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(Machine) Learning How to See Like a Rover: Feminist Objectivity and the Demonic Ground of Martian Sand

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Abstract

Mars has long been a space onto which fantasies of colonization have been projected in both popular and scientific imaginaries. Amidst these colonizing visions, can there be a feminist science of Mars? In this paper, I examine an emerging technology being developed at NASA's Jet Propulsion Laboratory designed to increase the capacity for future rovers to conduct autonomous scientific research on Mars using machine learning and computer vision, called the Soil Property and Object Classifier (SPOC), as a case study in crafting feminist objectivity. I bring together feminist studies, critical race and ethnic studies, Indigenous studies, and postcolonial studies approaches to the study of science and technology to analyze the ways in which SPOC evidences how contemporary techniques used to engineer autonomous scientific discovery on Mars through machine learning, artificial intelligence, and computer vision reproduce and redescribe the logics, imaginaries, and power relations of US settler colonialism in new technological terms. Ultimately, my work aims to gesture towards the possibilities that emerge for crafting a feminist objectivity of Mars when we situate scientific knowledge through the racialized conditions of its production.

Keywords

feminist objectivity, anti-colonial science, artificial intelligence, machine learning, Mars

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Can There Be a Feminist Science of Mars?

Mars has long been a space onto which fantasies of colonization have been projected. In the United States, Mars is often positioned as an expanding frontier of American empire, perhaps most recently on January 20, 2025, when President Donald Trump delivered his second inaugural address to the nation. In this address, Trump (2025) reasserted the colonization of Mars as a national priority, and many of the nation's billionaire tech elites cheered on excitedly behind him as he declared, "The United States will once again consider itself a growing nation—one that increases our wealth, expands our territory, builds our cities, raises our expectations, and carries our flag into new and beautiful horizons. And we will pursue our manifest destiny into the stars, launching American astronauts to plant the Stars and Stripes on the planet Mars."

While we often learn to see Mars through these kinds of overtly colonial public narratives and popular imaginaries that envision Mars as an American frontier, the technical images of Mars that are produced by scientific research programs such as NASA often tell a similar story. While NASA's *Viking 1* lander took the first photo of the surface of Mars in 1976, depicting a close-up, black-and-white image of rocks, sand, and soil, NASA's fleet of Mars Exploration rovers are now equipped with multiple specialized cameras that have produced countless types of images of the surface of Mars that serve technical or scientific functions *and* carry social and cultural power, depicting Mars as a space of exploration, discovery, and future human colonization. Janet Vertesi's (2015) work in *Seeing Like a Rover: How Robots, Teams, and Images Craft Knowledge of Mars* describes this phenomenon in depth, documenting how NASA's Mars Exploration Program scientists and engineers produce knowledge of Mars using rover images according to objectives that are both technical and political. Vertesi observes that images of Mars that circulate in popular and public spaces are often produced to deliberately transform Mars into a "familiarly American view of the Martian landscape" (228) as a frontier to communicate the ethos of exploration and discovery that is paramount to continued public support, and therefore the long-term success, of the Mars Exploration Program. Similarly, Lisa Messeri's ethnography, *Placing Outer Space: An Earthly Ethnography of Other Worlds,* shows how the work of NASA's computer scientists to construct interactive maps of the surface of Mars transforms Mars into a place that "naturalizes and makes widely available a planetary imagination that supports the resilient goal held by NASA and space enthusiasts to eventually set human foot on the awaiting Red Planet" (2016, 74).

As these visions of Mars appear to exemplify what Donna Haraway has described as "the god-trick" (1988, 581), presenting the "view from above" (590) or the infinite vision of the disembodied gaze of scientific objectivity, I often wonder, can there be a feminist science of Mars? How can we situate these colonizing visions of Mars to craft a version of feminist objectivity? After all, Haraway actually turns

to planetary images as examples of potential sites from which we can produce feminist objectivity:

> Feminist objectivity is about limited location and situated knowledge, not about transcendence and splitting of subject and object. It allows us to become answerable for what we learn how to see…All these pictures of the world should not be allegories of infinite mobility and interchangeability but of elaborate specificity and difference and the loving care people might take to learn how to see faithfully from another's point of view, even when the other is our own machine. That's not alienating distance; that's a *possible* allegory for feminist versions of objectivity. Understanding how these visual systems work technically, socially, and psychically ought to be a way of embodying feminist objectivity. (583)

In the field of science and technology studies, scholars have worked to address the question of situated knowledge in scientific images of Mars. Vertesi's (2015) work in *Seeing Like a Rover*, for example, stands out as one way that we might create situated knowledge of Mars—that is, through ethnographic accounts of the complex technical, social, and political practices that shape NASA's expert teams' work to produce Mars images. Interestingly, Vertesi actually dispels the illusion that images of Mars are a view from nowhere. Instead, Vertesi describes the social, scientific, and engineering practices that condition each image's production and the complex and collaborative ways in which scientists, engineers, and the rovers work collectively to explore Mars using digital images, arguing that the images of Mars that the public usually encounter reflect neither a god's-eye view (or the view from nowhere), nor even the rover's view, but instead are constructed to reflect the situated perspective of an imagined human observer.

