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Introduction

The possibility of describing the effects of lifestyles and/or environmental exposures through measures of epigenetic modifications has prompted a prolific debate around the responsibility claims attached to this knowledge. Social sciences and humanities scholars have formulated several critiques of individual claims regarding uses of epigenetic information for responsibility attribution (Hedlund, 2012; Dupras and Ravitsky, 2016; Chiapperino, 2018; Meloni and Müller, 2018; Bolt et al, 2020). Specifically, critiques have focused on the limitations of two intertwining responsibility claims (Vincent, 2011): one in terms of accountability for damaging one's own epigenome (liability or backward-looking responsibility), and another one highlighting prospective duties to protect it (remedial or forward-looking responsibility). Aside from these critiques, moral luck has been introduced as another challenge of such responsibility claims (Chiapperino, 2020). The long-standing debate on luck in moral philosophy (Williams, 1982; Nagel, 1991; Statman, 1993) has examined the effect that factors beyond one's control have on the justification and cogency of normative claims such as responsibilities. The challenge of luck for moral intuitions concerning responsibility resonates well with a consideration of the epigenome's complexity and stochasticity (Panzeri and Pospisilik, 2018). Unlike other critiques of responsibilities grounded on epigenetics (see Hedlund, 2012), considerations of luck question the causality conditions of these responsibility claims. Not only is it difficult to disentangle whether an epigenetic modification is solely due to lifestyle, environmental stimuli, genetic differences or stochasticity, but the complex causation of epigenetic modifications also calls into question

an agent's capacity to affect this course of action. Considering these factual considerations, previous work has challenged the idea that individuals really affect their epigenome and that they can therefore be held responsible for past behaviours and/or future actions remedying these health risk factors (Chiapperino, 2020).

However, such a criticism based on luck also dramatically jeopardizes the possibility to meaningfully ascribe responsibilities to prevent or correct epigenetic harms to collective agencies (for example, the state, corporations, public health agencies). Collectives are also subject to circumstances, conditions and vagaries in the outcomes of actions, raising the problem of moral luck (Chiapperino, 2020). But does considering luck in the normative uptake of epigenetics leave us without any notion of epigenetic responsibility altogether? This chapter aims to explore whether any residual collective epigenetic responsibility remains after taking into account the challenge of moral luck. Both ordinary language and the social function of collective responsibilities call for an effective societal uptake of epigenetic knowledge. However, this requires an appropriate language of responsibility. Our goal here is to specify in what salient ways collective agencies should be blamed for failing to prevent, remedy or be accountable for epigenetic predispositions to health problems caused by socio-environmental exposures. To this purpose, we develop a different approach to mitigate the effects of moral luck on (at least) a residual teleological/role version of responsibility. The model draws on notions of aretaic blame (Cheng-Guajardo, 2019) to argue that collective (for example, corporate, state or public health) commitments (or failures to commit) to the protection of our health are crucial for moral evaluation of the worth of these collective agents. This shall be taken to imply a preoccupation with the interaction between health and the environment insofar as this is mediated by the epigenome. As distinguished from a strong version of moral responsibility, this approach embraces a moral life of epigenetic knowledge that considers the complex circumstances, social processes, indirect agencies, intricate causalities and transformative opportunities characterizing the roles of both collective agents and the epigenome in shaping health trajectories. We first provide an overview of how evidence of epigenetic modifications is tied in the literature to questions of individual and collective responsibility. We then discuss how luck challenges the attribution of such responsibilities. We conclude by offering a resolution to this challenge, focusing on an assessment of collective agents' moral worth as residual collective responsibility.

Epigenetics and responsibility claims: strands of criticism

Commonly studied epigenetic modifications, such as DNA methylation, are currently emerging as accessible biomarkers of the effects of lifestyle

and/or environmental exposures on health (Guerrero-Preston et al, 2011). Global and gene-specific methylation patterns have been associated with different individual behaviours, social conditions, environmental exposures and lifestyles. Although the causal implication of epigenetic modifications in disease aetiology is still debated (Shanthikumar et al, 2020), several researchers have underlined the practical utility of this information (Cooney, 2007; Fiorito et al, 2019). Epigenetic modifications are not only regarded as a footprint of experiences, environmental exposures and life trajectories, but allegedly also offer an insight into the mechanisms of health and disease (Cavalli and Heard, 2019). In a nutshell, researchers invest this information with the potential to both illuminate the mode of action of exposures (chemical, social, lifestyle, and so on) on the body (how the body responds to environmental cues) (Jeremias et al, 2020), and offer actionable mechanisms of disease 'that can lead to better prediction, prevention, treatment, and policy' (Ladd-Acosta and Fallin, 2019, p 2).

