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Tragic Choices at Fukushima Dai-ichi Nuclear Power Plant

Elsa GISQUET¹

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Abstract

1 In high-risk industries, the development of reliable safety systems has made it easy to forget
2 that operators may one day be confronted with dramatic, life-threatening situations. This
3 article examines one such catastrophe, the Fukushima Daiichi nuclear accident. It will shed
4 light on the mechanisms at work in operators' attempts to mitigate the disaster, even as they
5 knew they would be exposed to a radioactive environment. Using available literature and
6 official reports, it will show how the decision process used by workers to make tragic choices
7 involving self-sacrifice unfolded within three orders of determination: institutional,
8 organizational, and the field.

9
10 While these regimes did help actors to make hard choices, we will show that they
11 simultaneously created ethical blind spots. Just as the complexity and tight coupling of this
12 high-risk industry leads to "normal accidents" (Perrow 1984), we argue that self-sacrifice in
13 the wake of such accidents is masked by what we call "normal blindness," which hides the
14 underlying tragic choices actors must make.

15
16 This article argues that normal blindness need not be inevitable, and that further exploration
17 of and reflection on the ethical lessons of the Fukushima accident could help us to better
18 prepare for such situations in the future.

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Introduction

In our society, industrial and technical developments designed to protect human well-being have created critical infrastructures that open the door to new vulnerabilities and new dangers (Beck 1992). Governments and industries must demonstrate that they are in control of these risks (Borraz and Cabane 2017; Gisquet 2020). High-risk industries are expected to operate more or less error-free over long periods of time by consistently making good decisions that result in strong quality and reliability (La Porte 1996). This often results in the widespread perception that risk control in these industries is sufficient to make disaster highly unlikely; however, the Fukushima Daiichi accident of 11 March 2011 is a tragic reminder that nuclear energy production has never been and never will be a risk-free undertaking (Uekoetter 2012).

The disaster at Fukushima was set in motion by an earthquake, which caused a trip in the reactors operating at the Fukushima Daiichi nuclear power plant (NPP). The tsunami that followed caused the plant's emergency generators to suddenly fail, plunging the NPP into an almost total blackout. Despite the operators' efforts to cool the reactor, by the evening of March 11 it became clear that venting would be necessary. High levels of radiation suggested that fuel could already be melting, making it imperative to vent the reactor core before pressure buildup caused an explosion, which would damage the containment building and release radioactive matter into the atmosphere. Normally, this would have been a simple matter of flicking switches on a control panel. Without electricity, however, the control panels could not function. To open and close the valves by hand, operators had to enter the reactor building, where radiation levels were already dangerously high. Ultimately, six TEPCO team members were exposed to radiation levels higher than 250 mSv, well above the emergency exposure dose limit (UNSCEAR Report 2013).

The term "suicide squad" has been used to describe the team preparing to manually open the valves during the accident (Asahi-Shimbun 2020), which brings home the level of sacrifice they were being asked to make. Despite this expression, it remains easy to think of these plant

operators' actions as natural or inevitable, and to forget the specifics of the situation, in which a small team of workers accept to risk their own lives to save others around them.

What process was used to arrive at such a difficult decision? How do individuals and teams take responsibility for tragic choices – in this case, selecting individuals to perform a task that might forever change their lives for the worse?

Until now, as we shall see, the literature has largely focused on such sacrifices from an individual angle (psychological or philosophical). For the most part, the mechanisms underlying the process of (self-)selection through which individuals end up choosing to engage in actions that will potentially harm or end their lives have remained unexplored. And the institutional and organizational patterns that lead to decisions of self-sacrifice in emergency situations have so far been completely ignored.

This article will explain how in the case of the Fukushima Daiichi accident, three different orders of determination – institutional, organizational, and in the field - helped to regulate tragic choices, while at the same time masking and distancing actors from the deep ethical quandary in which they found themselves. We will argue that this process of self-sacrifice was in part the result of “normal blindness” caused by the complexity and tight coupling that characterize the systems at work in a nuclear power plant, at the very heart of the high-risk industry of nuclear energy (Perrow 1984). In the context of the Fukushima Daiichi accident, it is possible to discern how a serious ethical problem – a “moral assessment of actions with uncertain outcomes on humans” (Vanem 2012) – was clouded from the view of those required to make a choice, rather than being clearly presented as a process of defining priorities in terms of specific ethics or values (Hadden and Hazleton 1980).

This in turn sheds light upon the “sacralization of technology” (Ellul, Wilkinson et al. 1964) that takes place in this high-risk industry, and on the subordination of humans to the needs of a system that such sacralization implies. However, unlike “normal accidents,” we argue that “normal blindness” to self-sacrifice is not necessarily inevitable, and that awareness of its presence can help us improve the way we think about preparedness and crisis management (Topper and Lagadec 2013).

Literature Review

Although they have been explored and analyzed in other fields, “sacrificial practices” in high-risk industries are a topic as yet unexamined by the social sciences. Moreover, most of the existing literature has focused almost exclusively on the individual (from a moral or psychological standpoint), largely ignoring the ways in which organizational or institutional structures play a role in such actions.

Existing literature on self-sacrifice in the social sciences has analyzed practices these process where an individual comes to assume that they have a duty to put an end to their own life (Cooley 2015). Schematically, this form of self-sacrifice falls into two broad categories: sacrifices for ideology and morality, and sacrifices made for considerations of beneficence (Bennett 2000).

Kamikazes or terrorist suicides may be placed squarely in this first category. Lankford identifies four broad types of suicidal behavior among these people (Lankford 2011):

- (1) conventional suicide terrorists, who become suicidal owing to classic risk factors,
- (2) coerced suicide terrorists, who become suicidal because they fear the organizational consequences of not carrying out attacks,
- (3) escapist suicide terrorists, who become suicidal because they fear being captured by the enemy, and
- (4) indirect suicide terrorists, who become suicidal at an unconscious level and orchestrate their deaths in ways that disguise their desire to die (Lankford 2014).