Messeri's (2016) ethnographic work in *Placing Outer Space* stands out, too, as an example of how images of Mars can be situated in the technical, social, and political conditions that shape their production. But Messeri offers a slightly different story. While Messeri's ethnography of The Mapmakers, a team of computer scientists at NASA's Ames Research Center working to create 3D maps of Mars for the public using surface images taken by the rovers, accounts for the complex political, social, and material conditions that shape the specific practices The Mapmakers use to construct Mars as a specific interactive "place" for imagined human users (rather than, for example, constructing a view from nowhere), Messeri does not suggest that these maps of Mars are therefore unequivocally situated knowledge. Instead, Messeri argues that "situated planetary knowledge is in some ways a double god trick. The user imagines himself or herself as the embodied viewer of the Martian landscape, but this is a way of seeing…that is specific to the Mars scientist…The positioning is simultaneously situated and universalizing" (108).

Taken together, Messeri's and Vertesi's work raises the question of what it would mean to produce situated knowledge of Mars, or a version of feminist objectivity that "allows us to become answerable for what we learn how to see" (Haraway 1988, 583) when that *we* and that *us* is so often configured as an unmarked, imagined human observer, and the very question of what "we" "learn" how to see in images of Mars is dramatically shifting with the application of machine learning and artificial intelligence. Many images of Mars are now, for example, described as "rover selfies" because they depict the figure of the increasingly autonomous Mars Exploration rover in the frame, positioned both visually (and narratively through captions on social media) as a heroic figure of scientific progress alone on the Martian frontier. But this vision of autonomous scientific discovery is not just a narrative fantasy—it reflects NASA's material efforts to engineer rovers with increasingly autonomous capabilities to perform key aspects of scientific research (like observation and navigation) using the visual capacities of the rover and the latest advances in machine learning and artificial intelligence. Engineering autonomous scientific discovery on Mars is thus evidence of what Neda Atanasoski and Kalindi Vora describe as the surrogate human effect of technoliberalism, where new technologies, and particularly artificially intelligent autonomous technologies, come to "stand in" for the human as "aspirational versions of humanity" (2018, 5) in a universalized postrace future that reflects (but disavows and obscures) the violent logics of racial difference that scaffold the human in relation to the figure of the liberal subject. In this moment marked by the technoliberal fantasy of rovers performing autonomous scientific discovery on behalf of an unmarked, universal human future, crafting a version of feminist objectivity becomes a practice of (riffing on Haraway and Vertesi) becoming answerable for what the *rover* "learns" how to see (*and* how we learn to see the rover) as an autonomous technology, by situating our fantasies of autonomous scientific discovery and the visions that proffer it in the long (violent) histories of their racial formation.

Thus, I aim to develop situated knowledge of contemporary visions of Mars that is routed through theories of the relationships between the racialized figure of autonomy and the human, space, scientific research and knowledge production that emerge at the intersections of intersectional feminist theory and critical race and ethnic studies, Indigenous studies, and postcolonial theory. In bringing these fields together with science and technology studies, my goal is to contribute to long-standing conversations on feminist objectivity by analyzing the ways in which the contemporary techniques used to engineer autonomous scientific discovery on Mars through machine learning, artificial intelligence, and computer vision reproduce and redescribe the logics, imaginaries, and power relations of US settler colonialism in new technological terms. I aim to build on existing scholarship at the intersections of these fields that emphasize how the relationships between science, technology, and society are co-produced with (and as) systems of power such as colonialism, and the intersecting categories and

relations of social difference (for example, race and nation) through which such systems are constituted. With emphasis on the heterogeneity of these fields, my goal is to enliven a version of feminist objectivity that is formed through the "elaborate specificity and difference" (Haraway 1988, 583) of the theories and histories of racial difference that these fields emerge from and offer, while also asking after the possibilities that might emerge for the broader project of an anti-colonial feminist science of Mars as we consider the coalitional relations that exist (or might yet be formed) through their interdisciplinary connection.

As a case study, I examine an emerging technology being developed at NASA's Jet Propulsion Laboratory that is designed to increase the capacity for future rovers to conduct autonomous scientific research on Mars using machine learning and computer vision, called the Soil Property and Object Classifier (SPOC). SPOC is a novel autonomous terrain classifier designed to make complex assessments of images of Martian terrain that will increase capacity for Mars rovers to make navigation decisions and identify targets for scientific research autonomously. As a highly visual technology, SPOC is a particularly compelling case study for grappling with the complexities and demands of situated knowledge and feminist objectivity. As I will show, SPOC signals a significant innovation in the engineering of autonomy in the Mars Exploration rovers because it has the capabilities to accurately classify Martian sand (an infamously dangerous and notoriously risky terrain for Mars rovers) for the very first time. But, I argue, SPOC's capacity to autonomously classify Martian sand as *trafficable terrain* also signals the reproduction of the logics, imaginaries, and power relations of US settler colonialism, now articulated at new scales of planetary difference. I bring together work in Black feminist theory, Indigenous studies, and postcolonial theory to understand how SPOC recasts the logics, imaginaries, and knowledge of autonomy, the self and its other, space and terra nullius in new technological (or technoliberal) terms. I argue that SPOC is evidence of what I describe as the emerging figure of the autonomous colonial laboratory—an innovation that marks the confluence of the racialized form and function of the figure of the colonial laboratory with the racialized form and function of human autonomy. I then dwell in the challenge of Martian sand as a ground for engineering human and machine autonomy, and "read against the grains" (Hartman 2019) of SPOC's technoliberal visions of Martian sand and learn to see at its limits, towards what escapes the gaze of its computational vision. To do this, I draw on Vanessa Agard-Jones's (2012) work in "What the Sands Remember" to see sand both technically (or scientifically) and speculatively (or poetically), and turn to the poetic technique of enjambment as a subversive mode of doubled vision, to learn to see both SPOC's computational visions of sand in juxtaposition with speculative visions of Martian sand as a version of Sylvia Wynter's (1990) and Katherine McKittrick's (2006) conceptualizations of demonic ground that can point us towards new modes of feminist science praxis. Ultimately, my work aims to gesture towards the

