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Latina/o/e technoscience: Labor, race, and gender in cybernetics and computing

Iván Chaar López

Abstract

The history of cybernetics has often displaced non-white actors and women from its accounts. Recentering them offers an opportunity to rearticulate the history of computing through its entanglements with labor and race/gender as network formations. In paying attention to these actors and the silences in the STS literature, this article offers an analysis of networked asymmetries, non-essential knowledge and disposability. In doing so, it redraws the boundaries of STS with race/gender integral to the field. It proposes hemispheric approaches that trouble national bounds and move us beyond the dominant sites of Europe and the United States, and that interrogate US empire. The article follows closely the role of Arturo Rosenblueth in the development of cybernetics and of Mexican women workers in computer semiconductor assembly. These stories of technoscience show the invisible work of Latina/o/es as unacknowledged and unaccounted entities in the infrastructural assemblage of cybernetics and computing.

Keywords

cybernetics, critical race STS, feminist STS, Latino studies, electronics manufacturing, invisible work

Visual and conceptual artists Rafael Lozano-Hemmer and Guillermo Gómez-Peña presciently redrew the boundaries of information and communication technology when they posted their net-art piece 'Tech-illa Sunrise (Lozano-Hemmer and Gómez-Peña, 2002) to the website, *Pocha-Nostra*. In their piece, they offered a new genealogy for the world wide

The University of Texas at Austin, Austin, TX, USA

Correspondence to:
Iván Chaar López, Department of American Studies, The University of Texas at Austin, 2505 University Avenue B7100, Burdine Hall 437, Austin TX 78712-1139, USA.
Email: ichaar@utexas.edu

web that centered the wide-ranging contributions of Chicana/os and other Latina/os. 'Dear cibernautas angloparlantes, ever wonder what is in the root directory of your Mexican server? Wouldn't you want to peek at the files of Chilicon Valley's most powerful sysadmin?' With this opening, the artists frame their intervention as a clandestine maneuver in the disclosure of forgotten knowledge found deep in the root servers of system administrators. Addressing an imagined Anglo or white reader, the artists reconceptualize computer and Internet terms through Spanglish to take ownership of these technologies. 'Tech-illa Sunrise' articulates a new mode of perception. As an allusion to the mixed drink cocktail, the poem produces an alternate state of being that is both code and skin deep. This gesture brings to light the central role played by Latina/o/es[1] in the development of scientific discoveries and technologies involved in shaping a global, networked modernity. In renaming Silicon Valley as 'Chilicon', the artists brought Internet users into a new territory, one which could not exist without Latina/o labor, though more specifically Chicana/o and Mexican labor.[2]

The science and technology studies (STS) toolkit, while rich and varied, would suffer demonstrably by the loss of critical concepts and frameworks from cybernetics, such as systems theory, communication and control, information theory, distributed passage points, legitimacy exchange, the human-machine boundary, cyborgs, and the closed world (Bowker, 1993; Edwards, 1996; Galison, 1994; Heims, 1991, 1993; Kline, 2015). Yet, despite its bountiful contributions, a persistent silence confounds this literature. STS scholarship on cybernetics has often glossed over the central role played by one of its key intellectual players, Arturo Rosenblueth. The Mexican scientist's contributions to cybernetics often fall into the narrative trope of the sidekick, *el escudero*, to Wiener's heroic and visionary efforts. Regardless of their continued transnational collaborations in Cambridge and Mexico City and the bountiful correspondence between them, Rosenblueth is treated as a passing player, an accidental one at best, instead of a fundamental actor and interlocutor in the development of the interdisciplinary science. The place of Rosenblueth in the STS scholarship on cybernetics is marked by the persistent dynamics of non-essential knowledge and disposability. The former is a rhetorical and material maneuver that decenters the knowledge practices of non-white actors. The latter is its concomitant effect, a description of their seemingly useful, but also discardable nature.

In tracing the rendering of prominence and visibility in stories of technoscience, such as the emphasis on Wiener, a shadow network posits some populations and their stories in other terms. This network of actors, their practices and ideas constitute a vast, unacknowledged and unaccounted infrastructural assemblage that was, and continues to be, critical in the development of electronics, cybernetics, and computing. Latina/o/es and the US-Mexico borderlands, this article argues, were, and continue to be, fundamental to the emergence and maintenance of a cybernetic technopolitical regime; in documenting their practices and stories, the boundaries of the field of STS are redrawn. Telling the story of the knowledge and labor of Rosenblueth in the emergence of cybernetics troubles its origin story. Some of the field's core ideas about human physiognomy and its interdisciplinarity, often cited as shifting the boundaries of collaboration and knowledge production in the mid-twentieth century (Kline, 2015: 37–67; Turner, 2008: 17–27), were among the key, rarely recognized contributions made by Rosenblueth. To demonstrate this, I rely on the scholarly record of cyberneticians like Rosenblueth and Wiener as well as their personal correspondence, along with the STS literature's assessment of the main actors in cybernetics.