While it is true that the prospect of publicity and media attention in a globalized world may encourage people to engage in self-sacrificial practices (Crelinsten 1994; Tosini 2018), most of the literature has understood suicide terrorism as an essentially individual choice, often motivated by the symbolic retribution such an act might bring. In this way, it may be seen as arising from what Piera Aulagnier called a “narcissistic pact” (Aulagnier 1975 p. 182-192).

In this literature, organizations are not seen as motivating forces. Instead, they tend to be perceived as dissuasive, to the extent that they are able to mobilize fears of institutional sanctions (Goffman 1968). Barzin (Barzin 2010) is one exception to this, underlining the importance of groups in the choice to engage in self-sacrifice. He has argued that any attempt

to understand suicide attackers at a purely individual level is fruitless: it is equally necessary to consider the systems of meaning in which they operate, through a sense of psychic belonging. Suicide attackers enter into a narcissistic pact with their group to ensure their psychic survival beyond the act of self-sacrifice – without this, their death would be definitive. In this sense, the group is an extension of individual dynamics.

The second category of sacrifice is based on considerations of beneficence that have a philosophical link to the utilitarianism of Mill and Bentham (Mill and Bentham 1987): the morality of an action depends on the consequence of the act. If the consequences of an individual action are negative for the individual but have a strong positive effect for the many, then it is morally desirable. This form of sacrifice presumes that the common good takes precedent over the welfare of a single individual. This utilitarian approach to ethics, echoes of which we will see in the case of the Fukushima accident, may lead to choices that sacrifice a few people to save a great many (Ersdal and Aven 2008).

This type of altruistic suicide has been a well-known phenomenon for a long time in the military (Durkheim 1897), and it has often been posited that individuals engaging in such acts see themselves not merely as instruments of the group but as willing to do more for the group than other members: a strong focus on honor codes correlates with soldiers' willingness to risk their lives in combat operations (Mandel and Litt 2013). Here again, though, analyses of the processes leading to self-sacrifice have focused on individual (moral) traits, rather than on institutional and organizational traits. Only recently has it been recognized that organizations may foster group alignments that tap into the motivational power of personal agency, both strengthening and emboldening it (Whitehouse 2018).

Studies of rescue workers who accept dangerous rescue missions to save others, also tend to focus on identity and social aspects (Ash and Smallman 2008). Accounts of volunteer rescue workers (Stallings and Quarantelli 1985) divide them into two categories: those who arrive at the scenes of disasters or emergencies through volunteer organizations (organized volunteers) and those who arrive independently, out of a desire to help the community (spontaneous volunteers). Here, again, the focus remains on the individual: "according to the social exchange theory, satisfaction is determined by the relation between the rewards which

are derived from the volunteer activity and the personal sacrifice of the volunteer in this activity" (Kulik, Arnon et al. 2016). Organizational variables, where noted, are merely taken into account as part of an individual perspective on self-sacrifice, as example the training organized for volunteers undergo to help them withstand stressful situations (Pardess 2005).

It is true that the role of the group is now occasionally recognized in this regard: if individuals participating in rescue missions seem willing to risk their lives in order to save others (Ash and Smallman 2008), the role of leadership has remained central to understanding how their choice to do so is made. Yet again, though, the group's role in the process of decisions involving self-sacrifice has been analyzed almost exclusively from an individual perspective: an organization's leadership is thought to set the ethical 'tone at the top' (Treviño, Brown et al. 2003) that plays out in the actions of individuals on the ground. In other words, leaders' moral qualities establish the ethical context of action (Treviño, Butterfield et al. 1998; Loviscky, Treviño et al. 2007), the ethical climate (Victor and Cullen 1988), or the ethical culture (Trevino and Youngblood 1990). Work on this topic refers to the characteristics of organizations in very general terms (Brown and Treviño 2006), without taking any interest in the specific and concrete ways in which they might orient decisions involving self-sacrifice, let alone mechanisms they may (or may not) put in place to guide or facilitate these decision-making processes.

As this brief overview shows, the literature on self-sacrifice takes an almost entirely individual and psychological approach, whatever the field it is examining. When organizations are mentioned in the context of sacrificial practices, it is simply for the values they uphold – values that in every case transcend the organizations themselves. The power relationships that exist within them are set aside. However, one context in which the common good is defined, experienced, and mobilized is certainly that of organizations. Organizations' roles in decisions relating to self-sacrifice may therefore have implications that go beyond an individual analytical and philosophical perspective.

Tragic choices

The literature on tragic choices explores the political and organizational factors guiding decision, when societies allocate scarce resources that affect people's lives (Calabresi and Bobbitt 1978; Elster and Herpin 1994). In the case of organ donation, for example, high patient

demand and low availability of donated organs can create situations in which tragic choices become necessary.

According to the literature on tragic choices, three orders of determination guide tragic choices. First-order determinations have to do with the general circumstances as they are defined institutionally (overall availability of resources, prevailing ethical principles). In the case of choosing candidates for organ donation, for example, two ethical paths may be chosen: prioritizing patients who need the transplants most to survive, or patients for whom the transplant is certain to succeed. Both are morally acceptable, but they lead to radically different decisions. Second-order determinations have to do with the allocation of available resources by hospital organizations - in other words, the means to implement the ethical principles. In the third order of determination, individual actors – here, health professionals – are central, as the procedures identified in the first two orders must be applied locally, in the field. Together, these orders of determination make it possible to rationalize decisions, thus relieving actors of at least some of the moral weight of decision-making by providing them with frameworks to use to make their choices (Gisquet and Friedberg 2011).

