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Broadening the lens for the governance of emerging technologies: Care ethics and agricultural biotechnology

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ABSTRACT

In this paper we argue that insights from feminist perspectives, particularly in the form of an ethics of care, have a number of advantages when used as a lens through which to consider questions relevant to the governance of emerging technologies. We highlight how an emphasis on central themes of importance in feminist theory and care ethics such as relationality, contextuality, dependence, power, affect, and narrative can shine a light on a number of salient issues that are typically missed by the dominant and largely consequentialist risk assessment frame. We argue that the care ethics lens is a better fit when technologies are understood not simply as devices designed to create a certain end experience for a user but as transformative systems that smuggle in numerous social and political interests. The advantages of these care ethics themes for emerging technologies are illustrated through a detailed consideration of agricultural biotechnology. We show how the feminist care ethics lens might have anticipated the very questions that have proved themselves to be the sticking points for this technology. We therefore suggest that applying a care ethics lens can significantly broaden the frame of appraisal processes used for the governance of emerging technologies and usefully grant legitimacy to questions and concerns that are prominent in public discourse but typically left out of practices of risk assessment.

1. Introduction

After thirty years of careful and innovative work, gender considerations have secured an important place within science and technology studies. Feminists have looked critically at the make-up of research communities and exposed the hidden values and assumptions those communities can perpetuate [8,12]. They have exposed the association between a hegemonic conception of masculinity and a culturally loaded understanding of science and technology [20]. By highlighting the material-semiotic dimension of technological products, feminists have explained how technologies can reproduce gender and recreate gender power relations in society [32,79]. In addition, feminist science studies theorists have scrutinized unquestioned representationalist frameworks utilized in science and have helpfully challenged classic dualisms between subject and object, active knower and passive known, nature and culture, human and non-human, organism and machine [28,2]. Through relentless analysis, the political dimensions of technoscience have been laid bare [80] and thanks to this body of work, it is hard to look at science or its products without wondering where gender appears, or remains concealed, within it.

Feminist care ethics, however, has made less frequent appearances in science and technology studies. Evelyn Fox Keller's examination of Barbara McClintock's "feeling for the organism" raised the prospect of an important role for affect in scientific research [40]. Recently, prompted by Bruno Latour's reframing of "matters of fact" as "matters of concern" [44], Maria Puig de la Bellacasa has raised the notion of "matters of care" to encourage "an ethos of care within the study of science and technology" [4; p. 85]. A special issue soon to be released focuses on the politics of care in technoscience, including some of the inherent ambiguities and challenges involved [50,77] as well as questions around temporalities of care [5,62]. There has also been a small amount of work investigating care under the banner of Responsible Research and Innovation (RRI), a frame for understanding the craft of scientific practice [16] and addressing concern about future generations in light of the uncertainty created by new technologies [23,24]. Aside from these sporadic shoots of recent interest, care ethics has thus far played only a minimal role in feminist science and technology studies.

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While we suspect that feminist care ethics might indeed provide a helpful lens through which to consider a proper relationship to the matters of concern in science, and also provide a vision of how to be responsible towards future generations, we think that the advantages of feminist care ethics in the context of powerful emerging technologies – such as biotechnology, nanotechnology, synthetic biology and geoengineering – reach considerably deeper. We suggest that, compared to the consequentialist and broadly utilitarian risk analysis approach that currently dominates decision-making, care ethics can provide a broader framework through which to appraise new and emerging technologies, one that usefully illuminates important issues tending to remain concealed in traditional risk assessments but often dominating public discourse and debate. This includes issues relating to shifting relationships, dependencies, and power distributions, as well as attention to specific context, to the affective dimensions of the experience of technology, and the interconnections illuminated in narrative forms of story-telling. In the body of this paper, we illustrate the value of approaching technology appraisal through a care ethics lens because of the way it opens for the legitimacy of these issues using the case study example of genetically modified organisms (GMOs) in agriculture. However, in order to reveal the advantages of the care ethics lens and explore their value in the context of a particular case study, it is helpful to first briefly review some of the recognized shortcomings of the existing risk analysis framework for appraising new and emerging technologies and to appreciate the relational philosophy of technology that feminist approaches tend to adopt.

2. Some limits of the dominant "risk" frame

Sociologist Ulrich Beck has argued that risk has become the central organizing concept of modern industrialized societies [3] and indeed, risk assessment has become the dominant tool for informing and aiding decision-making in the governance of new and emerging technologies [38,84]. In this context, risk is typically understood as involving the potential for negative consequences to attend the introduction of a new technology, the magnitude of these potential consequences, and the probability that they will occur [13,14]. When used for the governance of new and emerging technologies, the risks of interest are typically those relating to potential harms to human health and/or the environment.

One inherent problem with the use of risk analysis as the dominant approach to appraising emerging technologies is that the risks they pose to human health and the environment are often also novel. This leaves them poorly understood and requiring the development of new test methods and/or instrumentation to generate the empirical data required for such an assessment [52]. Such a lack of existing empirical data means that it is very difficult to predict and calculate prospective harms with any confidence in advance. This shortcoming is amplified by the fact that harms are often non-linear, incremental, emergent, and (sometimes) enduring. Rather than reducing uncertainties in a gradual stepwise fashion, conducting more research on the potential risks of emerging technologies can also open up previously unconsidered questions and reveal new fields of uncertainty. Furthermore, the uncertainties surrounding emerging technologies can exist in both quantitative and qualitative forms [70,87]. Some uncertainties will stem from a simple lack of knowledge and be reducible over time, while others will be more systemically embedded, stemming from the inherent limitations of scientific knowledge for understanding complex systems and the inevitable framing choices scientists make in the planning and conduct of their research [83].

