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News Media Representations of Gene Transcriptional Profiling: How Do the Culture/Nature Binary and Animal Ethics Factor In?

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Abstract: Developments in genomics, notably the development of transcriptomics, have enabled the "molecularization of life" (Rose, 2001, p.13). Most analyses of these developments focus on human medicine. Other realms warrant attention, specifically applications with nonhuman animals, which are increasingly likely in response to growing concerns regarding their adaptability to rapid environmental changes. Given that public understandings can impact adoption of novel technologies in important ways, and that the public mostly receives information about technologies from news media, this article examines communication of knowledge and socioethical (particularly animal ethics) considerations regarding transcriptomics in news media. One key consideration examined is the potential collapsing of the culture/nature binary in light of transcriptomics developments forecasted in the literature. We find that explicit attention to socioethical implications is least likely when nonhuman animals are involved, whereas it most often occurs in relation to ways transcriptomics could be used to unsettle what constitutes human nature, illustrating the ongoing power of the culture/nature binary.

Key Words: animal ethics, transcriptional profiling, gene expression, molecularization of life, culture/nature binary, news media

While some scientists labor to hone projections of the impacts of mounting greenhouse gases, others have turned their attention to improving the adaptability and adaptiveness of organisms to the already changing environment. One strategy receiving increased attention employs transcriptional profiling (a component of gene expression profiling)

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to identify specific genotypes with desirable characteristics that make organisms more adapted to the rapidly changing environment. This information could then be used for targeted breeding of animals with adaptive traits who can be released in strategic places with the goal of facilitating their proliferation. Although less invasive than direct genome modification, which the public has viewed with suspicion (e.g., genetically modified foods; see Kuntz, 2021), these strategies nonetheless have ethical implications. To date, however, it is unclear if and how these implications are being communicated to the public.

Public perceptions of technoscientific developments can be quite impactful. For instance, a line of genetically engineered pigs (called Enviropig) was developed and later killed at the University of Guelph in Canada due to late-stage assessment of public attitudes. The pigs were designed to emit less phosphorus into the environment. The project was considered successful (Clark, 2012, p. 111)—that is until researchers determined that potential consumers were reluctant to consume the genetically modified animals, at which point Ontario Pork stopped funding the project (Perkel, 2012). This case simultaneously illustrates the import of tending to the communication of technoscientific information to the public, as it can inform attitudes early in the technoscientific development process, as well as how in recent decades technoscientific developments have enabled, and some might say encouraged, the "molecularization of life" (Rose, 2001, p. 13), particularly nonhuman animal life.

Developments in genomics have created a new scientific vantage point that "envisages life at the molecular level, as a set of intelligible vital mechanisms among molecular entities that can be identified, isolated, manipulated, mobilized, recombined, in new practices of intervention, which are no longer constrained by the apparent normativity of a natural vital order" (Rose, 2007, pp. 5–6). It has been argued that this shift in scientific focus from the population level to the molecular level would have significant implications, which have been the subject of analysis and critique (see Raman & Tutton, 2010). While epistemologies and ontologies of the molecularization of life have been subject to exploration mostly in relation to human medicine, "relatively less analytic attention has been paid to visions of and movement towards specific *potential futures* [emphasis added] for molecular genetics/genomics in non-medical settings" (Shostak, 2004, p. 540).

One specific area that has received little analytical attention is the extent to which the "molecularization of life" might result in greater contestation of the culture/nature binary. Although Rose's (2001) work and that of his contemporaries has focused on the implications of these developments for human lives, he suggested more than 20 years ago that the "molecularization of life" would erode "the classical distinction made in moral philosophy between that which is not human—ownable, tradeable, commodifiable—and that which is human—not legitimate material for such commodification—[which] no longer seems so stable" (p. 15). An erosion of the stark distinction between human and nonhuman, and the culture/nature binary more generally, would have profound consequences and open important ethical discussions. This binary has undergirded the otherization of nature and those associated with it, particularly nonhuman animals, and

has been critiqued from several perspectives, including Marxist feminism (see Helmreich, 2008) and ecofeminism (e.g., Gruen, 2014; Taylor & Fitzgerald, 2018).

The purpose of this article is to explore what information is being disseminated to the public regarding transcriptional/gene expression profiling, with a particular focus on the presence of content regarding social and animal ethics considerations and meanings vis-à-vis the culture/nature binary. To do so, we examine the source from which most of the public receives information about technoscientific developments: the news media. We address several pertinent questions, including: What narratives regarding the ethical implications of this relatively novel technology are being communicated via news media? Do they differ based on context (i.e., between human/culture and nonhuman animal/nature)? Are they addressed explicitly, or merely implicitly?

