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Anticipatory governance and moral imagination: Methodological insights from a scenario-based public deliberation study

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ABSTRACT

The fields of Responsible Research and Innovation (RRI) and participatory foresight seek to establish, and to include publics within, anticipatory governance mechanisms. While scenario-based methods can bring to the publics' attention the ethical challenges associated to existing technologies, there has been little empirical research examining how, in practice, prospective public deliberative processes should be organized to inform anticipatory governance. The goal of this article is to generate methodological insights into the way such methods can stimulate the public's moral imagination regarding what may (or may not) happen in the future and what should (or should not) happen in the future. Our qualitative analyses draw on a public deliberation study that included videos and online scenarios to support participants' ($n = 57$) deliberations about fictional interventions for genetically at-risk individuals. Our findings clarify how participants: (1) challenged key elements of our scenarios; (2) extended several of their technical and moral prospects; (3) engaged personally with others, including our scenarios' characters; and (4) mobilized the past creatively to reason about the future. Our methodology enabled participants to creatively and empathetically envision complex sociotechnical futures. Yet, important methodological limits should be acknowledged by those who design, implement and use public engagement methods to inform anticipatory governance.

1. Introduction

—“It is the human capacity to learn rather than know which so impressed Dewey.” (Alexander, 1993)

Responsible Research and Innovation (RRI) (Sutcliffe, 2011; Zimmer-Merkle and Fleischer, 2017; Stahl et al., 2014; Stilgoe et al., 2013; Van Oudheusden, 2014) shares important affinities with participatory foresight (Kaivo-oja, 2017; Bourgeois et al., 2017; [; Low, 2017] since both fields of research seek to implement future-oriented, anticipatory forms of governance to orient innovations towards certain public goods or to mitigate the risks of innovation (Williams-Jones et al., 2013). Anticipatory governance refers to “a broad-based capacity extended through society that can act on a variety of inputs” in order to manage emerging technologies while it is still possible to realign their development (Guston, 2014). Members of the public, who give warrant to the development of innovations as citizens and

taxpayers and who may be exposed to their benefits and risks as users, are an important constituency in RRI, representing one of the stakeholder groups whose participation should be sought and facilitated (Arentshorst et al., 2016; Stilgoe et al., 2014). Similarly, participatory foresight activities seek to include civil society in the negotiation of a “more fruitful” social contract around technoscientific advances (Kaivo-oja, 2017).

Knowing how to design rigorous public engagement methods to inform anticipatory governance is important because many countries are struggling with the pace at which innovations are being developed and imparted to policymakers and citizens (Van Oudheusden, 2014; Fuerth, 2009; Heidingsfelder et al., 2015; Grunwald, 2014). Yet, little empirical research has examined how, in practice, prospective public deliberative processes should be organized to inform anticipatory governance (Bourgeois et al., 2017; Heidingsfelder et al., 2015). Current research suggests that scenario-based methods can bring to participants' attention the ethical dilemmas or challenges raised by existing

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technologies, but envisioning novel sociotechnical futures is not straightforward (Racine et al., 2014; Adam et al., 2011; Grunwald, 2012). Two key problems arise when one seeks to operationalize public engagement methods to inform anticipatory governance. First, because lay publics may “struggle to visualize” the tangible effects of innovations that are still at the stage of “blue-sky” research, these methods have to “make visible” technical options that may be hard to grasp and that may (or may not) materialize in the future (Davies and Selin, 2012). Second, these methods have to support participants’ ability to envision creative ways of governing innovation and ponder, from a moral standpoint, what should (or should not) happen in the future (Coeckelbergh, 2016; Boenink et al., 2010; Stemerding et al., 2010). Hence, the goal of this paper is to provide methodological insights into the way that scenario-based methods can stimulate the moral imagination of the publics, that is, their ability to creatively and empathetically envision problems as well as potential solutions to sociotechnical issues (Alexander, 1993; Karakas et al., 2017; Johnson, 1985; Johnson, 1994; Ryazanov et al., 2018).

Section 1 introduces the theoretical background to our study. Section 2 describes our qualitative study design, which included videos and scenarios to support face-to-face and online public deliberations on fictional interventions for genetically at-risk individuals. Section 3 presents participants’ reactions to two scenarios, which projected that by 2030 the use of genetic testing to recruit new staff and manage occupational health issues would be spreading and that by 2040 certain employers would use genetics to increase the fit between an employee’s genetic assets and assigned work tasks. These findings show how participants: (1) challenged key elements of these scenarios; (2) extended several of their technical and moral prospects; (3) engaged personally with implicated others, including our scenarios’ characters; and (4) mobilized the past creatively to reason about the future. While our methodology enabled participants to creatively and empathetically envision complex sociotechnical futures, Section 4 argues that important methodological limits to fostering moral imagination need to be acknowledged by those who design and implement public engagement methods to inform anticipatory governance.

Since few public engagement studies have used videos and online scenarios to support prospective deliberations, this study’s contribution to current knowledge is threefold. First, it provides novel empirical insights into the way such multimedia-based methodology stimulates public deliberations about fictional innovations. Second, it richly illustrates how participants can exercise their moral imagination by connecting ethical dilemmas of the past, present and future, by relating to the individuals implicated in these dilemmas and by envisioning plausible solutions. Third, while our study confirms that scenario-based methods like ours can productively inform the kind of anticipatory governance that RRI and participatory foresight seek to articulate, it also highlights caveats that scholars and practitioners should seek to avoid.

1.1. Anticipatory governance as a capacity building process that includes publics

While the notion that public authorities should rely on some form of anticipatory governance is not new, in the past decade it acquired a particular resonance in innovation policies (Van Oudheusden, 2014; Fuerth, 2009) and in the RRI scholarship stressing the need for anticipatory approaches (Genus and Stirling, 2018). For Sutcliffe, RRI “is about trying to get better at anticipating problems” and creating “flexible and adaptive systems” to deal with the unintended social, ethical and environmental consequences of innovation (Sutcliffe, 2011). RRI invites “individual scientists and research groups to be more reflective in the design and execution of research” (Boenink, 2016), but also acknowledges that significant responsibilities fall outside the scientific domain. Because the private sector, governments, the media and civil society “co-shape the world” in which

scientists and their partners develop innovations, they necessarily share responsibility (Boenink, 2016). RRI thus calls for a careful consideration of the multiple loci of decisions that affect innovations throughout their lifecycle, from initial funding to safe disposal.

The literature on RRI has grown rapidly in the past decade (Timmermans, 2017). Academics more closely examined how the RRI discourse may be adapted to the business sector (Lubberink et al., 2017; Dreyer et al., 2017; Martinuzzi et al., 2018; Lubberink et al., 2017), may support sustainable development goals (Lehoux et al., 2018), may inform the development of socially responsible nanotechnologies (Guston, 2014), robots and information technology systems (Stahl et al., 2014; Chatfield et al., 2017) and synthetic biology applications (Grunwald, 2012; Ribeiro and Shapira, 2018; Stemerding et al., 2018), and may steer the development of health technologies towards increased equity both within and across countries (Batayeh et al., 2018; Silva et al., 2018; Auer and Jarmai, 2017; Demers-Payette et al., 2016). This growing literature also engaged critically with the assumptions (Mertens, 2018; van de Poel and Sand, 2018; Timmermans and Blok, 2018) and conceptual limitations of RRI (Genus and Stirling, 2018; Kerr et al., 2018; von Schomberg and Blok, 2018; Blok and Lemmens, 2015) and underscored its “institutional ambiguity” (Pandza and Ellwood, 2013) as well as the paucity of empirical research going beyond single case studies (Mertens, 2018; de Hoop et al., 2016). For Martinuzzi and colleagues, the “institutional context that sets incentives and boundaries for action, not only including regulation and legislation, but also customs and culture” need to be better understood because they shape the way RRI is perceived and implemented (Martinuzzi et al., 2018). These authors thus call for further research on the organizational cultures, governance structures and regulatory frameworks that affect the embedding of responsibility into practice, which necessarily includes the industry.