possibilities that emerge for crafting a feminist objectivity of Mars when we situate scientific knowledge through the racialized conditions of its production.

Feminist Objectivity and the Emerging Figure of the Autonomous Colonial Laboratory

In the absence of immediate communication and direct human presence and oversight on Mars, engineering autonomy in the Mars Exploration rovers has been paramount to the success of the Mars Exploration Program. Earthbound scientists have relied on intermittent communication with rovers that have had increasingly autonomous capabilities to carry out mission objectives, but engineers at NASA's Jet Propulsion Laboratory state that "there is an urgent need for significantly enhancing on-board autonomy of future rover missions" (Ono et al. 2020), particularly for terrain navigation, path-planning, and decision-making. They explain, "Terrain is important to get around on Mars. Spirit got stuck in a sand pit and ended its mission after 7 years of exploring Mars (but far exceeding its nominal mission length of 90-days). Opportunity and Curiosity also have experienced getting stuck in sand, although they were able to continue on their missions. Don't you think it would be nice if the Mars rover could identify dangerous terrain by herself?" (AI4Mars, n.d.). But current communication and network infrastructure limits the amount of data that can be transmitted between Earth and Mars, which means manual navigation on the surface of Mars is not always possible (Ono et al. 2020). And it's not just an infrastructure problem, either—it's also a labor problem: "Manually performing [terrain] evaluation…all over the landing site, which typically spans over 10 km, is very laborious, if not impossible…[It] requires the eyes of experienced geologists and rover drivers, who are not available for spending hundreds of hours on manual terrain classification" (Rothrock et al. 2016).

So, in 2020, a team of researchers from NASA's Jet Propulsion Laboratory introduced MAARS (Machine learning-based Analytics for Automated Rover Systems), a suite of algorithms developed for use on NASA's future Mars Exploration rovers that includes the SPOC. Trained on open-source data sets using a citizen science program called AI4Mars (Swan et al. 2021), SPOC's developers are eager to "apply the judgment of experienced eyes on a significant volume of data with a marginal labor requirement" (Rothrock et al. 2016, 2). Once SPOC is adequately trained, it will be able to effectively manage terrain risk to the rover by predicting the likelihood of rover slippage and terrain traversability, key problems for NASA and the Jet Propulsion Laboratory's rover teams in rover path planning (Rothrock et al. 2016; Swan et al. 2021). SPOC will thus increase the capability of future rovers to plan routes more efficiently while identifying scientific targets of interest through autonomous navigation and decision-making while reducing risk to the rover (Ono et al. 2020; Swan et al. 2021).

Towards the broader project of crafting a version of feminist objectivity, we might first situate SPOC in the history of scientific objectivity in terms of how it signifies a new, hybrid formation of two historical modes of scientific objectivity, specifically, mechanical objectivity and trained judgment, and, accordingly, a new formation of the scientific self (Daston and Gallison 2007). For example, by classifying different types of terrain using images of the surface of Mars, SPOC performs an updated version of a practice described by Vertesi (2015) in *Seeing Like a Rover*, wherein computer scientists working on NASA's Mars Exploration Program team would disambiguate data from stereo images taken by the rover's Pancam using software to make certain aspects of the images salient according to the specific goals of certain teams. For example, Vertesi (2015) describes how computer scientists would make topographical aspects of an image salient for the operations side of the team (rather than spectral or morphological properties of the soil or rock features that might be useful for the interests of other teams) to allow operations team members to determine "where and how the rover can drive" (126). This disambiguation, Vertesi shows, is essential to *drawing* Mars *as* trafficable terrain" (126) and to make Mars "tangible, interactionable, and knowable" (130). In other words, SPOC can be seen as an updated form of scientific objectivity that combines the mechanical ability to classify images of Mars with the trained judgment of the scientific expert.