Further challenges abound. Not only can harms appear in radically different forms, conceptions of what actually constitutes a harm can also vary significantly. While harms to human health and well-being tend to be regarded as prototypes, they are certainly not the only form of harm. For example, economic harms (understood as costs or losses) are often given significant weight and can also be deployed as proxies to evaluate the seriousness of any predicted health and environmental impacts. Other types of harm, sometimes misleadingly called "moral losses", are also significant and impact the social fabric in ways that often resist formal accounting.[1] For example, harms to traditional knowledge, to community cohesiveness, or to a sense of place are different from harms to health and well-being but should be no less an important part of the assessment of a new technology. Harms to the non-human environment are also real and often relevant but tend to be difficult to identify and quantify. This challenge stems in part from the way that the object of interest can vary (e.g. harm to individual organisms, species, populations, ecosystems, functions) but also by the way in which constant change within nature gives no stable baseline for defining harm. Subtle shifts in symbiotic relationships (e.g. as one pollinator gets nudged aside by another that may be more suited to a changed crop system) have no clear metric for quantification. Growing interest in the significance of "socio-economic" impacts, "non-economic" damages and the "cultural services" of ecosystems, arguably highlight the incompleteness of technology appraisal processes focused solely on risks to human and environmental health.

For emerging technologies that promise deep transformations of social, economic, and biological life, the consequentialist approach of risk analysis is inadequate for identifying the varied forms of peril that may lurk beneath the hype and hyperbole surrounding the technology's introduction. This is not only because of the limited scope and quality of available information for assessing risks associated with emerging technologies, nor simply because the focus on impacts on human health and environment is too narrow. It is also importantly connected to how technology is being conceptualized.

3. Technology as a deep cultural practice

Feminists have joined a number of voices within the Science and Technology Studies (STS) community and argued that technological assemblages are not merely objects but "knots of social and political interests" [4] or what Bruno Latour called "embodied sociality" [43]. Such a standpoint demands a heightened sensitivity to the technology's "political qualities" [75]. The fact that this important point was missed for so long reflects the pervasiveness of the "device paradigm", which Albert Borgmann claims has dominated contemporary life [10]. In the device paradigm, "means" are concealed or shrink from view while "ends" – the commodity/outcome that the technology has promised to deliver – occupy all the attention. When technology is perceived as a device merely delivering an end, a certain kind of blindness to underlying social and cultural entanglements is encouraged. Within this paradigm, technology gets assessed only thinly for the kind of end experience it provides and not for the kind of transformations of material and social structures it creates. With emphasis only on the experienced end, it becomes reasonable to think that benefits and harms might be isolated and quantified using a consequentialist frame such as that involved in risk assessment.

From Heidegger to contemporary feminist technoscience, the warnings of the dangers of such a view are legion. Technology is not a neutral device, it stems from and frames our socio-cultural beliefs

[1] This characterization is misleading because most types of harm considered by risk assessment are in some sense 'moral.'

and structures. "We are delivered over to [a technology] in the worst possible way when we regard it as neutral …. utterly blind to [its] essence" [34: p. 1]. Technology is always more than simply a material object delivering a certain experience. "The machine is not an it to be animated, worshipped, and dominated. The machine is us, our processes, an aspect of our embodiment" [29: p. 180]. Technological artifacts are key components of social fabric, both reflecting and promoting a particular vision of society. They should be thought of "as formalizations, i.e., as frozen moments, of the fluid social interactions constituting them, but they should also be viewed as instruments for enforcing meanings" [29: p. 164]. With these insights in mind, technology can be viewed as *a system* embodied in a set of *practices* that both reflects the world from which it arose and in turn reconstitutes the world into which it is introduced.

If an emerging technology reorders the social and cultural system, then technological appraisal performed for the purpose of governance clearly requires that one look as much at shifts in social and political relationships as at benefits and harms. A utilitarian analysis of costs and benefits or a consequentialist focus on risk simply leaves too much concealed. It cannot fully recognize the dynamic social, cultural, and ecological restructuring the technology performs. A richer and deeper analysis would examine technology as a transformative practice that dramatically restructures relationships. This suggests the need for an ethic that is not just a consequentialist consideration of risks to human health and safety but which puts relationships at the forefront of concern.

4. GMOs: from isolated artifact to agri-food system

A highly illuminating example of how a narrowly consequentialist frame works to conceal issues of concern in the governance of emerging technology is agricultural biotechnology, and particularly genetically modified (GM) crops. While the risk-based approach to technology appraisal in this case has claimed to represent an objective assessment of safety and acceptability, and GMOs have been routinely approved as a result of such assessments, they have continued to generate fierce social and political disagreement for decades. Fueling this ongoing controversy is the fact that several concerns held by citizens are simply not accounted for when a GM crop is considered to be merely a biotechnical device for which the only legitimate questions concern empirically demonstrable risks to human health and the environment. An illustrative summary of some of the concerns that this form of assessment misses include: 1) the domineering or hubristic relationship between humans and nature that GMOs can be seen to represent and perpetuate [84,60], 2) the loss of freedom of choice for non-GM producers and non-GM consumers [7,58], 3) the increasing concentration of power and capital in the hands of ever fewer social actors in agri-food systems [53,71], 4) the widespread implementation of patents and intellectual property rights to control the distribution and development of seed and varieties [51,41], 5) the lack of sensitivity to uncertainties, paradigms and values in the production of scientific knowledge [11,61] and 6) competing narratives and visions of development and the future of agriculture [47,49]. This means that even if GMOs are judged to pose no significant risks to human health and the environment, they may still pose significant socio-economic and cultural concerns.