This dimension of actionability of epigenetic information has been the subject of substantial scrutiny. While the potential of policies focusing on social and environmental interventions based on epigenetics has been acknowledged (Chiapperino and Testa, 2016; Chung et al, 2016), it remains unclear how to incorporate epigenetic information into normative discourses of responsibility. What if epigenetics becomes politicized as the science of desert and accountability in healthcare, as well as responsibility for protecting the epigenome and health (Hedlund, 2012; Loi et al, 2013; Rothstein, 2013; Chiapperino and Testa, 2016; Bolt et al, 2020)? This debate has been particularly prolific because epigenetic knowledge touches upon standard conditions for models of both backward- and forward-looking responsibility (Pettit, 2007; Aristotle, 2009; Vincent, 2011; Talbert, 2019). First, epigenetics allegedly brings to light the causal connections between a particular agent, or a given set of actions (for example, lifestyles, environmental exposures), and a certain responsibility-relevant outcome with regard to responsibility (for example, one's health condition). For any claim of (backward- and forward-looking) responsibility, it is usually a necessary condition that the agent has causally contributed to an outcome or can contribute to remedying it. Epigenetic marks of past behaviours epitomize these causal intuitions around responsibility, even though they are far from doing so without any doubt (see below).

Second, another component of moral conceptions of responsibility is the so-called voluntary condition, which postulates that the agent may be judged responsible if the action under scrutiny was voluntary, that is the agent had control over whether the action/outcome emerged as this was neither a necessity nor a random event (see Talbert, 2019 for an introductory overview of various approaches to the voluntariness condition).

Finally, epigenetic information relates to the moral intuition connecting responsibility with the degree of knowledge that we hold about our

actions and their consequences: the more we know about what is at stake, the more we can be held responsible for our actions, or for remedying a state of affairs. Known as the epistemic condition (Pettit, 2007; Aristotle, 2009), this point is particularly relevant to the ethical scrutiny of epigenetic knowledge. Does this novel information about the impact of one's actions and/or life conditions over health 'make a change in degree' (Hedlund, 2012, p 178) in the responsibilities that individuals hold to protect their health? Does this open new questions of responsibility in light of previously unknown multigenerational effects of unhealthy behaviours (Chadwick and O'Connor, 2013)?

Critical studies of epigenetics provide a rich normative basis for deconstructing claims relating to both backward- and forward-looking individual responsibilities for protecting one's epigenome (reviewed in Chiapperino, 2018; Dupras et al, 2019; Santaló and Berdasco, 2022). Primarily, and following an extensive body of scholarship on responsibility in relation to health (Minkler, 1999; Resnik, 2007; Buyx, 2008; Brown, 2013; Voigt, 2013), scholars have questioned the voluntariness and cognizance conditions of backward-looking claims towards epigenetically grounded accountability for unhealthy lifestyles and behaviours (for example, Bolt et al, 2020). In a seminal article, political scientist Maria Hedlund pointed to the 'circumstances that to varying extent constrain individual choice' (Hedlund, 2012, p 179) to undermine claims of intentionality, voluntariness and capacity around responsibility concerning our epigenome (see also Chapter 6). In her view, these conditions rarely apply, as the involved parties are constrained by unequal social and economic structures. Even if one conceded that the epigenome highlights previously unknown mechanisms linking lifestyles, environmental exposures and our bodies, it would be excessive to claim that lifestyle behaviours result from individual deliberate and knowledgeable choices regarding a course of action. Individuals seldom have (in a morally relevant sense) control over their lifestyle behaviours as well as the (epigenetically mediated) outcomes they bring about. Instead, those behaviours stem from an intricate web of social structures and influences that 'strike unevenly' (Hedlund, 2012, p 179) in our societies, and thus unevenly hamper individual capacities to take full responsibility for their consequences, or for correcting them.

In the face of these criticisms of the voluntariness and epistemic conditions for epigenetic responsibilities (both backward- and forward-looking), several scholars have suggested that the responsibilities for protecting the population's epigenome should largely be ascribed to collective agents. As famously argued by Hedlund, epigenetic knowledge 'calls attention to the role of structural conditions, which as well could give rise to a focus on *the role of society and the state to protect and care for health and wellbeing of individuals,*

present and in the future' (Hedlund, 2012, p 181; emphasis added). As many of the contributions to this volume testify, the fact that large structural social configurations influence health, patterns of environmental exposures or individual behaviours – all processes with distinct epigenetic effects on health – demands collective, rather than individual, action to account for and/or remedy this state of affairs. Critical and cautious voices notwithstanding (Dupras and Ravitsky, 2016; Hens, 2017; Huang and King, 2018), an overarching consensus exists as to a normative translation of epigenetics promoting 'a forward-looking approach that calls for collective responsibility' (Pentecost and Meloni, 2018, p 62).