While distributing the decision-making process among different orders of determination may provide a framework for making a decision, it may also end up contradicting the ethical principles identified in the first order of determination: if a hospital's procedures for recruiting, identifying, and selecting patients are not in place, and the appropriate professionals are available or are not properly trained - then ethical principle defined by the first order of determination cannot be applied (Elster and Herpin 1994). Nevertheless, the approach described above remains a "top-down" approach, in that it starts with political and ethical principles and then analyses how they are translated into concrete choices. But this is just one way to understand such situations: a different one might be more appropriate in the case of processes leading to self-sacrifice because the person making the sacrifice is so deeply and directly involved.

Finally, it should be noted that the literature on tragic choices has until now dealt only with the distribution of scarce positive resources in situations such as the one described above. It has never considered the distribution of negative burdens. How does one assign misfortune?

How is it possible to distribute necessary but dangerous or even life-threatening tasks to a small number of individuals? This, too, requires tragic choices. Although this article situates itself in the literature on self-sacrifice, the methodological framework of tragic choices is central to understanding the social, institutional, and organizational dynamics at play in decisions that have profound effects on individual lives.

Method

Theoretical framework

In line with sociological work on disaster (Vaughan 1996; Dedieu 2010), this article has used the relevant literature to craft a qualitative method (Ash and Smallman 2008) capable of giving a fine-grained account of the practices of the actors engaged in making disaster mitigation decisions at the Fukushima Daiichi plant. In so doing, it seeks to reveal the logic of individuals' actions within the NPP – both among the leadership and the workers – as well as outside of it; for example, in government or regulatory agencies, as these also affect organizational dynamics (Mannarelli, Roberts et al. 1996).

To this end, we have developed a multifaceted analytical framework inspired by the literature on tragic choices (Calabresi and Bobbitt 1978), which aims to distinguish three orders of determination at work in choices that deeply affect people's lives: institutional, organizational, and in the field. To understand how first-order determination occurred at the institutional and legal level, we investigated how the legal definition of acceptable circumstances for sending operators into a highly uncertain environment was established. We used the available data on the Fukushima Daiichi accident to identify the acceptable dose and threshold values defined for carrying out the very dangerous actions that took place there. To understand the second-order determination occurring at the organizational level – establishing *when* to intervene on the ground – we attempted to reconstruct the decision-making process actors used to determine when intervention was necessary in an uncertain radiological context. To understand the third-order determination that took place on the field level, in the process of selecting *who* was to intervene on the ground, we used the available data to identify the process by which workers were selected (and self-selected) to carry out dangerous and daunting tasks that were potentially detrimental to their health, or even life-threatening.

Data sources

Our analysis relied on materials from the field, including official documents and testimonies, which we examined for information about the self-sacrifice process established onsite on day two of the crisis. Among the five official reports published in English by the Japanese authorities, we focused on the two released just after the accident (between 2011 and 2012); in addition to technical data, they provide information on the process used to decide to send workers into a hostile environment. The first set of reports from the Investigation Committee on the Accident at the Fukushima Nuclear Power Stations (ICANPS), established by the Japanese Government and composed of ten members from academic and other fields, chaired by Yotaro Hatamura (professor emeritus at the University of Tokyo and professor at Kogakuin University). Their investigation to determine the causes of the accident led to the publication of two reports (an Interim Report in December 2011 and a Final Report in July 2012). The authors conducted interviews with 772 different subjects, including plant workers, government officials, and evacuees. The second report was from the Nuclear Accident Independent Investigation Commission (The National Diet of Japan 2012), which was created by an act of Parliament to investigate the Fukushima accident, and composed of government officials and scientific experts (a seismologist, a chemist, physicists). Well over a thousand interviews (including with plant workers, government officials, and evacuees) were drawn on in the writing of the report, which was published in July 2012. Since the core goal of the present article is narrow and specific – to reconstruct how the decision was made to send workers into a hostile environment, and in particular to vent the reactor – we focused on these two official reports because of the volume of testimony they included.

From among the many worker testimonies included in the two reports, we gave particular attention to the official interview with Masao Yoshida included in the ICANP's report. Yoshida died of cancer in 2012, and the testimony in the ICANP report is one of the most complete and detailed available (an unabridged version of it was later published in English (Asahi-Shimbun 2020) and French (Guarnieri, Travadel et al. 2015)).

Previous researchers have already pointed out that official reports such as these are not value-free (Renå and Christensen ; Travadel, Guarnieri et al. 2018). Different interpretations of the facts they present are of course possible. While these limitations are important to recognize, our analysis was based almost exclusively on the raw data they included; namely, the factual

chronology of actors' decisions. A far more important limitation is the fact that only the subjective perspective of the plant's director was available for us to gather (Guarnieri, Travadel et al. 2015): in these reports and elsewhere, there is little information on the subjective perspectives of the operators working in the plant (ICANP report 2012, appendix II – "Voice from the field").

The paper is presented in three stages, which correspond to the three orders of determination for tragic choices. We then close with a discussion of possibilities for the regulation of human self-sacrifice in uncertain situations in high-risk industries.

The case study of the self-sacrifice process

The selection of workers to intervene in a radioactive environment to mitigate a disaster can be considered as a "tragic choice" because of the direct impact it has on those workers' lives. These self-sacrifice of these workers is voluntary in some sense, while at the same time being undertaken at the behest and with the permission of organizational leadership. These are not two sides of the same ontological coin (Denny 2019): we shall see as we walk through the chronology of the accident that in the making of these decisions, several different rationalities were at work within different and non-intersecting orders of determination at the NPP: institutional, organizational and in the field.