The way we feed ourselves from the earth represents one of humanity's most foundational relationships with nature. Agricultural practices significantly structure both community and personal identity, implicitly expressing deeply held moral convictions. Through eating we move "inside the differential relationalities that make us who and what we are and that materialize what we must do … Multispecies human and nonhuman ways of living and dying are at stake in practices of eating" [31: p. 295]. Agri-food systems represent a complex set of relationships and attitudes between people and land and different forms of agriculture engender radically different forms of practice and networks of socio-ecological relations. However, the way agricultural technologies, like GM crops, embody and engender particular socio-ecological relations is not immediately apparent to most people. As agri-food systems have become increasingly industrialized and globalized in the modern era, various elements of their practice have also become increasingly removed from lived experience. No longer what Borgmann calls "focal practices" that might sponsor engagement with the full "depth and context" of the world in which we live [10], industrialized agriculture turns the procurement of food into something shallow, disembodied, disengaged, and often destructive to both persons and place. Immersed in the device paradigm, people increasingly consume food solely as an end, disconnected from the means of its production and distribution and therefore typically disengaged from many of the ethical considerations at play.

Just as other technologies, GM crops do not exist in a vacuum but operate as socio-technical and eco-social systems. They are shaped by the interests, values, goals and visions that arise from their contexts of development and deployment and, at the same time, they themselves shape operating discourses, social practices, skills and knowledge. By narrowing regulatory considerations to an assessment of empirically demonstrable risks to human and environmental health, the appraisal process has failed to see GM technologies as agri-food systems and thereby failed to account for the complex networks of interrelation and co-construction this entails [45,57]. To do so requires thinking of the technology less as a thing and more as a system comprised of practices, a system that both breaks old relationships and establishes new ones, with significant implications for the socio-ecological matrix involved. The challenge is then to ensure that these shifting relationships are incorporated in an appraisal process and not quickly concealed from view. For this task, it is clear that a more comprehensive and sensitive ethical lens is required to replace, or at least to supplement, the utilitarian one.

5. GM crops through the care ethics lens

A number of feminist themes identifiable across several versions of care ethics make it a uniquely useful lens to apply in the appraisal of emerging technologies. These themes include: 1) A relational ontology, 2) Emphasis on particularity and context, 3) Recognition of the significance of dependence, 4) An analysis of power and concern for the most vulnerable, 5) Weight given to the affective dimensions of ethics, and 6) An important role for narrative. The case study of GM crops shows how each of these themes makes visible important issues of concern typically excluded or hidden in risk assessment approaches.

5.1. Relational ontology

In the original formulations of what was distinctive about feminist accounts of moral development, the contrast between the idea of autonomous individuals seeking to identify and follow certain rules for behavior, and persons embedded in networks of relationships they felt a responsibility to sustain, took on a high profile. In Carol Gilligan's studies of moral decision-making [22], the real difficulty in the paradigmatic case of Heinz's dilemma about whether or not to steal a potentially life-saving drug centered on what appeared to be the impossibility of Heinz maintaining the integrity of existing relationships with both his sick wife and the drug store owner. The need to sustain these relationships reflects

an insistence broadly accepted in care ethics that we are necessarily "second persons" always partly constituted by the relationships in which we stand [1]. A relational ontology shifts the view of what is ethically important so that the relevant harms to be identified are not so much harms to individuals (whether human or environmental) but the fracturing of relationships of personal, social, and cultural significance. Applied to new and emerging technologies, Susan Sherwin claims that the relational ontology in care ethics demands at the very least "consideration of the social, as well as the physical and psychological, impacts of proposed new technologies" [63: p. 290].

In modern agri-food systems, relationships extend across time and space and include a range of actors beyond the iconic land-farmer-consumer trio. For example, relationships exist across scientists working to develop improved varieties in research and development institutes, contractors producing seed for market, companies responsible for storing and treating seed, beekeepers operating on farm margins, workers operating mills, refineries and processing plants, as well as transport and delivery drivers, store owners and market vendors, just to name a few. Some of these relationships are purely economic, but others are highly constitutive of individual and collective identities.

The relationship between farmer and seed, for example, was traditionally an intimately interconnected one (stretching back though generations), in which farmers saved seed from year to year, carefully selecting and planting varieties that performed well according to desired criteria. This interaction facilitated the co-evolution of both crop plants and farming practice [75]. With the development and uptake of commercial hybrid seed, this intimate, personal and historically rooted relationship between farmers and seed was broken, as the technology required the purchase of new seed each year to achieve a consistent and reliable performance. Under a GM system, however, this relationship breaks down even further as GM crops have become patented inventions, which require not only that farmers purchase new seed each year for reliable performance, but that they sign a contract or "technology use agreement" which prohibits them from replanting the seed and removes their right to conduct any further research or experimentation with the seed [54].