TRANSCRIPTIONAL PROFILING AND NOVEL TECHNOLOGIES

The journey from gene to function is a complex and tightly controlled process contained within each cell. It consists of two major steps: transcription (DNA to RNA) and translation (RNA to protein). Together, transcription and translation are known as gene expression. Transcriptional profiling, also sometimes called gene-expression profiling, is a powerful genomics tool used to analyze the biological mechanisms that underlie gradients in health and other related fitness function (McDade et al., 2016), such as growth and reproduction. It involves the quantification of gene expression of multiple genes at the RNA level, termed transcripts. This quantification is completed by extracting RNA from biological samples and examining them as snapshots of patterns of gene expression at fixed points in time. Examining gene expression in different tissues, internal and external conditions, and/or at different points in time illuminates how genes are regulated and can help to infer the functions of previously unannotated genes (Lowe et al., 2017).

The first attempt at capturing part of a human transcriptome occurred in 1991, and technological advances since have made transcriptional profiling a widespread discipline (Lowe et al., 2017). This genomics tool is particularly powerful when used alongside bioinformatics techniques to extract biological themes based on correlated changes in large numbers of genes (McDade et al., 2016). Transcriptomic analysis has enabled the study of how gene expression changes in different organisms can aid our understanding of disease and how the underlying genomics programs and mediators get activated by varying social and other environmental conditions (Lowe et al., 2017; Mulligan, 2016; Pilkay & Combs-Orme, 2020; White & Wastell, 2017).

Beyond advancing scientific understanding of biological processes, transcriptomics tools can also be used to manipulate the original state of biological organisms, with genetic modification at the extreme end of interventions. Genetic modification of organisms has been hotly contested and has raised a number of socioethical questions (e.g., the Enviropig case discussed above). At a less extreme intervention point, transcriptional profiling can identify traits expressed at either the level of the individual, population, or species that confer adaptive capacity to cope with stressors. These findings could then be

used to actively select for or against individuals possessing this suite of traits in breeding conservation programs or selecting which populations to actively manage or not. While media discourses regarding genetically modified organisms have been analyzed (Motta, 2015; Tourangeau, 2018), media narratives vis-à-vis transcriptomics tools more broadly and inclusive of other applications have not yet been investigated. Less invasive transcriptomic interventions are likely to be increasingly relied upon in conservation efforts to assist free-ranging (so-called "wildlife") populations adapt to climate change (Semeniuk et al., 2022). Therefore, it would be useful going forward to characterize and understand how transcriptomics information is being communicated to the public, particularly how potential issues related to social and animal ethics are addressed (or go unaddressed). Moreover, it is important that the analysis cover transcriptomics generally instead of limiting it to specific uses (e.g., making free-living animals more adaptable) because, as demonstrated with other novel technologies (e.g., genetic modification), perceptions of the technology in general can spill across specific uses.

SCIENCE AND THE NEWS MEDIA

It is through the media that the public typically first becomes aware of new scientific and technological advances and associated socioethical issues (Arnaldi, 2008; Ching, 2010; Coveney et al., 2009). Mass media has an unparalleled role in not only reflecting but also shaping public perceptions and values (Arnaldi, 2008; Coveney et al., 2009; Songsore & Buzzelli, 2015). Issues represented in the media not only spark debates between science and the public but also gain the attention of policymakers, who further shape these debates (Arnaldi, 2008; Maddison & Watts, 2011).

While media is an important source for public education and engagement, it is not neutral (Ching, 2010). Media informs and provides a forum for discussion, but it also selectively chooses topics to cover based on public interest and shapes public perceptions through the ways information is presented (Yan et al., 2019). Analysis of media discourses surrounding technological advancements can expose the underlying structures of the debate and create more transparency and awareness (Sengers et al., 2010). It is therefore a good place to start in understanding what information the public is receiving regarding specific novel technologies and associated socioethical considerations.

ANALYTICAL APPROACH

Social theorist Nikolas Rose (2001) suggests we have moved beyond biopolitics as Foucault conceptualized it to an age where "a new configuration of control has taken shape, and that contemporary biopolitics is *risk politics* . . . as the truth regimes of the life sciences have mutated, contemporary biopolitics has become *molecular politics*" (p. 1; emphasis in original). Twenty-first century biopolitics is, as he suggests, ethopolitics: "The politics of life itself and how it should be lived" (Rose, 2001, p. 18). It is also an era that has more generally been referred to as the postgenomic era, demarcated by the completion of the Human Genome Project. The significance of this shift is summarized as follows:

> Rather than analyzing the sequence and function of individual genes, genomics tries to identify and understand both individual genes and their interaction with each other. Together with transcriptomics, proteomics, metabolomics, and bioinformatics, genomics spawned systems biology, which aims to understand and model the interaction of many components in the cell, not just genes, in an effort to explain how genetic information translates into phenotypic traits. (Perbal, 2015, p. 778)

In short, the gene was decentered, which did not blunt the molecularization of life but instead provided a greater space for appreciating context and interactions.