On their part, Genus and Stirling urge RRI scholars to revisit the research of David Collingridge, whose work from the late-1970s to the early-1990s was “concerned with increasing social agency over technology – away from incumbent interests in what have come to be called ‘innovation systems’” (Genus and Stirling, 2018). For these authors, there is a need to develop “more concrete and assertive frameworks for enabling practice of critical citizen engagement and participatory deliberation.” RRI research and practice should also foster “processes and discourses that illuminate, rather than suppress, contention among specialists and wider societal interests” (Genus and Stirling, 2018). This entails an active recognition of the fact that responsibility lies not in establishing weak forms of consensus, but in articulating points of contention and divergent interests (de Hoop et al., 2016). Considering that businesses “primarily involve stakeholders who share similar values or stakeholders who are motivated to align their interests with the shared objective of the innovation” (Lubberink et al., 2017), the RRI principles of inclusion, openness and responsiveness are likely to fall short when conflicting value systems are at play (Ribeiro et al., 2018). This may explain why Genus and Stirling stress that RRI approaches need to grapple with the notion that the governance of innovation is “fundamentally about ‘muddling through’ in the presence of steep power gradients and strongly asserted interests.” (Genus and Stirling, 2018)

One may indeed find useful guidance in the literature that more specifically focuses on the challenges of collaborative governance (Ribeiro and Shapira, 2018; Stemerding et al., 2018). Governance usually refers to the “rules and forms that guide collective decision-making” regarding the provision of public goods, the design and implementation of public policies and the management of public programs and assets (Ansell and Gash, 2008). For Ansell and Gash, collaborative governance is a particular type of governance in which “public and private actors work collectively in distinctive ways, using particular processes, to establish laws and rules for the provision of public goods” (Ansell and Gash, 2008). For these scholars, such a collective decision-making process should be understood as a formal, consensus-oriented

deliberative process. Nonetheless, many of the policy challenges raised by innovations consist of “cascading sequences of events that cannot be concretely predicted” because of the way technical, societal, economic and environmental issues interact (Low, 2017). This is one of the reasons why it is necessary to bring ‘anticipation’ and ‘governance’ together “rather than rely on the correct but incomplete supposition that all governing activities must have some disposition toward the future, whether it be predictive, precautionary, deterministic, or some other normative orientation” (Guston, 2014).

Unsurprisingly, the kinds of knowledge that should inform anticipatory governance are a matter of debate. As Zimmer-Merkle and Fleischer note, the “epistemic status” of anticipatory knowledge is controversial, yet such knowledge remains indispensable to decision-making:

On one hand, this knowledge is perceived by many observers as an inextricable mixture of fact, analogy, surmise, speculation, and outright fantasy – it is even contested whether this information should or may be considered as ‘knowledge’ in the first place. On the other hand, governments, parliaments, civil society organizations, and the general public find anticipatory knowledge to be indispensable for many purposes, such as providing guidance and support for political action, coordinating innovation actors across different societal spheres, and building trust in the outcomes and the quality of decision-making processes (Zimmer-Merkle and Fleischer, 2017).

Davies and Selin suggest that scenario-building and “futuring” can inform anticipatory governance, but should support “a fully integrated approach to technological development,” one that builds on the natural sciences as well as the social sciences (Davies and Selin, 2012). An interdisciplinary approach would help to reduce the problems raised by scenarios developed by a small group of experts, which are “subject to implicit, ambiguous assumptions about the shape of future developments, and to the biases that accompany the expertise of their proponents” (Low, 2017). Lehoux and colleagues underscore the importance of deliberative mechanisms that support mutual learning processes between experts and non-experts by exploring what these individuals know about a given innovation and what they value (Lehoux et al., 2009). For Pratt and colleagues, to enhance the social knowledge base used in policymaking, the participation of minority and disadvantaged social groups should be explicitly supported in order to pool the knowledge of “differently situated actors” (Pratt et al., 2016).

Since the goal of anticipatory governance is to implement a capacity building process wherein challenges that are unknown can be confronted and integrated into innovation governance, Guston argues that practice is central to anticipatory governance (Guston, 2014). Similarly, Bourgeois and colleagues underscore that a “mode 2 foresight” would not only be more inclusive, but also more emancipatory, that is, capable of bringing fundamental changes to existing technoscientific arrangements by instilling new, bottom-up transition paths. Rather than limiting foresight to its sequentialist dimension, these authors argue in favor of consolidating its emancipatory dimension; participatory foresight should be operationalized as a means to overcome “lock-ins” that keep the future “into a path dependent trajectory” and deprive non-experts of the capacity to engage in shaping the “future they want” (Bourgeois et al., 2017).

To summarize, the literature emphasizes the need to articulate the anticipatory nature of governance (Guston, 2014; Ribeiro and Shapira, 2018; Stemerding et al., 2018) and to engage a broad set of stakeholders, including non-experts (Arentshorst et al., 2016; Stilgoe et al., 2014; Lehoux et al., 2009; Aitken et al., 2016; Dijkstra and Schuijff, 2016), into productive, accountable and emancipatory innovation policymaking processes (Fuerth, 2009; Grunwald, 2014; Genus and Stirling, 2018).

1.2. Scenario-based methods and moral imagination

Research on scenario-based methods, which spans many disciplinary fields, ranging from product design to moral reasoning (Low, 2017; Ryazanov et al., 2018; Lehoux et al., 2016), suggests that such methods could support the capacity building processes called for in anticipatory governance. Scenarios are typically created by experts to explore, challenge and refine prototypes, models or policy options. Such scenarios may, however, be presented at a high level of abstraction, and so ignore the “lived-in daily experience of human interaction with technology” (Stahl et al., 2014). For Boenink and colleagues, while non-experts should be encouraged to use their experiential knowledge to reflect prospectively, their “imagination of the future may need enhancement” (Boenink et al., 2018). Indeed, experts’ scenarios often portray broad environmental, economic and social trends without considering the human understanding derived from living with a particular technology (Stahl et al., 2014).

This limitation speaks to one of the two challenges we evoked earlier. Practitioners of RRI and participatory foresight need public engagement methods that can make as tangible as possible the future context of use of innovations whose shape, form and functionalities are often still ill-defined (Arentshorst et al., 2016; Aitken et al., 2016; Dijkstra and Schuijff, 2016; Felt et al., 2014). Equally important is to adequately foreground current technoscientific arrangements that are, but perhaps should not be, “taken for granted” (Davies and Selin, 2012). Engagement methods should thus enable members of the public to fully ponder what may/may not technically happen in the future while fostering their reflections about what is/is not part of the present and why.

The second challenge is to devise methods that can stimulate the public’s ability to envision novel morally challenging situations, that is, situations where established ways of defining what a good or virtuous world should look like may not fit anymore (Stahl et al., 2014; Boenink et al., 2010; Karakas et al., 2017). It is indeed easier to be taken aback by how practices that are reprehensible today were considered legitimate in the past (e.g., human slavery) than to anticipate whether and how practices that are currently seen as morally acceptable may become unacceptable in the future. This emphasizes the need for methods that can push participants to articulate what should/should not happen in the future while remaining reflective about what is/is not acceptable in the present.

These two challenges suggest that anticipatory governance should be informed by methods that encourage the public to ponder whether and how innovations and moral principles interact and iteratively shape each other over time (Stemerding et al., 2010; Stemerding et al., 2018; Stahl and Coeckelbergh, 2016). From this evolutionary perspective, current moral values affect, on the one hand, the ways in which innovations may become embedded in society and certain innovations may challenge, on the other hand, current views about what the “public good” is or what “ethically acceptable” means (Boenink, 2016).