Does luck undermine collective epigenetic responsibilities?

Other critics have taken issue with the actionability of epigenetic information (or lack thereof). Another critique of these claims is, in other words, asking whether they meet the causal and epistemic conditions of responsibility. Does epigenetic knowledge offer novel avenues for taking control of one's health? And even if lifestyles and/or exposures are implicated in disease through epigenetic mechanisms, does this information really heighten our knowledge and inform action? Previous work (Chiapperino, 2018; Chiapperino, 2020) has deconstructed claims of the backward-looking type of responsibility by pointing to the nature of the epigenome and epigenetic mechanisms, as well as to the ways causal claims are discussed in the biomedical debate internal to environmental epigenetic and epigenetic epidemiology (Heijmans and Mill, 2012; Mill and Heijmans, 2013; Mitchell, 2018). In risk assessment contexts, it is still a 'fundamental challenge' to identify 'measurable causal relationships between epigenetic modifications and health outcomes' (Angrish et al, 2018). The existing scientific evidence reporting the epigenetic effects of past individual exposures, habits, life conditions and psychosocial factors on these mechanisms lacks a clear understanding of the causal connections required to establish responsibility. The relationship between epigenetic modifications, gene expression and resulting health phenotypes is complex. There is still limited knowledge of how the epigenome functions in different genomic contexts (for example, tissue types) (Jones, 2012; Birney et al, 2016). But also, an organism's complex traits (such as most diseases) are hard to predict from epigenetic parameters alone. Phenotypes result from multicausal relationships that flow in multiple directions among genetic, epigenetic, cellular, organismic and environmental factors. These processes are also heavily affected by developmental trajectories, and are partly the result of stochasticity in determining genomic regulatory outcomes and phenotypic effects (Panzeri and Pospisilik, 2018). Nowadays, epigenetic stochastic

variance is recognized as an important contributor to phenotypic variation within a population (Peaston and Whitelaw, 2006; Allis and Jenuwein, 2016). Stochastic changes in DNA methylation that may be transmitted from one generation to the next, also called 'spontaneous epimutations', have been studied for years in plant species (reviewed in Johannes and Schmitz, 2019) but remain a puzzle for scientists studying the impact of epigenetics on human disease and inheritance (Biwer et al, 2020). Finally, epigenetic evidence does not fully support the idea of reversibility, especially in cases where developmental dynamics have contributed to the establishment of a disease phenotype. Plasticity in adulthood is only residual, resulting in limited possibilities for individuals to revert aberrant metabolic processes and reduce disease progression through actions whose effects are mediated by the epigenome (Panzeri and Pospisilik, 2018).

These caveats are necessary to accurately interpret how this biological information affects the impact of agents on the body, ageing and disease (through the epigenome). There is little possibility of adjudicating whether an epigenetic modification is due solely to lifestyles, environmental stimuli, genetic differences or stochasticity. Similarly, it is also challenging to disentangle to what extent an outcome is due to any of these factors. A different and related version of this critique can be formulated concerning the duty to adjust one's behaviours or take a course of action to repair or remedy to aberrant epigenetic predispositions towards disease (forward-looking responsibilities). Dupras and Ravitsky (2016) have taken issue with these claims based on similar epistemic considerations about the epigenome. It would also be difficult to enact such responsibility claims prospectively in an informed way as the complexity of the epigenome undermines any definition of 'epigenetic normality' (Dupras and Ravitsky, 2016, p 536): this is highly contextual, being relative to a unique assessment of an organism's genetic, epigenetic, environmental and developmental trajectory, as well as open to luck and stochasticity. Thus, what 'healthy' behaviours and what specific epigenetic effects should one strive for? Furthermore, one may also add that the stochasticity of epigenetic effects questions an agent's capacity to causally affect this course of action: can individuals really affect their epigenome when the outcome of their actions lies beyond their control?