Rose's work and that of his contemporaries has stimulated scholarship across diverse fields and disciplines. To science and technology studies, it has contributed insight into the myriad ways molecular science collides with ethics and economics (see Helmreich, 2008, for a valuable overview). In criminology, his work has been used to illuminate risk politics (even at the biological level) in addressing (pre)crime (see, e.g., O'Malley, 2010). A more recently carved out criminological subfield referred to as green criminology extends the criminological attention to risk to encompass environmental risks posed by human actions (e.g., South, 2007). While much of this attention has been anthropocentric, there have been efforts to problematize the manifestation of the culture/nature dualism and develop more ecocentric understandings (Taylor & Fitzgerald, 2018). This scholarship is congruent with Twine's (2010) important observation that "biopolitics does not operate a human-animal dualism and so neither should our approach to its analysis" (p. 500).

In this article, we do not aim to engage with all elements of Rose's (2001) conceptualization of the "molecularization of life" (for a critical discussion of its applications, see Raman & Tutton, 2010). Instead, we focus on his suggestion that the molecularization of life would erode the moral distinction between human and nonhuman animals, conceptualized more generally as the culture/nature binary, and could elucidate ethical considerations around racism and speciesism in particular, given greater insight into similarities between not only groups of people but also with nonhuman animals (Rabinow & Rose, 2006). In the Anthropocene, more than ever, it is imperative to develop understandings of novel technologies inclusive of other species in addition to humans and sensitive to social and animal ethics implications, beginning with an understanding of how they are (or are not) articulated for public consumption.

METHODS

We analyzed news coverage of transcriptomics technologies in Canada and the United States via the *Globe and Mail* (*G&M*) and the *New York Times* (*NYT*), which in each respective country are considered "newspapers of record" (Caveder & Mulcahy, 1998, p. 703), meaning that they are both national in scope, enjoy high circulations, and are generally considered authoritative. All stories, op-ed columns, and editorials between January 1, 2000, and December 31, 2020, were analyzed. While transcriptomics constituted a field of study in the years prior to 2000, we selected this time span for the following main reasons: The turn of the century was a natural starting point; the Human Genome Project (completed in 2003) was wrapping up, ushering in the postgenomics era; this range of

years generated sufficient, saturated data for analysis; and we were most interested in contemporary understandings of this technology.

We compiled data by searching the two newspapers using the Factiva database with the keywords gene expression, transcription* profil*, gene regulation, micro array, RNA regulation, RNA expression, transcriptom*, and translatom*. We cocreated these specific search terms via consultation with experts in the transcriptomics field. Using this method, we identified 286 articles. A cursory review was conducted to determine which of these articles were indeed discussing transcriptomics instead of discussing other iterations of these keywords. We determined that 162 of these items addressed transcriptomics: 43 in the *G&M* and 119 in the *NYT*.

We engaged in in-depth coding of these 162 articles/editorials using qualitative thematic coding and analysis (Braun & Clarke, 2006; Guest et al., 2012). Our first round of coding was an inductive process that elicited coding categories. Our second round of coding entailed coding each article/editorial using our codes. Our final round involved teasing apart some coding categories and collapsing others, resulting in three main themes and nine subthemes. Some articles/editorials had several codes attached to them, and, as such, the categories are not mutually exclusive; instead, in some contexts the categories blend together in important ways.

We attended to implicit and explicit connotations in the articles/editorials, a useful strategy in other analyses of news media (e.g., McMullan, 2006). Thus, we employed both a denotative strategy, which engages with the actual text, and a connotative strategy, which "considers the signifying capacity of the texts for registering and re-registering latent messages in the reporting" (McMullan, 2006, p. 911). For each of the codes, we examined whether the topic and associated socioethical considerations were discussed implicitly or explicitly. That is, we examined whether the associated issues were addressed directly or inferred through a requisite knowledge of the broader context and socioethical issues.

An example from the data illustrates how we coded for implicit versus explicit messaging. One journalist provided accounts in two articles that we coded differently vis-à-vis race. In 2000b, Wade described the human genome being made fully visible for the first time and included a quote regarding the fear that people "will use this information to bolster racial and ethnic prejudices" (p. 2). This was coded as explicit because the author explicitly flagged an ethical issue associated with the theme (race). On the other hand, in a subsequent article, Wade (2001) remarked that transcriptomic data "would also bring out the genetic differences between different groups and races" (p. 1). We coded this instance as implicit because the ethical issue was implied but not explicitly discussed.

FINDINGS

We identified three main overarching themes (and nine subthemes): (1) transcriptomics and the human condition (socioeconomic disparities, human health, race), (2) transcriptomics and logistical considerations (issues of ownership, commercialization, legal considerations, and privacy), and (3) transcriptomics and the nonhuman (nonhuman animals, nature). Health disparities and nonhuman animals were the most commonly addressed

of the subthemes (see Figure 1). Implicit references were more voluminous than explicit for all the subthemes except one: nature (70% were explicit and 30% implicit). There was more explicit treatment of the categories in the *NYT* compared to the *G&M*, and the most common category overall was implicit treatment of the issues in the *NYT* (see Figures 2 and 3). Given the focus of this article on social and animal ethics, particularly the salience of the culture/nature binary, we focus on themes 1 and 3 here.