1. The institutional order

Following the declaration of the State of Nuclear Emergency, an emergency response center (ERC) was set up at the Fukushima Daiichi Nuclear Power Plant in an anti-seismic building, as is required in such circumstances. It was headed by Site Superintendent Masao Yoshida and included multiple specialized teams (a recovery team, an operations team, an information team, a medical team, an engineering team). In the field, the Main Control Room (MCR) on which we focus in this article, was shared between Reactors 1 and 2 (Reactors 4, 5, and 6 were off-line at the time of the tsunami, and are therefore not discussed in this article). Inside the MCR, because of the blackout, operators scoured the emergency procedures and manuals with flashlights, searching for guidance on how to cool down the reactor. They sent out teams of two to assess the damage on the ground, but a few hours later, arriving at the double doors

of the reactor building, the teams found their dosimeters were vibrating: they had already reached the legal limit for radiation exposure.

At this time, some international organizations recommend that exposures of workers in emergency situations remain, whenever possible, below the values of the dose limits while recognizing that it is not always feasible (AIEA/BSS 115 (1997) ; Euratom/Dir 1996/29). A reference level of the order of 100 mSv is generally recommended for such situations, with the possibility to exceed this value (e.g. 500 mSv by AIEA/GSR Part 3 (2011-14) and CIPR 103 (2007)).

At Fukushima, the dose limit for workers was set at 100 mSv. This threshold was quickly exceeded in the disaster. On March 14, three days after the nuclear accident occurred and in coordination with the Nuclear and Industrial Safety Agency, the government raised temporarily the limit to 250 mSv. This criterion was withdrawn gradually from November 2011 to 2012.

The decision to regulate access in the field by changing the exposure limit value was problematic in two ways. First, these new guidelines were decided upon in the absence of any objective way of determining ahead of time the level of radiation that operators would encounter in such situations: it was impossible to really integrate exposure measurements into evaluations of estimated doses conducted before the start of each mission. Team members' protective equipment prevented them from checking their personal cumulative dosimeters until they had returned to the MCR, and in any case, only a few on-site monitoring systems remained functional following the tsunami. Most personal electronic dosimeters, along with the computer systems for activating and recording doses from these devices and many portable survey instruments were lost in the flooding. Workers shared personal dosimeters, a major factor affecting the reliability of any monitoring performed.

Second, the application of this decision could not really be perceived as a safety measure for those working in the field. In the words of the plant's manager, Yoshida, "The government's ceiling made it possible, in institutional terms, for workers nearing their dose limits to stay on the front lines a while longer. But the step did not make human bodies more resistant to radiation"(Asahi-Shimbun 2020 Chapter 3, section 1).

The new rules and procedures did not make sense to the field operators, which threatened to jeopardize group cohesion. However, operators succeeded in adapting to this uncertain context by cobbling together practical ways to manage their exposure on the ground. Whether they were maintaining the fire engines for water injection or laying cables to try and restore electrical power to the plant, the operators, in addition to wearing face masks and fireproof clothing, improvised ways to mitigate their exposure to risk. Most of these involved taking turns and limiting their time in the field. Instead of leaving or rotating in and out of the control room where they were stationed, they made tiny adjustments, sitting or crouching on the floor, or moving to the side of the room with the least radiation.

The case of Fukushima Daiichi was one in which the government's legal limit was necessarily somewhat arbitrary and difficult to apply to the concrete circumstances that arose – as mentioned above, there was no way for anyone to know how much radiation workers would encounter as they rushed to secure the plant. As Vaughan (Vaughan 1996) writes of NASA programs in the period leading up to the Challenger disaster: "work groups were calculating risk under circumstances that made risk fundamentally incalculable." Underlying the measurements and thresholds of this regulatory decision is a normative approach (Weick 2010) that defines criteria for risk acceptance in the radiological field (Vanem 2012).

At Fukushima, as in other disasters, the use of measures and thresholds to express a normative approach made it possible to break down the problems disaster workers faced into rational and objective elements (Manning 1989; Rosenbrock, Dubois-Arber et al. 2000), streamlining ethical quandaries and making risk seem manageable, helping those involved to keep going by creating an assumption that there would be no meaningful sacrifice of life (Orentlicher 2003).

2. The Organizational order

After the institutional order comes the organizational order. At the Fukushima site, this order was embodied mainly by the supervisor, who also helped to define the circumstances in which operators could be sent into a highly uncertain environment, particularly as it became more and more apparent that venting would be necessary, despite the efforts of the field operators.

In the end of the day of March 11, the high levels of radiation (288 mSv/h close to the entrance of the reactor building) suggested that the fuel might already be melting, while the high

pressure raised concerns about the integrity of the core and containment (ICANPS, p. 168). It was absolutely crucial to vent the reactor core before the pressure led to an explosion, damaging the containment building and releasing radioactive material into the atmosphere.

Normally, as noted in the opening paragraphs of this article, this would have been a simple matter of flicking switches on the control panel. Without electricity, however, it would be necessary to open and close valves by hand from within the reactor building, where radiation levels were already dangerously high (ICANPS Interim 2012 , p. 233). Various solutions were sought to avoid traveling to and entering the reactor building. Notably, operators tried to restore the electrical circuits that would enable the buttons in the control room to work again, but to no avail.

In the middle of the night of March 11, it seemed that the only possible solution was to open the valve manually. The decision to intervene was made by Yoshida, the site superintendent, who asked the shift team managers to prepare for it. The team itself was not responsible for the decision. Indeed, up until that point, although several missions had been organized nearby the reactor building, the team leader had ordered his team to stop intervening too close to it, because of the excessively high levels of radioactivity.

Later, in testimony recalling the event, Yoshida noted that from his protected position inside the anti-seismic building, he did not sufficiently grasp the scope of the operation: *"that is quite unnerving, but in reality, those who worked on the front lines had a much harder time than I did. Some of them, in fact, got doses of nearly 100msv there"* (Guarnieri, Travadel et al. 2015).