A previous contribution to this debate (Chiapperino, 2020) formulated a critique of both retrospective and prospective epigenetic responsibilities under the banner of the renowned philosophical problem of moral luck (Williams, 1982; Nagel, 1991; Statman, 1993). Standard notions of responsibility are at odds with the idea that we might be held responsible for the epigenetic effects of our behaviours, lifestyles or exposures, if it cannot be proved that we have willingly and intentionally brought them about. The considerations previously discussed concerning how stochasticity and luck affect our epigenome as a result of behavioural and environmental factors

raise precisely this challenge to standard notions of responsibility; a paradox that may be well apprehended in terms of moral luck. On the one hand, it may be argued that the epigenome's complexity and stochasticity indicate that we cannot be held morally responsible for epigenetic modifications because we do not actually cause and control them, requiring the admission that the pervasiveness of luck in our lives (and epigenomes) dramatically undermines responsibility for these effects. On the other hand, those considerations might be taken as a reason for shielding our judgements of someone's responsibility for these effects from luck. But then we would end up dramatically restricting the ground for attributability and ownership of these actions. Luck (as stochasticity, but not exclusively: see Chiapperino, 2020) is in fact ubiquitous in the way complex metabolic phenotypes emerge, to the extent that excluding luck would leave little scope for responsibility to apply.

Let us spell out how luck provides another source for critique against responsibility claims around the epigenome. Luck wears out the moral concept of responsibility in relation to biological factors regarding the effects resulting from one's action. To paraphrase philosopher Thomas Nagel, there is luck in 'the way things turn out' in the epigenome and its role in health (Statman, 1993, p 61). Our epigenome is characterized by environmental plasticity, individual variability and a general indeterminacy of change–effect mechanisms. By putting resultant luck into the picture, we are left with a very different understanding of the moral cogency of claims towards (epigenetic) responsibility. Specifically, one may highlight three potential sources of resultant luck for a given agent and an epigenetic outcome.[1] First, the outcome itself of lifestyles and/or exposures may occur or fail to occur. It is far from clear whether specific lifestyles or environmental exposures produce aberrant epigenetic predispositions (other factors, including stochasticity, may bring them about). Second, it is unclear whether the agent may bring about a specific outcome at the level of the epigenome or fail to bring it about; this is conditional on factors that are not affected by the actions themselves (for example, temporalities, genetic variability, stochasticity). Third, and most relevant to forward-looking claims, it is uncertain whether there is a 'right' way in which an agent can bring about the outcome. Epigenomes change during the course of development, as a result of individual genetic differences and due to stochasticity, which defies precise determination of what behaviours are conducive to health and should be pursued. As argued elsewhere, the 'success – and, perhaps, also the praise or blame – attached to these exercises of responsibility seems to be the result of much more than behaviours, choices and actions of the concerned agents' (Chiapperino, 2020, p 8).

However, the problem with this luck-based critique is that it also has a dramatic impact on the assumption that there are collective epigenetic responsibilities. A luck-based approach highlights the vulnerabilities,

circumstances and uncertainties that call into question the coherence of agents to whom responsibility is ascribed. Similar concerns may be relevant for the ascription of responsibility to collective agents (Lewis, 1948; Feinberg, 1968; French, 1984; Arendt, 1987; Smiley, 2022; see also Chapter 2). A previous paper pointed out how luck suggests that collective epigenetic responsibilities 'fail to be an obvious alternative normative construct to their individualistic counterparts' (Chiapperino, 2020, p 2). Even if we hold a coherent view of collective agents as the bearers of responsibility, these are in fact no less exposed to luck than individual agents, in ways that would temper attributions of responsibility. In fact, it may be questioned whether their actions to prevent, neutralize or reverse potentially damaging epigenetic effects are reasonably the target of responsibility judgements. A series of intertwining factors outside policy control or corporate agency may arguably be invoked to deflect these claims. Whether an individual or a group is predisposed or vulnerable to the epigenetic drivers of complex diseases results from many factors, including the stochastic or highly contextual dependency of epigenetic mechanisms (Panzeri and Pospisilik, 2018). Whether an individual is likely to be exposed more than another, and what the harmful consequences for that specific individual may be, are all outcomes that are not strictly under the control of these collective agents. These consequences may depend on historically distant actions, practices and inequalities that persist, or even unique combinations of biological and/or environmental determinants of health for the individual in question. As argued by environmental justice scholar Levente Szentkirályi (in a separate yet contiguous context), it is partly a matter of luck 'whether or not emitters who create uncertain threats are culpable' of anything, as much as it is a matter of luck 'whether some may be injured by their actions' (Szentkirályi, 2020, p 8). Given the inability to ascertain whether environmental exposures, social structures or life contexts do cause aberrant epigenetic predispositions to disease, the responsibility of collective agents under such circumstances appears to diminish. But does this mean that collective agents are blameless under all circumstances for not taking (backward- and forward-looking) responsibility for the proliferation of epigenetic predispositions towards disease among their populations?