In addition to farmer-seed relations, farmer-farmer relationships can also be severely damaged by patented GMO crops. Adjacent farmers have always had to negotiate a suite of issues that include spraying, drainage, fences, escaping livestock, and cross-pollination. Such issues demanded a particular type of neighbor-neighbor tolerance, communication, and understanding. The introduction of patentable seed inserts a third party into this relationship, the technology's "inventor", and thereby raises the stake considerably when lawsuits over patent infringement occur. This happened in the paradigmatic case of *Monsanto Canada Inc. vs. Schmeiser* where Monsanto successfully sued Canadian canola farmer Percy Schmeiser for growing their patented GM crop, which the court judged to be intentionally planted but the farmer maintained was an unintentional result of wind carrying pollen from a neighboring farm [41]. Organic agri-food systems are particularly vulnerable to negative impacts from this type of "contamination" since being GM-free has become one of their key distinguishing features. Some farmers have now moved away from organic farming so as to avoid potential legal ramifications from cross-pollination contamination and from a specific desire not to destroy relations with their GM crop-growing neighbors and the social cohesion of their small rural villages [6].

These examples indicate how the GM agri-food system can radically transform existing relationships and how new social and ecological relationships of interaction are created through the introduction of the technology. The shifting dynamic between actors such as different farmers, farmers and consumers, seed producers and purchasers, and even between research scientists working on patentable and patented technologies, should all be scrutinized for a comprehensive appraisal of agricultural biotechnology. This would include not only considering the impact that the technology as object would have on human health and the environment, but also importantly how the technology as practice may restructure relationships in significant ways and the extent to which such reconfigurations are desirable and just. The emphasis that feminist care ethics places on the maintenance of nourishing relationships could usefully bring such issues under consideration, issues which are currently outside the scope of risk analysis frames.

5.2. Particularity and context

In an important article contrasting the justice and the care approach to ethics, Seyla Benhabib elucidates the difference between an ethics that considers the "generalized other" and one that considers the "concrete other" [6]. Benhabib articulates a common complaint in feminist ethics that masculinist justice approaches abstract from the "individuality and concrete identity" of any given person in order to make ethics into a non-partial enterprise dealing only with nameless and autonomous others [6]. Ethical actors become mere placeholders in moral equations who lack particularity or specificity. Jake, one of the research subjects in Kohlberg's original studies of moral development, claimed that the famous Heinz's dilemma amounted to "a math problem with humans" [22: p. 26]. Regarding moral dilemmas as math problems requires abstracting away from all the particularities of any one individual and the context in which they operate to focus only on a "generalized other."

The emphasis on relational ontologies mentioned above immediately starts to discourage this sort of abstraction because individuals are understood to be constituted by their relationships to very particular human and non-human others in concrete contexts. The abstraction is further discouraged by the move in feminist care ethics away from ethics as an entirely rule governed endeavor applying formulaically to the generic individuals that fall under it. Feminist care approaches do not consider ethics to be "math problems with humans," suggesting instead that ethics typically demands sensitivity to context and might include, in certain situations, room for partiality.

While the impacts of GM crops are inevitably impacts on particular people and particular situations, it is rare that the specificity of the concrete other is accounted for in either the development of GMOs or in the formal risk assessment processes applied to them (which are often based on quantitative research, statistical analysis and expert judgment). Actual stakeholders are rarely incorporated into assessment processes, and where they are, it is typically through an opening to comment on expert scientific assessments of risk rather than to describe how they themselves may be directly affected. It is also the case that public engagement exercises around emerging technologies have often specifically sought to engage only "the innocent citizen" [37] or those without any specific interests, stakes or established opinions on the issue [17]. This again favours the views of an impartial, generalized other rather than those particularly involved in the issue.

Assessment processes for GM crops arguably demand a certain level of abstraction simply by the scale of their operation and the location of decision-making power – e.g. approval is usually given to a GM crop by a national or supranational authority (such as the European Commission). While there is clearly a place for generalized statistical analyses of harm when assessing a new agricultural practice or product, the variability of social and ecological contexts means that such abstractions can also be misleading. In risk

assessment, some degree of consideration may be given to how different environments can influence the potential risks of GMOs, however, there has historically been very little acceptance that social and cultural particularities and context should be permitted to influence decision-making.

This tendency to deny the significance of social and cultural particularities has been most starkly demonstrated by the World Trade Organisation's (WTO) arbitration of divergent decisions on GMO regulation. In a famous case, the USA (and others) challenged the legitimacy of a *de facto* moratorium on GM crops that the European Union had in place as they attempted to manage consumer concern. The challengers won the case on the basis of a ruling that the moratorium was not based on *scientific evidence*, which was interpreted as an empirically informed assessment of health and/or environmental risks [72]. The socio-political particularities connected to cultural context were deemed not to be legitimate factors for decision-making.

This lack of acceptance of the importance of context sensitivity has also been an historical feature of the European regulatory system for GMOs itself. Member States have previously not been permitted to take their own decisions concerning the acceptability of GMOs unless it is specifically based on new scientific evidence [85]. Interestingly and – we would argue – appropriately, this controversial situation has recently been overturned with a new resolution of the European Parliament [19] that allows Member States to prohibit the cultivation of GMOs within their territory on the basis of grounds such as agricultural and environmental policy objectives and socio-economic impacts.

