darrin Durant: "Elephants in the Rooms where Publics Encounter 'Science': A Response to Darrin Durant, 'Accounting for Expertise: Wynne and the Autonomy of the Lay Public,' *Public Understanding of Science* 17 (2008): 21–33.

[11] Some examples of the most cited works are: Phil Brown, "Popular Epidemiology and Toxic Waste Contamination: Lay and Professional Ways of Knowing," *Journal of Health and Social Behavior* 33, 3 (1992): 267–81; Alan Irwin, *Citizen Science: A Study of People, Expertise and Sustainable Development* (Routledge, 1995); and Jason Corburn, *Street Science: Community Knowledge and Environmental Health Justice*, (MIT Press, 2005).

and consider their nation-wide or transnational ramifications, the elements of homogeneity become less obvious and defined.[12]

The second cause is that many STS critiques of idealistic models of scientific rationality and objectivity have empirically documented the epistemic contributions and participatory practices that enable citizen scientists and lay experts to reduce the power gap between themselves and technoscientific institutions.[13] This emphasis on non-experts' resistance vis-à-vis powerful technoscientific institutions and paradigms, however, results in overarching narratives that reify "a dichotomy between 'scientific' and 'public' forms of knowledge and understanding … and a level of homogeneity and coherence within both 'scientific' and 'public' understandings."[14] "The possibility of disagreements and contradiction within each form of understanding is played down [while] the use of 'knowledges' in this context can suggest a static account, rather than directing attention to the kinds of sense-making activities engaged in by public and other groups."[15] I would add that this schematic and selective take on lay/expert controversies has been reinforced through rigid interpretations of Ulrich Beck's theses on "risk society," which came out four years before Wynne's study.[16]

Exploring the interdependence of experts and non-expert knowledges in and across specific contexts has proved challenging, even though a number of studies, including some outside of STS, have examined collaborations between expert-activists and local communities that have led to hybrid forms of knowledge production.[17] But even a "conflict-based approach" to environmental controversies need not assume distinct expert and non-experts

[12] See, for example, Dorothy Nelkin and Michael Pollak, *The Atom Besieged: Anti-Nuclear Movements in France and Germany* (MIT Press, 1981); Alain Touraine et al., *Anti-Nuclear Protest: The Opposition to Nuclear Energy in France*, P. Fawcett, trans. (Cambridge University Press, 1983). For an example of more recent "object-oriented" approaches, see Andrew Barry, *Material Politics: Disputes along the Pipeline* (Wiley-Blackwell, 2013).

[13] For a recent critical review, see Aya H. Kimura and Abby Kinchy, "Citizen Science: Probing the Virtues and Contexts of Participatory Research," *Engaging Science, Technology, and Society* 2 (2016): 331–61.

[14] Alan Irwin, P. Simmons, and G. Walker, "Faulty Environments and Risk Reasoning: The Local Understanding of Industrial Hazards," *Environment and Planning A* 31 (1999): 1311–26, 1312–13.

[15] Ibid., 1312.

[16] Ulrich Beck, *Risk Society: Towards a New Modernity* (SAGE, 1992). One of the most important theses in Beck's work is that modern society is characterized by a new fundamental cleavage, which he evocatively conceptualizes as "relations of definition": the uneven distribution of expertise (normatively defined) that creates a status of subalternity of laypeople vis-à-vis technoscientific knowledge production. I cannot here illustrate all the critiques that STS scholars have addressed to Beck's argument, But for an overview of the most controversial points, see Soraja Boudia and Nathalie Jas, "Risk and 'Risk Society' in Historical Perspective," *History and Technology* 23, 4 (2007): 317–31; and Wynne, "May the Sheep Safely Graze?"

[17] Anthropologist Joshua Reno contends that by focusing on risk as the central analytical category, STS scholars tend to represent and conceptually reproduce the same lay-expert divides that they want to deconstruct: "Beyond Risk: Emplacement and the Production of Environmental

ways of knowing the world.[18] Indeed, recent STS works have attempted to pluralize citizen science by: (1) decentering participation as the sole and ultimate goal or value of citizen activism and exploring other dimensions, logics, and meanings that citizens attribute to their involvement in technoscience; (2) problematizing the boundaries between experts and non-experts and showing the complexity of boundary-work strategies; and (3) incorporating failures, contextual limitations, and unexpected effects of participatory practices into their analyses of lay/expert controversies.[19]

Despite these attempts to move away from schematic interpretations of activists' successes or failures in "breaking the expertise barrier,"[20] STS scholars have indulged in a sort of "ethnographic refusal," to use Sherry Ortner's words, to deal with the internal politics, contradictions, and power inequalities within subaltern groups and local communities fighting for epistemic recognition and environmental justice.[21]

Evidence," *American Ethnologist* 38, 3 (2011): 516–30. I am not convinced, though, that there is any inherent problem making risk a focus of analysis. Several works in STS have focused on how collaborations between expert-activists and local communities shape hybrid forms of knowledge to leverage citizens' resources for environmental justice. See, for example, Barbara Allen, *Uneasy Alchemy: Citizens and Experts in Louisiana's Chemical Corridor Disputes* (MIT Press, 2003); and Gwen Ottinger, *Refining Expertise: How Responsible Engineers Subvert Environmental Justice Challenges* (NYU Press, 2013).

[18] Marco Armiero, "Seeing Like a Protester: Nature, Power, and Environmental Struggles," *Left History* 31, 1 (2008): 59–76.

[19] Abby Kinchy and Daniel Lee Kleinman, "Organizing Credibility: Discursive and Organizational Orthodoxy on the Borders of Ecology and Politics," *Social Studies of Science* 33, 6 (2003): 869–96; David Hess, "To Tell the Truth: On Scientific Counterpublics," *Public Understanding of Science* 20, 5 (2011): 627–41; Abby Kinchy, Kirk Jalbert, and Jessica Lyons, "What Is Volunteer Water Monitoring Good For? Fracking and the Plural Logics of Participatory Science," in the special issue "Fields of Knowledge: Science, Politics and Publics in the Neoliberal Age," *Political Power and Social Theory* 27 (2014): 259–89; Aya H. Kimura and Abby Kinchy, "Citizen Science"; Abby Kinchy, *Seeds, Science, and Struggle: The Global Politics of Transgenic Crops* (MIT Press, 2012); and Aya H. Kimura, *Radiation Brain Moms and Citizen Scientists: The Gender Politics of Food Contamination after Fukushima* (Duke University Press, 2016).

[20] Shobita Parthasarathy, "Breaking the Expertise Barrier: Understanding Activist Strategies in Science and Technology Policy Domains," *Science and Public Policy* 37, 5 (2010): 355–67.

[21] Sherry Ortner, "Resistance and the Problem of Ethnographic Refusal," *Comparative Studies in Society and History* 37, 1 (1995): 173–93. Barbara Allen's work on the Alabama chemical corridor is an exception to this point of view. Her analysis of the uneasy alliances between the heterogeneous and more inclusive social movements and movements based on identity politics fighting for environmental justice exemplifies the kind of "thickness" that Ortner argued for when discussing the "ethnographic refusal" to deal with the contradictions of subaltern groups. Furthermore, a now abundant literature on expert activists shows that controversies are not always between experts and lay people, the powerful and the subaltern. A case in point is the example of AIDS activists strategies to acquire authority and credibility, explored by Steven Epstein in *Impure Science: AIDS, Activism, and the Politics of Knowledge,* (University of California Press, 1998). Likewise, see the recent collection of case studies edited by Gwen Ottinger and Benjamin Cohen, *Technoscience and Environmental Justice: Expert Cultures in a Grassroots Movement* (MIT Press, 2011).