The centrality of cybernetics in computing and electronics (Turner, 2008) opens the door to think about networked relations and sites of production like manufacturing, moving from the 'lab' of cybernetics to the (experimental) 'field'. Rosenblueth's intellectual labor constitutes a critical contribution to cybernetics, a key knowledge formation in the development of computing and the information revolution. Investments in artificial intelligence today are possible thanks to decades of cybernetics research and thinking that blurred the material and metaphorical boundaries between humans and machines (Edwards, 1996: 27). Meanwhile, Mexican maquila workers' bodies were enrolled in the physical fabrication of the material substrate of computing, the semiconductors hardwiring the same information revolution shaped by cybernetics. When it comes to artificial intelligence, maquila workers constitute a crucial node of this global extractive industry, cheap labor entangled with the exploitation of mineral and data resources (Crawford, 2021; Irani, 2015; Mbembe, 2021; Precarity Lab, 2020). Race and gender differentially positioned Latina/o/e actors in the long history of making today's information and communication infrastructures.

Maquiladoras along the US-Mexico borderlands articulate what I call 'networked asymmetries' – the uneven associations and differential arrangements through which actors are enrolled in shifting relations. While the *maquila* system comprises a range of industries, according to data from the National Institutes of Statistics and Geography in Mexico (Castillo and De Vries, 2018: 204), the electrical/electronics segment of this system has been responsible for about 50% of its gross output since the 1980s. Archival materials (Anonymous, 1977; Grynbaum, 1975) and the secondary literature (Cowie, 1999; Gaspar de Alba and Guzmán, 2010; Guendelman and Silberg, 1993; Weissman, 2010) documenting *maquila* operations and development since 1965 show that maquila workers were precariously employed and subjected to the racialized and gendered violence of disposability. More importantly, these workers made the artifacts that symbolized modernity elsewhere, even while they were disavowed from living such modernity.

The STS orientation proposed here asks: How is non-essential knowledge about science and technology made; how are operations of disposability enacted, perceived, reproduced and contested? And, as Murphy (2016) suggests, what forms of living are pursued with and against sociotechnical arrangements? This article proposes the conceptual trio of networked asymmetries, non-essential knowledge, and disposability as means for theorizing the historical treatment of Latina/o/es in science and technology. The figures of Rosenblueth and the *maquiladoras*, while central, are differently situated in the production of technoscience. Rosenblueth was a relatively privileged light-skin Latin American scientist, a cis man at an elite, white space (Harvard), which afforded him some recognition and reward in the racial order of the US. Meanwhile, maquila workers' labor was treated through racial and gendered lenses entrenching women of color as extractable and invisible subjects. Understanding the differential arrangements that produce and are produced through networked asymmetries allows for a nuanced understanding of the privileged yet discriminated experiences of Rosenblueth and the disadvantageous treatments of a workforce comprising predominantly women in *maquiladoras*. After all, as Chun (2016: 43–44, 53) contends, 'precarity … is the dominant network condition' and networks, despite their trappings and noise, are a productive theoretical tool to make

the invisible visible. Networks, as theoretical interventions, help us imagine or draw out the unimaginable expanse of global capital and imperial formations. They describe the social and technical just as they constitute them (Chun, 2016: 26). When it comes to Latina/o/es, stories of technoscience have often occluded arrangements that the concept of networked asymmetries brings to the fore.

The historical treatment addressed here is a double one that draws from Trouillot (1995): examine what happened in the past – the facts of the matter – and interrogate the stories we tell of what happened in the past. This is a double articulation that is traversed by processes of inclusion and exclusion, mentions and silences that frame our understandings of the past as well as our perception of the present. Tracing networked asymmetries unfolds both at the level of storytelling and of description, which is why these asymmetries can be elicited more clearly through the dynamics of non-essential knowledge and of disposability. The latter two operate in making indispensable work invisible – 'relegated to a background of expectation' and taken-for-granted as much as abstracting away from the process of work itself (Star and Strauss, 1999: 15, 22; Suchman, 1995). Treating 'creative' work as an entry point to the production of technoscience – either cybernetics or electronics/computing – STS scholars prioritized a representation of work that privileged the intellectual labor of white scholars and relegated non-white actors in the lab and in the assembly lines to the background. Similarly, the labor that created and coordinated spaces for action was abstracted and 'knowledge' work alone was posited as an indicator of worth. The historical treatment of the labor of non-white actors operated through and created enduring silences.