In the end, the allocation of necessary but dangerous and potentially lethal tasks was a decision of the organizational order. A threat to the safety of the few – in this case, a small team of workers – was accepted for the sake of the many – all those who would have been affected by a total meltdown and nuclear explosion. Here, a decision was made for the “common good” in application of what (Ersdal and Aven 2008) describe as the utilitarian principle, according to which people – and human life – become an instrument or means to save the health, and even the lives, of a great number of people.

Nevertheless, when the field operators arrived on the contaminated site to open the valve, the field mission was suspended due to excessively high levels of exposure. They then regrouped: three teams were defined in order to limit exposure time to 17 minutes. The first

team opened the valve by 25%, as planned. But the second team was forced to return before completing the mission: the radiation levels were too high for them to even reach the torus room (ICANPS interim 2012, p233).

Sacrifice reasoning has its limitations. Informed of the impossibility of entering the torus room, the ERC realized that it would be impossible to open the valve and begin venting manually, which delayed mitigation activities. They were forced to use an air compressor to open the valve from a distance (ICANPS Interim 2012). Since TEPCO did not have the compressor on site, the team had to look for one among the sub-contractors and in other nearby NPPs.

Two major problems may be noted within this order of determination. First, the option to sacrifice a few people to save a great number of lives was selected before all other options had been exhausted, in order to avoid the unnecessary exposure of workers. Second, the top management making the decision was unaware of the reality onsite. As Superintendent Yoshida explained in his testimony, *"we felt that if asked to vent, they would just have to open the valve for this to be done"* (Guarnieri, Travadel et al. 2015). From inside the seismic building, it was difficult for the superintendent – to say nothing of the Prime Minister's team – to grasp the full scope of the operation and the human risk involved.

3 - The field order

Going back to the beginning and observing events from the perspective of the operators in the MCR, late in the night of 11 March, once it had been determined by the organizational order that it was necessary to intervene on the ground, the feared instruction was passed on to prepare the second attempt at venting and select the teams to perform it.

It was at this point that third-order determination took place, among team leaders and their subordinates, who had to delegate people to undertake the dreaded task. Operators played a decisive role here, as they had to give their consent to participate. Even if risks are more acceptable when people consent to being exposed to them (Doorn 2015), the limitation of reason and freedom are clear: protagonists bear responsibility for situations they cannot fully understand, let alone control (van Domselaar 2017). The field operators in the MCR had not been prepared to engage in this kind of ethical reasoning. Nevertheless, they heeded their superintendent's request to prioritize the *"common good"* over individual safety: *"If we do not take action, Japan will fall into a serious situation. Could you still work on the sites, please?"*

(Kobayashi 2019). Applying the principle of the common good helped them to reach an ethical consensus, one that was never challenged by other actors.

Workers were acutely aware of the mission's perils, having already been forced to return early from the reactor building after their first attempt to vent, when the highly radioactive environment set off their dosimeter alarms. They knew that outside the MCR, and even within it, radiation levels were gradually rising. Some plant workers had likely already been exposed to radiation levels exceeding the emergency legal limit of 100 mSv. The atmosphere of danger was heightened by the alarms sounding across the site, which had been set off by debris from the earthquake.

In the MCR, Isawa, the shift team leader, asked for volunteers: *"I wanted to free myself from the pain of selecting them. I was not necessarily convinced by the request of my elders, but I finally submitted to it"*, he later explained (Kobayashi 2019). Isawa recalled that as he stood waiting to write down volunteers' names on a whiteboard, *"a relatively young operator raised his hand and my eyes welled up with tears"* (ICANPS Final 2012 Appendix II, p.173). He excluded the younger operators for health reasons. When no one else volunteered, Isawa announced he would go himself. His proposition demonstrated his solidarity with the group, as well as his courage in the face of terrible risk, but some of the operators asked him to stay in the MCR – they needed his leadership: *"a colleague said to me to 'stay here in command until the end!' I bowed my head. I was speechless. I couldn't help but feel guilty"* (ICANPS Final 2012 Appendix II, p.170).

At that point, some of the more senior operators began offering to go. In order of age, the names of older and more experienced operators were written on the whiteboard. Those who had already entered the reactor building would be last to return to it. They began pairing off in preparation to return to the venting mission.

Clearly, ethical principles were being applied here: some volunteered to carry out dangerous tasks for the "common good"; others ended up agreeing to cooperate. The testimony about the deliberations that took place in the MCR shows how different principles of local justice (Elster 1992) were tested out and deployed. First, the *egalitarian principle* was considered. This would have consisted of assigning equal chances of performing the task to all participants, by means of a lottery, for example. This was rejected, mostly because workers knew that there

is a latency period as long as several decades for the types of cancers that develop after exposure to low-dose ionizing radiation. This meant that elderly workers would be less likely to develop cancer in the course of their natural remaining lifespan. Operators therefore preferred to select teams using status-related principles based on biophysical and, more generally, social characteristics, with age as the main criterion.

The need for efficiency was also adopted as a principle, and the resulting procedure was a compromise between local efficiency and overall efficiency. Overall efficiency meant choosing the workers with the best chance of success in the shortest possible time. Local efficiency meant ensuring that the operational teams continued to function properly by maintaining the integrity of the existing leadership. They therefore compromised by selecting experienced personnel who were not leaders.

The *time principle* plays an important role in tragic choices (Jon and Nicolas 1992), and this situation was no different; however, figuring out how to apply it was unusually complicated. Taking timed turns at a dangerous but necessary task might be a relatively simple solution in some cases. In this one, the work that needed to be done was necessarily spread out over time. Because of the problems with dosimeters cited above, it was extremely difficult to assess exposure doses, and while operators attempted to calculate exposure in terms of time, rising radioactivity levels meant that the more time elapsed, the more dangerous the tasks became.