A symmetrical analysis of the politics of knowledge formation requires, among other things, that we renounce the assumption that lay or local knowledge is always already *in place*, as if it were a constitutive feature of any community by virtue of that community's osmotic relationship with the surrounding environment.[22] Another problem is that, while Wynne's point is well taken that "the most germane risks are (social) *relational*," and that perceptions of risk depend largely on evaluations of the trustworthiness, competence, and independence of expert institutions, he leaves unexplored and undertheorized the problem of materiality and the role it plays in processes of signification. Analysis of the material entanglements through which communities experience the emergence of unprecedented and complex issues allows us to fully grasp the ethical implications of Wynne's relational approach. It is in moments of disorientation, surprise, ambiguity, and extraordinary attention sparked by unexpected events that affected publics formulate hypotheses about what is going on and what will come next. People cannot already possess knowledge about something never previously experienced, and to the extent that such knowledge is ultimately, collectively acquired, it emerges through an asymptotical process that is necessarily subject to failures.

The anti-foundational approach Wynne proposes bears its full implications if we extend its logic to actors' identities and their presuppositions about the existence of irreconcilable life-worlds. This has been the project of Actor Network Theory for some time. "Material-semiotics" studies the processual assemblages of hybrid networks through which "programs" (visions of the world that bear moral and ethical implications embodied in technical objects and scientific projects) acquire their reality while the actors involved define their roles and identities relationally and always temporarily, as a function of their translations into sociotechnical networks.[23]

[22] This point has been largely debated and problematized within the field of political ecology. For a review, see Leah Horowitz, "Local Environmental Knowledge," in Tom Perreault, Gavin Bridge, and James McCarthy, eds., *The Routledge Handbook of Political Ecology* (Routledge, 2015), 235–48. For a discussion of the misuses and misappropriations of the concept of "indigenous knowledge" in the context of developmental politics, see Arun Agrawal, "Dismantling the Divide between Indigenous and Scientific Knowledge," *Development and Change* 26 (1995): 413–39. In STS, this problem is clearly laid out by Gwen Ottinger, in "Changing Knowledge, Local Knowledge, and Knowledge Gaps: STS Insights into Procedural Justice," *Science Technology & Human Values* 38, 2 (2013): 250–70.

[23] Here I cannot do justice of the complexity of "semiotic relationality" as conceptualized by ANT, so I invite the readers to look at John Law, "Actor Network Theory and Material Semiotics," in Bryan S. Turner, ed., *The New Blackwell Companion to Social Theory* (Blackwell, 2008): 141–58; Michel Callon, "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay," *Sociological Review* 32, 1 (1984): 196–233; and Madeleine Akrich, "The Description of Technical Objects," in Wiebe E. Bijker and John Law, eds., *Shaping Technology/Shaping Society* (MIT Press, 1992): 205–24. Bruno Latour has illustrated this point in many writings, but I think his clearest explanation can

Object-oriented analyses of public involvement in technoscience, such as that of Nortje Marres, have foregrounded the role of objects in public participation and have helped STS move beyond schematic analyses of lay/expert controversies.[24] Marres' argument is similar to Sasha Newell's about the semiotic effectiveness of material objects, as capable of impressing "affective forces between bodies, things, and other entities" without having to be fully articulated in individual consciousness. Marres shows how domestic devices and other objects allow different modes of participation, whether the role of objects is consciously articulated in the enactment of participatory practices or remains unaccounted for and "under-articulated."[25]

Marres borrows one of her main concepts, that of "affected publics," from the pragmatist philosophical tradition, specifically from Dewey's idea that "the public" (singular) does not exist as a permanent space for discussion, as is normatively posited by democratic ideologies. Instead, publics (plural) come into being when controversial, unprecedented issues cannot be addressed through the "normal" tools of democratic institutions. If publics, as in Dewey's conceptualization, could be defined as "communities of affected people" and if, like Latour suggests, we need to explore how "matters of concern" catalyze assemblies of heterogenous actors, then the problem becomes: what happens after "issues spark a public into being?"[26] To move beyond the recognition that objects actively enable, enhance, and constrain forms of participation through their affordances, we need to attend to the material processes of signification publics are involved in when they try to make sense of the circumstances that concern them.

In sum, how do publics move from being concerned with and affected by something they do not know about to making sense of their experiences? This is a question that Actor Network Theory has not fully answered because it has been primarily focused on processes of translation, which involve movement, actions, and reactions—indexical relations among heterogeneous actors forming a network. This does not allow us to distinguish and move across

be found in "Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts," in Wiebe E. Bijker and John Law, eds., *Shaping Technology/Shaping Society* (MIT Press, 1992), 151–80.

[24] Nortje Marres, *Material Participation: Technology, the Environment, and Everyday Publics* (Cambridge University Press, 2012).

[25] Ibid., 65; Sasha Newell, "The Affectiveness of Symbols: Materiality, Magicality, and the Limits of the Antisemiotic Turn," *Current Anthropology* 59, 1 (2018): 1–22. I thank two anonymous *CSSH* reviewers who pointed Newell's insightful work out to me.

[26] Nortje Marres, "Issues Spark a Public into Being: A Key but Often Forgotten Point of the Lippmann-Dewey Debate," in Bruno Latour and Peter Weibel, eds., *Making Things Public: Atmospheres of Democracy* (MIT Press, 2005): 208–17.

different semiotic orders.[27] The concept of semiotic ideology helps us explain just this: how we move from the realm of affectedness to that of representation, or in Peircean terms, how we move from the level of secondness (being struck by and reacting to something or someone) to that of thirdness (thinking about, conceiving of, and representing something, such as radiological risk, trust, or others' intentions). I will return to this problem, but first let me briefly illustrate the practical implications of the questions I have just posed with some examples from the recent literature on the phenomenology of risk perception.

The Materiality of Signs, Radiological Risk, and Sense-Making

Recent works in environmental anthropology have shown that, before focusing on discourses of risk as displayed in public controversies, we need to look at the material processes of signification that allow non-experts and experts alike to make sense of risk in the first place. Analyses of the phenomenology of knowledge formation about toxic materials in domestic environments and around landfills have focused on the bodily and sensorial experiences that non-experts use to produce evidence of exposure to contaminants that are not easily detectable, sometimes with the help of expert activists.

Nicholas Shapiro deploys the concept of "chemical sublime" to explain how bodily experiences of formaldehyde's domestic contamination become evidence that informs "patho-logic" ways of knowing.[28] Understanding the bodily effects of daily encounters with chemically saturated domestic environments requires an attunement of the senses to "the background noise of everyday life." One of the main protagonists of Shapiro's ethnographic account is Linda Kincaid, an engineer who started measuring formaldehyde exposures with monitoring equipment, which allowed her to make sense of exposure symptoms. The use of measuring instruments at the moment at which bodily sensations were experienced allowed Kincaid to map out formaldehyde's presence as the cause of the bodily effects registered by affected citizens.

In a similar vein, Joshua Reno has described how Michigan communities living around landfills have developed an "olfactory epistemology" to distinguish the odors of trash from other smells and to produce evidence of landfill leaks that challenged waste-industry technicians and government inspectors assessments of the porousness of the sites.[29] These forms of

[27] This point is clearly discussed in Sasha Newell's "The Affectiveness of Symbols," and especially in Paul Manning's comments (pp. 14–16) about affect as a dyadic relation between two entities, which is not yet articulated and non-representational. As such it is not mediated by reflexive thought (thirdness).

[28] Nicholas Shapiro, "Attuning to the Chemosphere: Domestic Formaldehyde, Bodily Reasoning, and the Chemical Sublime," *Cultural Anthropology* 30, 3 (2015): 368–93.

[29] Reno, "Beyond Risk."

embodied knowledge help both experts and non-experts make sense of bodily symptoms and environmental changes that would remain otherwise undetected. Again, we see that "affected" groups get hit by bodily symptoms that signal that something is wrong or out of place. But making sense of these experiences requires a process of abstraction, a generalization about the phenomenon at hand. So, the central question is: how do affected communities move from a level of relationality and indexicality (being hit and struck by something strange or out of place) to a process of abstracting their experiences that allows them to make sense of what has been experienced?

Relying on Freud's definition of the uncanny, Joseph Masco describes the "nuclear uncanny" as the sensorial disorientation produced by the invisible properties of radioactivity and its dilated spatiotemporal effects on human bodies and the environment.[30] As Masco and others suggest, exactly because of its physical properties (invisibility, lack of smell, and the disorienting spatiotemporal dilation of its effects), radioactivity (like related risks of exposure and contamination) is a difficult object to deal with, especially for people who have had no direct or indirect acquaintance with it and lack technical knowledge of its characteristics, potential effects, and possible patterns of dispersion.