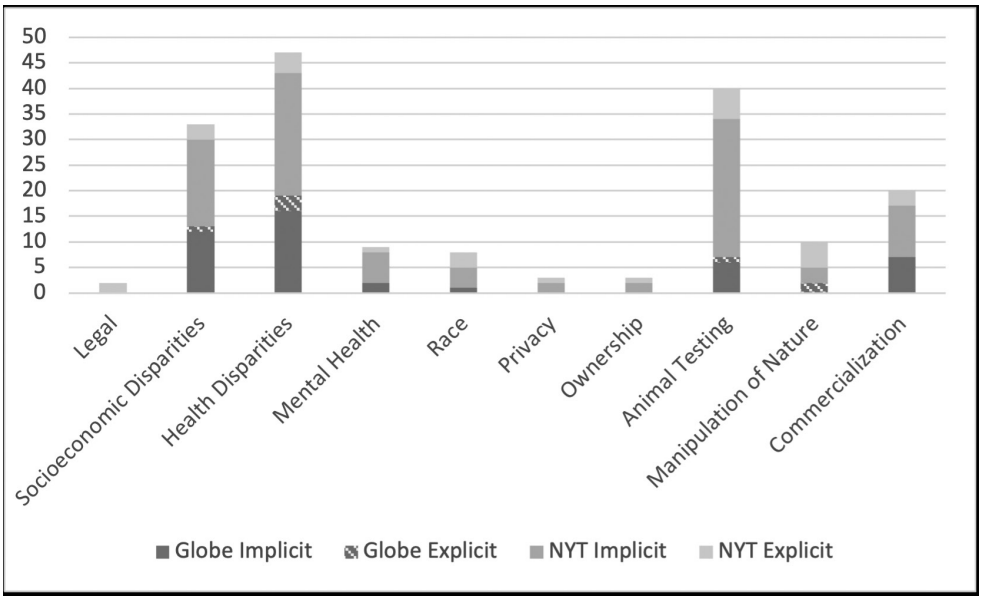

FIGURE 1: Distribution of the Subthemes Across Both Publications

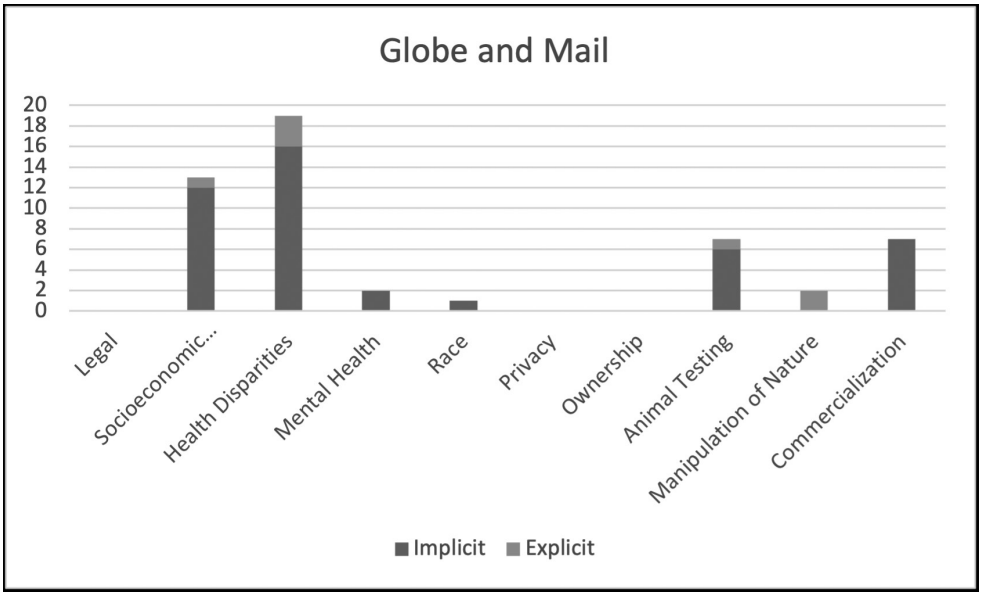

FIGURE 2: Implicit and Explicit Treatment of the Subthemes in the *Globe and Mail*.