This is where the concept of moral imagination and “works of imagination” (e.g., vignettes, short stories, comics, etc.), which have long been used in bioethics and the medical humanities (Alexander, 1993; Ziv et al., 2003; Chambers, 2015; Davis, 1997), can improve our ability to address the methodological challenges introduced above. For pragmatist philosophers like Dewey, the “capacity to understand the actual in light of the possible” calls upon imagination, which entails “a creative exploration of structures inherited from past experience” and posits “the future as a horizon of possible actions” (Alexander, 1993). From this perspective, moral deliberation does not simply involve the immediate application of principles to a situation, assuming that known, fixed outcomes will result (Johnson, 1994). Rather, it requires creative judgment and entails comparing and combining various representations of the world (Johnson, 1985). More specifically, when deliberating upon a particular prospective situation, individuals: (1) “organize various details and select out some as more

significant than others”; (2) seek to identify the rules and values that are relevant to the situation; (3) “imaginatively weigh similarities and differences” between the scenario being proposed and other more or less similar situations where existing rules were applicable; and (4) tailor these previously experienced moral rules to the novel situation as they grasp it “here and now” (Johnson, 1985). When short stories, photographs or videos are integrated into scenario-based methods (Stahl et al., 2014; Davies and Selin, 2012), the concept of moral imagination also brings to the fore a fundamental human ability, that is, to empathetically relate with others. Moral imagination enables one to imaginatively develop “bonds with people over space and time” and to envision the “possibility of connecting to other people in a different way” (Karakas et al., 2017). This imaginative activity aims to discern what is morally relevant by seeking to understand empathetically how others may experience a situation (Coeckelbergh, 2006).

Hence, the concept of moral imagination recognizes that individuals may connect past, present and future ethical dilemmas creatively and selectively. It also draws our attention to the way individuals relate (empathetically or not) to those involved in a prospective scenario or others seen as being implicated in a given ethically challenging situation.

Because little empirical research has examined how public deliberative processes should be organized to inform anticipatory governance, this paper aims to generate insights into the way the public's moral imagination is stimulated, in practice, by scenario-based methods that seek to overcome the two challenges described above by illustrating how technical and moral dimensions may interact in a prospective context of use and influence each other over time. Such methodological insights are particularly important to RRI and participatory foresight, two distinct fields of policy-oriented research that aspire to include civil society in the steering of innovations towards the common good.

2. Methods

2.1. Study design

Our study was inspired by the prospective scenario-based approach of Boenink and colleagues (Boenink et al., 2010). Following their methods, and with the help of a literature review and our expert committee (see Acknowledgements), we “invented” three fictional innovations to explore issues that affect publics of different age groups: (1) a “smart” sweater to support cognitive and behavioral enhancement in teenagers; (2) an implantable cardiac “rectifier” for genetically at-risk adults; and (3) an assistive robot for the elderly. We created three videos (3 min.) to describe how each fictional innovation “worked” and the future context of its use and two scenarios for each innovation. Our deliberative study entailed a face-to-face component consisting of four workshops, followed by an asynchronous online forum to discuss the scenarios.

To fulfill the aim of this paper, we have chosen to focus our analyses on the participants' online reactions to the two scenarios related to the second innovation (for genetically at-risk adults). Since the online deliberations facilitated introspection (Felt et al., 2014) and allowed ample time for participants to read, reflect upon and respond to the scenarios, their content constitutes rich empirical material that can be analyzed in detail to explore the ways in which our scenarios stimulated (or not) participants' moral imagination.

2.2. Participants and data collection

To constitute a purposive sample of young adults (18–25 years), adults (30–55) and people over 60, multiple recruitment strategies were deployed in parallel and carried out through associations that organize cultural, professional, educational or sporting activities for these target groups. These associations shared our invitation with their members

Table 1
Characteristics of the participants.

		n	%
Age	18 - 29	9	20%
	30 - 39	6	13%
	40 - 49	3	7%
	50 - 59	7	15%
	60 - 69	17	37%
	> 70	4	8%
Gender	Women	33	72%
	Men	13	28%
Education	High school	4	9%
	Collegial	5	11%
	University	37	80%
Household income	< CDN\$20,000	4	9%
	\$20,000 to \$39,999	9	19%
	\$40,000 to \$59,999	17	37%
	> \$60,000	16	35%

Note: Forty-six participants completed the demographic survey.

(via posters, e-bulletins, websites, social media, etc.) and those interested were invited to contact us by e-mail or phone. Using occupation and hobbies as diversification criteria, four groups were assembled for the workshops (3.5 h). A total of 38 individuals participated in the workshops and were invited to join twenty-five additional participants on the forum; 32 accepted, hence a total of 57 individuals contributed to the forum. Participant characteristics are presented in Table 1.

The four workshops and the forum were facilitated by the same professional moderator. After the last workshop took place, the forum was hosted on a login/password-secured blog platform (WordPress®). Participants were invited to watch the video, read the scenarios, react to prompts and comment on each other's responses over a 5-week period. All comments ($n = 355$) were downloaded from the platform and integrated into our database. A total of 106 comments referred to the scenarios we analyze in this paper.

2.3. The online scenarios

The two online scenarios were developed to explore the ethical tensions associated with predictive medicine for genetically at-risk adults and the use of genetics in the workplace. When writing these 500-word scenarios, we sought to provide concrete details, introduce positive and negative aspects and leave the dilemmas opened (Boenink et al., 2018). Their full content can be found in Tables 2 and 3.

As Table 2 indicates, the 2030 scenario invited participants to ponder whether genetic data could be used to improve health at work, the responsibilities of employers and employees, and the role of genetic counselors.

As Table 3 indicates, the 2040 scenario invited participants to comment on the personal dilemma of Nathan (the character appearing in the video) and on his genetic counselor's advice, which combined factors related to Nathan's reproductive history and a work-family balance program available in his workplace. In the video, the fictional cardiac “rectifier” was described as an extremely tiny device, meant to be used by healthy adults who would be genetically at-risk of developing arrhythmia later on in their life (www.inferi.umontreal.ca/DMUF/). By being a “connected” implantable device, the “rectifier” would be able to gather, analyze and send information to a central office where medical experts would confirm whether or not certain cardiac cells should be destroyed in order to reduce the likelihood of developing arrhythmia.

2.4. Data analysis

Using the qualitative analysis software Dedoose™, we developed a coding strategy that was both deductive and inductive (Miles et al., 2014), with the following considerations in mind. First, the way

Table 2
The 2030 online scenario.

The scenario	Element being introduced
Improving occupational health through genetic data?	
We are in 2030. The people we are talking about in this scenario dread sickness, its impact and the suffering it inflicts. Fortunately for them, we can intervene well before certain diseases manifest themselves, while they are still only probabilities.	Setting the prospective context
Indeed, genetic tests have multiplied. They are much more elaborate and go well beyond prenatal diagnosis and hereditary diseases. The expertise of genetic counselors, whose field of intervention has expanded, is paramount to the interpretation of these tests.	Introducing genetic testing and genetic counselors
<i>Genetic counseling, a more global science</i>	
Full-fledged professionals, genetic counselors calculate, somewhat like actuaries do, life-long probabilities that are modulated by environmental factors. Like psychologists, genetic counselors provide personalized support and advice to each client. To help individuals develop their genetic potential as much as possible, all aspects affecting their well-being and health —such as work, family, hereditary factors and lifestyle— are taken into consideration.	Explaining what genetic counselors can do Stressing that biological and environmental factors are considered
Genetic tests, however, indicate probabilities, rarely certainties. Their results must therefore be interpreted in light of their respective margins of error and the particular context of the individual.	Introducing the limitations of genetic testing
With this inclusive expertise, genetic counselors work in the health system but also often for insurers and banks that offer “genetic assets” management services.	Introducing a novel role for genetic counselors
<i>An employer at the forefront of knowledge!</i>	
As a result of growing research on the human genome, knowledge in the field of occupational health has come a long way. For example, we know how to modify the immediate environment of a worker to mitigate his genetic disposition to develop physical or mental illnesses.	Explaining how genetics can be used in the workplace
This science has not gone unnoticed by <i>Bille inc.</i> , a company known for its dynamism and desire to stand out. It has just announced a pilot project in which the company commits to adapt the tasks of its employees according to their genetic profile. One could read on the website of <i>Bille inc.</i> :	Introducing an employer's willingness to use genetics
<i>“Our company operates in a highly competitive environment. The creativity and ability of our staff to excel is the greatest value of our company, which now has 10,000 workers located here and elsewhere in the world. We have trained them with care and want to maintain their vitality and satisfaction at work as long as possible.</i>	Explaining why this company sets in place a pilot study
<i>We recruited a team of genetic counselors at the forefront of science in the domains of mental and physical health at work. This 5-year project will allow us to evaluate the extent to which the well-being and health of all our employees has been improved.”</i>	Explaining the role played by genetic counselors in this company
Some unions have expressed support for this highly publicized initiative: <i>“In recent years, we have seen significant health gains for workers who have greater flexibility in their work. Such progress, however, is slow to materialize for workers at lower levels of the ladder. The pilot project by Bille inc. will fill this gap. Employers will no longer be able to ignore how the work environment and genetic factors interact.”</i>	Introducing an implicated actor: workers' unions