Interestingly, engineering autonomous terrain classification through SPOC indexes a moment in the history of objectivity where the scientific self is effected by an artificially intelligent machine, here configured as an autonomous rover-as-laboratory that enacts expert interpretation and choice that both replicates and exceeds the capacity of the earthbound human scientist. While objectivity, the laboratory, and classification are classic concepts and figures in science and technology studies (see, for example, Bowker and Star 1999), I am interested in building on this body of work by reading calls from postcolonial studies of science and technology (especially Warwick Anderson 2009). In so doing, I aim to understand the figure of the scientific laboratory and its techniques of classification as a racial formation (Omi and Winant 1994) that emerges through histories of colonialism in relation to both the critique of SPOC's production of the surrogate effect of technoliberalism as an artificially intelligent machine, and Indigenous studies theories of the land relations of US settler colonialism. If, as I have suggested, crafting a version of feminist objectivity becomes a practice of becoming answerable for what the rover "learns" how to see (*and* how we learn to see the rover) as an autonomous technology by situating our fantasies of autonomous scientific discovery and the visions that proffer it in the long (violent) histories of their racial formation, then we need to situate SPOC's capacity to perform autonomous terrain classification in the histories of colonialism that shape it. So, while the fields of science and technology studies and feminist science and technology studies have long been critical of scientific objectivity and the scientific self, critical race and ethnic studies, Indigenous studies, and

postcolonial theories of the study of science, technology, and society are crucial for situating SPOC's new formations of scientific objectivity and the scientific self with attention to their racial histories of production.

Specifically, I find Atanasoski and Vora's (2018) theory of the surrogate human effect of technoliberalism to be particularly helpful. As a political structure, technoliberalism describes a particular relationship between the figure of the human and technological innovation in engineering projects that claim to revolutionize human life through the development of artificially intelligent robots that liberate the human subject from devalued and degraded labor so it can have the freedom to pursue its creative potential (Atanasoski and Vora 2018). But the figure of the human under technoliberalism is scaffolded according to racial and gendered logics that have always differentially and hierarchically defined who can be fully human, and who cannot (Atanasoski and Vora 2018). These ideas of differential categorization become incorporated into (and constitutive of) the engineering projects that produce the surrogate human effect, where technologies that come to stand in for the human produce the liberal subject through a surrogate-self relation that operates as the "racial 'grammar' of technoliberalism" (Atanasoski and Vora 2018, 5). By "racial grammar," Atanasoski and Vora draw on Hortense Spiller's (1987) use of grammar to "draw attention to the composition of the human as an abstract category whose expansive capacities continually reaffirm the racial order of things that undergirds Euro-American modernity" (Atanasoski and Vora 2018, 5), particularly through the affirmation of the liberal subject through the devaluation of its others, as the "disappearance, erasure, and elimination necessary to maintain the liberal subject as the agent of historical progress" (6).

Read through technoliberalism, while SPOC stands in for the expert and creative classification labor once designated only for a human scientist to classifying multiple types of geological features (including big rock, bedrock, and soil) to transform the surface of Mars into trafficable terrain, SPOC stands to expand the reach and scope of future rovers' navigational capacities. Specifically, SPOC can be seen to "stand in" for the human and thus produce the surrogate human effect of technoliberalism by innovating on older techniques of scientific vision using artificial intelligence and machine learning that reassert and maintain the right of an aspirational version of an unmarked, universal human or figure of humanity to overcome the limits of space and the limits of the human to ensure the "right of the liberal subject to those spaces previously impenetrable" (Atanasoski and Vora 2018, 150).

And yet, it is not simply the fact that SPOC can transform the surface of Mars into trafficable terrain that interests me. SPOC is unique among terrain classifiers because it can effectively predict the presence of sand in a given image for the very first time. Using images of the surface of Mars taken by the navigation cameras of *Curiosity*, *Spirit*, and *Opportunity* rovers as input (Swan et al. 2021), SPOC "outputs

the probability of sand in the image space" (Ono 2018, 0:38–48) with sufficiently high accuracy such that its error margins are unlikely to result in misclassifications of terrain features or areas that are the size of the rover. This means, therefore, that SPOC is unlikely to produce classification errors that are large enough to present significant risk to the rover's navigation, thus accurately classifying sandy terrain in a range of probability that is useful for the first time (Ono 2018, 0:28–33). As a case study in crafting a version of feminist objectivity in terms of the production of the surrogate effect of technoliberalism, I'm interested in SPOC's novel capacity to make complex assessments of Martian sand as an innovation or technological fix (Atanasoski and Vora 2018; Benjamin 2019) that operates as a racial grammar of technoliberalism, as the very technique that reasserts the Euro-American racial order of things by producing and affirming the liberal subject (here configured as the rover as the heroic figure of scientific progress) while reasserting the devaluation, disappearance, erasure, and elimination of its racial others. Here, I want to focus on SPOC's capacity to perform the autonomous classification of sand as trafficable terrain to offer a case study that, following Atanasoski and Vora, can "extend critical race and ethnic studies analyses of gendered racialization to include machine 'others'…[taking] the weight of an ethnic studies analysis off of racialized people so that we can see how this relationship functions even in their absence…to attend to techniques through which difference (whether human-nonhuman or interhuman) is produced, while understanding categories of difference as historically specific" (2018, 8).

To do this, I am interested in turning to scholarship across Indigenous studies and Black studies (and more specifically Indigenous geographies and Black geographies) that have theorized the way in which land relations are constitutive of maintaining colonial control and essential to the reproduction of the liberal subject. For example, Ojibwe geographer Niiyokamigaabaw Deondre Smiles (2020) has observed that current US space exploration programs operate within settler-colonial logics wherein "space represents yet another 'unknown' to be conquered and bent to America's will." Building on Smiles' argument, I suggest that as SPOC categorizes the surface of Mars into trafficable terrain, SPOC performs what McKittrick (2006) and Wynter (2003) might describe as the transformation of the unknown and uninhabitable into "a geography of Man" (McKittrick 2006, 132) or a racialized, biocentric ordering of space that is known and knowable for the racialized figure of Man (or the Euro-American conceptualization of the human).