Moral worth and the residual responsibilities of collective agents

One problem with the criticism from luck and its significance for ascribing collective responsibility is that it undermines the possibility of ascribing blame to collective agents for failing to remedy or prevent health risks and epigenetic predispositions to diseases. While the coherence and moral cogency of collective agents may be the focus of a prolific philosophical

debate, the public expression of blame also plays an important social function. The state and its public health branches are expected to contribute to the overall welfare of citizens (Pettit, 2007). Whether philosophically cogent or not, in reality, corporations are the target of moral blame when they fail to respond to the needs of society or fail to benefit society through their actions. Such a 'collectivist' position on responsibility is attractive and feeds into common moral intuitions about the state, public health agencies or corporations: they should be held accountable for their actions, especially when they perform or fail to perform some of them. Otherwise stated, there can be no denying that 'we lose something important' (Cheng-Guajardo, 2019, p 295) if we fail to account for typical moral sentiments (for example, disappointment, expectation, blame) that are commonly oriented towards collective agents.

Following the suggestion of moral theorist Luis Cheng-Guajardo[2], our intention in this section is to formulate an approach for blaming collective agents and holding them residually responsible for protecting our epigenomes in the face of the challenge that luck poses for the coherence of moral theories of collective responsibility. By using the term 'residually', we intend to underline a distinction between full responsibility claims (for example, those that meet the criteria of standard moral conceptions of responsibility) and weak or expansive uses of the term (see Wolf, 2001). These can encompass: (1) the pragmatic foreshortening of responsibility due to lack of insight into whether responsibility conditions are met (such a foreshortening therefore lacks an assessment of the coherent agency of collective agents, see Sand, 2018, chapter 6), (2) attributions of responsibility based on the role that collective agents can play more than their actual ownership of the actions for which responsibility is sought (Pettit, 2007), and (3) exercises of responsibility that exceed the challenges of luck and objective responsibilities for reasons of virtue, solidarity and the moral community (Wolf, 2001). The model we propose relies on the idea that the moral 'worth' of collective agents can justify responsibility claims of the third type to prevent the health effects of structural social conditions or exposures, including adverse epigenetic modifications.

Our approach draws from notions of aretaic blame (Watson, 1996; Cheng-Guajardo, 2019) that emphasize blameworthiness as a teleological failure, or the failure to meet one's purpose, objective and goals. Failing/succeeding in the realization of one's *telos* in fact reveals something about oneself, namely that one achieves what one is well-positioned to achieve, that one cares about others, that one participates for the benefit of a community of shared values and goals beyond mere obligations and bounded responsibilities. This suggests that collective commitments (or failures to commit) to the protection of our health and epigenomes have a deep ethical import for the evaluation of these collective agents vis à vis their *telos*. Given the intricacies

of attribution, aretaic blame does not consider individual actions of collective agents. Rather it takes those agents as temporally extended entities, whose various ways of affecting society lead to the emergence of patterns that allow identification of their dispositions and traits. Without the need for a full notion of moral responsibility, an aretaic appraisal of collective agents involves a weaker attribution of responsibility to act on the social structures and environmental factors that contribute to the epigenetic dysregulation of bodies and the occurrence of disease in a given population.

Let us begin with the problem that arises from the difficulty of disentangling the relationship between certain undertakings (damaging or protecting the epigenome of a population) and a given (successful or not) outcome from the perspective of luck. As we have shown, these outcomes depend on stochasticity, multiple causations and the complexity of epigenetically driven phenotypic variation. Generally speaking, resultant luck refers to the outcome of an agent's acts, characterizing these results as being 'beyond the agent's control, or not fully within the agent's control' (Sartorio, 2012, p 63). Based on this view, it seems unreasonable to hold agents morally responsible for some of those results. For any course of action aiming to prevent an epigenetic effect, one could plausibly find in fact an alternative course of action that differs only for factors that may be bona fide taken as luck (for example, genetic contribution to an epigenetic effect and/or to the resulting phenotype, stochasticity, an environmental confounder). Hence, can collective agents be praised for bringing about a beneficial outcome, or blamed for failing to produce courses of action beyond their control?