Note: The kick-start questions were as follows: Your brother works for Bille inc. and shares with you his concerns as well as his hopes. He asks for your opinion: Do you think that knowledge in the field of genetics could contribute to improve health at work? What is the responsibility of employers and employees regarding probabilities of developing diseases or not? How can genetic counselors serve the good of society?

Table 3
The 2040 online scenario.

The scenario	Element being introduced
What will Nathan do about his risk of heart disease?	
We are now in 2040. Nathan is 35 years old. His employer is one of the companies that have integrated genetic counselors into their human resource management teams. Genetic testing is done at hiring and any promotion request is evaluated based on the employee's genetic assets.	Setting the prospective context Introducing the main character and his work environment
Following a test, Nathan realizes he is carrying a gene associated with a form of cardiac arrhythmia that triggers after the age of 50. This compromises his assignment to a more demanding position that Nathan hoped to occupy. He learns that performing more routine tasks would be better, in his condition.	Explaining the main character's genetic predisposition and dilemma
<i>Nathan's choice, hesitations and reservations</i>	
Nathan cannot put aside his deep desire to climb the professional ladder of the company and get involved in a stimulating job... especially since he is currently in perfect health! What if a cardiac rectifier was implanted?	Introducing a fictional innovation that may suit the main character's preferences
He read a lot on the subject! He even met the <i>TechSanté</i> nurse who explained to him how this implantable device could correct heart cells making him likely to develop arrhythmias later (see video <i>“The performance of the cardiac rectifier according to the company TechSanté”</i>).	3-min. video describing how the “rectifier” works and what it does
Since this visit, Nathan hesitates... The rectifier is still in experimental mode. On the website of a public research laboratory, Nathan has read some serious caveats:	Introducing the limitations of the innovation
<i>“The use of rectifiers for preventive purposes is not yet conclusive. Due to the limited number of implanted patients and the very large heterogeneity in forms of arrhythmia, the margin of error inherent to the decision algorithms is at least 15%.</i>	
<i>In addition, the ‘fast track’ market approval process requires the manufacturer to send all data related to incidents to regulatory agencies. Something the manufacturer has not done yet, evoking legal matters.”</i> This information complements... and contradicts the information given by <i>TechSanté!</i>	Introducing regulatory requirements not fulfilled by the manufacturer
<i>An alternative</i>	
Nathan discusses his hesitations with the genetic counselor who has been assigned to him since he was hired, five years ago. The counselor evokes a possible scenario: <i>“Have you thought of having a second child? You had positive family relationships when you were young. And, as recent studies show, a harmonious family engagement is an important protective factor against the disease.</i>	Introducing the genetic counselor's advice, for whom having a child represents a protective factor
<i>In addition, in our company, with a second child you become eligible for a position with work-family balance features. All of this would help reduce your risk of arrhythmia.”</i>	Introducing the employer's work-family balance program

Note: The kick-start questions were as follows: If Nathan was your friend and asked for your advice: What would you say to help him ponder probabilities and choices of such a different nature? What should he think about? What should he value? What should he give up?

individuals form a moral judgement depends upon the “intuitive moral theory” they hold and is thus affected by factors that are not built into a given scenario (Ryazanov et al., 2018). Second, participants may accept some but not all of the claims made in a scenario regarding the protagonists’ behavior, the outcomes of their actions and the likelihoods that certain situations may occur (Ryazanov et al., 2018). We thus paid attention to the way participants challenged or extended specific elements of our scenario (e.g., by adding new actors, alternative solutions) (Stahl et al., 2014). We first coded all the empirical material to identify the scenario elements that were being commented upon (e.g., genetic counselors’ role, employer’s responsibilities, Nathan’s dilemma). Then, relying on concepts from the literature summarized above, we created codes to capture participants’ reasoning processes about what may/may not happen as well as what should/should not happen in the future. Once all the data was coded, we looked for patterns across the 2030 and 2040 scenarios and observed that participants: (1) challenged key elements of both scenarios; (2) extended several of their technical and moral prospects; (3) personally engaged with others, including our scenarios’ characters; and (4) mobilized the past creatively to reason about the future. Below, these empirical patterns are illustrated with quotes that were translated from French to English and using pseudonyms for participants. Ethics approval was obtained from the Health Research Ethics Board of the University of Montreal (CÉRES); all participants gave their informed consent to participate in the study.

3. Findings

3.1. Reactions to the 2030 scenario: “Improving occupational health through genetic data?”

Our 2030 scenario described a prospective context wherein a company was launching a pilot project to assess whether its employees’ well-being and health could be improved by adapting their tasks to their genetic profile (see Table 2). It also introduced an equivocal role for genetic counselors, described as combining actuarial and psychological skills, who could be operating within and outside the formal health system, e.g., in enterprises, banks and insurance companies. Intriguingly, while participants strongly challenged the possibility that an employer should gather genetic information about its employees and called for governmental regulation, their vision of the future provided workers’ unions with a limited role.

Maude was “puzzled” by the idea that genetic counselors could “work in the health system as well as for insurers and banks” and found the possibility of serving “several masters” altogether “inconceivable.” Most participants rejected the very prospect of introducing genetic counselors into the workplace: “it looks like the movie *Gattaca*!! [...] I would not want a society with more genetic counselors, no thanks!” (Gisèle); “genetic counselors seem to be the new gods who can explain everything in a flash” (Héloïse); “society needs social workers and epidemiologists more than genetic counselors” (Magali); they “have nothing to do in the workplace, nor in insurance companies, nor in banks. In this scenario, these counselors would have an impressive power... far too much power” (Adèle).

To such objections, other participants provided diverse counter-arguments. In Simon’s mind, genetics “is the future in many fields” including occupational health since diseases can “be prevented from birth.” For Céline, the diverse tests that job candidates must undergo “are not new since companies have always tried to predict how individuals can successfully serve their needs.” Michelle extended our scenario by stressing that “genetic counselors could be available not only in businesses but in all kinds of workplaces, which could only be beneficial.” Likewise, Lea believed that their role would be “paramount because, in addition to improving employees’ quality of life, it [would enable] society to reduce spending associated with occupational health problems.” For Samuel, however, “society as a whole does not have to take a stand” since market principles would determine the future of

genetic counselors:

If the advice they provide is really useful for individuals, they will have clients. Otherwise, they will not. [...] Like for other professional consulting services (e.g., psychologists, ergonomists), an employer may judge whether providing access to such a counselor is valuable if it makes its staff more productive. Productivity gains pay for this type of service.