But, SPOC *innovates* on the technique of classification as a tool and extension of the colonial laboratory to accomplish the remote control and command of space in new, updated technological terms. As an *autonomous* terrain classifier designed to increase the capacity for increasingly *autonomous* rovers (or laboratories) to carry out scientific research remotely, SPOC demonstrates how innovations in machine learning and artificial intelligence are changing the ways in which terrain

classification for the remote command and control of space operate as modes of colonial power by indexing a new kind of relationship between the command and control of space and the reproduction of the liberal subject. Here I am thinking with Smiles (2020), who has argued, citing Patrick Wolfe's (2006) work, that "the settler state seeks to make use of land and resources in order to continue on [through] any number of activities that settler colonial logic deems necessary to its own survival." Smiles (2020) elaborates, "the settler colony is intimately tied with the space within which it exists—it cannot exist or sustain itself without settler control over land and space" such that "the ultimate aims of settler colonialism is therefore the occupation and remaking of space" to sustain the permanent presence of colonists and the settler state. With these theories in mind, I observe that SPOC's novel capacity to effectively classify and predict the presence of Martian sand is not only crucial to the survival of the Mars Exploration Program as an extension of the US settler state, but, by design, aims to guarantee its continued expansion: As the rover drives, more images are generated of the surface of Mars, and, crucially, more images of Martian sand; these images become more data that can be used to further train the terrain classifier and perfect its capacity to predict the presence of sand; as the terrain classifier is further trained and perfected, the rover is able to navigate further, with reduced risk to its overall safety; as the rover navigates further, it produces more images of Martian sand, which become more data to train SPOC, and thus, cyclically, ensure the increased command and control over space. In other words, with the use of machine learning and artificial intelligence, computer vision, and images as data, SPOC's ensures the very success and continuation of the Mars Exploration Program through its very design and capacity to perform and perfect autonomous terrain classification of sand. This is, I argue, the mark of what I will describe as the emerging figure of the Mars Exploration rovers as autonomous colonial laboratories: The expansion and perfection of the command and control over space for liberal subject through the techniques of autonomous classification of Martian sand not only operates as the racial grammar of technoliberalism but, by design, guarantees its reproduction.

I want to be careful here not to conflate scientific research on Mars and the engineering of autonomous terrain classifiers with the histories of US settler colonialism and their violent mechanisms of racial domination that I have positioned as their conditions of production, particularly in my elaboration of the surrogate effect of technoliberalism through the terrestrial histories of violence that Smiles, Wolfe, Wynter, and McKittrick draw upon in their work. I want also to be careful not to conflate terrestrial histories of settler-colonial land relations with the particular relations I have traced through Martian sand and the expansion of colonialism in outer space. If anything, my goal in tracing these new relations reflects my interest in the Precarity Lab's (2020) observation that "digital networks signal not novel dystopias but old paradigms of domination (the plantation, the colony, the prison, the military industrial complex, the laboratory, and the special economic zone)" to suggest that SPOC evidences how the logics

and imaginaries of the racialized order of US modernity are engineered into new technologies like SPOC as a part of their default form and function. SPOC thus *inherits* the histories of US settler colonialism and recasts its logics and imaginaries at new scales of planetary difference, configuring Mars as an emerging frontier of US colonialism while simultaneously appearing to be disconnected from it as the mark of technoliberalism. The demand of a feminist objectivity is therefore to become accountable to the histories these technologies inherit, *especially* those from which they appear to be disconnected. As engineering autonomy through the application of machine learning and artificial intelligence for the classification of Martian sand becomes an arbiter of US settler-colonial expansion on Mars, how might a feminist science respond? What would it take to become answerable or accountable to what the rover, or autonomous colonial laboratory, learns how to see—and how we've learned to see it?

Enjambment and the Demonic Ground of Sand

In all of this, I am conscious that as SPOC "learns" to see Martian sand as trafficable terrain, it is produced as a devalued, racialized other, imagined as a resource for engineering autonomy within broader technoliberal narratives that posit sand as risky and dangerous to proffer the figure of the universal human and guarantee its access to technological futures on Mars. But sand is, after all, a multitude. Might Martian sand hold more for us than risk and danger, and more for us than resource? Can we "read against the grains" (Hartman 2019) of SPOC's visions of sand to craft a version of feminist objectivity that is situated in (and against) its devaluation? Put another way, following Haraway (1988), can we read at the technical limits of our visual systems to learn to see what escapes SPOC's computational visions of sand as a practice of crafting feminist objectivity and anti-colonial science?

To this end, I observe that while SPOC appears to guarantee the reproduction (and perfection) of the autonomous colonial laboratory and its racial order of things, reading against the grain at the limits of its visual systems reminds us that SPOC is a predictive algorithm, which means that although it predicts the presence of sand more or less accurately, it is unable to do so perfectly, and there is always a margin of error (Ono 2018). This means there is always a percentage of sand that escapes the capture of SPOC's computational vision—a space of uncertainty that persists within and against the effort to engineer more perfect, more intelligent, and more expansive scientific vision.