The aim is to open the field of STS to account for its near-sightedness. This requires a reconfiguration of the space of action to include not only the laboratory and its experts, but its epidermal fields of enactment and varied knowledge practices. Who are the 'experts' and how might we redraw the category's conceptual boundaries? Or better yet, perhaps we ought to look beyond the conceptual bounds of expertise to tune into wider discursive practices and fields of enactment. Who leverages the lab? With and against whom? Whose knowledge is construed as reliable and fundamental in science and technology? All these questions point to a research agenda that works against what Mascarenhas (2018) argues are the color-blind explanations making STS into a white space. Color blindness constitutes 'a real reluctance to debate and theorize contemporary forms of racism, and this reticence has morphed into silence and denial' (p. 153). A white space of (white cis male) 'experts' imagines itself abstracted from the knotted dynamics of gendered racial formations and white (Eurocentric) supremacy.

This article calls for redrawing boundaries in STS by making race and gender integral (not supplemental) to the field, proposing hemispheric approaches that trouble national bounds and that move us beyond the dominant sites of Europe and the United States, while interrogating the US empire. It contributes to ongoing STS scholarship expanding analytical and theoretical frameworks that place the knowledge making practices and experiences of marginalized communities at the center of inquiry as well as making them critical interlocutors.[3] I draw inspiration from Lozano-Hemmer and Gómez-Peña who worked to rewrite the origin stories told about cybernetics and computing. I center Latina/o/es to widen STS beyond narrowly defined national concerns by encouraging an approach that documents and analyzes the articulation of subject formations that move

across geopolitical boundaries. The article examines such subjects in relation to networked asymmetries as processes co-constructed with US imperial formations.[4] The goal is to offer analytical insight into how Latina/o/es' practices and experiences are made invisible in stories of technoscience as well as elucidate the operations of race/gender and/as technology.

Invisible work, race, and gender

The approach articulated here is indebted to feminist STS and critical race digital studies. I draw from feminist insights on invisible, though indispensable, labor contributing to the making of science and technology, as well as how gender relations and discourses set the conditions of possibility for these contributions. However, as I show, feminist STS builds on the theorizations and critiques of sociotechnical arrangements produced by Latinas and other Third World feminists. Critical race digital studies offer a way to trace networked asymmetries tethered to racial formations and to their prescriptions; racial formations are sociohistorical processes entangled with technologies, infrastructures, actors and ideas (Omi and Winant, 2014).[5] I make sense of the stories of Rosenblueth and the *maquila* workers through a feminist and critical race lens of invisible work.

Women of color feminisms opened analytical pathways to question the situated articulations of knowledge. Situated knowledges, as Haraway (1991: 191) suggests, are 'partial, locatable, critical knowledges sustaining the possibility of webs of connections called solidarity in politics and shared conversations in epistemology'. These knowledges open pathways for a practice of objectivity that operates through itinerant and persistent contestations, deconstructions, constructions, interlinked connections and transformation of systems of knowledge. Such a conceptualization is possible through Sandoval's (2000) oppositional consciousness. This is a model of political identity produced by those refused membership in or controlled through social categories of race, sex and class. Oppositional consciousness emerges from systematically interrogating the ideas and knowledge practices of the so-called Western tradition, even while operating within its constructs (Sandoval, in Haraway, 1991: 155–156). Sandoval seeks to center the practices, experiences and stories of those strategically placed on the margins, 'the outsiders' of a Western tradition. Oppositional consciousness, then, is a dialectical framework, a contingent, itinerant and self-referential positionality that traces ideas and relations across individuals, groups of actors, artifacts, and the self. It does so through an assortment of techniques that simultaneously challenge dominant ideological signs, open new ideological fields of practice and bring about not only just, but egalitarian social relations (Sandoval, 1994: 78). In thinking with women of color feminisms, the inquiry that follows is concerned with drawing out relations not only through affinities, but differences across entities to account for the kinds of subjects/objects made possible by these relations.

Among the key techniques of differentiation considered here are race and gender. Chun (2009: 10) suggests we think of race as a 'mapping tool' for the way it constructs and marks origins and boundaries on bodies; these visible traces are bound to embodied, yet invisible, characteristics. To think of 'race and/as a technology', as Chun proposes, is to shift focus 'from the *what* of race to the *how* of race' (p. 8). It means to trace the intricately material-symbolic assemblage enfolding our world. That is, race and/as a

technology guides how individuals come to imagine and value relations with each other. From the diagram of the slave ship as the paradigmatic construct of the (racial) panopticon (Browne, 2015) to Navajo women's 'special' technique for making semiconductors in the 1960s (Nakamura, 2014), race is integral as an instrument that assembles the social and it is also embedded in those material artifacts through which we make our supposedly modern world. 'Race and/as technology' should not be understood as displacing an analysis of gender, but rather is informed by intersectional frameworks. This much is clear in Atanasoski and Vora's (2019: 4) critique of 'technoliberalism' as a political formation in racial capitalism, positing humanity as an aspirational figuration made possible through technological transformations. This formation, they tell us, attempts to obscure the uneven racial and gendered relations in capitalist production; its advocacy for universal liberation is grounded in the externalization of oppression, an externalization fastened to an Other. Technoliberalism relies on the racialized and gendered division of labor so prevalent under colonialism to maintain white heteropatriarchy (Atanasoski and Vora, 2019: 89–90). When considering the place of value in race/gender and/as a technology, we are led down the path of addressing how people – though especially some people instead of others – come to be differentially inscribed as standing reserves. In other words, race/gender and/as technology opens critical avenues for studying sociotechnical arrangements in the making of racial capitalism.