While many participants called for “a tight boundary between the medical world and the occupational world” (Lorraine) and for genetic counselors to be “bound by professional secrecy” (Alice), others shared creative nuances. Charles anticipated that a privately hired genetic counselor would manipulate disease probabilities “just like a financial advisor manipulates return on investment probabilities.” He thus envisioned novel applications of genetics “at a much more generalized level.” Referring to the past, he thought that society could benefit from genetics “in a broader public health context, as happened with vaccination, water fluoridation, etc.” A similar creative moral reasoning process pushed Alice to extend our scenario:

A genetic counselor for society, why not? A Local Genetics Center (LGC) could, for example, advise couples in certain regions of Quebec affected by genetic diseases, such as spastic ataxia in Charlevoix-Saguenay [...] It could also be involved at the level of local and provincial governments to control environmental factors that might be triggers for certain diseases.

Bringing participants’ attention back to the past, Martine asked them to “excuse her pessimism” since “history shows that the discourses promoting the adoption of new technologies which always heralded ‘a better society’ have often proved wrong” and their application “rarely achieved these very commendable objectives.” To support her claim, she made a creative historical comparison with the uptake of agronomists’ genetic knowledge by cattle farmers:

In the past 50 years, our cows have become true small dairy industries and yet they live shorter lives than their ancestors. Ultimately, technology does not affect the environment of these genetically improved animals, but rather their productivity. These cows mature faster, are healthier during their life cycle, produce more, but die faster. Have their environment—the stables—become more comfortable? They barely changed in 50 years!

This critical view was supported by Magali who could not even “see a semblance of realism in this scenario.” Drawing on her professional experience in occupational health and safety, a domain where “causality is probably the most difficult element to ‘prove’ or demonstrate in cases of illness,” she emphasized an important power imbalance:

If the employer pays for genetic counseling services, he will be in control of the information collected and will be able to challenge any potential impact on the worker’s health. ‘Industrial secret’ is evoked entirely and completely to avoid identifying the products used, or their dosage or their effects. While it is true that the genetic background of one employee may be more fragile compared to others, the fact remains that all workers are affected, even to varying degrees, by pollutants or toxic products. An employer will not favor conditions that could incriminate its business.

Even if the purpose were to improve occupational health, participants challenged the idea that an employer should be allowed to gather genetic information about its employees. Such motivations could not be considered sincere: “a company that wants to know the genetic profile of its employees wants too much control” (Frédéric); “the goal of employers will always be to maximize returns. Even if they have the best candidates, they will push them to their limit” (Samantha); “I disagree with an employer meddling so much with the lives of its employees. It is too intrusive” (Bertrand); “do you believe that individual results indicating a vulnerability will prompt the employer’s desire to protect the

employee, to shelter him, to adapt his tasks?" (Adèle).

Among the key reasons for discarding the prospect of a benevolent employer was the understanding that knowledge about workers' genetic potential would "only support some form of 'profiling' in order to exclude any individual who has physical, psychological or mental weaknesses" (Maude). For Laura, who felt she was "in a sci-fi movie," it is currently "the factory employees hired at minimum wage or where employers are unscrupulous who pay the price of the lack of resources, training or equipment. It's hard even to do simple prevention." A similar "reality check" grounded in the present was provided by Michelle:

Today's reality and the capitalist world confirm that it is the maximization of profits that matters most. An employer who cares about the health of his employees rather than their performance [...] must belong to an exemplary society, not our own.

Within this train of thought, a "very important player" was missing: "the state or an arbitrator" who can support the enforcement of occupational health and safety legislation. Gisèle indeed invited other participants to reflect upon recent regulatory achievements:

If we remember, employers who are not governed by laws do anything they want like hiring children, having people work 70 h a week, forcing workers to handle poisons without protection. Thus, unlike other [participants who] want ethical and honest employers to manage genetics data appropriately, I believe this is impossible because their business interest is not there. I'm not saying that all bosses are naughty, no, I say that it is the reality of the labor market to tend towards the selection of employees providing greater performance. It is as a collectivity that we can counter-balance this tendency.

Gisèle's argument, urging public policymakers "to protect people's privacy and prohibit employers" from accessing their employees' genetic information, resonated with the understanding that one's DNA is a "private matter": "it's about the health and privacy of individuals" (Lisandre); "My [Social Insurance Number], ok, but don't touch my genotype!" (Alice); "no, sorry, I disagree with this scenario [...] Wow! DNA is private! The test must be done on a voluntary basis!" (Madeleine). At this point in the deliberations, Frédéric shared a subtle nuance according to which "it would be legitimate for an employer to possess certain genetic information," for example, for "an airplane pilot, a nuclear power station operator, etc." In these exceptional circumstances, knowing about potential diseases that may affect the "safety of the population, service users or colleagues" could be beneficial. In a similarly forward-looking reflection, Maude extended our scenario by evoking the regulatory consequences of discovering, by 2030, "additional environmental factors."

One may wonder if the disclosure of their effects on humans, by researchers and subsequently by the governments, will be accessible to the population. Employers will have the responsibility to seek out information and to take note of it vis-à-vis their workers, while the latter will have to ask for measures to counter any repercussions on their health, and will have to comply with them if they are put in place (Maude).

Thinking that a workers' union would eventually agree with the use of genetics in the workplace seemed "very unlikely" (Magali). For Samuel, "standards for the quality of work environments must be kept up-to-date with new discoveries, including in genetics," but it would be "totally unrealistic economically" to "ask an employer to adapt to each employee;" henceforth, "an employee who knows his genetic profile must target a suitable job." Clémence doubted "that in 2030 the capitalist model will have changed a lot" and wondered whether "a workplace adapted to the needs of each individual was a utopia." Participants thus had a clear vision about what should happen, but wondered whether it *could* happen:

In an ideal world, the boss, the union and the employees would have to come together to talk about this project and put the pros and the cons on the table and work hand-in-hand for the well-being of all and not to the detriment of one for others. But is it possible? (Laura)

Overall, this scenario triggered participants' moral imagination by enabling them to envision and challenge the prospect of applying genetics in the workplace and of having genetic counselors operating outside healthcare institutions. They pushed further both technical and moral issues (e.g., public health applications, professional secrecy, collective costs of occupational ill-health, exceptions) and mobilized the past creatively to reason around the need for public policies to protect workers' rights. However, they doubted that a different future in terms of power relationships between employers and employees could unfold.

3.2. Reactions to the 2040 scenario: "What will Nathan do about his risk of heart disease?"

The 2040 scenario described a prospective context wherein Nathan, a 35-year old man working for a company that integrated genetics years ago, ponders the possibility of using an implantable cardiac "rectifier" because he carries a gene that is associated with a form of cardiac arrhythmia that may develop after the age of 50 (see Table 3). His genetic counselor tells him that having a second child could reduce his risk and that he would be eligible for a work-family balance program. This scenario pushed participants to engage both personally and creatively with Nathan's dilemma.

Exemplifying very well how scenario-based methods may open up the possibility of relating to others, several participants addressed their comments to Nathan directly and sought to bring to his attention the risks associated with the "rectifier." For instance, Clémence engaged in a fictional conversation with Nathan:

Is the gene in question a 100% guarantee that you will develop a form of arrhythmia after 50? You may be as likely to die in a car accident or whatever. [...] Fortunately, you did research on this rectifier. You see that not everything is right. Maybe you are being used as a guinea pig? Nobody knows if there are complications and risks involved with the intervention (infection, rehabilitation, etc.).

Justine underscored that Nathan's "health problem is still latent," that "nothing says he will suffer" from it and Carine warned him about unforeseen "technical problems and hacking." Seeking to "solve a problem that does not exist now" with an unproven technology was considered "the very image of excessiveness" by Adèle, for whom a manufacturer that is "eager to have its market approval but does not fulfill the obligation of disclosing incidents, it's more than fishy." Our scenario made her think of a current TV ad in which a car insurance company promises up to 25% savings on their premium if clients install a monitoring device in their cars: "the company wants to control the behavior of the driver through the gadget. What will they do with the data do you think?"