There is important precedent in ethnic studies and Black studies to think with the materiality of sand as a space of uncertainty and absence, to mark the limits of objectivity, in environments that are dominated by colonial control. Here I am particularly moved by Agard-Jones's (2012) work to learn to see sand *both* scientifically and speculatively in "What the Sands Remember" as a mode of anti-colonial practice. In this article, Agard-Jones articulates sand as *both* a geological

formation *and* affective ground, describing the ways in which scientific epistemologies capture sand as a geologic formation but that sand exceeds these frameworks through affective, poetic, and speculative dimensions that are the conditions of its material formation that cannot be recorded. Agard-Jones writes, "Ever in motion, yet connected to particular places, sand both holds geological memories in its elemental structure and calls forth referential memories through its color, feel between the fingers, and quality of grain. Today's sands are yesterday's mountains, coral reefs, and outcroppings of stone. Each grain possesses a geological lineage that links sand to a place and to its history, and each grain also carries a symbolic association that indexes that history as well" (326). For Agard-Jones, "turning to sand as a metaphor for the repository of memory may help our analyses engage with more fine-grained and ephemeral presences than our usual archives would allow" (340). Taking seriously the idea that affective, speculative, and "more fine-grained and ephemeral presences" can escape what our scientific epistemologies and modes of vision would "allow," I want to dwell in the absences and uncertainty that Martian sand always presents for SPOC (and for the promise of objectivity) to trace the affective, speculative, and "more fine-grained and ephemeral presences" (340) that may be present but yet unseen, as a mode through which we might craft a version of feminist objectivity that is deeply situated at the limits of our technical systems.

To this end, I find the poetic technique of enjambment to be an apt method of seeing sand in this speculative mode of double vision. In poetry, enjambment is "(in verse) the continuation of a sentence without a pause beyond the end of a line, couplet, or stanza"; to stride over, and go beyond (OED 2022). Reading SPOC's images of sand through enjambment, what becomes clear is that SPOC's computational visions of sand "see" sand at the level of the surface (literally) but absent what is continued, without pause, beyond what it can record and interpret—specifically, the depth of sand as layered formations that evidence histories of planetary movement and processes, present and yet "unseen." SPOC's computational visions of sand therefore index an enjambment between the accumulation of sand as data for the engineering of rover autonomy, and the accumulation of sand in another register, as planetary movement, history, and formation.

Attuning to the movements and processes of sand, we might catch a glimpse of the "liveliness" of sand and (rover forbid) speculate towards its cognitive power or autonomy as a subversive practice of feminist objectivity, perhaps as a move to revivify sand against its devaluation as *dangerous* and *risky* in the racial grammar of technoliberalism effected by SPOC. This kind of move is perhaps reflected in new materialist efforts to critique anthropocentric frameworks of intelligence, autonomy, and cognition, and move towards more expansive epistemologies that account for the liveliness of nonhuman or more than human, multispecies, ecological, or planetary forms of life, as a kind of ethics or politics of living in our current moment. For example, the accumulation of sand as planetary movements,

histories, and formation is what Jane Bennett might describe as the "vital capacity" (2010, viii) of Martian sand. In this sense, the vital capacity of Martian sand becomes evident from the danger and risk it poses to the safety of the rover as sand movements and formations not only, in Bennett's words, "impede or block the will and designs of humans but also…act as quasi agents or forces with trajectories, propensities, or tendencies of their own" (viii). At the same time, N. Katherine Hayles's (2017) work to rethink, redescribe, and attribute cognition to nonhuman processes and forms of life as part of a "distributed planetary cognitive ecology" (2017, 3–4) stands out as a counterpoint to any attempt to theorize the cognitive power or autonomy of Martian sand. While Hayles seeks to recast what counts as cognitive, defining "cognition" expansively through the enactment of choice and interpretation across distributions of human, biological, technical, and material components (rather than through specific forms of consciousness that are unique to human actors), cognition "excludes material processes such as tsunamis, glaciers, sandstorms, etc." (3) because, Hayles argues, such material processes do not possess the capacity to enact interpretation and choice. In Hayles's distributed planetary cognitive ecology, Martian sand would be a non-cognitive agent.

And yet, if SPOC produces the surrogate human effect of technoliberalism through, in part, the devaluation of sand as a racialized other, then as we learn to see in its vision an enjambment between the accumulation of sand as data for the engineering of rover autonomy, and the accumulation of sand as planetary movement, history, and formation, our vision of this enjambment is a call to bring critical race and ethnic studies perspectives to bear on these movements, history, and formation and the production of the surrogate-self relation (Atanasoski and Vora 2018). Consider, for example, that Hayles uses the concept of the "unthought" in three ways: to describe a "mode of interacting with the world…that forever eludes the belated grasp of consciousness" (2017, 1–2); as "the terra incognita that beckons beyond our received notions of how consciousness operates" (1–2); and as "the potent force of conceptualizing interactions between human and technical systems that enable us to understand more clearly the political, cultural, and ethical stakes of living in contemporary developed societies" (1–2). But by contrast, in "The Position of the Unthought," Saidiya Hartman and Frank Wilderson III (2003) have named the unthought as a speculative mode, which, Hartman emphasizes, describes the impossibility of accounting for the positionality of the slave in Western epistemologies (185) and therefore signals the need for a racialized account of positionality (Hartman and Wilderson 2003, 184). Attuning to the apparent liveliness of Martian sand thus requires that we foreground a racialized account of their positionality in the production of Western scientific epistemology.