Empirical work on the ways in which experts and non-experts deal with radiological hazards, though, demonstrates that measuring devices, bodily practices, configurations of spatial delimitations like zones of exclusions, warning signals, and demonstrations all enhance people's capacity to pay attention to the signs of radiological hazards and to morph those hazards into visible and measurable risks.[31]

Historian Joy Parr describes how, during the 1960s and 1970s, the Canadian nuclear industry implemented a series of theoretical and practical training programs through which nuclear workers achieved a practical knowledge of radiation hazards.[32] Due to collaborative training with experts, workers developed what Parr calls "a somatic mode of attention"—that is, embodied knowledge of radiation hazards that led workers to enact prescribed radioprotection measures.[33]

[30] Joseph Masco, *The Nuclear Borderlands: The Manhattan Project in Post-Cold War New Mexico* (Princeton University Press, 2006).

[31] See, for example, Joy Parr, "A Working Knowledge of the Insensible? Radiation Protection in Nuclear Generating Stations, 1962–1992," *Comparative Studies in Society and History* 48, 4 (2006): 820–51; Olga Kuchinskaya, "Articulating the Signs of Danger: Lay Experiences of Post-Chernobyl Radiation Risks and Effects," *Public Understanding of Science* 20, 3 (2011): 405–21; Atsuro Morita, Anders Blok, and Shuhei Kimura, "Environmental Infrastructures of Emergency: The Formation of a Civic Radiation Monitoring Map during the Fukushima Disaster," in Richard Hindmarsh, ed., *Nuclear Disaster at Fukushima Daiichi* (Routledge, 2013), 78–96.

[32] Parr, "A Working Knowledge of the Insensible?"

[33] Joy Parr borrowed the concept of "somatic mode of attention" from anthropologist Thomas Csordas, "Somatic Modes of Attention," *Cultural Anthropology* 8, 2 (1993): 135–56.

More recently, Olga Kuchinskaya has analyzed the ways in which communities affected by post-Chernobyl contamination in Belarus experience radiological contamination and its effects.[34] Because radiation is not directly perceivable, communities living in contaminated areas rely on indirect strategies of risk objectification. Only scientific tools and instruments of visualization, together with explanations that experts provide during radiological tests, allow citizens to "articulate" the meanings of radiation and its effects. These interactions between experts and citizens in contexts of scientific examination and radiation assessment make risk visible and inspire risk-conscious behavior. They do so by establishing causal links between individual precautionary choices, such as not eating mushrooms and boiling meat, and the chances of being contaminated. Without these opportunities for "risk articulation," citizens are more likely to infer the presence or absence of radiocontamination by observing their neighbors' behavior or relying upon state authorities' designations of accessible and inaccessible areas.

As distant from radiological risk as it may sound, practitioners of Cuban folk-religion share the problem of making the invisible visible. In her analysis of folk religious practices, Kristina Wirtz shows how spiritual mediums use specific signs to make spiritual presences manifest.[35] As in the case of the Canadian nuclear workers, training with experts helps practitioners of Cuban folk religion develop a sensorial orientation, which Wirtz calls "perspicience," through which they interpret shivers as indicating the presence of spirits. These practical signs, Wirtz argues, can be interpreted because (1) they are taken to be signs in the first place, and (2) they acquire an indexical value (the shivers signal the presence of spirits through possession) through a shared "semiotic ideology."[36] But these interpretations of the shivers are possible because practitioners of folk-religion share assumptions about spirits' existence and agency.

Semiotic ideology can help STS and other scholars analyze a wide variety of cases across cultural and historical contexts by recuperating the role of materiality in processes of signification and discursive representations of risks in sociotechnical controversies. Semiotic ideology provides a potentially unifying methodology for understanding how experts and non-experts attain objectifications of risks by making sense of sensorial

[34] Olga Kuchinskaya, *The Politics of Invisibility: Public Knowledge about Radiation Health Effects after Chernobyl* (MIT Press, 2014).

[35] Kristina Wirtz, "Spiritual Agency, Materiality, and Knowledge in Cuba," in Paul C. Johnson, ed., *Spirited Things: The Work of "Possession" in Afro-Atlantic Religions* (University of Chicago Press, 2014), 99–129.

[36] Keane, "Semiotics and Social Analysis."

perceptions through guessing practices and metasemiotic operations, which connect cognitive process with larger cultural assumptions with political and ethical implications. Peirce's semiotic theory is an essential part of Keane's conceptualization, and I will now discuss them in tandem.

FROM MATERIAL SEMIOTICS TO SEMIOTIC IDEOLOGIES

"Semiotic ideology" refers to "background assumptions about what signs are and how they function in the world."[37] A thunder clap may be taken to signal a looming storm, but it may also be interpreted as a sign of divine intervention if one believes that gods or spirits exist as real agents. As Keane underscores, the word ideology in this context should not be thought of as false consciousness but rather as indicating "a fundamental reflexive dimension of the general human capacity to use signs," subject to history and struggle.[38] According to Keane: "semiotic ideologies provide instructions" for how to use abductive reasoning in processes of signification, but they involve much more than this, since they "mediate between abductive inference or interpretation, which are general cognitive processes, and the more material and conceptual circumstances that prompt them, forms of judgement to which they give rise, along with hopes and anxieties that attend them."[39]

An example of the reflexive dimension of semiotic ideologies and their consequences is that sometimes the same sign may be interpreted as iconic or indexical. For example, in Wynne's analysis of the interactions between experts and farmers the problem of incommunicability resulted from underlying assumptions by the farmers about the untrustworthiness of the experts, given the history of secrecy and reticence surrounding the activities of Sellafield. The farmers took the ambiguous and contradictory behavior of experts on the ground to be iconic; that is, as a reflection of their true essence rather than an index of how difficult it was to apply standard scientific protocols under that specific circumstance.[40] Semiotic ideologies instruct us in how to connect signs with objects. This aspect will become clear after a brief illustration of the constitutive elements of Peircean semiotics.

"A sign, or *representamen*, is something which stands to somebody for something [object] in some respect or capacity [ground]."[41] Signs impress in

[37] Ibid., 418.
[38] Webb Keane, "On Semiotic Ideology," *Signs and Society* 6, 1 (2018): 64–87.
[39] Ibid., 66–67.
[40] On the importance of metasemiotic reflexivity in social life, see ibid., especially pages 74–80.
[41] Charles Sanders Peirce, "Logic as Semiotic: The Theory of Signs," in Justus Buchler, ed., *Philosophical Writings of Peirce* (Dover Publications, 1955), 99–119.

the mind of a person an equivalent or more developed sign, which Peirce calls the *interpretant* of the first sign. Signs stand for an *object* or a class of objects in some respect or capacity, in reference to "a sort of idea," which Peirce calls *ground.* The triadic relation of the sign with its object, interpretant, and ground is what makes Peirce's semiotic theory particularly appealing to scholars interested in studying processes of signification that arise from active engagement with the material world.

Peirce repeatedly clarified that signs cannot deliver any information unless they stand for and connect with some portion of the real world as experienced by the interpreter: "A sign can only represent the Object and tell about it. It cannot furnish acquaintance with or recognition of that Object."[42] This implies that the perceiver's access to an object—direct or indirect—is always semiotically mediated and the identity of the object must be inferred abductively on the basis of a percept, an intellectual construction that allows the mind to judge what has been experienced through the sign vehicle and to establish a connection, in some respect or capacity, with the possible object of that concrete experience. In Peirce's words, abduction "supposes something of a different kind from what we have directly observed, and frequently something which it would be impossible for us to observe directly."[43]

Umberto Eco makes a useful distinction between "dynamical object," which is the entire reality of the object as it exists independently from whom is capable and willing to perceive it, and the "immediate object" of perception, which is the object as experienced through the sign vehicle that stands for the object in some respect or capacity. Thus connecting signs and objects always involves an inferential process, for, "although [the dynamical object] is, from a semiotic point of view, the possible object of a concrete experience, from an ontological point of view it is the concrete object of a possible experience."[44] This is why Keane emphasizes Peirce's assertion, "A sign does not function as a sign unless it be understood as a sign." That is to say that the material qualities and processes of causation in the world out there exist whether we are aware of them or not, but for something to be meaningful it needs to come to our attention and be understood to be a sign. Semiotic ideologies instruct us on how to be aware of and recognize signs.