For many participants, genetic tests are now common and "will be inevitable in the future" (Frédéric). Since "cardiologists are already providing advice based on our medical history and what they know about our genetic profile (parents, siblings)," our scenario "did not bring anything new" (Samuel). For Laura, however, it is "essential" to prevent diseases that have "very real" consequences for the families affected. In a similarly empathetic reflection, Marie brought to participants' attention current unmet needs:

The guarantee of a healthy life, in my humble opinion, is not based so much on inventions, probabilities, predictions of life-years and survival... [...] Increasingly, we are trying to make the sun shine for all, to provide work for the handicapped, to support their mobility and provide them with high-tech equipment, etc. Urgency is already

on this side it seems to me. [...] We have a hard time finding work for the disabled, for older people, etc. Why not create technologies for such people who do want to be 'productive' in their own way?

Through creative comparisons, participants contextualized the "rectifier's" risks: "very functional drugs like Vioxx®" had been withdrawn from the market for lesser known adverse effects (Charles). Frédéric emphasized the conflicts of interest in Nathan's dilemma by reminding participants that "we forbid doctors to sell drugs" and are "puzzled by the dentist who is the one who advises... and who at the same time has a direct interest in the choices made by his client!" Participants also suggested alternatives to the "rectifier": drugs that control well arrhythmia have been available "for more than 40 years" (Joseph); "other less aggressive and newer medical solutions" will be developed in the future (Justine); and Nathan "should put the odds on his side by eating 'healthy' food and exercising" (Claudine).

Participants' imagination was provoked in a way that we had not anticipated and which aligns with their unyielding reaction to the physical appearance of the actor who played Nathan in the video: "Nathan, who is overweight, should return to a healthy weight and potentially change his diet and do exercise" (Mathieu). Laura perceived Nathan as "frightened and terribly insecure" and prompted him to pay attention to his "life regimen" and "think in the present positively." Justine proposed to solve Nathan's dilemma by enjoining him to adopt a healthy life style *with* his family, "which would enable him to develop more enjoyable and stronger family values, rather than focus only on his job." Along similar lines, participants questioned the professional ambitions of Nathan and his position toward his employer, like Alice who wrote a personal letter to Nathan:

My poor Nathan

Did you not read the tiny, tiny print at the bottom of your contract before signing it? You should have. Myself, I did and ran away at full speed. You really have to have your employer deep in the skin, not to say in the genes, to let him control you like a robot!

Myself, I work for a company that cares about the well-being of its employees without interfering in their organs and immune systems. A medical examination that confirms that I am healthy at the time of hiring? That's all I allow the company to know about my health. I offer my best years, in return, it offers me a healthy and pleasant environment. It's win-win, right?

Above all, admit in the first place that you got caught up by conforming to obligations that for my part I consider degrading. It's a bit because of your insatiable appetite to stand out that, collectively, we all have to work very, very hard to retire at 50 given the risk that the employer takes by hiring individuals who might one day suffer from one disease or another.

I also heard that your employer is about to require the genotype of his employees' young children to estimate the parenting days required in the event of a health problem.

I wish I could advise you but your greed to climb the ladder of this company will make you bend to its requirements anyway. Thus, I urge you to do a serious self-examination.

Your friend Alice,

Alice's letter prompted other participants to react: Nathan should have indeed "read the fine print" since his boss is getting "into his private life and ambition, [and] that's what will make him sick and not his heart disease genes" (Laura). Walter argued that Nathan could "clearly prefer to die young and have lived the life he wanted, rather than grow old quietly without having achieved anything." He even went as far as suggesting that Nathan could "sign a discharge saying that he is aware of the risks and it will not be his employer's responsibility if something happens." This ran counter to Adèle's position: she invited Nathan to quit his job because a large number of employees can

exert power against a single employer:

The company would live with the perverse effect it causes, i.e., losing a dedicated employee, motivated for complex tasks, who has the potential to achieve them and who is currently in full health. If several employees reacted in this way to the manipulation of the employer, would the company eventually understand that it loses in return?

Unsurprisingly, participants' moral reasoning processes led them to strongly challenge the genetic counselors' advice of having a second child (presumed to be a protective health factor). Two participants referred to the cultural turmoil of the Quebec *Quiet Revolution* of the 1960s (which marked the separation between the Catholic church and the state): "the proposal of the 2nd child is downright hilarious! It feels like we are back to the time of Duplessis! [Quebec Prime Minister, 1944–59]" (Adele); it is like "the priest of the village telling a woman she must absolutely have a fourth child for the sake of her faith and that of her family" (Charles). Sarah did "not even see why Nathan had a choice to make" since it was "completely twisted to do this association." Letting "Nathan be used and manipulated by technology [was] really unacceptable" (Baptiste) and to "fabricate" a child so that he could get rid of his arrhythmia and get an interesting job" was a "foolish thing" (Héloïse). Within this perspective, Céline evoked the well-being that comes with having "more intrinsic motivations" for raising children. This argument was directly challenged by Line: "Giving birth to a child is an immense responsibility! So much stress is bound to it, so many worries and doubts can regularly arise and eat up one's energy, make one perform less well at work." While Lisandre believed that one should refrain from putting "so much weight on the frail shoulders of an unborn baby!," David went a step further by imagining a future conversation between Nathan and his potential child:

Dad, why did I come into the world?

So, that I can keep my job, son.

Overall, participants warned Nathan creatively about the risks of the cardiac "rectifier," proposed alternatives to it and opposed the idea that reproductive decisions be influenced by work. They also engaged with Nathan's dilemma in personal, emotional and judgmental terms by commenting on his physical and psychological appearance and questioning his professional motivations.

4. Discussion

We began this paper by underscoring the challenges that practitioners of RRI and participatory foresight face when they design public engagement methods to inform anticipatory governance. Members of the public need to envision how complex technical and moral issues may interact over time and the possible ways to govern their future. This is why our study aimed at providing empirically grounded insights into the way scenario-based methods support participants' ability to exercise their moral imagination. Below, we clarify our study's contribution to current knowledge and underscore how the limits of future-oriented deliberative methods may be handled in RRI and participatory foresight.

4.1. Contribution of our study

The literature on public engagement is extensive (Lehoux et al., 2009; Aitken et al., 2016; Dijkstra and Schuijff, 2016; Felt et al., 2014). It stresses that several different purposes may be pursued, more than one method may be adopted, varying types of outcome may be generated and decision-makers may or may not be involved. The decision support tool called the "Action catalogue" provides researchers and policymakers with useful criteria to determine whether a specific method may fit their needs (www.actioncatalogue.eu). Our own

deliberative process was not embedded in a formal governance process since one of our key aims was to better understand the strengths and weaknesses of a novel multimedia-based methodology. This paper contributes accordingly to current knowledge by providing novel empirical insights into the way this methodology provoked and stimulated participants' deliberations. To our knowledge, very few public engagement studies have used videos and online scenarios to support prospective deliberations on fictional health innovations. Felt and colleagues (Felt et al., 2014) developed a card-based method (called IMAGINE) to deliberate about the future of nanotechnologies, which was inspired by an existing card game (PlayDecide) meant to support small "fact-based" group debates on a range of policy issues. While these authors explored the prospective and retrospective dimensions of imagination, they did not address its moral dimension. Boenink and colleagues adapted the IMAGINE method to "give voice" to patients in translational biomedical research and chose not to use scenarios, arguing that they would have left "limited room for patients' own imagination" (Boenink et al., 2018). Our study as well as recent findings (Stemerding et al., 2018) indicate that this may not necessarily be the case.