This recent move in the European Union to open up and allow for particular socio-cultural contexts to be given more weight in assessment processes was implemented as an attempt to break the long standing political impasse on GM crops in Europe. Global policies that do not account for national, regional, or even local differences in culture, economy, or ecology clearly treat technological appraisal as simply a math problem. But with agri-food systems often being such a fundamental constituent of cultural identity, there appears to be an emerging recognition that approaching GM crops as a universal math problem is stimulating rather than diminishing debate. A feminist emphasis on concreteness and particularity in ethical decision-making can legitimize the differences and divergences across actors that are clearly already present in debates over emerging technologies but routinely dismissed. As such, it can open up space for different nations or regions to legitimately adopt different positions on technologies like agricultural biotechnologies depending on the particularities of their context and culture (and not just across USA/Europe but also the global north/south). It also opens space for different agricultural biotechnologies themselves to be assessed for their individual particularities, rather than treated as an indiscriminate block. Furthermore, it would open appraisal processes to more directly consider the impacts of the technology as a system on specific actors, such as organic or smallholder farmers, seed companies of different sizes, publicly funded researchers and plant breeders. Such an openness to the relevance of context and particularity may also allow for the development of a more nuanced debate rather than the highly polarized and bifurcated division we currently see around GMOs.

5.3. Dependence

The turn away from ethics as a set of rules applying equally to groups of nameless and faceless individuals also suggests a rethinking of the emphasis on autonomy that has pervaded ethics since Kant. In both Nel Noddings' [55] and Eva Kittay's [42] articulations of a care ethic, there is recognition that caring relationships often take place between those who are not equally situated or autonomous. Kittay insists that a foundational human experience in the world is one of dependence in which some kind of difference in capacity exists between the persons in the relationship. “We are all some mother's child,” she points out [42: p. 19]. This idea that there are often important differences between persons in a relationship also appears in Noddings' differentiation between the “one caring” and the “cared for.” This emphasis on asymmetrical relationships, while critiqued by some feminists [36], can draw attention to the ways in which agri-food systems are also comprised of networks of linked dependencies. In light of these linked dependencies, individuals and groups of individuals can be highly vulnerable to the possibility of network disruption. Particular shifts in relationships expose individuals to the possibility of harm through the loss of the provision of something important on which they depend, whether that be parental care, essential health or educational services, or food itself. Though neither Kittay nor Noddings are eager to extend their accounts of care and dependency to include the natural world due to the specific emotional and cognitive components of care demanded by their views, it is clear that an additional type of dependency exists between humans and ecological systems.

It is central to this feminist analyses that dependence itself is not necessarily problematic, it is simply an inevitable part of the fabric of life. What Noddings and Kittay show us is that relationships of dependence can be nourishing or destructive for the people involved. They can be socially legitimated and supportive or they can be taken for granted and oppressive. An emphasis on dependence draws attention to the values and structures that might sustain this oppression.

Just as people inevitably depend on certain human others, they also depend on functioning agri-food systems and the institutional arrangements they contain (be they self-sustaining or otherwise). Within GM agri-food systems, one of the major concerns has been with how the technology creates new depths of dependency for both producers and consumers on a select few powerful agents, namely the multi-national corporations that own GM crops as their patented property. The dependency of GM agri-food systems on multi-national corporations includes not only access to seed, but also to ‘co-technologies’ such as chemicals for production (such as herbicides, pesticides and fertilizers) and to technical information and support. As farmers and consumers become increasingly dependent on a small selection of powerful actors, relevant questions arise concerning whether those actors are engaged in the relationship in a caring and nurturing manner or whether the relation is extractive, profit-driven, and destructive [64]. The predominance of herbicide tolerant GM crops (such as Roundup ready® soybeans, corn, cotton and canola), which are designed to be used together with particular chemicals that are owned by the same companies selling the GMO, has raised significant questions about the motivations involved, particularly as benefits for consumers have not been prominent in the first generation of GM crops.[2]

The point here is obviously not that dependency in agri-food systems is always bad. Farmers have always been dependent upon experience, know-how, local knowledge, and a range of existing economic relationships. Some degree of locally distributed dependency is in fact a source of the very relationships and

[2] While there is little evidence to support a link between farmer suicides in India [25] and the introduction of Bt cotton, concerns about the relationship between farmer debt, the seed economy created by GM crops, and suicide have created a fierce and emotional public debate around the pros and cons of biotechnology use in the developing world.

practices that create and sustain a community over time. With this more traditional type of dependency, the agents on whom one depends are typically relatively accessible/present and therefore potentially more engaged and attentive (as demanded by Noddings and Kittay) than abstract and distant. This type of dependency is, however, arguably different in scale and scope from the type of dependency that GM crops have created. GM crops amplify and intensify the move within agri-food systems away from a locally distributed dependency and towards a dependency imposed from the outside by a handful of powerful actors. In the globalized system of industrialized agriculture that GM crops emerge from, perpetuate and strengthen, dependencies are increasingly concentrated in a select few distant actors rather than distributed amongst diverse and more accessible agents. A feminist ethic lens would call for specific attention to be paid to the types of dependency being created by a new technology and question the extent to which they were constitutive of a healthy community.

5.4. Power and vulnerability

Feminist thinking is particularly concerned with power relationships and Kittay's work on dependency is only one of the ways in which power inequalities have been highlighted. Iris Marion Young has talked about the "structural injustices" that systematically pervade society [89,90]. Even if they are not intentionally malevolent, these injustices subject certain individuals and communities to the "systematic threat of domination or deprivation of the means to develop and exercise their capacities" [90: p. 114]. In a further illustration of the central concern with power in feminist thought, Hilde Lindemann defines gender itself as a normative power relation [48]. Gender often rudely instructs people on how to act in the world, containing strong social prescriptions for what are deemed appropriate roles and behaviors. Lindemann identifies feminism's concern with gender as being about "understanding, criticizing, and correcting" these power moves and exposing the ways they make some people vulnerable while empowering others.