Differential sociotechnical arrangements are the products and producers of 'networked asymmetries' (Srinivasan, 2017: 54). These are a drawing together of variable degrees of intensity that are strategically positioned in the making of our (unequal) world. Networked asymmetries are actionable associations between actors and actants that institute lopsided treatments. Networks today, as exemplified by the Internet, social network sites or stock markets, are both diagrams and the material substrate of contemporary interrelationality (Galloway, 2004). This is an interrelationality articulated through connections that institute, reproduce and, at times, undo unevenness and inequity. Material connections themselves, as computer scientists show (Balakrishnan and Padmanabhan, 2001), are pivotal in the production of asymmetry in an information network. Bandwidth and degrees of access are hardwired into the matter of networked data flows – that is, cellular connection versus fiber optic cable. Participation, capacities, vulnerabilities, and more are part and parcel of the affordances of connection. Entities brought into the warm cover or, perhaps, the cool logical program of the network still go through processes of differentiation. To speak of networked asymmetries, then, is to draw out the discriminated inscription of entities, whether organic, inorganic or both, into particular and strategic roles – roles that seek to dictate specific behaviors, expectations and objectives particular to the network's ideal and differentiating topology.

When thinking through the framework provided by networked asymmetries, non-essential knowledge and disposability can be understood as its co-constructed qualities and not its natural conditions. Writing as the COVID-19 pandemic ravaged Black, Indigenous and people of color (BIPoC) communities across the US in May 2020, García Peña (2020) theorized the boundaries defining certain bodies and their labor as 'essential'. These boundaries often marked non-white populations for their vital role in maintaining the functioning of cities and rural spaces, of sustaining and weaving together contemporary life. But the underside of this required BIPoC to expose themselves, to risk contagion. Hence,

their lives were expendable for the sake of a collectivity that would not care for them. 'Essential' workers, García Peña holds, 'must continue to risk their lives and die in order to provide the services the rest of us need to survive'. Paradoxically, in being deemed 'essential', they are 'non-essential'. Overcoming the pandemic comes at the expense of the lives of 'non-essential' workers, those treated by the governments and capital as expendable 'extras'. Probing the classification of some workers as 'essential' makes plain how 'systems of classification (and of standardization) form a juncture of social organization, moral order and layers of technical integration' (Bowker and Star, 1999: 33). To maintain a functioning collectivity meant that some bodies were made 'essential' for the lives of others. Rosenblueth's work and contributions to cybernetics, as the next section demonstrates, have been treated by the STS scholarship under the rubric of non-essential knowledge. His role was that of an expendable subject.

Discussions about disposability recall socioeconomic processes through which laborers are dispossessed and displaced into wage-less joblessness. Millar's (2018) ethnographic work offers a rich account of the association between humans and the discarded, of so-called 'surplus humanity' and 'human-as-waste' across anthropology, sociology and associated fields. These processes, she tells us, were described in the late-nineteenth century by Karl Marx in his discussions of the lumpenproletariat, 'the unemployable fraction of the working class, consisting of vagabonds, petty criminals and beggars', the 'refuse of all classes' (Millar, 2018: 5). Capital's operations led to the systemic fabrication of people as discardable matter, as non-essential to the means of production. Such metaphorical associations reemerged in late capitalism with the articulations of neoliberal practices that pushed (some) people to live lives of precarity, of abject vulnerability (Tadiar, 2013). Disposable lives are bound to capitalist modes of production, spatial technologies and to modernization efforts, such as the *maquiladora* system of the US-Mexico borderlands, crisscrossing the Global North and Global South (Ong, 2006). Though initially discarded as unemployable, these subjects play important roles in disciplining labor power (i.e. a persistent threat to their employment) and in offering capital an outside to incorporate through the expansion of markets and the emergence of new commodities.