A second contribution of our study is to have empirically illustrated how participants exercise their moral imagination. In Section 1, we summarized bodies of knowledge that explain why, in principle, scenario-based methods like ours may inform anticipatory governance by supporting the public's moral imagination. Our study brings important support to this claim (but also highlights caveats that are discussed below). As summarized in Table 4, the 2030 scenario triggered participants' moral imagination by enabling them to challenge the use of genetics in the workplace as well as the role that genetic counselors could play in the future. Participants raised novel issues by extending several technical and moral elements of this scenario (e.g., public health applications, exceptions, regulatory consequences). By engaging with others, they emphasized the need for public policies to protect workers' rights. They mobilized the past creatively and envisioned a future in which power imbalances would not threaten employees, but doubted that such a future would be realized. In reaction to the 2040 scenario, participants disputed the idea that reproductive decisions be part of the purview of genetic counselors hired by their employers. They engaged with Nathan's dilemma both creatively and emotionally, warning him about the risks involved and encouraging him to adopt a "healthy lifestyle." Pointing out other unmet needs, they also suggested alternatives to the "rectifier" by mobilizing the past and envisioned

creatively potential long-term consequences. Participants thus connected past, present and future dilemmas, related to others and envisioned plausible solutions.

These findings concur with studies examining the contribution non-experts can bring to anticipatory governance. Boenink et al. found that patients can handle a "plurality of perspectives" about technoscientific futures and are "quite capable" of identifying and acknowledging their "ambivalences and complexities" (Boenink et al., 2018). Stemerding and colleagues showed that participants may develop reflexive awareness and enriched viewpoints by engaging in a form of "virtual prototyping" where they imaginatively develop and test future sociotechnical design options and their likely risks and consequences (Stemerding et al., 2018). As the literature on moral imagination suggests, our participants' reasoning processes were creative and the deliberations prompted counter-arguments that deepened their discussions. This is compatible with the view that morality is rarely a "multiple-choice problem of ticking off boxes" (Coeckelbergh, 2006). Foregrounding the principle that moral reasoning is developed through cultural symbols, stories and myths (Alexander, 1993), our participants indeed used comparisons, metaphors and colloquial expressions to ponder in greater detail the responsibilities of the actors and institutions involved in our scenarios.

The third contribution of our study is to confirm that scenario-based methods like ours can productively inform the kind of anticipatory governance that RRI and participatory foresight seek to articulate, while highlighting caveats that future studies should seek to avoid. On the one hand, our findings suggest that the methodology we designed supported participants' creative moral thinking and enabled them to compare different options regarding what may or may not happen in the future, as well as what should or should not happen considering the past and the present state of affairs. More specifically, as Table 4 indicates, when participants challenge the scenarios presented to them (1) or extend these scenarios (2), their capacity to call for other preferable options and to envision more elaborate futures is supported. For instance, the 2030 scenario led participants to identify public health applications for genetics as well as exceptions where genetic testing could be legitimate. When participants engage with others, including the scenarios' characters (3), and mobilize the past to reason creatively about the future (4), the method enables them to voice their personal concerns and eventually contribute to a historically more informed anticipatory governance. For instance, the 2040 scenario pushed participants to raise the importance of addressing the unmet needs of

Table 4
A summary of participants' reactions to our scenarios.

	2030 Scenario: Improving occupational health through genetic data?	2040 Scenario: What will Nathan do about his risk of heart disease?
1. Challenging our scenarios	Disapproving the use of genetics by employers Disapproving that genetic counselors work in the private sector	Disapproving that reproductive decisions be part of the purview of genetic counselors who are hired by employers
2. Extending our scenarios	Supporting the idea of having genetic counselors in all kinds of workplace, not just the private sector Identifying public health applications for genetics Identifying exceptions where genetic testing could be legitimate (e.g., airplane pilots) Envisioning the regulatory consequences of future knowledge	Identifying additional risks associated to the "rectifier" (e.g., hacking) Envisioning alternatives to the "rectifier" as well as broader purposes for predictive medicine Identifying solutions to Nathan's dilemma (e.g., signing a discharge, quitting his job)
3. Engaging with others, including our scenarios' characters	Noticing the "absent" player and the need for public policies to protect employees' rights to genetic privacy Applying an individualized understanding of employees' responsibilities Downplaying the role of workers' unions	Addressing Nathan directly and creatively (e.g., letter to Nathan) Reflecting about the unmet needs of others (e.g., families afflicted by debilitating genetic diseases, persons who live with a disability) Applying an individualized understanding of health promotion when enticing Nathan to adopt a healthy lifestyle because of his weight and perceived anxiety
4. Mobilizing the past to reason about the future	Comparing the use of genetics in occupational health with past applications in agriculture (e.g., dairy cows) Using the past as a proof that employers' real motives cannot include the improvement of employees' health and well-being	Comparing the risks of the "rectifier" to precedents (e.g., Vioxx®) or other applications (e.g., drivers' monitoring) Imagining long-term consequences (e.g. child asking why he was born)

families afflicted by debilitating genetic diseases and of anticipating the long-term consequences of linking reproductive decisions to individual health decisions.

On the other hand, our findings lend support to the scholarship that asks “whether there are limits to the value” of public engagement methods (Davies and Selin, 2012). Our participants had a clear vision about what should happen regarding genetic profiling in the workplace, but the 2030 scenario failed to foster in-depth group discussions about the way unions or other regulatory mechanisms could contribute to implement such vision. This scenario may also have presented too cursorily the notion that genetics could lead to the identification of protective factors (not only risks) since this possibility was barely discussed. The 2040 scenario prompted deliberations that emphasized an individualized understanding of what makes people healthy and of what responsible employees must do, which runs against what is known about social inequalities (Batayeh et al., 2018; Silva et al., 2018). Davies and Selin argue that short documentaries showing that life could be lived differently can produce “revelatory experiences” and help to unpack practices that are taken for granted (Davies and Selin, 2012). Perhaps our study design should have included a debriefing session with participants to share our research team’s preliminary observations. Overall, our scenario-based method did not enable participants to envision an alternative route of action for regulating the future deployment of interventions for genetically at-risk adults in the workplace.

4.2. Implications for RRI and participatory foresight

Academics and practitioners of RRI and participatory foresight share a critical responsibility since the methodological limits of scenario-based methods like ours have implications for their design, the interpretation of their findings and the uptake of their outcomes. Our study suggests that two kinds of limit to our capacity as public engagement methodologists to foster moral imagination need to be carefully considered. First, the imaginaries of the future that may be captured at one point in time through a participatory process should be understood as provisional and incomplete since moral imagination dynamically evolves within broader societal learning processes (Lehoux et al., 2009). A moral life reflects complex interplays between the cultural world surrounding individuals (be they experts or non-experts) and the training (or blunting) of their disposition for creatively developing meanings (Alexander, 1993). The skill of weighing various options through moral imagination is, in Dewey’s theory of ethics, a skill that grows through action, experience and the ability to understand other ways of life (Alexander, 1993). From this perspective, the possibility to cooperatively discover solutions through a one-time prospective deliberative event represents a precious, yet insufficient learning moment (Grunwald, 2014; van de Poel and Sand, 2018; Grunwald, 2011). The skill of exerting one’s moral imagination should be developed, consolidated and continuously tested (Johnson, 1985). This is a challenge even for ethicists who should be able to think in novel ways when confronted to emerging technoscientific advances. For Edgecoke, the “presupposition that technologies need to exist, if only in a promissory sense, before their ethical aspects can be debated” has led bioethicists to ignore issues that fell beyond established disciplinary discourses (Hedgecoke, 2010). In addition, in certain areas of innovation policy, both experts and non-experts must understand cultures that are different from their own (Elliott and Elliott, 1991). As our findings regarding Nathan’s presumed lifestyle showed, the effort to perform such a “leap of the moral imagination” may come with puzzling assumptions or biases (Elliott and Elliott, 1991). Recognizing that what is perceived as acceptable in the present may prove less so in the future, we suggest that those who conduct prospective participatory processes learn to unpack their own normative assumptions as well as those of participants (Lehoux et al., 2009).