The underdetermination of signs derives from their implication in the contingencies of the material world. For Peirce, signs can also be classified according to their relations with objects. "A sign is either an *icon*, an *index*, or a *symbol*."[45] Icons are signs that are qualities (red, large, triangular, etc.) and

[42] Ibid., 100.
[43] Cited in K. T. Fann, *Peirce's Theory of Abduction* (Martinus Nijhoff, 1970), 9.
[44] Umberto Eco, "Peirce's Analysis of Meaning," in Kenneth Ketner et al., eds., *Proceedings of the C. S. Peirce Bicentennial International Congress* (Texas Tech Press, 1993), 179–93, 193.
[45] Peirce, "Logic as Semiotic," 104.

their relation with the object is established by virtue of sensuous resemblance or analogy. Being qualities, icons exist independently from objects, but cannot be apprehended without some form of material embodiment. For example, redness or roundness are qualities that can be practically experienced through the acquaintance with certain objects like an apple or a basketball. Because objects as material things possess multiple qualities, "qualisigns bundled together in any object will shift their relative value, utility, and relevance across contexts."[46] From this perspective, the interpreter of a qualitative sign will always connect sign and object by making a selection of the quality or qualities that seem relevant in the contextual process of interpretation. "Iconicity is only a matter of potential. The realization or suppression of that potential cannot be ascribed simply to the qualities of the object in themselves. There must always be other social processes involved."[47]

Indexes are existing things, or events that are in a real connection (through contiguity or causality) with their objects. Indexes focus the attention of the interpreter, who is "forced" to immediately establish an association between an event and another phenomenon (its object). For example: "A low barometer with a moist air is an index of rain."[48] In the case of indexes, the ground that connects sign and object is "association by contiguity" and from this point of view they diverge from icons, whose connection with objects is qualitative resemblance.[49] To clarify the specificity of indexes in comparison to icons and symbols, we can use Peirce's example that an index "would lose the character which makes it a sign if its object were removed, but would not lose that character if there were no interpretant. Such, for instance, is a piece of mould with a bullet hole in it as a sign of a shot; for without the shot there would have been no hole; but there is a hole there whether anybody has the sense to attribute it to a shot or not."[50]

A symbol is instead a sign whose representative character resides in being a rule, which determines its interpretation. Symbols are conventions that elicit expectations of regularities in the "indefinite future."[51] Genuine symbols are general in their character, because they represent kinds of things, not single things. Anyway, any particular instance or example of a symbol has a denotative function. Symbols function on the basis of intellectual operations since, "The symbol is connected with its object by virtue of the idea of the symbol-using mind, without which no such connection would exist."[52]

[46] Keane, "Semiotics and Social Analysis," 414.
[47] Webb Keane, "Signs Are Not the Garb of Meaning: On the Social Analysis of Material Things," in Daniel Miller, ed., *Materiality* (Duke University Press, 2005), 182–205, 190.
[48] Peirce, "Logic as Semiotic," 109.
[49] Ibid., 108.
[50] Ibid., 104.
[51] Ibid., 112.
[52] Ibid., 114.

There are two advantages of using Peirce's semiotic theory to analyze how experts and non-experts make sense of risk signs. First, the definition of what a sign is includes many phenomena, not just words, but also objects, signals, natural phenomena, and so forth. Second, meaning emanates from the experience of the outer world. The interpretation of signs presupposes acquaintance with the material world and a degree of familiarity with the rules that give instructions as to how to perceive it: habits, implicit assumptions, or explicit metasemiotic operations that delimit potentially infinite semiotic regressions that take place in the process of abstraction.

Eco brilliantly illustrates this point by discussing a passage in Peirce's writings where the philosopher lists the potential characters that can be imputed to lithium when defined as an entry in the encyclopedia.[53] Even the most accurate and comprehensive definition of a chemical element can only be partial, for it will never catch the totality of its characteristics and the potential characteristics that could be further inferred in other possible contexts of experience, like physical manipulations by an experimenter. The relevance of lithium's characteristics and behavior will also vary according to the contexts in which that element is perceived and considered, that is the "universe of discourse" shaped by different communities of sign users. For instance, a miner excavating lithium might well have a different conception of it than does a cell phone user.

Practically, for knowledge to exist, the potentially infinite number of objects that can determine the sign vehicle must be circumscribed on the basis of a mental habit that allows us to establish the plausible nature of the relationship between the sign and its object, that is the ground.[54] Abduction is the cognitive process through which we make sense of our feelings of qualities ("firstness") and experiences of single facts ("secondness"), by taking icons and indexes, which "assert nothing," to the "third grade of apprehension," that of representation, which involves generating expectations about what, given certain premises, must be the consequences of signs. For Peirce, this is the essence of "thought"—the capacity to reflect on past experiences and present sensations which informs our ability to "predict what is to be."[55]

In the next sections, I will give some ethnographic examples of how long-term residents of La Maddalena constructed hypotheses about the presence or

[53] Eco, "Peirce's Analysis," 188–89.

[54] On the problem of potentially infinite semiotic regressions and the possibility of knowing the world, Parmentier offers an interpretation of Peirce's position based on passages where the philosopher asserts that knowledge and truth are not individual achievements but collective endeavors, based on the evidence that scientifically logical minds will eventually provide to arrive at settled beliefs. See Richard J. Parmentier, "Peirce Divested for Non-Intimates," *RSSI: Recherches semiotiques/Semiotic Inquiry* 7, 1 (1987): 19–39, esp. 33–35.

[55] Justus Buchler, ed., *Philosophical Writings of Peirce* (Dover Publications, 1955), 91.

absence of radiocontamination based on their observations of the environmental status of the archipelago, the behavior of U.S. Navy personnel, and their interpretations of unprecedented events such as episodes of birth defects. If they could not fully grasp the meaning of risk as provided in formal expert representations, or access classified information about the nuclear submarines, the Maddalenini could still try to understand the meaning of risk by abstracting the implications of potential radiological hazards through their daily observations of the environment and anomalous events.

INTERPRETING SIGNS, MAKING HYPOTHESES

Lacking knowledge of radiation effects and reliable information about the risks they were being subjected to, residents of the archipelago had to rely on their knowledge of the environment and on hypotheses about the possible consequences of living near a nuclear installation. Non-expert inferences were not randomly drawn or simply the reflection of conspiracy theories. Rather, local residents formulated hypotheses about the presence or absence or radiocontamination on the basis of evidence they gained through daily observations of the behaviors of other groups' such as Navy personnel, and expert authorities, the surrounding environment, and disquieting events like novel birth defects.

Even in this small and relatively insular community of ten thousand people, ideas about risk were often contradictory. Rumors and gossip about accidents inside the base, and partial data provided by Italian expert agencies fed fears and uncertainties about the probabilities of contamination. Even today, ten years after the closure of the base, some members of the community express doubts about the validity of reassuring assessments from experts about radioactivity levels. During my interviews or informal conversations with local residents and former base employees, they seemed ready to dismiss concerns about radiation exposure on the job and in the area generally, but toward the ends of our conversations they often asked me: "You have collected data on this, right? So, what did you discover? Did we have nuclear contamination or not?"

Contradictions and uncertainties emerged as local residents interpreted material changes and continuities in the archipelago. This was because, lacking direct or indirect knowledge of the object (radiation), they had to infer its presence or absence by observing their surroundings to see whether radiation effects, as imagined through abstractions of its conceivable consequences, were or were not evident.