As argued by philosopher John Greco in a seminal article on luck and responsibility (Greco, 1995), this formulation of the paradox of luck may be solved in two main ways. The first rescues causation and control from the challenge that resultant luck seems to raise. This famous solution to the paradox of luck portrays the problem as being only an apparent one (Zimmerman, 1987). There is more than one sense in which an agent can willingly cause an action. Hardly anyone would think that the state, or a public health agency, is responsible, for instance, for the outcome of policies preventing aberrant epigenetic modifications due to environmental exposures. What one expects from any agent is to exercise the 'restricted' control (Zimmerman, 1987, p 376) that they can exert to remove the sources of these exposures, and not to control all those events on which their epigenetically mediated effects over health depend. As argued elsewhere, this solution, although appealing in several respects, may nonetheless be only partial (Sand and Klenk, 2021). Zimmerman's critique of the luck paradox restores standard intuitions on the control condition for responsibility: agents whose undertakings are susceptible to luck can nonetheless be morally responsible for wanting to bring them about (Zimmerman, 2002, p 559; Hanna, 2014). Yet, this critique may only partly solve the problem raised

by the normative exercises demanded by epigenetic knowledge. At least to the extent that many of these epigenetic effects are open to multiple causalities and indeterminacy, the challenge from luck is not just about the responsibility-undermining lack of control over the outcomes of such potential policies. The problem also lies in acquiring genuine knowledge of the causal chain of events that brings about a beneficial outcome and choosing a course of action that brings about that outcome. Let us consider an example.

Tests that are used to assess the risk of a family of chemicals such as endocrine disruptors rarely address persistent effects arising from early-life exposures, microdoses or mixtures of these chemicals to which we are exposed on a daily basis (Alavian-Ghavanini and Rüegg, 2018). Most importantly, data on the adverse phenotypic outcomes of exposure to these substances are often absent or there is a lack of evidence of any causal relationship between the adverse outcomes and the exposure to the chemicals in question. There is a growing recognition that, while this is partly a problem of uncertainty (understood as knowledge to be yet produced), it is also difficult to draw definitive conclusions about harm from environmental exposure (for a critique of uncertainties and inaction in environmental risk assessment, see Szentkirályi, 2020). The incorporation of epigenetic endpoints into chemical risk assessment may offer novel mechanistic insights into the modes of action of a substance. However, it does not necessarily provide a more effective characterization of its hazardous properties (Garcia-Reyero and Murphy, 2018). In fact, within regulatory circles, a paradigm shift is often called for, from a hazard-driven risk assessment to one that is exposure-driven (European Commission Directorate-General for Health and Consumers, 2013). This approach focuses on the vulnerabilities that various kinds of factors bring, and suggests switching the focus of responsible agency from assessing harm and risks to a precautionary approach. Epigenetic information here may ultimately increase awareness of the conditions of uncertainty and indeterminacy under which these harmful substances may affect citizens, rather than revealing the deleterious consequences of these exposures that the state, corporations or public health actors are compelled to address. Epigenetic alterations are neither necessary nor sufficient conditions of the possibility of disease, but only factors in a probabilistic estimation of their occurrence. As indeterminate threats and genuinely unforeseeable contributors to an outcome, these exposures and their health consequences offer little foundation for the collective agent's obligation to control them.

This is where the second intuition suggested by Greco (1995) may come in handy. In contrast to Zimmerman, he proposes a solution to the paradox of luck that challenges the assumption that 'moral worth' has to be 'closely tied to one's moral record' (Greco, 1995, p 90). This suggestion, he argues, sets out to counter the way we think about the import of luck on morality. Going

back to the example of aberrant exposures mentioned earlier, we consider that luck is responsibility-mitigating (for collective agents) because it makes it difficult for agents to select a course of action and control its outcomes. Physiological traits are the integrated output of many biological and non-biological variables in ways that undermine our ability to predict and bring about an exact outcome from epigenetic information (Panzeri and Pospisilik, 2018). Thus, the vagaries of luck affect our evaluation of a collective agent's actions in ways that make us question the intuitive plausibility of their responsibilities. Greco takes up this problem of recognition, and asks whether the outcomes for which an agent can be rightfully praised or blamed are all that matters for one's moral worth. Giving a negative answer to this question, he suggests that moral worth is also what an agent '*would* voluntarily decide and *would* voluntarily do in a variety of circumstances' (Greco, 1995, p 91, original emphasis) that they may never encounter. This allows him to drive a wedge between the difficulty of making a practical judgement about responsibility and the moral quality of the voluntary and deliberative actions performed by an agent. The worth of corporations creating a hazardous environment, under this account, is independent of their actual record of epigenetically driven effects of exposures on people's health. The failure of a state agency to prevent epigenetically mediated health risks is independent of whether these biological processes actually result in a heightened burden of diseases on the exposed population. Simply put, Greco's point is that the actual results or uncertainties beyond the agent's control may be distinguished from judgements about their moral blameworthiness (see also Jensen, 1984).