Second, one may question the extent to which the past and the present are adequately mobilized by experts and non-experts to justify

whether or not current morally accepted practices can evolve in the future. When the objective is to steer technological development in a more desirable direction, Fuerth (2009) argues that the past can be seen as a prologue, but not a destiny. For Zimmer-Merkle and Fleischer, “engaging with history is inscribed into the foundations of RRI,” but it is important to avoid simplistic analogies about political, economic and societal events that happened in the past and which are understood as determining what can or cannot happen in the future (Zimmer-Merkle and Fleischer, 2017). In view of our participants’ “reality checks” about the difficulty of replacing an established neoliberal system with more desirable socioeconomic alternatives, it would be vexing if the outcomes of public engagement studies like ours were used by policymakers or other sponsors to legitimize the maintenance of ways of life that are problematic or known to be deleterious (Davies and Selin, 2012). This may explain why Stahl and colleagues argue that certain visions of the future have to be provoked to raise awareness and instill willingness to change (Stahl et al., 2014) and why Bourgeois and colleagues underscore that future studies should empower participants and provoke a “process of societal transformation” (Bourgeois et al., 2017). Hence, to properly inform anticipatory governance, practitioners of RRI and participatory foresight should be able to deconstruct visions of the past that are used to support the status quo. This seems especially important when path-dependent trajectories are at play (Genus and Stirling, 2018).

4.3. Linking moral imagination with anticipatory governance

One important critique directed at anticipatory governance lies with its tendency to reify emerging technoscientific developments by taking their hyped “imaginaries as objects” and ignoring extant ethical challenges in favor of hypothetical ones that may never unfold (Guston, 2014). In addition, anticipatory governance tends to augur a “sweet” reward: it “seems to promise that if we govern collaboratively, we may avoid the high costs of adversarial policy making, expand democratic participation, and even restore rationality to public management” (Ansell and Gash, 2008). Ansell and Gash’s review of the literature shows, however, that such governance may generate problematic results (e.g., manipulation by powerful stakeholders, lack of policy commitment, distrust) as well as valuable achievements (e.g., more fruitful relationships, sophisticated forms of collective learning and problem solving) (Ansell and Gash, 2008). Our findings suggest that RRI and participatory foresight scholars who design public engagement methods should conceive of anticipatory governance as a long-term moral imagination capacity building process and remain reflexive about the way these methods inform the future.

For Stermerding and colleagues, scenario-based methods can inform anticipatory governance by “involving various parties in debates in which both the plausibility and desirability of particular scenarios can be scrutinised” (Stermerding et al., 2010). Yet, the integration of such a mode of “future making in daily practices” remains a challenge for RRI, due to the lack of skills and incentives in innovation settings to undertake the kind of “inclusive and reflexive explorations” suggested by the RRI principles and tools (Stermerding et al., 2018). This partly explains why Martinuzzi and colleagues call for further research on the commercial drivers of innovation in order to enrich RRI scholars’ understanding of the relationships between firms, stakeholders and society (Martinuzzi et al., 2018). This view contrasts with the RRI scholarship that calls for “a powerful co-creation infrastructure, inspired by democratic and public values, granting civil society much more influence in future making efforts” (Stermerding et al., 2018). Similarly, Genus and Stirling argue that the “most responsible way to govern innovation is by democracy itself” and RRI institutions and practices are “only progressive insofar as they help to strengthen, rather than weaken, this general aim” (Genus and Stirling, 2018). Within this perspective, we broadly disseminated the outcomes of our study by developing a non-technical synthesis of all our academic papers and by

asking a cartoonist to produce a graphic report summarising our key findings. The latter was sent to all participants by postal mail and both documents are available on our study's website (www.inferi.umontreal.ca/DMUF/).

When seeking to introduce moral imagination into anticipatory governance, RRI and participatory foresight scholars and practitioners should recognize that inclusive, future-oriented deliberative processes often raise concerns pointing at issues beyond one single actor's domain of influence (Boenink et al., 2018). Those who may act upon the results of these deliberations typically include policymakers, research funding agencies, scientists, professionals, regulatory bodies, the private sector and community organizations. For Pandza and Ellwood, a growing call for RRI "by institutionally powerful players (e.g. government, funding agencies)" can make more visible the broader constituencies of innovations as well as their "hugely dispersed and asymmetric interests" (Pandza and Ellwood, 2013). As Ribeiro and Shapira underscore, RRI scholars have to develop a deeper understanding of the distributed responsibilities of the various actors involved in innovation development (Ribeiro and Shapira, 2018). These various responsibilities are likely to condition how moral imagination and governance co-determine each other and may eventually restrict the plausibility of certain futures.

We thus believe that anticipatory governance should be conceived of as a continuous moral imagination capacity building process that integrates, iteratively a broad variety of inputs while remaining reflexive about the way these inputs inform the future (Stahl et al., 2014). To this end, not only the public's moral imagination should be fostered, practiced and tested, but also the moral imagination of those who design, implement and use public engagement methods, including innovation policymakers and stakeholders.

4.4. Strengths and limitations of our study and further research

The academic orientation of our deliberative process was considered appropriate in view of the constraints a formal policymaking entity may have imposed over the study design. This decision implies that we cannot comment on the likely uptake of our findings. Despite this limitation, the online deliberations constituted particularly well-suited empirical material to fulfill the goal of this paper since they provided ample time for participants to reflect upon the scenarios and write down their responses. It is important to include within scenario development processes mechanisms to increase their quality (Bourgeois et al., 2017; Boenink et al., 2010). To this end, our expert committee was diversified (holding expertise in medicine, nursing, genetics, biomedical engineering, bioethics, citizen engagement) and its role was to criticize earlier drafts of our scenarios. However, one issue that our analyses cannot account for lies with the recognition that it is impossible to identify what elements of a scenario participants may have ignored, deliberately or not. Research into moral reasoning processes suggests that personal intuitions regarding likelihoods that certain events will occur or not affect their judgments (Ryazanov et al., 2018). In addition, practitioners of public deliberation "should be aware that meanings of familiar terms are likely to be contested by different actors" but that such "contestation may not be overt" (Davies and Selin, 2012). Hence, readers should keep in mind that our participants may have considered some possibilities more likely than others or may have "silently" challenged certain parts of our scenarios.

We applied a rigorous inductive and deductive coding strategy and identified a consistent set of empirical patterns across two scenarios, which increases the credibility of our findings. Their transferability to other settings is clearly limited by the fact that our sample was comprised of educated individuals and more women than men participated. We thus did not achieve the "deep inclusion" recommended by Pratt and colleagues (Pratt et al., 2016). When participants pondered potential applications of genetics, roles for genetic counselors and the rights and responsibilities of employers and employees, they were

generally critical of profit-driven dynamics and tended to value public policies that are motivated by the common good. This is aligned with the context of Quebec's publicly funded healthcare system in which these participants evolve.

Since we analyzed participants' reactions to our scenarios taking the whole group as the unit of analysis, further research could explore the linkages between the personal imagination and the "social imagination" (Alexander, 1993). It would also be useful to study the way the imaginaries of participants may be affected by their training and background as some occupational identities emphasize human relationships and others technical objects and artifacts (Coeckelbergh, 2006).

5. Conclusion

Publics are seen as an important constituency in RRI and participatory foresight, which call for inclusive and emancipatory innovation development processes. While previous research showed that scenario-based methods can support participants' deliberations about the ethical dilemmas raised by existing technologies, this study offers novel insights into the way these methods stimulate the public's moral imagination regarding the future. This includes: (1) challenging key elements of a scenario; (2) extending its technical and moral prospects; (3) engaging personally with implicated others, including the scenario's characters; and (4) mobilizing the past creatively to reason about the future. Yet, there is a need to acknowledge the limits of public engagement methods and to make sure that they are designed, implemented and used responsibly. The focus on moral imagination "reveals that we are constantly creating our worlds, for better or worse, and that this is an art which must be attended to with care" (Alexander, 1993). Hence, to inform anticipatory governance, practitioners of RRI and participatory foresight should conceive of scenario-based methods as a means for both experts and non-experts to contemplate the past with the benefit of hindsight, critically reconsider the present and creatively contribute to shaping the future.

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