As Kittay's examination of dependency illustrates, lack of power is not always inherently bad; some power imbalances are simply an ineradicable feature of a world riddled with complex and uneven relationships. In these cases, power imbalances are simply something to pay attention to so that the imbalance does not systematically disadvantage some groups over others. Furthermore, imbalances in power need not suggest a lack of agency or capability. Feminist standpoint theorists draw attention to the possibility that those who are structurally disadvantaged might end up having particular insights available to them for critiquing the status quo [33]. Recognizing a power dynamic can ensure that voices currently missing from the political discourse are sought out and that hidden structural effects of power imbalances are illuminated.

In the case of GM crops, the significance of power has already been mentioned in the discussions of dependency and relational ontology. However, there are additional aspects of relevance in the unfolding of GM technology as an agri-food system. The adoption of GM crops has in some cases created an uneven power balance and set of burdens amongst different types of farmers. In Europe, for example, there is a general commitment to the importance of maintaining separation between GM and non-GM agri-food production and consumption chains. However, the burdens of upholding these "co-existence" regimes are typically unjustly distributed. Since gene flow can occur between certain crops through cross pollination, and contamination can occur through unintentional mixing during seed and grain production and along transport and processing chains, maintaining separation between GM and non-GM crops requires preventative actions. This can, for example, include implementing crop separation distances in the field. Implementing such distances is, however, typically voluntary (leaving non-GM farmers reliant on the good will of those cultivating neighboring fields) and extremely difficult for small-scale and subsistence farmers (since it significantly reduces the amount of land that can be farmed with that crop). Furthermore, conducting consistent monitoring of seed and grain samples throughout different stages of the agri-food system is also required to assure separation of GM and non-GM crops. Currently, the costs of monitoring for GM contamination and mixing must be born by those choosing not to adopt the technology, i.e. it is those that do not wish to be contaminated with GM material that bear the burden of monitoring [9].

Power issues are also in play over the issues of labeling. Consumers in countries such as the United States are currently prevented from avoiding GM foodstuffs by the lack of a requirement for labeling. Efforts to impose mandatory GM labeling at the state level are repeatedly thwarted by expensive advertising campaigns, manipulation strategies by GM interests and by national authorities. These interests exert their power to deny choice to consumers who are at present unable to determine whether a certain product contains GM crops or not. Lack of labeling clearly undermines not only the power of consumers to exercise control over the food they consume, but also their ability to invest in and express support for a certain type of agri-food system through their purchases.

The way in which GM agri-food systems have come to dominate particular contexts and sectors can also been seen as a relevant issue when scrutinizing the potential creation of vulnerabilities. For example, in the US in 2014, 93% of all corn, 96% of all cotton and 94% of all soybean acreage was GM [76]. Such a high level of dependence on GM crops rather than a broad range of agricultural biodiversity, and therefore also on the select few powerful actors that control them, can clearly leave people highly vulnerable to economic/ecological change. Resilience in socio-ecological systems, and particularly in agri-food systems, is a character trait linked to diversity and flexibility. Should a particular disease or problem befall these crops, or a particular disease or problem emerge as linked to cultivation or consumption of these crops, then this system of heavy dependency will quickly create extensive challenges and be revealed in all its fragility.

It is also worth highlighting that the dominance of risk based approaches for assessing emerging technologies already makes particular power moves, e.g. by granting power over questions of public acceptability and what counts as relevant knowledge to a select group of scientific experts [86]. As shown, however, these methods do not provide any mechanism for detecting power distributions and vulnerabilities created by new technologies. There is simply no way for a utilitarian risk-assessment frame to account for issues such as a consumer's freedom to choose or the question of whether the dominance of one type of system creates unacceptable vulnerabilities. A similar challenge arises with the problem of the additional burden on subsistence, organic, or conventional farmers for monitoring their crop against GMO infiltration and patent infringement. A feminist care ethics approach comes to the problem already sensitized to the way power operates in relationships and is particularly attentive to the needs of the most vulnerable. Using this lens in an appraisal of the technology would therefore ensure that these types of burdens are less likely to escape notice.

5.5. Affect

One of the most widely articulated features of feminist care ethics is its emphasis on the affective dimensions of moral experience. Where ethics has previously been characterized as essentially rational, the efforts of feminist care ethicists have created a

growing appreciation that moral decision-making has a significant emotional core [35]. Morality is lived and experienced by flesh and blood individuals who respond to real world situations both rationally and emotionally. It is not lived by abstract and fully autonomous rational agents, who make decisions according to logic and formula. As a result, responses to situations need not exclusively focus on reason. Action may be legitimately motivated by the affective demands of a situation, for example, by the emotional importance of the personal relationships comprising it and resistance to their potential loss and transformation.