Cybernetics: Beyond imported magic

Let's return to the story of Rosenblueth and his invisible intellectual and organizational work in the development of cybernetics. Rosenblueth was born in 1900 in Ciudad Guerrero, Chihuahua, to a father with Jewish and Hungarian ancestry and a US-born Catholic mother (Guzik Glantz, 2009). His family's middle-class status afforded him access to elite primary schooling in Mexico City's Institut Franco-Anglais Sainte Marie. Years later, as he struggled to finish his degree in medicine due to economic hardships, the director of the National School of Medicine in Mexico, Guillermo Parra, secured a scholarship for Rosenbleuth to pursue studies with Felipe Brockenheimer at the School of Medicine in Berlin. His stay there was short-lived, and after 6 months he left for the Sorbonne's School of Medicine in Paris, from which he graduated in 1927. He described his time in Berlin as 'unpleasant' – it confirmed to him his 'Latinamericanism' (cited in Guzik Glantz, 2009: 49). While in Mexico he was the son of seemingly white,

middle-class parents, in Germany he was racialized differently: a non-white foreigner and the son of a Jewish father at a time when Nazi anti-Semitism was growing (Quintanilla, 2002: 305). Once he returned to Mexico to teach and research, Guzik Glantz recounts, he struggled with inflexible disciplinary practices at the Universidad Nacional de México's (UNAM) School of Medicine. The Guggenheim Foundation, which was starting a series of programs to expand its reach in Latin America, offered him a scholarship in 1930 to pursue research at Harvard University with Walter B Cannon. Known as a key collaborator of Norbert Wiener, along with Julian Bigelow, Rosenblueth helped develop the transdisciplinary science of cybernetics.

His insights on homeostasis, neurological processes and the nervous system informed new understandings on what the three authors identified as core processes in organisms and machines (Cannon and Rosenblueth, 1933; Rosenblueth, 1932; Rosenblueth and Cannon, 1942; Wiener, 1965: 8, 11–12, 16–22). Rosenblueth (1932), as a result of Cannon's mentorship, studied the sympathetic nervous system of a cat with special focus on nerve responses to electric stimuli and the role of chemical mediations. His attention to neuromuscular mechanisms and stimuli meant Rosenblueth was already concerned with the ways systems responded to inputs and how processing these led to distinct control outputs. By the time Rosenblueth et al. (1943) published their field-defining article, Rosenblueth was an expert in neurophysiological processes. Their article translated his concerns for stimuli, mediation and response into behavior, purpose and teleology. These processes, the authors concluded, were central to understanding how any complex system sustains itself and relates to its immediate environment. Behavior, they contended, is 'any change of an entity with respect to its surroundings' (Rosenblueth et al., 1943: 18). While such a definition may be too broad, it is important to qualify behavior through goals. That is, many entities enact voluntary activity that follows a given objective, a purpose. A clock, for example, seeks to mark time and a gun is designed to hit its target, even if neither of them is purposeful in their effort. An understanding of purposeful behavior, then, offers insight into feedback mechanisms. This is the output energy generated by an entity that is then returned to it as input. The cycling of outputs and inputs shapes the behavior of the entity, and as a result they are understood to be teleological. A cat pursuing a mouse strikes it by anticipating its future position – information on the target's direction and velocity, the cat's own direction and velocity, and the contours of the specific place modify and guide the purposeful behavior of the cat. 'Cybernetic theory gave machine metaphors a new theoretical foundation, creating a new technical terminology and system of quantification – information theory – for describing flexible, self-directed behavior in both machines and minds' (Edwards, 1996: 184). Rosenblueth et al. reconfigured biological and psychological concepts of stimuli, mediation, response, purposes, goals and will through the language of engineering into inputs, outputs and feedbacks. Biology and psychology were now understood through information theory.

In their correspondence, cyberneticians often remarked on Rosenblueth's role within cybernetics as an expert in biology – though he also excelled in mathematics. Their recollections often described him as contributing to the wider project of cybernetics, yet his contributions are left as unacknowledged background. In writing about Norbert Wiener, Warren S McCulloch (1947–1962) noted how he first met Wiener during a dinner with Rosenblueth and Bigelow. McCulloch commented that, at that time, the three scholars

'were mechanizing teleology', a reference to what soon became their major co-authored piece on 'Behavior, purpose, teleology' (Rosenblueth et al., 1943). Biological processes were understood as following a steady, logical progress with information comprising an essential role. The purposeful behavior of organic, biological matter was understood as a model for other non-organic phenomena, although it was the language of engineering that translated such matter into other realms and objects. By abstracting biological phenomena, they were rationalized. The mechanization of teleology, initially understood within a biological context, implied the integration of discreet human and machine elements into a single human-machine assemblage processing information or what later is described as a cyborg – a fundamental metaphorical construct in future research into artificial intelligence. The mechanization of teleology shows that Rosenblueth's neurophysiological background allowed Wiener and Bigelow to finally put their engineering worldview in conversation with living organisms. McCulloch concluded that, with this meeting between Rosenblueth, Wiener and Bigelow, 'the dream began of team play between biologist, mathematician and communication engineer, which eventually flowered into Cybernetics'. Describing Rosenblueth's role as 'biologist' emphasizes what his expertise made possible in their collaboration – the blurring between living organisms and machines.