For example, Giulio worked on the U.S. base for thirty years. He managed forty employees who maintained a complex system of diesel electric generators. He and his wife Roberta, also a former Navy employee, remember that around the base "everything was clean and organized. Safety rules were always respected and the sanitary conditions were regarded as an

extremely important matter."[56] Like many Italian former employees of the Navy, the couple shared with me their opinions that "the Americans" were diligent and respectful of rules, in contrast to Italians, "who always do things approximately." In La Maddalena, they told me, the Navy introduced exemplary norms of environmental preservation that were unimaginable under the Italian standards: "They taught us how to recycle, for example. We were simply dumping trash inside a hole and burning it!"[57] When I asked them what they thought of the risks of radiocontamination in the area, they argued that that was mostly a political critique mounted by the anti-base movements, and offered evidence to convince me of that: "Look, sometimes during our lunch break at the base we were allowed to take a walk. They knew us well and trusted us. We usually looked down into the water at the pier … and you can't imagine the spectacle! There were always huge *orate* swimming around undisturbed," emphasized Giulio, an expert fisherman. "Do you think that fish would be there if the seawater was polluted or contaminated?"[58]

Yet, other fishermen, like Carlo, who had no access to the base, scrupulously avoided fishing in waters close to it: "In general I do not think that the submarines were contaminating the islands. But honestly, we did not fish in places where the currents were passing through Santo Stefano. You know what I mean? When in doubt, better to avoid problems."[59]

Repeated observations of the environment around the base, and cautionary tales to avoid fishing where currents from the bay of Santo Stefano might carry radioactive substances, reflect contrasting views of the Navy installation. While Giulio and Roberta, two insiders, saw it to be a clean place, Carlo did not dismiss the idea that the base might leak radioactive contaminants, even as he reassured me that it did not pollute the environment. These stories and the everyday evidentiary practices drawn upon to establish the porousness and the environmental impact of the base resemble what Joshua Reno has called "emplacement," meaning a set of epistemological strategies that involve "knowing and narrating the boundaries, leakages, and ongoing transformation" of places designed to contain the "out of place."[60] Here, these evidentiary practices were grounded in interpretations of environmental signs mediated through broader assumptions about the behavior of the Navy and of fish. I will return to this point.

[56] Giulio and Roberta are pseudonyms. From author's interview with them, La Maddalena, Sept. 2012.

[57] Here, Giulio refers to the area known as Sasso Rosso, which the local administration used until the early 1990s as a landfill for the entire archipelago.

[58] In Italy *orata* (pl. *orate*) is the common name for *Sparus aurata* (Gilt-head Bream).

[59] Interviewed by the author, La Maddalena, Oct. 2012.

[60] Reno uses Harri Englund's concept of emplacement: "a phenomenological fact [that] is molded by histories of boundary making and constraint" (in "Beyond Risk.")

Observations by local residents frequently focused on the fact that every two years some Navy personnel were transferred away from the base to new posts in the United States or elsewhere. "Were they sent away because they could not stay anymore near the nuclear subs?" asked someone, speculating on the possible radiation exposure to which base sailors and workers could be subjected. Those familiar with the mechanisms of duty rotation on overseas military outposts know that Navy personnel are rarely allowed to serve on the same post for more than two years. They might be deployed to the same location after an interval, but usually not.

What I am suggesting here is not that local residents should have asked before formulating hypotheses about the reasons behind the "sudden" departure of U.S. sailors. The point is that living near a strategic nuclear submarines base, replete with obscure technological and organizational codes, might induce anyone to guess about "unusual," "suspect," and "incomprehensible" behavior of military personnel and interpret it using the pieces of information they have and their assumptions about others' intentions.

All of the above examples share a common element. Local residents gathered evidence about the presence or absence of radioactive contamination through observations of the environment and the behaviors of other groups. They relied also on past experiences of the local environment and on their knowledge of the base. For example, Giulio and Roberta took their observations of the healthy-looking fish near the base as an indexical icon of cleanness. Their experiences as fishermen and dwellers in the archipelago allowed them to formulate the following syllogism: it is common knowledge that a particular species of fish only swims in clean seawater, so if we see that species swimming around the base, we can conclude that the base is clean. The iconic value of the sign (fish that look healthy) contributes to shaping the meaning of lack of pollution, and the fish's proximity to the base where the nuclear submarines are stationed indexes absence of pollution. But Giulio and Roberta took these observations, made episodically but repeatedly, as evidence of a regularity based on assumptions and background information about the behavior of the Navy personnel, their superior environmental-preservation standards and practices, and ultimately the Navy's ethics. Thus, Giulio and Roberta interpreted the evidence they gathered around the base as an instance of a general regularity: wherever healthy-looking fish swim there is no pollution.

Other Maddalenini interpreted the presence of Navy servicemen as an index of the safety of the base: "Otherwise," some asked me rhetorically, "why would the U.S. Navy put its personnel in danger? If they felt safe, we were safe too!" Observations of the personnel behavior could also lead residents to different conclusions, based on opposite views of the Navy: they could attribute sudden departures of personnel from La Maddalena to their having to leave after a certain amount of time to avoid prolonged exposure

to radiation of submarines and other unknown materials. These contrasting interpretations emerge from mutually exclusive assumptions about the Navy's ethical standards, specifically whether the United States does or does not protect its servicemen on military duty by providing all the necessary safeguards on the job. Assumptions about the intentions of Navy personnel provided the background information that made certain hypotheses about their behavior plausible in the eyes of those who advanced them. This seems to confirm that "specific ecological judgments are not separable from moral statements about the way the world 'should' be."[61]

Despite the perfectly logical inferences that local residents used to interpret their daily observations as signs of cleanness or potential pollution, their experiences and knowledge of the local environment were not sufficient to produce sound evidence that the archipelago was not in fact contaminated. For example, an expert radioecologist could easily challenge Giulio and Roberta's reassuring conclusions. Based on their specialized knowledge of radioactivity, experts could disregard the same signs (healthy-looking fish swimming near the base) as insignificant, as not indicative of levels of radioactivity. In reality, in radiocontaminated environments what looks healthy and thriving is not necessarily safe or clean.[62] Scientists' acquaintance, at least in theory, with the potential effects of radiation and radioecological methods puts them on a different footing so far as knowing which signs are relevant (significant) and how to interpret them. Their semiotic ideology differed substantially from ideologies of local residents, not in terms of logic but, for example, in terms of what signs should be taken as relevant in the first place and the meaning of evidence drawn from inferences based on single observations. As Eco observed, "Detectives are rewarded by society for their impudence in betting meta-abductionally, whereas scientists are socially rewarded for their patience in testing their abductions."[63]

But in circumstances of uncertainty, when the stakes are high, experts may not have time to test their hypotheses or be able to answer pressing questions

[61] Irwin, Simmons, and Walker, "Faulty Environments," 1319.

[62] In their work, Kate Brown, Joseph Masco, and Olga Kuchinskaya observe that around Chernobyl, Los Alamos, and in radiocontaminated areas of Belarus, fauna and flora are thriving. They use these examples to underscore the perceptive distortions that radiation introduces into the world and the sensorial and cognitive disorientation it provokes in communities living in contaminated areas where the healthy appearance of natural life masks the invisible hazards of radiocontamination. Kate Brown, *Plutopia: Nuclear Families, Atomic Cities, and the Great Soviet and American Plutonium Disasters* (Oxford University Press, 2013); Masco, *Nuclear Borderlands*; Kuchinskaya, *Politics of Invisibility.*

[63] Umberto Eco, "Guessing: from Aristotle to Sherlock Holmes," *VERSUS Quaderni di Studi Semiotici Milano* 30 (1981): 3–19, 18.

quickly.[64] This was the case in the spring of 1976, when three babies were born in La Maddalena with cranioschisis, a fatal deformation or absence of cranial bones. The parents hypothesized a causal relationship between the birth defects and the presence of the nuclear submarines. They pointed to the submarines' proximity to La Maddalena and that there had been no similar cases before the U.S. Navy's arrival. Italian experts rejected that possibility but offered no alternative explanation.[65] From a semiotic and practical perspective, a concrete and dramatic experience such as babies being born with a fatal malformation was a sign whose object remained unknown, except that radioactivity was excluded as a possible cause. The semiotic ideology of the Italian experts acted negatively, to exclude a potential object of the sign, but they could indicate no alternative interpretation.