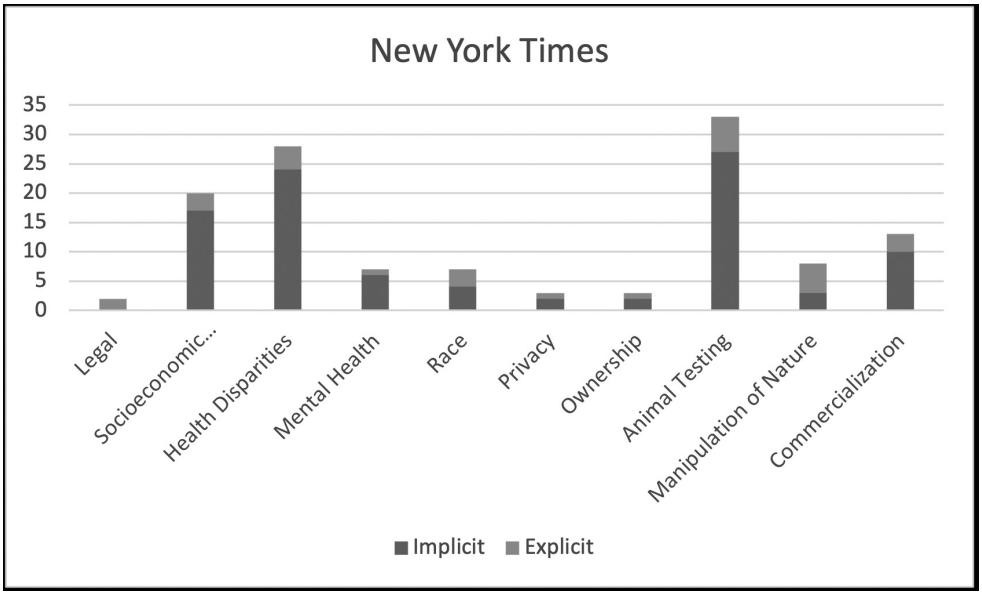

FIGURE 3: Implicit and Explicit Treatment of the Subthemes in the *New York Times*.

Transcriptomics and the Human Condition

Socioeconomic Disparities Socioeconomic considerations entered the discussion of gene transcriptional profiling primarily in relation to the cost of using this technology. Most of the discussion of socioethical considerations was implicit (29 instances or 88%) versus explicit (four instances or 12%), and the proportions were similar across the two newspapers, although there was more coverage overall in the *NYT*.

Illustrative of how socioeconomic considerations were present but not explicitly addressed, several articles discussed new developments in skin care products targeted at impacting gene expression related to aging but did not explicitly address that the costs of the products are prohibitive for many (Agnew, 2018). Socioeconomic considerations also implicitly entered news reporting vis-à-vis the costs of poverty that the technology has exposed, such as discussions of how one's diet can impact gene expression in ways linked to cancer and other diseases. Consuming fruits and vegetables was touted (e.g., Beck, 2011), but differential access to these foods was not explicitly addressed.

Although there were only four articles that explicitly discussed the relevance of socioeconomic factors vis-à-vis access to the technology, they were forthright. An article describing a group of doctors who had been examining the genomes and transcriptomes of patients is illustrative: It includes a quote from a critic, who states, "The approach is unlikely to work for people most in need—those who are poor, are barely hanging on, and have other things to worry about than monitoring themselves constantly" (Zimmer, 2019, p. 10).

Human Health Disparities

Variable ability to pay for gene transcription profiling can result in health disparities. Forty-seven articles specifically addressed such health disparities. Once again, there was

slightly more coverage in the *NYT*, but the proportion of explicit versus implicit coverage was similar across the two newspapers. Overall, 15% of the articles that addressed health disparities did so explicitly, while 85% only did so implicitly. In implicit and explicit references, the technology is framed in quite positive terms—as providing hope for halting and reversing diseases and the aging process.

The implicit discussions revolved around issues such as methods for reversing the aging process, such as weight training (e.g., Picard, 2007), the hazards of stress on one's own body and on one's children (e.g., Mate, 2007), the positive impacts of vegetable-rich diets on the activity of genes (e.g., Taylor, 2008), and the negative impacts of environmental hazards on one's chances of developing several diseases (Ubelacker, 2010). They did not, however, explicitly address underlying disparities that could impact health in these ways.

Explicit discussions of ethical considerations vis-à-vis health disparities related to how the technology addressed gender and race. Some articles discussed problems associated with the fact that medical research is geared toward male bodies and male illnesses, which is particularly problematic given that "approximately 70% of the human genome shows sex-biased expression contributing to the gender differences seen in biology, behavior and susceptibilities. Lifestyle factors and environmental exposures affect the health of women differently from men" (Pearlman, 2014, p. L7).

Race

Eight articles discussed race in conjunction with the technology in a manner distinct from the socioeconomic and health disparity themes; of these, 36% did so in an explicit manner—a greater proportion than in the previously discussed themes.

