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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

19 In our society, industrial and technical developments designed to protect human well-being
20 have created critical infrastructures that open the door to new vulnerabilities and new
21 dangers (Beck 1992). Governments and industries must demonstrate that they are in control
22 of these risks (Borraz and Cabane 2017; Gisquet 2020). High-risk industries are expected to
23 operate more or less error-free over long periods of time by consistently making good
24 decisions that result in strong quality and reliability (La Porte 1996). This often results in the
25 widespread perception that risk control in these industries is sufficient to make disaster highly
26 unlikely; however, the Fukushima Daiichi accident of 11 March 2011 is a tragic reminder that
27 nuclear energy production has never been and never will be a risk-free undertaking (Uekoetter
28 2012).

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

42

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

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

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

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

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

68

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

Literature Review

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

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

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

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

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

99

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

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

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

117

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

127

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

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

139

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

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

Tragic choices

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

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

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

180

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

192

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

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

Method

Theoretical framework

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

208
209 To this end, we have developed a multifaceted analytical framework inspired by the literature
210 on tragic choices (Calabresi and Bobbitt 1978), which aims to distinguish three orders of
211 determination at work in choices that deeply affect people's lives: institutional, organizational,
212 and in the field. To understand how first-order determination occurred at the institutional and
213 legal level, we investigated how the legal definition of acceptable circumstances for sending
214 operators into a highly uncertain environment was established. We used the available data on
215 the Fukushima Daiichi accident to identify the acceptable dose and threshold values defined
216 for carrying out the very dangerous actions that took place there. To understand the second-
217 order determination occurring at the organizational level – establishing *when* to intervene on
218 the ground – we attempted to reconstruct the decision-making process actors used to
219 determine when intervention was necessary in an uncertain radiological context. To
220 understand the third-order determination that took place on the field level, in the process of
221 selecting *who* was to intervene on the ground, we used the available data to identify the
222 process by which workers were selected (and self-selected) to carry out dangerous and
223 daunting tasks that were potentially detrimental to their health, or even life-threatening.

Data sources

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

245 From among the many worker testimonies included in the two reports, we gave particular
246 attention to the official interview with Masao Yoshida included in the ICANP's report. Yoshida
247 died of cancer in 2012, and the testimony in the ICANP report is one of the most complete and
248 detailed available (an unabridged version of it was later published in English (Asahi-Shimbun
249 2020) and French (Guarnieri, Travadel et al. 2015).

250

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

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

260

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

The case study of the self-sacrifice process

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

1. The institutional order

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

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

284 At this time, some international organizations recommend that exposures of workers in
285 emergency situations remain, whenever possible, below the values of the dose limits while
286 recognizing that it is not always feasible (AIEA/BSS 115 (1997) ; Euratom/Dir 1996/29). A
287 reference level of the order of 100 mSv is generally recommended for such situations, with
288 the possibility to exceed this value (e.g. 500 mSv by AIEA/GSR Part 3 (2011-14) and CIPR 103
289 (2007)).

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

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

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

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

320 The case of Fukushima Daiichi was one in which the government's legal limit was necessarily
321 somewhat arbitrary and difficult to apply to the concrete circumstances that arose – as
322 mentioned above, there was no way for anyone to know how much radiation workers would
323 encounter as they rushed to secure the plant. As Vaughan (Vaughan 1996) writes of NASA
324 programs in the period leading up to the Challenger disaster: "work groups were calculating
325 risk under circumstances that made risk fundamentally incalculable." Underlying the
326 measurements and thresholds of this regulatory decision is a normative approach (Weick
327 2010) that defines criteria for risk acceptance in the radiological field (Vanem 2012).

328 At Fukushima, as in other disasters, the use of measures and thresholds to express a normative
329 approach made it possible to break down the problems disaster workers faced into rational
330 and objective elements (Manning 1989; Rosenbrock, Dubois-Arber et al. 2000), streamlining
331 ethical quandaries and making risk seem manageable, helping those involved to keep going
332 by creating an assumption that there would be no meaningful sacrifice of life (Orentlicher
333 2003).