The material I will discuss next illustrates my second argument: objectifications and representations of radiological risk in La Maddalena changed over time as new signs became available for interpretation. Keane suggests that semiotic ideologies should not be intended as totalizing determinants of interpretants, but rather as sets of background assumptions that guide the interpretation of signs, whose relevance and observation are subject to change and struggle. I will show how different semiotic ideologies clashed over how to interpret the cranioschisis deaths.

EVENTS, RUMORS, AND CROSS-BOUNDARY ALLIANCES: SAFE USES OF RISK

In cases of radiological hazards, especially when we have no direct knowledge or conception of them, environmental signs can provide inferential evidence for the presence or absence of radiocontamination. Given the political stakes of risk assessment in La Maddalena in the 1970s, unprecedented and disquieting events like the spike in the rate of birth defects became obvious candidates for evidence of radiocontamination. One feature of semiotic ideologies is the ability to use signs and perform metasemiotic operations to establish and fix their correct function by indicating, explicitly or implicitly, the basis of the signs' relationships with potential objects. This is what Richard Parmentier—using a concept developed by Michael Silverstein—calls "metasemiotic regimentation, the semiotic process of stipulating, controlling, or defining the contextual, indexical, or pragmatic dimension of sign function in 'discursive text' by means of the construction of a relatively fixed or coherent 'interactional text.'"[66]

[64] Silvio O. Funtowicz and Jerome R. Ravetz, "Science for the Post-Normal Age," *Futures* 25, 7 (1993): 739–55.

[65] According to CNEN and ISS experts interviewed by national and local newspapers, four years were not enough for subjects exposed to low-level radiation to experience genetic effects. See notes 72–75.

[66] Parmentier, "Semiotic Regimentation," 360.

I want to consider the struggles to establish, fix, or challenge interpretations of unprecedented events. I examine how local intellectuals and anti-base activists refrained from citing the birth defects as evidence of nuclear contamination. They policed and controlled the proliferation of hypotheses about the causal nexus between the defects and the presence of submarines. This calculation about the plausibility of the malformation argument operated as a form of social control through semiotic regimentation, delimiting, de facto, possibilities for interpreting the events as consequences of radiocontamination. In doing so, local members of the Communist Party decided to rely on the expertise of allied scientists for information about the environmental status of the archipelago so as to acquire the necessary authority for advancing credible arguments against a permanent U.S. Navy presence in La Maddalena.

On 28 May 1976, the Sardinian newspaper *L'Unione Sarda* published the first of a series of articles focused on the anomalous deaths of the three babies (image 1),[67] all born between August 1975 and March 1976. According to Sardinian journalist Giacomo Mameli, similar cases may have occurred before but were scattered across time, and some of them were attributed to causes unrelated to radiocontamination. Mameli wrote his report as "a response to many anonymous requests coming from La Maddalena," where rumors of the possible nuclear origins of the cranioschisis had spread quickly in corner grocery stores, bars, and the church courtyard. "People, especially women, are afraid," admitted Rosanna Abati, director of the municipal register since 1970. "In five years of working in this office, I have never seen anything like this. These things leave us with many doubts."[68]

Doctors with the local civilian hospital interpreted the defects as "natural events." According to them, local families in the past had tended to keep such dramatic events private. Furthermore, before the construction of the local hospital in 1970, many women from La Maddalena and the surrounding towns of northern Sardinia had given birth in the city of Sassari, so any previous cases had probably been recorded there. Dr. Milani, director of La Maddalena's hospital, and his colleagues advanced no hypotheses about what caused the malformations. They all concurred that the community should not be alarmed, even if, they admitted, "the problem has been dramatized because of the presence of the U.S. nuclear submarines."[69]

The parents of the babies agreed to speak publicly. Two of the mothers said that their pregnancies had gone well, while the third had nearly miscarried during the fourth month. All three had previously given birth to healthy babies and, in their families, and those of their husbands, there was

[67] "Nascite anormali a La Maddalena," *L'Unione Sarda*, 28 May 1976: 3.
[68] Ibid.
[69] Ibid.

L'UNIONE SARDA — 28 Maggio 1976 — Pagina 3

INCHIESTE / Nell'arco di sette mesi tre casi di gravissime malformazioni craniche che hanno provocato la morte di tre neonati, sollevano inquietanti interrogativi

Nascite anormali a La Maddalena

«Ora fra le donne c'è apprensione e inutile nasconderlo, tanta paura» — Tuttavia i medici dell'ospedale sostengono che i tre casi non devono essere collegati a possibili effetti radioattivi — «Allo stato attuale nessuna ipotesi scientificamente valida può essere fatta»: così sostiene l'ufficiale sanitario dell'Arcipelago — Il racconto di tre madri

dal nostro inviato Giacomo Mameli

Contro l'allarmismo

Non ci hanno detto nulla

Soprattutto pesci e riso

Curiosità scientifica

Testimonianze contrastanti

Image 1. *L'Unione Sarda,* "Nascite anormali a La Maddalena," 28 May 1976. Source: Library Archive, University of Sassari.

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no record of malformations or diseases that might point to a genetic origin of the deaths. The doctors said the painful experiences of the three families were random "tricks of nature" and constituted no scientific problem, but the mothers and fathers argued otherwise and sought scientific explanations for their losses, which even doctors working in the larger hospital of Sassari could not provide. In the words of one father, "We are afraid. We think many things. Maybe the nuclear submarines had something to do with what happened, but what can we know about it? The scientists should tell."[70]

Two days after the first article, *L'Unione Sarda* reported on the opinions of scientists from the University of Cagliari, two geneticists and two pediatric neurologists.[71] They agreed that the cases should not be dismissed as simply random and they called for a careful investigation. Citing the uncertain etiologies reported in the scientific literature, the specialists advanced prudent hypotheses correlating cranioschisis with poor socioeconomic and sanitary conditions of the archipelago, and pharmacological and environmental factors. Only one of the four experts, citing reports about Hiroshima and Nagasaki, said that ionizing radiation might correlate with occurrences of genetic mutation.

On 1 June 1976, Dr. Osvaldo Ilari, head of the Environmental Radioactivity Division of the National Committee for Nuclear Energy (CNEN), sent an official note to the national press to clarify that, according to the current health physics literature, cranioschisis could not be caused by radioactive contamination.[72] Of the same tenor was an interview that professor Carlo Polvani, head of the Radioprotection Division of CNEN, gave to the national newspaper *La Stampa* the next day: "Even if there are traces of radiocontaminants, and this is yet to be demonstrated, they are so small that they could not have caused any genetic effect on individuals in such a short amount of time [between 1972 and 1976]."[73] The official position of expert agencies, though, left citizens with many doubts because Ilari, Polvani, and colleagues limited themselves to refuting the hypothesis that radiocontamination caused the cranioschisis without offering any alternative explanation.

Lack of univocal communication and interpretations of the unprecedented events, either from expert agencies or local institutions, encouraged rumors. The national press reported extensively about the "strange cases of La Maddalena" to point to, sometimes with dramatic tones, the lack of any

[70] Ibid.
[71] "Occorre un'indagine seria sulle nascite alla Maddalena," *L'Unione Sarda*, 30 May 1976: 3.
[72] "Una smentita che non smentisce," *L'Avanti*, 2 June 1976; "La Maddalena: smentite le morti da radioattività," *Corriere della Sera*, 2 June 1976; "Si studierà la radio-attività a La Maddalena," *Il Giorno*, 4 June 1976.
[73] "I tre bimbi anormali: analizzate alghe, mitili della base Maddalena," *La Stampa*, 3 June 1976.

serious program of radioprotection around the base, and to comment on the difficult conditions under which nuclear experts had to work.[74]

At the local level, political leaders like Vice-Mayor Franco Tamponi, a longtime member of the Italian Socialist Party (PSI), expressed ambivalence regarding any connections between the cranioschisis and the Navy presence: "There are no elements to establish a direct causal relation between our dead kids and the presence of the U.S. base, but this event cannot do anything but increase our doubts. Honestly, we cannot stop thinking about it because our community has no memory of cases like these.… Also, I received confirmation from one of the obstetricians here that in recent years there have been suspect miscarriages."[75] In Tamponi's ambivalent interpretation of the defects we can detect a degree of self-restraint: while he clearly alluded to the possibility that malformations could be caused by radiocontamination, he also advised the public to reflect on the formal requirement that scientific hypotheses be tested from solid evidence, which precluded asserting a causal nexus between malformations and the Navy presence. Thus, after voicing the concerns of his fellow Maddalenini, Tamponi switched his focus to critical flaws in the system of risk management in La Maddalena. He borrowed both legal and scientific arguments from nuclear experts and educated activists: "We want all the necessary safety measures around this base. We need to know immediately if there is an increase in the levels of radioactivity and to design an adequate emergency plan in case an accident occurs."[76]

While unofficial reports and rumors fed hypotheses about the possible health effects of the submarines' presence, local political leaders issued public statements that portrayed these hypotheses as "unscientific" and unlikely to travel far beyond the limits of the archipelago. Local opponents of the Navy presence thought that to acquire credibility they needed robust evidence of scientific facts provided by reliable and independent experts.