As we have seen, it was at the point of third-order determination that criteria used to assign responsibility for a tragic choice were actually adjusted to fit the concrete realities of the emergency situation. The principles that actors use to make tragic choices cannot all be deduced theoretically: while some will be formal (here, relating to socio-demographic criteria such as age or experience), others will be more contextual (here, for example, the factor of time and radiation exposure). Deliberation and decision-making are time consuming, which presumably made an already extremely stressful situation even more so; having guidelines ahead of time would have been helpful both to individuals and to the group as a whole – and it also presumably would have speeded up the task itself. Ultimately, they were able to make decentralization work to their advantage, as their distance from those higher up in the hierarchy gave them space to define new procedures and new reference points among themselves. Using a democratic process that engaged the entire group preserved the

legitimacy of their leadership on the ground, and helped to reinforce their group values and social structures.

Discussion

In high-risk industries, submission to authority and sacrifice for the common good do not always perfectly mesh. As the response to the Fukushima disaster unfolded, no one single rationality was at work in the process by which certain people engaged in self-sacrifice; instead, multiple rationalities emerged in the different orders of regulation.

It is only logical, therefore, to argue that we must move past the individual psychological or moral approach to sacrifice habitually taken by the literature. Particularly in high-risk industries, understanding decisions involving self-sacrifice requires a more complex and nuanced approach that takes into account the many processes and different orders of determination that produce these decisions. Furthermore, as our analysis of the Fukushima Daiichi case shows, different orders of determination do not merely support those engaged in making tragic choices. They also simultaneously obscure the tragic nature of these choices. In the following section, we will discuss the nature of this concealment, arguing that it creates a phenomenon we have called “normal blindness,” which, similar to Perrow’s “normal accident,” is a feature of the complex socio-technical systems and processes of regulation that characterize high-risk industries.

According to C. Perrow (Perrow 1984), high technological risk may be understood to exist in operations, infrastructures, or organizations characterized by *interactive complexity* and a *tightly coupled system* whose failure would lead to a catastrophe situation. From this definition, Perrow developed his Normal Accident Theory (Perrow 1984), which stated that certain systems are so complex and so tightly coupled that accidents become inevitable. We argue that because of tight coupling and interactive complexity, the socio-technical features of high-risk industries create “normal blindness,” in which the tragic aspects of the sacrifices required in catastrophes are masked with an exclusive focus on how operators will contribute to keeping the system functional. Just as C. Perrow (*Ibid*) sees accidents as inevitable in the

487 complex technical systems or high-risk industries, so, too, is the clouding of the processes
488 leading to self-sacrifice in the wake of such accidents.

489 Normalization of radiation exposure as a form of “normal blindness”

490 When tragic choices become necessary, the decision-making processes used to make them
491 often involve over-determined procedures and regimes of regulation, which, instead of
492 helping actors to deploy ethical principles and values, blinker them to these considerations
493 (Gisquet and Friedberg 2011), contributing to their “normal blindness.” The law, by
494 authorizing levels of radiation exposure that would be forbidden under ordinary
495 circumstances, helps to protect institutions against legal liability (Boin, T' Hart et al. 2009) and
496 to burnish their reputations (Roberts and Dowling 2002; Barton 2005; Coombs 2007) in the
497 wake of an accident.

498
499 At the same time, the use of measurements and threshold values to normalize radiation
500 exposure for workers in a radiological emergency makes it more acceptable – again,
501 theoretically – by transforming an invisible and intangible threat into a specific, known, and
502 therefore seemingly controllable risk (Manning 1989). This in turn makes it possible to skirt
503 around the ethical problems raised by sacrifice (Ersdal and Aven 2008).

504 In other words, this approach creates a form of “normal blindness” that helps shield both
505 workers and the general population from the tragic or frightening nature of the disaster at
506 hand. But as we have seen, this dose-based approach was of no use in regulating the tragic
507 choices to be made in the control room, because it was too distant from the reality in the field
508 (Elster 1992): measuring was not sufficient to account for the complex adjustments required
509 as the accident response unfolded .

510
511 Hazards related to complex socio-technical systems in emergency situations require
512 management and regulatory commitments that engender vulnerability (Egan 2011). While it
513 is clear that the dose-based approach used at Fukushima was insufficient to regulate the tragic
514 choices that were made there, it has not been called into question in the nuclear field. And
515 while the nuclear industry often laments the existence of restrictive regulations in its planned

and day-to-day operations (Levendis, Block et al. 2006), there appears to be strong agreement among governments and industry operators when it comes to strong regulations in emergency situations where radiological exposure must be managed and controlled. A highly normative approach to such situations renders radiological risk more socially acceptable, even though it does nothing to lessen the uncertainty of outcomes (Orentlicher 2003): it is far easier to justify life-and-death decisions in terms of rules and principles than in terms of sacrifice.

Accompanying nuclear industries with regard to their responsibilities in the realm of tragic choices does not necessarily mean producing legislative rules or guidelines; nor does it mean helping organizations to learn how to solve urgent problems more reflectively and adaptively (Starbuck 2015). Further regulating tragic choices, as the example of dose regulation shows, runs the risk of legitimizing or normalizing them (Slater 2006), and masking the ethical quandaries at their core. Instead, we must foster conditions under which it is possible for *all* those involved in tragic choices to confront them in the concrete contexts in which they unfold. One way to do this would be to establish guidelines for building narrative bridges (Gisquet 2020); that is, narrative techniques for the construction and management of time and space that allow actors to better apprehend their place in challenging circumstances, which can be powerful tools for fostering communication among the different orders of determination at work in highly complex emergency situations.

“Normal blindness” in tightly complex systems

The *interactive complexity* and *tight coupling* of a nuclear power plant are typical of systems in which normal accidents are likely to occur: any fail in a sequence or set of components could provoke a catastrophic failure, destroying the entire system and causing untold damage.