Among the articles that explicitly addressed the attendant ethical issues vis-à-vis race is a *NYT* article titled "In DNA Era, New Worries About Prejudice" (Harmon, 2007). The article described medications developed and targeted to specific racial/ethnic groups because they "seem genetically predisposed to respond to it" (Harmon, 2007, p. 1). The author articulated the associated problem as follows: "Such developments are providing some of the first tangible benefits of the genetic revolution. Yet some social critics fear they may also be giving long-discredited racial prejudices a new potency. The notion that race is more than skin deep, they fear, could undermine principles of equal treatment and opportunity" (Harmon, 2007, p. 1). In contrast, an article published in 2001 is illustrative of the implicit treatment of the ethical issues surrounding race. The author wrote, "Data would also bring out the genetic differences between different groups and races . . . with this massive amount of data available the issue of distinguishing among groups will come into much clearer and quantitative focus" (Wade, 2001, p. F1).

Transcriptomics and the Nonhuman

Nonhuman Animals References to the use of nonhuman animals for research purposes were relatively numerous (seven in *G&M* and 28 in *NYT*). Notably, only one instance in each newspaper explicitly addressed associated ethical considerations, making this coding category the one with the smallest proportion (6%) of explicit relative to implicit references.

Most of the articles in this category mentioned mice and rats (less commonly discussed animals included macaques, fishes, and birds) being used in research lab environments and described the research in a matter-of-fact manner. For instance, an article on an exercise pill in development stated, "A new study has found that two experimental drugs can turn mice into long-distance runners" (Mick, 2008, p. L1). The death of animals in research was rarely discussed. A notable exception is an article that described research on night-migrating birds as "exposing them to periods of simulated night. The birds were then killed, and the brains were preserved, sliced and stained to show gene expression related to the firing of neurons. This enabled the researchers to spot parts of the brain that were active during the simulated night" (Fountain, 2005, p. 3).

Among the two articles that explicitly addressed attendant animal ethics concerns is one on research undertaken on chicken embryos to see if it was possible for them to grow tails similar to dinosaurs. The article explained that chickens and dinosaurs share a significant amount of genes:

> This is the pattern of gene expression . . . the complex choreography in which particular genes and combinations of genes get turned on or off at specific times and places as an embryo grows a spine, feet, wings and a brain. Changes to this pattern are what give animals different anatomies: scales instead of a skin, a wing instead of an arm. (McIlroy, 2007)

The research was part of a field referred to as evolutionary developmental biology, or evo-devo. Midway through the article, the author raised ethical questions regarding the possibility of creating other animal hybrids, and whether this work should be done on humans, writing, "Along with ethical issues, evo-devo also raises humbling questions about what it means to be human and what we might look like in the future" (McIlroy, 2007). At the time the article was published, the chicken embryos had not been allowed to mature and hatch, despite the researcher's interest in allowing at least one to live.

The other article explicitly addressing animal ethics concerns focused on the threat global climate change poses to fish populations (Caron, 2018). The article explained that according to the Intergovernmental Panel on Climate Change, the amount of carbon expected to be in seawater by 2100 will result in negative effects on fish sensitivity to smell, gene expression, behavior, and potentially reproduction. The article stressed that it is unknown if fishes will be able to adapt quickly enough to these changing conditions and closed with a quote from a researcher imploring the public to take these impacts seriously and another researcher urging for the use of measures to reduce carbon emissions while there is still time (Caron, 2018).

Intervening in Nature Ten articles raised the problem of the manipulation of nature in the context of discussions around technologies such as genetic modification of organisms, cloning, and gene editing. The explicit-to-implicit ratio is the opposite in this theme compared to the others; here there are more explicit (70%) than implicit (30%) references to socioethical considerations. Implicit treatment of these issues was coded in articles about research into how insects originally developed the ability to fly, conducted by genetically

engineering beetles so that they develop wings on their abdomens (Elbein, 2018), and modifying grapes so that they contain more vitamin C (Fountain, 2006).

The ethical issues associated with potential interventions with human nature were addressed more explicitly, such as in the case of cloning. One article framed the problem as follows:

> The clones that have been produced, they say, often have problems severe enough—developmental delays, heart defects, lung problems and malfunctioning immune systems—to give pause to anyone thinking of cloning a human being . . . leading cloning experts and developmental biologists said in recent interviews, the cloning process seems to create random errors in the expression of individual genes. Those errors can produce any number of unpredictable problems. (Kolata, 2001, p. L4)

Another raised the specter of science altering human nature. The article focused on longevity research and opened by stating:

> Advances in research in recent years have raised the possibility of extending human life by decades. At a conference held here to discuss the consequences of such a development, scientists described the techniques of extending life, only to be assailed for presenting a threat to human nature. Far from accepting greater longevity as a blessing, ethicists and some theologians offered passionate praise of death. They argued that life without death would be meaningless and that the natural ambitions of career and family were satisfied within a life span of 80 years. (Wade, 2000b, p. F4)

The article explained that work on genes and gene expression may eventually make it possible to control aging and mortality. An ethicist's response to this possibility is quoted as follows: "To argue that human life is better without death is to argue human life would be better without being human" (Wade, 2000b, p. F4).