So, while Hayles's (2017) and Bennett's (2010) work adjudicate the cognitive power or vitality of sand in ways that reinforce binary, biocentric, and humanistic terms, I am interested in an alternative project. Rather than theorize whether or not Martian sand exhibits a version of autonomy as a subversive project against

the formation of the rover as an autonomous colonial laboratory, I am instead interested in thinking with Hartman and Wilderson (2003) to mark the *very impossibility* of the cognitive power, autonomy, or vitality of Martian sand within SPOC's epistemology (its techniques of visualization and the dominant scientific and engineering epistemologies that designed them). Such a project, I argue, is one way of situating and becoming accountable to the colonizing power of SPOC's visions of Martian sand and the racial formation of autonomy that they proffer and inherit, without expanding the terms of autonomy (and its attendant formations of consciousness, choice, agency, and vitality). This project aligns with calls in critical race and ethnic studies approaches to feminist science and technology studies to resist the expansion of artificial intelligence as an arbiter of colonial power by disrupting *intelligence* as a category and "[pillar] of conscious autonomy" (Atanasoski and Vora 2018, 196) rather than *expand* it. As such, I want to learn to see the impossibility of the intelligence, cognition, vitality, or autonomy of Martian sand—not argue that sand is (or is not) intelligent, cognitive, or autonomous—because so long as we insist that sand is *not* intelligent, *non*-cognitive, or *not* autonomous, we foreclose the potential to become accountable to the racialized conditions of domination under which autonomy, intelligence, and cognition are made legible and reproduced in the first place. Learning to see how SPOC's computational visions of sand index an enjambment between the accumulation of sand as data for the engineering of rover autonomy, and the accumulation of sand in another register, as planetary movement, history, and formation that escapes capture, is not a project of expanding what counts as autonomous, intelligent, or cognitive, but rather an effort to disrupt these categories altogether.

In other words, if Martian sand has a version of what we call agential, vital, or cognitive power, it is *outside* SPOC's epistemic frame, in the space of uncertainty that always remains beyond the limits of our technical systems. Martian sand, therefore, represents a version of what Wynter (1990) has theorized as demonic ground, which McKittrick describes as "the space of Otherness…*terra nullius*/the lands of no one" (2006, 123), where there is "always something else besides the dominant cultural logic going on, and that something else constituted another—but also transgressive—ground of understanding…not simply a sociodemographic location but the site both of a form of life and of possible critical intervention" (Scott 2000, 164). McKittrick offers an incisive analysis of "demonic" in *Demonic Grounds: Black Women and the Cartographies of Struggle*:

> Etymologically, demonic is defined as spirits—most likely the devil, demons, or deities—capable of possessing a human being. It is attributed to the human or the object through which the spirit makes itself known, rather than the demon itself, thus identifying unusual, frenzied, fierce, cruel human behaviors. While demons, devils, and deities, and the behavioral energies they pass on to others, are

> unquestionably wrapped up in religious hierarchies and the supernatural, the demonic has also been understood in terms that are less ecclesiastical. In mathematics, physics, and computer science, the demonic connotes a working system that cannot have a determined, or knowable, outcome. The demonic, then, is a non-deterministic schema; it is a process that is hinged on uncertainty and non-linearity because the organizing principle cannot predict the future. This schema, this way of producing or desiring an outcome, calls into question "the always non-arbitrary pre-prescribed" parameters of sequential and classificatory linearity. With this in mind, the demonic invites a slightly different conceptual pathway—while retaining its supernatural etymology—and acts to identify a system (social, geographic, technological) that can only unfold and produce an outcome if uncertainty, or (dis)organization, or something supernaturally demonic, is integral to the methodology. (2006, xxiv)

What would it mean, then, for the project of feminist objectivity to name Martian sand as a demonic model of cognition that can form a new science of the human, against the reproduction of SPOC's surrogate effect of technoliberalism? Enacting a mode of feminist science practice, I am thinking with Wynter's call to move "to a frame of reference which parallels the 'demonic models' posited by physicists who seek to conceive of a vantage point outside the space-time orientation of the homuncular observer…a 'demonic model' outside the 'consolidated field' of our present mode of being/feeling/knowing" (1990, 364). Thinking thus outside but in relation to SPOC and its formation of an autonomous colonial laboratory, I want to learn to see Martian sand as what Wynter describes as a "demonic model of cognition" (365) that can erode SPOC's visions of sand that proffer the liberal subject, by moving towards what Wynter describes as "a new self-assertion…this time as one which brings together the human and natural sciences in a new projected science of the human" (365).