This type of *interactive complexity* in an organization obliges it to maintain the highest possible levels of organizational integration, both in analysis and in action (Schulman 1993). Its technical systems cannot be broken down into uncoupled components (Schulman 1996). In this context, it is easy to see humans working in an NPP as one of the many components in a complex system. This perspective helps to explain Yoshida’s inability to fully perceive the difficulty of the task he was asking the operators in the MCR. There were material reasons for this: he could not visualize the extremely challenging conditions on the ground and almost no communication was possible between the MCR and ERC because of heavy damage to the telephone lines from the earthquake and the tsunami. But there were organizational reasons,

as well. This inability to visualize conditions in the field may also be seen as resulting from the perception of humans as components of this technical system (who, moreover, cannot be uncoupled from the system). Seeing operators as components – and emphasizing quantifiable considerations such as doses and thresholds – means that the moral assessments required for them to take action are not perceived as problems of human ethics applied in highly uncertain conditions with unknown consequences (Vanem 2012).

A nuclear power plant is also a *tightly coupled system*, meaning that problems spread quickly from one component to another. Time was short at the Fukushima Daiichi site, and it made sense to select the fastest and easiest way to open the valve, which was to send a team to do it manually. To leaders outside the MCR, who were thinking in terms of the system's needs, sending a group of workers to open the valve was the obvious choice. Decisions relating to the sacrifice of human safety on the ground were thus indirectly reduced to utilitarian and even instrumentalist terms to act faster: human needs became subordinate to technical ones (Oughton 2011).

No narrative space built into this *tightly coupled system* could help to establish a robust account of what was really happening in the field. Here, again, a form of normal blindness was at play; the result was that considerations surrounding the tragic choices to be made were limited to dose levels and exposure times, rather than expanded to include the actual texture of reality on the ground. In the descriptions operators did sketch out for the organization, they had not been trained with the cognitive tools they would have needed to build narrative bridges (Gisquet 2020), to report the difficulties they were encountering as they tried to gain access to the places they needed to be on the ground (due to seismic aftershocks and tsunami warnings), or describe how they mentally followed the path they would walk to vent the plant before attempting it on the ground. Nor did operators report having to visualize the actions required to successfully open the valve manually before they actually carried them out. As a result, the rest of the organization was unable to "see" that the mission they were asking operators to undertake meant entering a flooded building very close to radiation sources.

When ethical quandaries are masked in this way, a question emerges: is the existence of "sacrificial practices" in high-risk industries evidence of a sacralization of technology? To the extent that they are, narrative is a powerful tool for revealing, interrogating, and even

combating this often-hidden trend. It is an invaluable tool for navigating group responses to seemingly insurmountable difficulty – and for preserving (Gisquet 2020). Without narrative, it is all too easy for groups and individuals to be dwarfed by the presence of huge and complex technology (Uekoetter 2012) and fall back into fatalistic worrying over a shapeless, indistinct, nocturnal totality (De Certeau 1984). Moreover, narrative can help to anticipate problems, by helping actors to project and imagine different actions and possible outcomes. Without it, the problems to which their actions might lead may only be discovered after the fact, when it is already too late (van Domselaar 2017).

“Normal blindness” in processes of self-sacrifice

"Normal blindness" played a part in the operators' sacrifices on the field, both because human actors were subordinating their needs to technological ones, *and* because their organization did not fully recognize this sacrifice before or after the event – and therefore could not support them through it.

First, under the circumstances of the Fukushima accident, the operators, working as subordinates to the technical imperatives of a tightly coupled system, might not have even considered that deferring to technical requirements is a form of sacrifice of human life. The need to overcome failures or dysfunctions in huge and complex nuclear technologies can blind actors to the sacrificial choices that must be made (Nussbaum 2001).

Today, looking back on the operators' accident response, we are able to perceive the force of “normal blindness” in the field. Certainly, the notion of subordination to the group, or to the technical system, is often disrupted by the possibility of death, which individualizes existence in a radical way (Kouba 2019). However, in the case of Fukushima the collective framework used by the operators in the MCR allowed them to accept their sacrifice without discussing the relevance of the order they had been given, without reporting the terrible conditions they were facing on the ground.

Second, the “normal blindness” we have seen at work in the field persisted after the accident, and affect how the accident response, and the self-sacrifice decisions, were perceived. In the aftermath of the Fukushima Daiichi accident, the non-controversial figure of Yoshida, the plant

leader was widely showcased – his capacity as a unifier, his ability to quickly and effectively take the lead (Martínez-Córcoles 2018). He was hailed unanimously as a courageous manager who had succeeded in rallying his teams and making difficult decisions, sometimes at odds with orders from the prime minister and his teams. TEPCO also hailed the director of the Fukushima Daiichi plant as a hero, praised for the courage, tenacity, and ingenuity he deployed to avoid catastrophe.

But very little attention was ever given to the uncomfortably tragic choices of the workers venting the reactor. The prime minister of Japan was fully aware that at the heart of the accident at Fukushima Daiichi was a little team of workers who had taken action despite the threat to their very lives. As mentioned in the opening of this article, by March 14, 2011, the term “suicide squad” had already appeared twice in the records of TEPCO’s teleconferencing system (Asahi-Shimbun 2020). And yet, in the wake of the accident, they were never treated as heroes. Their names, and that of their team leader, remain largely unknown to the greater public.

In literary narratives (Schulman 1996), two different hero figures are commonly identified: first, the hero who sticks with their assigned role, transcending it only over time (including the number of hours they work) and under duress, without ever overstepping the bounds of their authority. The second is the hero who sets themselves apart by undertaking individual risks or initiatives that fall outside the scope of their duties.