But what, then, are the grounds on which to define the moral worth of collective agents such as corporations, the state or public health agencies? What appears to be at stake with regard to moral worth in Greco's account is an agent's fundamental character, fundamental goals and evaluative orientations – the agent's *telos*. Otherwise stated, worth relates here to an appraisal of the function that these agents play in the moral community and society. It involves these collective agents' practical identity, or appeals to their success/failure as contributors to society and its wellbeing. This 'aretaic' perspective has ethical depth in an obvious sense (Watson, 1996; Cheng-Guajardo, 2019). It highlights that blame is attributable to agents when they adopt an end, or commit to a conception of value, that they fail to realize although this was in their power. Without entailing the attribution of full (standard) responsibility, aretaic blame offers a condition to assess residual ways of taking responsibility.

This becomes clearer by using further examples. Consider a corporation that releases endocrine-disruptive chemicals into the environment, which may affect population health through epigenetically mediated mechanisms. Whether they are responsible for harming anyone, or whether they are responsible for remedying that harm, depends on the predispositions of the

individuals, or co-occurring vulnerabilities (for example, environmental, biological/genetic). It also depends in part on the stochasticity of the epigenome and complex phenotypic traits. Several of these factors are not within the control or comprehension of the corporation, and therefore luck-based considerations mitigating responsibility apply to a judgement of the liability of the corporation. Aretaic forms of moral evaluation instead re-focus evaluation of the moral worth of the company on whether this hazardous situation, to which they contribute, constitutes the proper functioning of the enterprise. The epigenetic consequences of the omnipresence of the endocrine disruptors in post-industrial societies may therefore not be morally apprehended from mere ascriptions of causal responsibility and the accountability of corporations. Rather, an aretaic assessment of their actions allows us to justifiably blame them in a deep sense for endangering the health of a community. Are these companies failing with regard to their role and contribution to the welfare of society?

Another example could be based on a similar evaluation of public health agencies that fail to remedy these hazards. Again, without the need to hold them morally responsible (in the standard sense) for removing the risks that endocrine disruptors cause to the population (via the epigenome), one may interrogate the function of public health agencies and provide an aretaic evaluation as to whether these agencies should be concerned with this course of action, and, consequently, whether they can be blamed for failing to enact such concern adequately. As examples, one may cite the UK Health Security Agency and the Office for Health Improvements and Disparities – the executive branches of government that have replaced Public Health England in holding the role of promoting the health protection and health improvement of the population in England. Even a cursory look at their websites and statutory documents reveals that these agencies have unique as well as distinctive roles in structuring a collective response to the epigenetically mediated threats to health deriving from exposure to chemicals. The worth of these public health structures is fairly well-defined (one could refer to it as their 'virtues' or *telos*, see Rogers, 2004; MacKay, 2022). The UK Health Security Agency, for instance, aims to offer 'intellectual, scientific and operational leadership' to protect communities from the impact of 'health threats' (UK Health Security Agency, 2023). In this respect, its social function is to spearhead an organized and collective effort in society towards containing and minimizing risks of disease and their distribution. Similarly, the Office for Health Improvements and Disparities focuses on 'improving the nation's health' in ways that level 'up health disparities' and 'break the link between background and prospects for a healthy life' (Allison et al, 2023, p 2). This is a particularly relevant element when thinking about the ethical and political dimensions of environmental epigenetics. Even though this information may not compel public health

agencies to remove these exposures, it certainly shows that these exposures (and their ensuing biological vulnerabilities) are unequally distributed in society (Hooten, 2022). Public health agencies therefore have powers and goals that are not shared by other civic organizations or governmental branches of the state and are organized around a referent set of virtues – such as compassion, justice, precaution, solidarity – that define their worth. The 'good of their life', as qualified by moral theorist of virtues Alasdair MacIntyre (2007), heavily depends on pursuing standards of excellence and abiding to certain rules that should encompass accepting a certain, residual responsibility to protect our epigenomes and health. Even if this is not their responsibility in a strong, moral sense of the notion, it may be, at the very least, an important or even central consideration when assessing their worth.