Thinking with Wynter (1990) and McKittrick (2006), the demonic cognition of Martian sand is enjambed in SPOC's computational visions, emerging in the uncertainty and unpredictability that always remains in its calculations, integral to the broader epistemology of dominant science. If "[a] biocentric frame does not take into account stories and storytelling as modes of livingness" (McKittrick 2006, 126), then, read one way, the demonic cognition of Martian sand emerges through the stories we tell about it, in our imaginaries of its danger, riskiness, unpredictability, and uncertainty. Reading against the biocentric view of sand, my desire to read demonic cognition in the danger of the sand, its space of uncertainty, unpredictability, and in the absented depth of sand as planetary movement and formation, might become a feminist practice of learning to see Martian sand as demonic ground through which we can catch a glimpse of the livingness of an anti-colonial consciousness in the sand—a different, if not antithetical, form of consciousness than the subject-effect of the rover as it

threatens to erode what Wynter (2003) would describe as its overrepresentation and futurity. While this account of the liveliness of Martian sand might resonate with Bennett's theory, reading liveliness as an anti-colonial consciousness is markedly different from new materialist projects to categorize the liveliness of materialities like sand because this form of consciousness is a project to unsettle the racial category of the human and its others, rather than expand on its terms.

And yet, if subjectivity and objectivity are co-constituted in scientific visions, then SPOC's visions of sand produce both the subject-effect of the autonomous rover *and* its racialized other—here figured through the sand as terra nullius, indexing sand as demonic ground. So, read another way, in this enjambment we catch a glimpse of the competing imaginaries of the timescales of the engineering of human autonomy on the one hand, and the formations of planetary time on the other. SPOC indexes the speed of data capture, extraction, and accumulation, which is enjambed in its visions with the speed of the accumulation of sand in another register in planetary time. We might consider planetary time as a version of geological time, a timescale that Joseph Masco (2021) has so usefully marked as an urgently needed mode of planetary stewardship. But planetary time also signals the timescales of the longue durée of US settler colonialism and the racial formations of the autonomous subject. Here, I am thinking with Martian sand as a liminal space (between speculation and material, the poetic and scientific, surface and depth, grain and aggregate, static and movement, the human and the other) resonant with Tiffany Lethabo King's brilliant work in *The Black Shoals* to mark the space of the shoal as a demonic ground (2019, 3), in order to learn to see Martian sand as a form of life *outside* of biocentric frames and human conceptualizations of space-time.

To this end, I am reminded of M Murphy's theory of distributed reproduction as "the extensive sense of existing over time that stretches beyond bodies to include the uneven relations and infrastructures that shape what forms of life are supported to persist, thrive, and alter, and what forms of life are destroyed, injured, and constrained" (2017, 141–43). Perhaps riffing on Hayles's use of "distributed" in her theorization of a distributed planetary cognitive ecology, Murphy's distributed reproduction thus prompts us towards a politics of living in our current planetary moment that is accountable to the ways in which the demand for engineering autonomy is "a fraught process of becoming-in-time that has been constituted through violence, uneven accumulations and abandonments, and not merely an affirmation of life" (143). Learning to see the demonic cognition of Martian sand therefore brings us towards a feminist objectivity crafted through an account of the racialized positionalities that form the situated, partial perspectives of the autonomous colonial laboratory.

Conclusion

In my effort to articulate feminist science of Mars, or a situated knowledge of NASA's efforts to engineer increasingly autonomous rovers using autonomous terrain classification algorithms and computer vision, I have tried to read at the technical limits of our visual systems to learn to see the subversive potential of what escapes the scientific gaze, as a practice of feminist objectivity and anti-colonial science. To this end, as NASA's rovers enact new forms of scientific objectivity as autonomous colonial laboratories, I have tried to craft a version of feminist objectivity that emerges from a racialized account of their positionality—that is, to account for the emergence of the figure of the autonomous colonial laboratory in terms of its settler-colonial conditions of production that proffer its racialized subject-effect within technoliberalism.

This can, however, often prove to be dissonant work, as Mars is a site that often appears to be disconnected from terrestrial histories of racial domination. While I have theorized this disconnect as evidence of technoliberalism, this is not to discount the dissonance that emerges in the work to trace how the logics and imaginaries of colonialism are, as I have argued, reproduced and redescribed at new scales of planetary difference, often changing form as they are updated by new technologies such as SPOC. Rather than assume the portability of any frameworks, histories, or concepts, I want to dwell in the dissonance as productive frictions that point to how difference emerges across scale. Put another way, my goal is not to compare US settler colonialism on Mars to US settler colonialism on Earth—but rather, to begin to trace its expansion across new scales of planetary difference in ways that ask after, and insist upon, the ways in which US visions of Mars inherit the histories of US settler colonialism that have made them possible. In so doing, I hope that we can come to understand Mars as a racial formation that has emerged in relation to terrestrial histories of racial difference, while pointing towards new modes of critique and coalition.

While I have learned to see the demonic ground of Martian sand as a practice of feminist objectivity, I have here only begun to attune to the potential of Martian sand (and other planetary formations) as demonic models of cognition that might form not only what Wynter has described as a new science of the human, but a feminist science of Mars as well that can situate, both materially and speculatively, scientific research on Mars within the conditions of colonialism, imperialism, and racial capitalism through which it has emerged. My goal in this work is, therefore, to invite further theorizations of intersectional feminist sciences of Mars that are premised on accountability to the racial histories of science, technology, and the human, as a practice of learning to become accountable for what we learn how to see on the expanding frontier of American empire.

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