In La Maddalena the processes of discursive elaboration, of which Tamponi's is just one example, did not occur spontaneously, but rather corresponded to precise strategies deployed by local political elites to construct their arguments and to win the consensus of public opinion, especially at higher levels of the technopolitical debate.

[74] *Il Messaggero*, 31 May 1976.
[75] Ibid.
[76] "Il ministro della Sanità rischia l'incriminazione," *L'Avanti*, 10 June 1976. Tamponi's arguments echoed and sometimes explicitly referred to statements about the status of the radiosurveillance system in La Maddalena that ISS and CNEN experts made in public debates and scientific conferences. Moreover he used legal arguments offered by environmental activist judge Gianfranco Amendola, leader of the environmental organization "Gruppo Ambiente." He intervened frequently in the public debates concerning the lack of radioprotection protocols in La Maddalena through op-eds in national newspapers: Gianfranco Amendola, "Basi infette," *Il Messaggero*, 22 Mar. 1974.

The spread and incorporation of scientific arguments and expert opinions into the common understandings of citizens was an objective of both pro- and anti-base parties in La Maddalena. Both sides looked for expert opinions that could back their arguments that the base was safe or was not. But anti-base activists saw the proliferation of uncontrolled rumors and hypotheses as detrimental to their cause. Unchecked statements or exaggerated or distorted versions of facts and incidents were double-edged swords. They could be used to provoke public reactions and shake the militarized community of La Maddalena, but at other times they could boomerang because they could be easily dismissed by local and national parties that favored the base, backed by connivant scientific authorities. Local opposition groups had experienced first-hand how, in 1972–1974, the Italian government and the local municipal administration, both ruled by a strong pro-NATO Christian Democrat majority, tried to black-box safety issues in the archipelago by using ad hoc reports produced by experts and military authorities. For this reason, leftist political leaders opposed to the base, in particular, tried to police the proliferation of hypotheses surrounding events like the cranioschisis cases and to stifle sensationalistic reports in general.[77]

Local anti-base elites employed a communicative strategy to shape and steer the debate over the risks of radiocontamination based on three tactical elements: (1) They exploited the political valence of events that could re-launch the debate over the weaknesses of the radioprotection system. (2) They policed rumors and unchecked statements about nuclear contamination so as to avoid their rebuttal by official authorities and the consequent loss of credibility for their arguments. (3) They relied on allied experts to verify the technical accuracy of their interpretations and to enroll expert opinions that national, local, and military authorities could not easily dismiss. This set of strategies constituted what I call *politics of coherence*.

These tactical moves, sometimes collectively organized and at other times individually undertaken, are evident in both the arguments and omissions of newspaper articles and editorials of the 1970s.[78] For example, it is notable that *La Nuova Sardegna* (the second Sardinian newspaper), whose editorial line was usually critical of the U.S. Navy operations in La Maddalena,

[77] I say especially leftist political leaders because they were a minority in La Maddalena and were generally denied the resources that the dominant elites monopolized through their affiliation with the central government, the local church, and the Italian Navy. The anti-base front had to elaborate a strategy to break through widespread reticence and undermine official narratives about the economic benefits of the U.S. Navy's "innocuous" presence.

[78] For the period 1972–1976, I relied on newspaper articles from *La Nuova Sardegna* and *L'Unione Sarda* available at the archive of the municipal library of Sassari, Sardinia. For 1976–2008, I drew from a rich collection of articles about the base assembled daily by the Information Office of the Italian Navy command of La Maddalena. I had access to the collection thanks to the precious collaboration of Mr. Francesco Nardini, director of the library at the Navy Officer Club of La Maddalena, where it was deposited after the base closed.

published no articles about the cranioschisis cases. Struck by this surprising finding, I asked Gian Carlo Tusceri, the newspaper's local correspondent from the early 1970s to 1991, to explain the silence. After a brief period as an activist with the young Christian Democrats, Tusceri became a sympathizer of the Communist Party, and his critical views of the U.S. nuclear installation were well-known in La Maddalena. However, due to his professional and intellectual curiosity, he had preserved an independent position on the base, and even established a friendly relationship with Commodore Burkhalter, commander of the 22nd U.S. Navy Submarine Squadron.[79] This liminal position allowed him to weigh competing arguments, but his choice of coherence and thorough documentation attracted the sympathies of neither opponents nor supporters of the Navy presence.[80] Consider the following excerpt from our interview:

Orsini: Why didn't you write anything about the babies born with cranioschisis?

Tusceri: Look, I have been among the strongest opponents of the U.S. Navy in La Maddalena, and I paid the consequences for it.[81] But I refused to fall into the trap of the malformations. Everybody was using the story for political reasons. Many colleagues of mine wrote about the malformations because that was 'the news' of the moment! I started to document them myself and understood that emphasizing those stories was scientifically incorrect and consequently detrimental to the anti-base political strategy.

Orsini: But couldn't you have tried to explain and contextualize those cases better?

Tusceri: In that situation, it was impossible to get into the debate and present more accurate accounts. I decided to not participate in what I thought was a weak political move and conformist attitude of many colleagues. The argument that the radioactivity supposedly released by the submarines could cause the malformations, in general, was exposed to easy counterarguments and was ultimately indemonstrable. It was the wrong way to conduct the right political battle against the permanence of the U.S. Navy.[82]

[79] The base in La Maddalena was the station of the squadron.

[80] During informal conversations, former U.S. Navy servicemen mentioned the name of Gian Carlo Tusceri as the clearest example of anti-base attitudes in La Maddalena. A retired U.S. Navy officer, who requested anonymity, told me: "That shit that G.C.T. [how Tusceri signed his articles] wrote on *La Nuova* was just political propaganda."

[81] During our conversation, Tusceri mentioned several times that he had been intimidated and threatened, but he would provide no specifics.

[82] Author's interview, La Maddalena, Apr. 2012.

Tusceri was not alone in resisting the temptation to use the dramatic cranioschisis deaths for political argument. Gianfranco Dedóla, a former Communist Party member, union activist, and worker at the local Italian Navy arsenal, remembered that inside the party there was reluctance to use the cranioschisis cases for political propaganda against the base. In June 1976, when Italians voted in the general elections, Giovanni Berlinguer, brother of the famous Sardinian P.C.I. secretary Enrico, gave a political speech in La Maddalena. Dedóla remembered that day in detail: "We were in front of the city hall. The square was full of people waiting for Berlinguer's speech. A few minutes before the start, Berlinguer asked me if there were particular themes that the comrades in La Maddalena considered important. He asked whether he should mention or not the story of the babies and I immediately said no! He agreed with me that that wasn't the right thing to do."[83] Dedóla and Tusceri's explanations provide examples of how local anti-base intellectuals and party activists tried to suppress the interpretation of the cranioschisis cases as signs of nuclear contamination. By policing interpretations of them, they regimented the meaning of the cases by severing their indexical connection (the ground) with nuclear contamination. They accomplished this with help from allied experts from CNEN.