Wiener echoed McCulloch's assessment of Rosenblueth's contributions. In a letter to JBS Haldane, a professor in the Department of Biometry at University College London, Wiener (1946b) explained how his work with Rosenblueth was devoted to understanding 'servo-mechanisms in the nervous system and in animal behavior'. From 1944 to 1946, their work focused 'on problems which have both mathematical and physical implications'. Once again, Rosenblueth's contributions are emphasized as offering insights into biological processes. It is no surprise that Wiener held 'Art', as he caringly referred to Rosenblueth, in high esteem. Wiener's (1946a) letter to Fremont F Smith highlights how his collaboration with Rosenblueth in Mexico would be central to his presentation at the Macy Conference in October, 1946. Rosenblueth's expertise in neurophysiology opened an experimental program to corroborate the mathematical analysis. Their work together would allow them to apply such methods 'to the cortex of the brain', which built on those 'developed for the cortex of the brain by Mr Pitts and Dr McCulloch in Chicago' (Wiener, 1946a). While it was McCulloch and Pitts (1943) who produced a computational theory of mind, Rosenblueth's neurophysiological expertise was instrumental in setting the conditions of possibility for such computational metaphor.

Without Rosenblueth's expertise in biology and physiology, Wiener and Bigelow would have been constrained to matters in mathematics and communication engineering. Rosenblueth and Wiener (1950: 326) concluded in a different paper that, 'as objects of scientific enquiry, humans do not differ from machines'. The behavioral study of living organisms and machines helped blur the boundaries between them and, in doing so, propped up a transdisciplinary science with insights into a plethora of phenomena. Rosenblueth contributed the knowledge of physiological and natural phenomena that allowed them to make a substantive leap: to articulate an abstract conceptualization that expanded the category of 'machines' to include living organisms (Edwards, 1996: 182).

Though Rosenblueth was much more than a passenger in the cybernetic ship piloted by Wiener, his influence has been either understudied or unexplored. Google Scholar

shows almost 2000 citations for Rosenblueth, Wiener and Bigelow's 'Behavior, purpose, teleology', but over 17,000 for Wiener's *Cybernetics*. Citational and attribution practices concerning Rosenblueth et al. (1943) reveal that scholars often imagine Rosenblueth as a non-essential contributor, since Wiener's last name is often mentioned first, even though it was Rosenblueth who was first author in the publication (see Bowker, 1993: 108). Similarly, ideas from the article are often attributed to Wiener instead of all authors. Even Galison's (1994) fundamental article 'The ontology of the enemy' perpetuates the idea that Rosenblueth was a minimal figure in cybernetics, describing him as 'visiting Harvard Medical School' while he collaborated with Wiener and Bigelow. Rosenblueth had, in fact, been researching and mentoring at Harvard for more than a decade. Turner's (2008) work is an exception to the rule in that he acknowledges Rosenblueth's expertise in biology as pivotal to Wiener and Bigelow and he describes Rosenblueth's presentation at the Macy Conference as offering a distinct version of causality that 'was both genuinely new and open to study with traditional mathematical methods' (pp. 22, 122). In contrast, Kline (2015: 11) describes Wiener as having consulted Rosenblueth in 1942, when he realized engineering theories of control and communication could explain behavior in humans and machines. Yet, no explanations are offered as to why Rosenblueth is the first author nor what role he might have played in actually conceptualizing feedback in relation to causality. None of the descriptions articulated by his interlocutors, including Wiener himself, which underscore the critical role Rosenblueth played in translating mathematical and engineering abstractions into the world of living matter, figured into other historical understandings of him and of cybernetics.

For Rosenblueth (1970: vii–viii), interdisciplinarity was the result of asking 'questions about the purpose and the validity' of his investigations. Such questions, he said, led him to convene and organize a seminar devoted to the scientific method and that brought together scientists from a range of disciplines at Harvard and at MIT. Interdisciplinarity was already something that the Social Science Research Council fomented since its inception in the 1920s and that the Josiah Macy, Jr, Foundation promoted in medical research since 1930 (Kline, 2015: 39). But Harvard's *ad hoc* 'Philosophy of Science Club' – historian of science Steve J Heims calls it a 'supper club' – helped create a truly interdisciplinary space with participants from different scientific fields. Speakers, Wiener (1965): 1) recounted, 'had to run the gauntlet of an acute criticism, good-natured but unsparing' that led many of the participants to feel the meetings 'were an important and permanent contribution to our scientific unfolding'. The group fostered the kind of independent, collaborative and innovative scientific work Rosenblueth and Wiener envisioned (Heims, 1991: 48). Rosenblueth's seminar, the result of his invisible intellectual and coordinating labor, became the springboard for his collaborations with Wiener and catalyzed discussions that helped redraw the boundaries of natural and social science research in the twentieth century.