The figure of the hero in high-risk industries falls firmly into the first category, which does much to explain why the government, the TEPCO hierarchy, and the media were primed to perceive the Fukushima Daiichi and Fukushima Daiichi plant leaders as heroes, and to largely ignore or gloss over the “suicide squad.” While there is margin for different styles of behavior in high-risk industries (Mannarelli, Roberts et al. 1996), leaders are expected to carry out continuous monitoring and coordination (Thompson 1967) as part of their duties. If the small group of operators at Fukushima who risked everything to vent the reactors was not widely lionized, it is very likely because celebrating their heroic conduct would draw attention to their success in circumventing blueprints for actions and initiatives to be undertaken by individuals in case of disaster – which in turn would imply acknowledging organizational weakness and the failure of procedure in a normative world.

Not recognizing the processes at work in decisions relating to self-sacrifice contributes to the persistence of the phenomenon of “normal blindness” even after an accident has ended. This deprives high-risk industries of an invaluable opportunity to draw important ethical lessons from accidents such as the one at Fukushima, so that they are better prepared for similar situations in the future.

As this case study has shown, even in contexts where the idea of sacrificing their own lives or well-being to the common good is acceptable to workers, they still need ethical criteria to justify the choice to die (Cooley 2015), or at least to identify a link between individual sacrifice and the common good. Workers must seek criteria for rationalizations that are distinct from the goal of operational reliability laid down by the organizational order.

Up until now, the existing literature has limited itself to showing the crucial role of organization and leadership in altruistic sacrifice in individual terms, or in terms relating to the values expressed by an organization or group as a whole. While this may be highly pertinent in the military or the field of professional rescue work (Pardess 2005), things change when it comes to people volunteering to accept hazardous missions in which they may need to be willing to risk their lives in order to save others (Ash and Smallman 2008). In all such circumstances, the role of organizations and leadership are central: the ethical ‘tone at the top’ (Treviño, Brown et al. 2003), in which leaders’ moral qualities establish the ethical context of action (Treviño, Butterfield et al. 1998; Loviscky, Treviño et al. 2007), the ethical climate (Victor and Cullen 1988), or the ethical culture (Trevino and Youngblood 1990).

However, the ethical ‘tone at the top’ refers only to the characteristics of organizations as a whole (Brown and Treviño 2006), which are not enough to guide – or explain – the nitty-gritty of decisions on the ground, particularly those relating to self-sacrifice. Indeed, in our case, the ‘tone at the top’ was, for all intents and purposes, nearly inaudible to workers on the ground, and vice versa. While the first two orders of determination – institutional and organizational – did help to make it possible to act in a situation of uncertainty, they did not support the process of selection that operators faced at the third order of determination, in the field.

On the ground, an ethical selection process had to be set up in complete isolation from the rest of the organization. Front-line operators improvised using dynamic problem solving and the reconfiguration of available recourses to come up with a solution of last resort to prevent total system failure (Meshkati and Khashe 2015). No one has ever reflected on this system of local justice set up at the field level during the Fukushima Daiichi accident with the goal of identifying lessons that might be learned from it. It has not been examined for what it might teach us about self-sacrifice in high-risk industries – or about mitigating the phenomenon of “normal blindness” in such situations.

Conclusion

Lakoff has described the emergence of a “*preparedness*” paradigm in Western societies. At stake here is not the question of whether we need to be prepared, but of *how* to prepare for risk, and *what* we need to prepare for, even if the definition of this word is not entirely clear (Staupe-Delgado and Kruke 2018; Borraz and Gisquet 2019) : “*Preparedness calls for both an ethos and a set of techniques for reflecting about intervening in an uncertain, potentially catastrophic future*” (Lakoff 2007).

In terms of preparation, the case of Fukushima teaches us that it is ultimately impossible to hide behind rules and measurements: attempting to do so merely forces ethical quandaries down the chain of command. In the end, it was the plant’s operators who were forced to make tragic decisions on their own, in the field. It is clear that we need to collectively reflect on ethical issues that might emerge in such situations: preparedness means thinking about ethics beforehand, and discussing with others all the way up – and down – the chain of command. While many of us are reluctant to discuss these issues – the same reservations emerge as in discussions of end-of-life choices or organ donation (Gisquet and Friedberg 2011) – it is essential to consider tragic choices if we are to be properly prepared for them. We must be better equipped to face ethical quandaries when they arise in emergency situations in high risk industries – to identify potential areas of “normal blindness” at all levels and to build narrative spaces that help us to combat it.

While defining acceptable circumstances for sending operators into highly uncertain environments is a question that risk ethics cannot ignore, the nuclear industry seems unwilling

to address it. The value of ethics as a field of reflection has been recognized in engineering education (Guntzburger, Pauchant et al. 2017), but only certain aspects of it are taken into account in considerations of decision-making processes or risk assessment (Guntzburger, Pauchant et al. 2017). Nuclear engineers and workers are not trained in issues relating to tragic choice.

And yet, tragic choices become unavoidable in crisis situations where dangerous but necessary tasks must be carried out. In such contexts, how to decide? How to affirm or sanction the sacrifice of human life a decision may entail? In another context, questioning the regulation of acts of torture in times of war, Slater (Slater 2006) raised the question of whether an effort to seriously regulate and control torture could trivialize it or even legitimize it. He framed the question as a dilemma: either we morally refuse this practice, or we accept the practice as inevitable, thus tacitly consenting to legal deviations from the rule by acknowledging that negotiations and adjustments will inevitably take place in the context of war. With this dilemma in mind, it is worth reconsidering the relevance of regulating acts of sacrifice in the context of nuclear emergency, not necessarily with more rules and measures, but with cognitive and communication tools that, by providing more humane and nuanced approaches to disaster, help to lift the “normal blindness” that keeps emergency response teams navigating in the dark.

Data Availability statement

All data, models, and code generated or used during the study appear in the submitted article.

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