This emphasis on affect does not mean that reason is excluded from moral decision-making. Matters of justice, for example, have both emotional and rational dimensions [27]. It does mean, however, that a significant part of the process of responding to a situation perceived to contain moral dimensions involves emotions, which can be shaped by personal, historical, and cultural context. This emphasis on emotions is consistent with the possibility of partiality. An emotional connection is likely to be stronger when a relationship is more intimate or direct. This partiality might be directed towards a family member, a farmer that supplies a community with food, a crop that has important cultural significance, or even a landscape identified as home and for which a person has a particular attachment. A feminist sensitivity does not dismiss an affective response as irrational but recognizes it as a core component of morality.

The GMO debate has clearly had a very strong affective dimension, with people often reacting emotionally to either the transgenic element of the technology itself or the transformation it threatens. The very thought of GMO's create in some people a kind of "yuck" response, often connected to the perceived "unnaturalness" of the technology [39]. The emotional and intuitive nature of this response can often leave those who have it unable to fully explain it [26], even though, as theorists such as Mary Douglas [18] and Martijntje Smits [68] have argued, such reactions relate to the transgression of important ordering concepts and cultural categories that people use to orient their understanding of the world and their action within it. While some are quick to reject these types of worry as irrational or ill-informed [59,73], public engagement exercises have found that those gut reactions or moral doubts are highly important and often "act as a veto irrespective of people's views on use and risk" [21: p. 845]. It is also notable that affect in the debate over GM crops is not restricted to members of the general public; it is powerfully apparent within the scientific community as demonstrated by the way various scientists publishing potential harmful effects from GM crops have come under vicious and vindictive attack from supporters of the technology. These attacks have been described as being emotional, personal and crossing over into a form of harassment [81]. Although typically ignored by decision-makers, affect drives a significant portion of the GM debate.

Within the realm of technology governance, the call has consistently been for rational decision-making based on sound scientific evidence, with emotions sidelined as having no place in the assessment process. This is despite the clear role that they continue to play in people's own assessments of the technology and its acceptability. This has often forced opponents of GM agri-food systems to campaign on the basis of spurious risk-based concerns when their position actually stems from other considerations and issues, particularly ethical concerns, questions over the proposed purpose of the technology, or commitments to competing visions of the good life [46]. This has been necessary because other considerations are permitted no place within a risk assessment frame [88]. Many of the aspects of GM technologies that people react emotionally to, such as the loss of traditional identities and practices (such as seed saving, subsistence farming, polycultural cropping), the challenge to established ordering concepts (such as a species, a plant, a farmer), or the perceived "unnaturalness" of GM crops (whatever its philosophical merits or demerits), are extremely hard to quantify but are a type of gut level reaction to an infringement of a worldview rather than a response to an empirically demonstrable risk to human or environmental health. These affective dimensions are excluded by risk assessment frames but could potentially find a place for articulation through a feminist lens that takes such elements of moral experience seriously.

5.6. Narrative

A number of care ethicists have proposed narrative or storytelling as an appropriate mechanism to employ for unpacking moral situations. Karen Warren suggests that narrative is a useful tool that can be employed to highlight issues "often lost or underplayed in mainstream philosophical ethics" [82: p. 134]. Stories also have the potential to "entertain, explain, connect, and emancipate" [74] and can be particularly effective at unearthing the detail that matters for an individual or community. In addition to the capacity for expanding the moral imagination [56], narratives can open the door to power considerations by providing room for the voice of those who might ordinarily be excluded, e.g. those who may not comprise the dominant majority and/or may be vulnerable to a transformational change. Narratives can not only help capture certain ineffable and very personal features of moral experience, they can also help capture the emergent nature of certain moral challenges. Narrative illuminates "the location of human beings' feelings, psychological states, needs, and understandings as nodes of a story (or of the intersection of stories) that has already begun, and will continue beyond a given juncture…" [78: p. 18]. This could be particularly important for new and transformational technologies where shifts in relationships may not be visible in advance but start to emerge over time.

A narrative mode would arguably be well suited for revealing issues connected to each of the five themes already highlighted. Narrative can bring attention to particularity and context, emphasizing the importance of allowing individuals to control their own story. It can make connections between actors and events clear and generate questions about how relationships might unfold. Narrative can also serve as a prompt for the moral imagination (i.e. expanding our horizons to include the plight of others) and can be used to recognize and affirm affective experience. Furthermore, given the way narrative articulates interconnections and views of relationships, narrative could also help reveal the underlying worldviews, socio-technical imaginaries and future visions that inform and shape the development of technological trajectories.

Research on the psychology of risk perception for emerging technologies has clearly demonstrated not only the importance of gender [15,65,66], but also the significance of worldviews, values and beliefs [67]. Competing worldviews and visions are arguably central in the debate over GM crop acceptability, e.g. disagreements concerning what is a desirable model for the future of agriculture, what is an appropriate relationship with the natural world, what is the basis or cause of the challenges we face in feeding a growing population, etc. Understanding, analyzing and addressing this dimension is, however, never formally a part of decision-making conducted within a risk assessment frame. Opening up space for narrative and paying attention to storytelling would arguably allow this significant dimension of moral consideration to become a legitimate part of the assessment process. Permitting different actors to frame and tell their own stories in a technology appraisal and policy making context would allow both the political deliberations and the social debates more broadly to take place not just in terms of the

scientific risks involved with using a particular device, but importantly, to also engage with and illuminate questions around how the technological system relates to and/or advances concepts of the good life, the good community, and appropriate relations between humans and nature.