Conclusion

In this chapter, we set out to offer an alternative basis for normative claims concerning epigenetic knowledge as a matter of collective agency. First, we highlighted the fact that the origins of epigenetic variance cannot easily be pinned down to environmental exposures, behaviours, lifestyles or social determinants of health alone. Variation in the distribution of epigenetic marks (and their impact on health) is often unpredictable and is open to the effects of developmental trajectories, stochasticity and genetic susceptibilities (Biwer et al, 2020). Second, we detailed how the implications of such epigenetic variability are also moral: this recognition constitutes a major epistemic and causal limitation to responsibility claims addressed at collective agents (as well as individuals for that matter; Chiapperino, 2020). Stochastic epigenetic variability and multiple causalities in the epigenome preclude blame for socio-environmental conditions that are just risks (among others) of disease, and mitigate the backward-looking responsibility of collective agents (for example corporate, state or public health agencies) for any actual disease outcome emerging from this state of affairs. Roughly put, these agents had no control over the way that things turned out for anyone's health and epigenome. Also, these considerations diminish their blameworthiness for failing to remedy such epigenetic risks, or rather their socio-environmental causes: the conditions of uncertainty, stochasticity and complex causation governing their actions make remedying this state of affairs an outcome beyond their control. Thus, collective (forward-looking) responsibilities also lie beyond their fault.

Contra the idea that luck undermines responsibility *tout court*, we have tried to identify other sources in addition to moral or causal responsibility to justify a residual or weaker epigenetic responsibility for collective agents. In doing so, we have not sought to deconstruct the argument from luck (as many have done already; see endnote 1). Rather, we have developed the

idea that the 'problem' of moral luck is a reminder about the impure nature of collective moral agency (Walker, 1991). Collective responsibilities do not fit a perfect match between will, cognizance, choice, action and control over outcomes (Smiley, 2022). These agencies are messy in ways that weaken strict considerations of accountability, desert, or even attributability and duty (Sand, 2018, chapter 6). Epigenetic predispositions and their contribution to resultant luck add another dimension to these complexities of collective responsibilities: these normative claims are often conditional on a contested understanding of collective agents, their coherence, limitations, scope and definition. They are also heavily impacted by the material conditions of the possibility for these agencies to produce their target phenomenon. Simply put, collective agents may have limited control over the health outcomes affected by the epigenome as this is open to several other sources of causality and influence. Our point is therefore to separate moral attributions from the diminishing effects that uncertainties and the indeterminacy of the epigenome have on moral responsibility. It may be more productive to orient our moral evaluations of the state, corporations or public health agencies in relation to the epigenome towards the purpose of these agents in the moral community and society. It is worth asking whether reparation for or protection from the uneven distribution of epigenetic predispositions to disease in society requires attributing full moral responsibilities to these collective agents.

From the perspective of what constitutes the proper functioning of these collective agents, there are reasons to work towards promoting a higher appreciation of the ways that such agents commit to conceptions of value and whether they fail to realize it in the end. Preventive and public health measures addressing health inequalities embodied through the epigenome, or the epigenetic effects of polluted environments, should not require serious threats of harm or even actual harm to demand action. Rather, these may be reframed as duties to exercise due care, which define the collective agent's *telos* and moral worth. It may neither be permissible nor excusable for public health agencies to fail to exercise their powers and goals, which are not shared by other organizations or branches of the state, to maximize pursuit of the referent set of virtues defining their role and worth for society. In other words, the above discussion shows that pragmatism and a defined set of collective goals may be better grounds for action on the heightened health risks from exposures and social structures highlighted by epigenetic evidence. Better, specifically, than the requirement to establish the moral responsibilities of collective agents regarding these effects. In a public health system with limited resources, it may also be necessary to complement the above discussion with a consideration of probability estimates for health outcomes of epigenetic marks, or a justification for the need for more public attention regarding this knowledge, as well as

an explanation for the prioritization of interventions targeting epigenetic effects. An argument from luck may only be an entry point on the need for a conceptual sharpening of the role of epigenetics for our moral lives. In turn, our model based on worth may only be a broad sketch of the thick moral reasoning and sophisticated actions required to comprehend these collective risks and the benefits stemming from correcting them. What is certain, however, is that the dominant critique pitting collective epigenetic responsibilities against individual ones may not really deliver on such an objective. This chapter suggests that one possible explanation for this is that simply pinning collective responsibilities against individual ones may be missing its target.

Notes

[1] See Sartorio (2012) for the philosophical specification of these dimensions of resultant luck.

[2] In contrast to the author and other contributors to this debate, we do not engage with the metaphysical question on the distinctive traits that make collective agencies autonomous from the agency of their members or lack thereof (Velasquez, 1983). Chapter 2 in this volume offers a rich analysis of the moral cogency of collective responsibilities.

Contributor statement

L.C. is the leading author in the conception and writing of this chapter. M.S. critically reworked the text for important intellectual content. The chapter's revision and finalization have been thoroughly collegial.

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