2. The Organizational order

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

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

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

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

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

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

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

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

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

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

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

3 - The field order

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

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

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

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

408 In the MCR, Isawa, the shift team leader, asked for volunteers: "*I wanted to free myself from*
409 *the pain of selecting them. I was not necessarily convinced by the request of my elders, but I*
410 *finally submitted to it*", he later explained (Kobayashi 2019). Isawa recalled that as he stood
411 waiting to write down volunteers' names on a whiteboard, "*a relatively young operator raised*
412 *his hand and my eyes welled up with tears*" (ICANPS Final 2012 Appendix II, p.173). He
413 excluded the younger operators for health reasons. When no one else volunteered, Isawa
414 announced he would go himself. His proposition demonstrated his solidarity with the group,
415 as well as his courage in the face of terrible risk, but some of the operators asked him to stay
416 in the MCR – they needed his leadership: "*a colleague said to me to 'stay here in command*
417 *until the end!' I bowed my head. I was speechless. I couldn't help but feel guilty*" (ICANPS Final
418 2012 Appendix II, p.170).

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

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

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

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

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

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

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

Discussion

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

465
466 It is only logical, therefore, to argue that we must move past the individual psychological or
467 moral approach to sacrifice habitually taken by the literature. Particularly in high-risk
468 industries, understanding decisions involving self-sacrifice requires a more complex and
469 nuanced approach that takes into account the many processes and different orders of
470 determination that produce these decisions. Furthermore, as our analysis of the Fukushima
471 Daiichi case shows, different orders of determination do not merely support those engaged in
472 making tragic choices. They also simultaneously obscure the tragic nature of these choices. In
473 the following section, we will discuss the nature of this concealment, arguing that it creates a
474 phenomenon we have called “normal blindness,” which, similar to Perrow’s “normal
475 accident,” is a feature of the complex socio-technical systems and processes of regulation that
476 characterize high-risk industries.

477
478 According to C. Perrow (Perrow 1984), high technological risk may be understood to exist in
479 operations, infrastructures, or organizations characterized by *interactive complexity* and a
480 *tightly coupled system* whose failure would lead to a catastrophe situation. From this
481 definition, Perrow developed his Normal Accident Theory (Perrow 1984), which stated that
482 certain systems are so complex and so tightly coupled that accidents become inevitable. We
483 argue that because of tight coupling and interactive complexity, the socio-technical features
484 of high-risk industries create “normal blindness,” in which the tragic aspects of the sacrifices
485 required in catastrophes are masked with an exclusive focus on how operators will contribute
486 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

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

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

“Normal blindness” in tightly complex systems

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

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

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

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

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

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

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

“Normal blindness” in processes of self-sacrifice

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

588

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

594

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

602

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

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

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

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

625

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

637

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

643

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

649

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

660

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

668

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

Conclusion

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

683
684 In terms of preparation, the case of Fukushima teaches us that it is ultimately impossible to
685 hide behind rules and measurements: attempting to do so merely forces ethical quandaries
686 down the chain of command. In the end, it was the plant's operators who were forced to make
687 tragic decisions on their own, in the field. It is clear that we need to collectively reflect on
688 ethical issues that might emerge in such situations: preparedness means thinking about ethics
689 beforehand, and discussing with others all the way up – and down – the chain of command.
690 While many of us are reluctant to discuss these issues – the same reservations emerge as in
691 discussions of end-of-life choices or organ donation (Gisquet and Friedberg 2011) – it is
692 essential to consider tragic choices if we are to be properly prepared for them. We must be
693 better equipped to face ethical quandaries when they arise in emergency situations in high
694 risk industries – to identify potential areas of “normal blindness” at all levels and to build
695 narrative spaces that help us to combat it.

696
697 While defining acceptable circumstances for sending operators into highly uncertain
698 environments is a question that risk ethics cannot ignore, the nuclear industry seems unwilling

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

704

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

718

Data Availability statement

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

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