The problems that have arisen for GM crops as highlighted in this paper tend to surface most clearly through the stories people tell about their own lived experience with GMOs. Applying a feminist ethics lens to technology appraisal in this case would allow the appraisal to pay particular attention to the (often competing) stories being told by various actors about what GMOs are, where they have come from, what they offer, and where they are leading us. This would be highly instructive and revealing of underlying beliefs and motivations and allow these to become a transparent component of the appraisal process.

6. Conclusion

The six features associated with a feminist perspective and care ethic described above are neither exhaustive nor exclusive. There are other features of feminist care ethics that might have been identified and other feminist approaches and ethical frameworks that might have also highlighted them. What the feminist ethics lens clearly provides, however, is an illumination of issues that appear particularly relevant when attempting to approach the governance of new and emerging technologies from a socio-ecological systems-based perspective. Through this paper we have sought to demonstrate that if technology appraisal were to be conducted with these features of care ethics in mind, different impacts would be noticed and made legitimate, different questions would be asked, and different conclusions potentially drawn. In this article we have focused on how a care ethics lens can be used to broaden technology appraisal. However, it could be argued that the lens could also be used to improve governance through informing, shaping and guiding the actual development of emerging technologies (rather than just their regulation). In this case, the features of a relational ontology and attention to particularity, context, dependencies, power and narrative would become important considerations incorporated into the imagination and development of future agricultural biotechnologies. This means that although existing GM crops may not necessarily meet a favorable appraisal when viewed through a care ethics lens, this need not be the fate of all agricultural biotechnologies. How the lens may be used to shape more 'caring' technologies and socio-technical systems in the future (and what these would look like in practice) is arguably a topic worthy of further research and another paper. It is also worth noting here that although agricultural biotechnology provides a particularly useful illustration of the potential benefit of adopting a care ethics lens, the lens will also likely be of value for the appraisal of emerging technologies more generally, as well as for complex global challenges such as climate change.

The advantages of the care ethics lens that we have highlighted should not be taken to suggest that a traditional risk assessment frame misses everything of moral significance about a new technology. Scientific and statistical assessment of the risk of harm has an important role to play in the governance of emerging technologies. However, it is clear from feminist science studies that the relevant impacts of a new technology reach far further than physiological or environmental harm. They also infiltrate the "embodied sociality" of the technology [43]. The feminist care ethics lens seems well suited to identify impacts that not only can be missed by traditional risk assessment, but which can also turn out to represent some of the most salient dimensions of technological change. The care ethics lens therefore helps to bring focus to these transformations and does it in a way that illuminates aspects that actually matter to real people in their daily lives.

Would such an approach ever be adopted in practice though? While it is beyond the scope of this paper to engage in a detailed analysis of the political obstacles and challenges facing the adoption and use of a care ethics lens for the governance of emerging technologies, one argument often touted in favor of traditional quantitative risk-assessment is that it can offer a clear numerical answer to complex questions. In contrast, care ethics is often accused of lacking both precision and normativity. However, we would argue that the science of risk assessment is falsely definitive, narrowly defining risk as the only relevant element for consideration of a technology's public acceptability and often failing to account for the ambiguity of risk-based research. Since care ethics does not tend to see moral dilemmas as math problems, the answers it gives to moral situations may not always be definitive and indeed this may be the point. While it is clear that the process may be messy and decision-making not always clear, this seems to better reflect the social reality that surrounds emerging technologies. Feminist care ethics may therefore be seen to provide the kind of "plural and conditional" policy advice that is being called for in this domain [70]. Indeed, the new European resolution now creates room for a more pluralized and context specific approach to GMOs, enabling individual Member States to take decisions based on factors such as socio-economic impacts, agricultural policy objectives and cultural traditions [19]. Such an opening for alternative appraisal criteria could be leveraged for the exploration of a care ethics lens in the governance of agricultural biotechnologies. This may see different socio-ecological and cultural contexts yield diverse assessments of GMOs, some favorable and others not. More broadly though, the increasing emphasis within science policy on the need to advance 'responsible research and innovation', and the conceptions of responsibility as care within this [69], also open a crack for a care ethics lens to be further developed and applied. While our focus in this paper has been on providing an argument for the potential benefits and value of a care ethics lens, political obstacles to uptake clearly remain and, we suggest, offer a fruitful area for further research and work should our argument of the advantages prove convincing.

To quell any concerns about normative vagueness, it is clear that guidance from other ethical frameworks can easily be brought in to supplement the care frame. For example, policy-making can be guided by the norm of *sustaining healthy relationships* between (social and ecological) community members and curtailing those relationships that are destructive. It might seek to *protect the most vulnerable* and avoid situations where concentrated power is used to *structurally disadvantage* certain segments of the population. It might embrace *caring forms of distributed dependency* and avoid types of dependency that *foster exploitation*. It might take more note of *negative affective* responses and seek ways to ensure positive ones. It could seek to give people *control of their own stories and their unfolding* and try to avoid forms of life being *imposed from the outside*. Certainly, the practicalities of implementing a care ethics approach and the alliances it will demand remain to be articulated in greater detail in future work. However, the worry about normative vagueness does not appear to be debilitating.

The important socio-cultural dimensions of technological innovation that have been concealed by the device paradigm and the reliance on risk assessment seem to provide a clear and significant opening for a better assessment frame. If Donna Haraway was right about the need to realign the technical and political so that "questions about possible livable worlds lie visibly at the heart of our best science" [30] then we need decision-aiding tools that are better suited to the task of technology appraisal. We hope that this article might spur additional exploration of what could be a new and important role for the care ethics approach.

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