DISCUSSION

The articles/editorials analyzed represent gene transcriptomics as powerful and novel, yet few explicitly address the socioethical implications of this powerful intervention. This study's findings are consistent with Kamenova and colleagues' (2016) observation in their media analysis (of prenatal testing) that ethical considerations of technological innovations are infrequently addressed. Our analysis of implicit and explicit socioethical dimensions further enabled us to discern between when ethical considerations are alluded to versus when they are explicitly addressed. Overall, (potential) ethical considerations regarding the development and use of gene transcription with animals in particular, which is where it is most likely to be used, are underexplored in these news media outlets.

Of the subthemes, only the *interventions in nature* theme contained more explicit discussion than implicit reference to (potential) socioethical issues, primarily in relation to the ways that transcriptomic research could be used to unsettle what constitutes human nature. Rose (2001) suggested more than 20 years ago that the normative distinction between what is nonhuman, and can be used as a means to an end, and human, which

ought not be commodified (i.e., the culture/nature binary), would be eroded by the "molecularization of life." Based on the news media accounts analyzed here, however, thus far it remains intact. Erosion of the culture/nature binary would have significant consequences and undoubtedly facilitate important discussions regarding the ethics of (socially, legally, etc.) erected boundaries between those identified with human culture and those with nature (notably nonhuman animals). To date, however, in news media at least, attention remains focused not only on the ethical implications of this novel technology for humans but also potential risks to human nature instead of considerations regarding nature writ large.

That human health was the most common theme identified in the analysis is consistent with Shostak's (2004) point that most analytical attention paid to the molecularization of life has been in the context of human medicine. It appears the same is true of news media attention, at least in the two newspapers examined here. In this context, the novel technology is framed in positive terms: as a tool for addressing myriad risks to human health. It is also presented as a valuable tool for mitigating health disparities, yet only 12% of articles/editorials that address this issue explicitly reference associated ethical concerns regarding only some of the population being able to make use of the technology.

The findings are also consistent with Kaushik Sunder Rajan's (2006) analysis of narratives constructed by genomics stakeholders in the United States and Rose's (2001) observation that increasingly "the rationale for political interest in the health of the population is no longer framed in terms of the consequences of unfitness of the population as an organic whole for the struggle between nations" (p. 5). The focus has become increasingly concentrated on individual risk; however, it should be noted that this attention to individualized risk is specific to humans—animals continue to be framed as a mass group instead of as individuals. This continued "massivity," as Buller (2013) described it, has important ethical and applied consequences: "In their massivity, these herds and flocks become metaphoric and, as such, killable. It is not only numbers that help us to stop thinking but also the hubris of our selective anthropomorphic conceit" (p. 170). We return to the significance of this "massivity" after delineation of the socioethical issues vis-à-vis humans below.

More explicit attention is paid in the articles/editorials to the ethical considerations regarding race than in other discussions of the human condition. This attention focused on a side effect of the use of gene expression research to better target treatments for different racial and ethnic groups: The research could be co-opted to support racist claims of innate differences between racial and ethnic groups. Thus, while the "molecularization of life" can be an individualizing force, it can also collectivize in problematic ways (Rose, 2001).

Thirty six percent of the articles/editorials addressed ways the technology could assist in developing more tailored treatments than the standard use of a white male model while also explicitly addressing the myriad ways social context shapes the potential benefits and introduces disadvantages.

The news articles, both implicitly and explicitly, collectively elucidated the promise and the problem that Rabinow and Rose (2006) articulated regarding the molecular

gaze and race, as well as speciesism: By demonstrating "that humans shared over 98% of their genome with chimpanzees . . . it appeared that genomics itself would mark the terminal point of biological racism (perhaps even species-ism). But this humanitarian dream proved to be short-lived" (p. 206). Indeed, the findings indicate that speciesism in particular is normalized via news media accounts of this technology in spite of the potential that advances in genomics hold for eroding it.

Although the nonhuman animal category was the second most frequently occurring theme, the attendant ethical considerations were rarely explicitly discussed (only two of the 35 instances coded). The quantitative presence of animals therefore is not a measure of their relative value or importance: The animal theme was so common due to the use of animals in experiments related to the technology. Of the two instances where the ethical considerations were explicitly addressed, one urged quick response to global climate change because of catastrophic impacts on fishes, which would have human impacts by extension. The second problematized the creation of hybrid animal bodies, largely because it could create a slippery slope toward creating hybridized humans. Thus, even in the rare instances where ethical concerns are explicitly raised regarding animals, it occurs in contexts where humans could also be negatively impacted as a result vis-à-vis the use under consideration.