As a result of the meetings, the pair of scientists began to collaborate in what Wiener (1965: 2) called 'the most fruitful areas for the growth of the sciences', that is, those areas 'neglected as a no-man's land between various established fields'. Cybernetics, one of these areas, was imagined through the metaphor and logics of frontier thinking. Those areas considered as 'no-man's land' were reimagined by the 'supper club' as space open for settlement. The military-academic-industrial interactions at the heart of much

technoscientific research during World War II and the Macy Conferences are generally regarded as helping to blur the boundaries of collaboration across the disciplines – from philosophy, anthropology and psychology to mathematics, physiology and engineering (Heims, 1993: 7–13; Turner, 2008: 17). The Cybernetics Group constituted 'a community with a shared idiom' that 'reached a consensus on the scientific importance of a set of notions' around the brain/mind and the central role of communication across phenomena (Heims, 1993: 11). Most important was that the conferences fomented boundary-crossing knowledge. Heims (1993: 273–274) concludes that the conferences 'consisted of talk among participants – conversations, presentation of papers, argument and critique' which formed the bedrock of real scientific work. The fact that cybernetics imagined itself as the universal language for an abstraction inherent to the real world (Bowker, 1993: 114–115) revealed an imperial logic at its core: to identify, describe, produce and control differentiation. This is what leads Ali (2013: 102) to consider cybernetics and informatics as racial formations. The settler colonial and imperial ethos of these meetings cannot be disentangled from its product, cybernetics. And neither can Rosenblueth's labor.

Latino masculinity, even that of white-passing folks like Rosenblueth, is differentially positioned in relation to innovation. Innovation has historic associations in the US to the tinkering practices of men (Ensmenger, 2015; Oldenziel, 1997). Yet, these are not racially unmarked practices, as the language deployed in their descriptions suggests. Their sheer will and determination to chart new paths for settlement in the scientific frontier link innovation to settler colonial imaginaries. This is as much a masculine project as it is a racial one. Even if kept on the margins, Rosenblueth's capacity to 'pass' awarded him limited access to the white space of innovation and higher education. His white-passing masculinity redrew the boundaries of network asymmetries by creating opportunities for inclusion while also confirming differentiation. Networked asymmetries operationalized gendered and racial orders that kept Rosenblueth as an absent presence, a non-essential subject for relevant and reliable knowledge in the making of modern science.

By 1943, Rosenblueth's inclusion within the 'no-man's land' of scientific research at Harvard University came to an end when the university did not retain him. He had contributed to the Ivy League institution's cutting-edge scientific community for fourteen years (Heims, 1991: 49), but without a job, he returned to Mexico. To avoid interruptions to their collaboration, Wiener and Rosenblueth secured institutional support from the Rockefeller and Macy foundations in the mid-1940s. This allowed Wiener to have prolonged stays in Mexico every other year. Manuel Sandoval Vallarta, a former Wiener mentee at MIT, also supported their work. He invited Wiener to Guadalajara for the annual congress of the Sociedad Matemática Mexicana, while Rosenblueth himself secured temporary positions for Wiener in México's Instituto Nacional de Cardiología and the UNAM. According to Quintanilla (2002: 312–314), it was through Wiener's stay in México and the various relationships developed from this experience that he got the opportunity to write one of the most consequential books in the history of science and computing. Consequently, it is no surprise that the discipline-defying Cybernetics (1965) was dedicated to Arturo Rosenblueth, whom Wiener considered 'for many years my companion in science'. But book dedications do not necessarily make their way to citation figures or elaborate scholarly considerations. Rosenblueth's position in México, a peripheral space in the historical treatment

of the STS literature, reinforced the unevenness of technoscience and his relative absence from the cybernetics story.

And yet, the brave new world conjured by *Cybernetics* was, in part, the product of what Heims (1991: 44) identifies as 'the MIT-Mexico City and Chicago teams', in reference to Wiener, Bigelow, Rosenblueth and Warren S McCulloch and Walter H Pitts Jr, respectively. Stressing the Mexican connection is a line of inquiry yet to be explored in STS and computing histories, and something this article begins to correct (see also Izaguirre, forthcoming). Future projects ought to pursue more complicated narratives that go beyond what Eden Medina et al. (2014) call the 'imported magic' model and that recognize the agency of Latina/o/es and Latin Americans in science and technology. To break with the imaginary of imported magic is to take stock of 'processes of reinvention, adaptation and use' in the Global South and that 'innovation, invention and discovery take many forms, occur in multiple contexts and travel in many directions'; it is to de-emphasize 'the transfer of supposedly superior technologies and ideas from North to South' (Medina et al., 2014: 2). In resituating Rosenblueth as a critical thinker, interlocutor and collaborator in the development of cybernetics, I propose we reconsider the boundaries of this transdisciplinary science in relation to computing and the place of Latina/o/s within it.