Within the Italian Communist Party, both at the local and regional levels, high-ranking activists assembled highly accurate arguments that could stand against the propaganda of the Christian Democrats and attempts by national authorities and the U.S. Navy to minimize the problems of the radiosurveillance system in La Maddalena. Salvatore Sanna, speaker of the P.C.I. group in the city council, was a prominent political figure in the archipelago. For decades he had been on the frontline against the U.S. installation and through his efforts to document the environmental impacts of military activities in Sardinia he became an expert on the topic.

During the 1970s, Sanna maintained an active correspondence with Carlo Papucci, a radioecologist from the CNEN Laboratory of Marine Contamination, who, starting in 1975, took part in all the campaigns to monitor La Maddalena. Papucci's leadership inside the CGIL-Ricerca (the union of research employees affiliated with the Communist Party and other leftist parties and labor unions) facilitated his exchanges with Sanna and other P.C.I. leaders.[84] Sanna relied on Papucci's expertise and position inside CNEN to get technical information about the radio surveillance plans.

[83] Author's interview, La Maddalena, Oct. 2012.

[84] The Italian General Confederation of Labor (CGIL) remains the largest leftist union of the country. CGIL was considered the closest union to the Italian Communist Party and other parties of the socialist constellation. The CGIL-Ricerca was the union branch that represented the sector of public employees inside national research institutions like CNEN and ISS.

Their private correspondence reveals that Sanna was sending Papucci his speeches and official notes to make sure that the details he reported were "technically" correct.[85] Papucci's expert voice was authoritative, and sometimes Sanna asked him to use his affiliation with the CGIL-Ricerca and his expertise to support the communicative strategy of the local communist group. For example, in a letter dated 11 March 1977, Sanna illustrated the "points of attack" on the problematic implementation of the radio surveillance plan, and asked Papucci to support his intervention: "If these points are correct in their formulation, it would be necessary that the *tecnici* [experts] confirm them when (if we are successful) the Ministry of Health and the other authorities involved say that everything is under control and that [the radio surveillance plan] is in an advanced state of implementation."[86] In sum, not only did Papucci provide technical mentorship, but he actively contributed to shaping the public debate about the hazards of the U.S. installation.

Sanna and other Communist Party members were competing with powerful organizations: the U.S. Navy, CNEN high officials, and the Ministry of Defense. The cultural and economic leverage of agencies like the Italian Navy and the Catholic Church were formidable tools of social control in the archipelago, where the sense of identification with military institutions was almost unquestioned. To challenge this power structure, Sanna and others had to carefully and accurately construct technopolitical arguments that could not be dismissed as simply prejudiced ideological positions against the U.S. Navy. That is why the technoscientific components of the disputes around the radiosurveillance system became so relevant after the base was installed.[87] In this context, the political organization of the party, its use of coherent scientific explanations, and its control over the spread of hypotheses based on anecdotal evidence, were key weapons in a battle between unequal adversaries. In its attempt to build a consensus against the base, the Communist Party decided to silence the hypotheses coming from the affected members of the local community that the cranioschisis cases were caused by radiocontamination and to rely instead on "scientized" arguments and technical advice from allied experts.

[85] I thank Carlo Papucci for granting me access to his private archive.

[86] Salvatore Sanna to Carlo Papucci, private correspondence, 11 Mar. 1977, Carlo Papucci private archive (my italics).

[87] In 1972 the Italian government admitted that the news of the imminent arrival of the U.S. Navy in La Maddalena reported by some newspapers was true. This led several scientific organizations, including the Italian Physics Society, to express concerns about the risks involved in installing a nuclear submarine base at the hearth of the Mediterranean Sea. During the plenary assembly of the Society in Cagliari, on 2 November 1972, some members emphasized the importance of maintaining a "technical profile" in order to gain credibility in the eyes of political authorities and the members of the public who were ready to dismiss their advice as the "opinion of a bunch of communists."

CONCLUSIONS

In La Maddalena, radioecologists and health physicists, U.S. Navy personnel, local administrators, and long-term residents publicly debated the environmental consequences and the possible health effects of the presence of the U.S. military base.

During disputes over the meanings of nuclear contamination associated with the presence of the submarines, experts' discourses focused on the technical and decontextualized characteristics of risk. Abstract expert definitions and a lack of previous direct experience with radiation and its effects left local residents with no clear idea of what radiocontamination might look like. They adopted other strategies to objectify risk. I have argued that for radiological risk to become visible, material signs must be available for interpretation. But material signs, such as radiometric results, instrument measurements, environmental changes, and unusual events cannot be interpreted without what Keane calls semiotic ideologies—shared codes or assumptions about the ontological order of the world, moral values, agency, intentionality, and political orientations that regiment their meanings.

I have explored here how exchanges and circulations of technical information between experts and non-experts work, and how more fluid and porous interactions between experts and non-experts influence activists' arguments vis-à-vis official narratives of expert and public authorities. The archival and ethnographic material I have examined reveals that when analyzing processes of signification about risk in technopolitical controversies, scholars need to consider how material objects of experience inform meanings of risk and how the latter do or do not travel. In the case of La Maddalena in the 1970s, political party organizations, labor unions, and the Catholic Church were loci of pedagogy, cultural elaboration, and exchanges between different levels and forms of knowledge production. More importantly, this case shows that experts and non-experts are not necessarily opposed or homogeneous social entities. Internal differentiations emerge when we look closely at material processes of signification, information control, and political strategies that enable both groups to reduce complexity and present (what appear to them to be) coherent arguments in sociotechnical controversies. This involves working to understand how experts and non-experts form meanings of risk during their interactions, rather than assuming that incompatible socio-cultural identities or irreconcilable ways of knowing, or reasoning, lie at the core of their conflicts. I did not assume that people of La Maddalena knew more about the effects of radiological risk than did scientists or that they could deploy alternative forms of knowledge about it based on their close daily interactions with the local environment. My goal instead was to show how non-experts deal with invisible risks and how they formulate hypotheses about phenomena about which they lack direct experience and knowledge.

In a place such as La Maddalena, where only radioecology experts and U.S. Navy personnel trained in radioprotection had acquired common understandings of radiological risk, local residents had to make sense of radiological hazards in an uneven representational economy shaped by what Ulrich Beck calls "relations of definitions."

Understandings of risk changed over time. New facts, such as the cranioschisis deaths, became potential signs of risk that could be politically mobilized, especially in the absence of conclusive scientific explanations for them. However, because the causal nexuses between the malformations and the presence of the nuclear submarines was unstable (because it was undemonstrated), local anti-base elites abstained from using them in their technopolitical arguments. The organizational efforts of local anti-base activists to assemble sound arguments against the Navy's presence involved policing rumors about the cranioschisis episodes in order to exclude dubious evidence that expert and central political authorities could easily dismiss. They regimented the meanings of risk by assimilating scientific discourses into their representational strategies, with the help of allied experts.

Abstract: This study draws on ethnographic and archival evidence from the Italian Archipelago of La Maddalena, offshore from the northeastern corner of Sardinia, where in 1972 the U.S. Navy installed a base for nuclear submarines. It addresses two questions: (1) How do non-experts make sense of radiological risk absent knowledge and classified information about its instantiations and consequences? (2) How do objectifications of risk change and stabilize within the same community over time? STS scholarship has emphasized the epistemic and relational dimensions of lay/expert controversies over risk assessment. Many case studies, mostly focused on the Anglo-Saxon world, have assumed lay and expert ways of knowing are incompatible due to clashing cultural identities. I use Keane's concept of "semiotic ideologies" and Peircean semiotic theory to critically reassess the validity of that assumption and examine the role of material evidence in processes of signification to explain how experts and non-experts fix, challenge, and negotiate the meanings of radiological risk in sociotechnical controversies. I critically review empirical studies and analyze ethnographic and archival data to advance a set of methodological and substantive arguments: meanings of risk change as new signs become available for interpretation; and meanings of risk are semiotically regimented: their emergence or silencing depend upon the power relations in place in a given community and organizational efforts to assemble coherent technopolitical arguments. I call this set of organizational practices "politics of coherence."

Key words: risk, lay/expert controversies, STS, semiotic ideology, Italy, nuclear submarines, nuclear contamination, environment