There are many potential ethical considerations related to use of transcriptomics research with animals. We wish to flag three related to the subjects addressed in the news articles analyzed in this article. First, and perhaps most obviously, there are ethical considerations associated with the use of yet more animals in scientific research. The articles analyzed herein referenced but a few species of animals being used in transcriptomics research (e.g., mice, rats, macaques, fishes, and birds), but there are undoubtedly more. Space constraints preclude us from getting into a detailed weighing of the ethical considerations related to the use of animals in science. However, it is worth noting that if we were going to employ a utilitarian calculus, for instance, to weigh these considerations, we would need to know, among other things, the potential benefits of the research to be weighed against the instrumentalization of animals and the potential infliction of pain and death (see Bass, 2012). While some content was offered in the news articles regarding the former, there was scant attention paid to the latter.

This brings us to our second, related point: The potential benefits of some of the research may not meet the threshold warranting the use of animals, even by utilitarian calculations. It is hard to discern based on the content of the news articles, which is important because as noted several times herein, the general public is most likely to get information regarding science and technology from the media. Take, for example, the news article detailing research assessing whether chickens can be made to grow dinosaur tails. The article provides significant details of the research, as well as other research being conducted with other species of animals, but the outcomes or benefits are addressed in extremely general terms as follows: "It is to produce the complete book of life, one that would explain where modern animals come from and how our different bodies took shape" (McIlroy, 2007).

Finally, the article that raised ethical considerations related to the threat posed to global fish populations by global climate change and associated increased carbon in seawater, which will impact their gene expression and test their ability to adapt (Caron, 2018), came close to addressing an important ethical consideration noted earlier in this article that is likely to become increasingly germane. As global climate change and other drivers of environmental change and degradation challenge the ability of animals to adapt to their environment, transcriptomics technology could be used to assess if/how they are adapting to their changing environments and that information could be used to selectively breed more adaptable animals in order to supplement species populations, potentially even staving off extinction.

This raises a suite of ethical considerations, one of which is at the heart of what can arguably be termed an ongoing tension between environmental and animal ethics: Simply stated, there is divergence regarding what the primary unit of analysis ought to be. For the former, it is the species and ecosystem, and for the latter, it is the individual animals involved (see Fitzgerald, 2018, for a discussion of this and other points of tension between the two). What the analysis provided in this article indicates is that while the molecularization of life may have facilitated a shift in focus from population-level risks to individual risks (Rose, 2001), as noted earlier, this is only true for humans. In these news media sources, nonhuman animals remain conceptualized as a mass group at the population level, which is consistent with conservation biopolitics more generally (Braverman, 2017), and obviates meaningfully attending to considerations of animal ethics. This dearth of attention to animal ethics, particularly in the context of technology they are likely to be at the forefront of being impacted by, is important. The relative absence in news media analyzed here is important given that media not only shapes scientific information for the public but also because the absence of coverage of ethical considerations can exclude these dimensions from public consciousness.

Although it is important to evaluate how the public understands the use of gene transcription, its ethical implications, and its limitations, the current study did not aim to assess individual interpretations of news media framings. Instead, it is intended as a first step in understanding what information is being communicated to the public. Future research on knowledge uptake, perceived usefulness, ethical considerations, and limitations of this novel technology would be useful. Research with stakeholders focused on areas of increasing application, particularly with free-living animals in efforts to enhance their adaptability to rapid environmental changes, would be particularly timely and valuable.

CONCLUSION

In closing his 2001 paper on the molecularization of life, Rose declared, "We have entered the age of vital politics, of biological ethics and genetic responsibility" (p. 22). While this may indeed be the case, our analysis provides evidence that the politics, ethics, and responsibilities referenced by Rose are not being communicated to the public, at least not vis-à-vis gene transcription (particularly not regarding animals) in a meaningful way

in news media—the source people are most likely to go to for information on this and similar topics.

This finding underlines the importance of researchers reflecting upon the ethical implications of their own work and of transdisciplinary collaborations, because in this context, pressure to do so is not (yet) likely to emerge from society informed by news media. As Rose (2001) observes, "I do not think that, today, the most far-reaching ethical innovations concerning our relations to ourselves are being made in the deliberations of the bioethicists and moral philosophers—they are being made within medical and biomedical thought and technique itself" (p. 20). This points to the import of transdisciplinary work, where ethicists, philosophers, sociologists, and the like work on projects alongside researchers in the natural sciences in order to elucidate socioethical considerations, instead of doing so in a post hoc, reactive manner.

The importance is illustrated well by the newspaper article analyzed here that details gene expression research conducted to assess if chickens can grow dinosaur tails. According to the article, the researcher is aware that ethical questions need to be asked, notably: "Should this organism be allowed to live? Should we even be doing this to an embryo with the intent of letting it live? Those questions have not been brought in the public eye yet" (McIlroy, 2007). Near the end of the article, the author asks a most pertinent question: "So when should we start the conversation about this type of work and where it may lead? Some might say it is already too late, that the proverbial genie is out of the bottle. Prof. Larsson argues that it is better to wait until we know what is possible" (McIlroy, 2007). Yet, as illustrated by the Enviropig saga detailed earlier, if socioethical considerations of the molecularization of life are not addressed proactively, it is as if they have not been addressed at all.

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