Thinking with *maquiladoras*

Mexican women in electronics manufacturing, and more specifically assembling computer semiconductors, continue and differently locate the absent presence of Latina/o/es in the history of computing. While the gendered labor of these women in electronics is widely known, I position them as critical actors in the fabrication of past and present digital lifeworlds. The closed world conjured by cybernetics, of information and communication flows, of blurred boundaries between computational systems and human bodies required a material infrastructure to bring it forth. *Maquiladoras*, with their multitude of Mexican workers, are part of this unacknowledged story.

Maquiladoras are an expression of our contemporary networked asymmetries. Assembling gendered and racialized modes of production since the mid-1960s, *maquilas* have, along with an expansive network of outsourced manufacturing sites, contributed to the creation of our datafied and interconnected 'global village'. Yet, not everyone participates the same in this global village. It is made through the making of 'zones of depletion', areas where racial capitalism has subjected specific populations 'to long eras of resource extraction both human and natural, leaving behind toxic and depleted environments' (Precarity Lab, 2020: 2). Zones of depletion are not new, but part of the history and sedimented remains of imperial formations; they are products and producers of processes of differentiation and exception. They often work through racialized and gendered labor regimes such as electronics and semiconductor manufacturing in Asia and México (Ong, 2006: 124). The precarity of those inhabiting and working within the labor regimes of depletion zones is the invisible backdrop to the narratives of innovation in Silicon Valley (Lécuyer, 2007).

The system of manufacturing we know as *maquiladoras* began in the US-Mexico borderlands in the 1960s. *Maquilas* are factories destined for the import of materials to

be assembled into a new, finished commodity for export. A *maquila* is also a portion of grain, flour or oil used by the miller in their mill. Drawing from this associated meaning of the *maquila*, we can sketch the physical and symbolic contours of a relation of production that relies on the transformation of raw materials as means of extracting value while producing something else. Announced as the Border Industrialization Program (BIP) in 1965, the factory system itself was the product of modernization and industrialization efforts pursued by the US and Mexican governments as they brought the farm guest-worker program, known as the Bracero Program, to a close in 1964. The Mexican government designed the system to attract foreign capital by doing away with duties and regulations meant to restrict and control foreign capital (Ericson, 1970: 33). The Mexican government also pursued aggressive investments in infrastructure on its northern borderlands through the construction of industrial parks and railroad spurs, the paving of roads, and the extension of water and electricity grids (Alvarez, 2019: 143). US capital, meanwhile, sought a way to reply to ongoing working-class struggles, especially within the US electronics industry, making it harder on them to compete with lower-cost European- and Asian-manufactured goods (Peña, 1981).[6] This was not merely the result of economic and political opportunity, but of a specific worldview that imagined Mexican labor, especially Mexican women's labor, as conscriptable and exploitable (Cowie, 1999).[7] The BIP implemented zoning technologies drawing together multiple sovereignties to manage and administer racialized and gendered labor regimes.

To think of labor in the electronics and computing industries requires an account of their racial and gendered logics (Abbate, 2012; Chun, 2004; Light, 1999; Nakamura, 2014). Nakamura (2014), for example, shows that Navajo women were enrolled by Fairchild Semiconductor in the manufacture of integrated circuits (IC) in the 1960s after the company learned of a range of economic incentives to establish operations in Shiprock, New Mexico – from tax incentives to subsidize the project to the large number of surplus, non-union labor. Navajo women were imagined by corporate officials and journalists as inherently flexible laborers due to their adaptability – being willing and available for low-wage work – and because of their cultural competence in weaving patterns. These same weaving patterns made them ideal laborers for the design and etching required in semiconductor manufacturing. Depicting IC manufacture 'as a high-tech version of blanket weaving performed by willing and skillful indigenous women', Nakamura (2014: 931) concludes, made possible 'the incursion of factories into Indian reservations to be seen as a continuation of rather than a break from 'traditional' Indian activities, and it pioneered the blurring of the line between wage labor and creative-cultural labor; one seamlessly became the other'. While racial traits were identified after economic motives drove the company to New Mexico, differentiation did not supersede the profit motive. The process of identifying and enrolling Navajo and Mexican women as conscript-able and exploit-able labor was not a post-facto process to accumulation. It is, as Robinson (1983) shows, integral to the dynamics at the heart of racial capital. The tendency to differentiate between populations, 'to exaggerate regional, subcultural and dialectical differences into "racial" ones' was integral to the profit motive in European civilization (Robinson, 1983: 26). This tendency to differentiate has persisted over time as European colonialism intervened in the Americas and new societies emerged. Capitalist accumulation, as a technology in the making of the 'modern' world, necessitates difference – it is

produced by and producing differentiation. Differentiation is concomitant to construing certain populations as non-essential and disposable for the ways that it helps materialize their asymmetrical entanglement with networks of production.

Like the stories of Navajo women at Fairchild, race/gender and/as technology was enacted in the *maquila system*. Mexican women were imagined by electronics industry corporate officials as ideal workers for their small, nimble-fingered hands. Officials at RCA, for example, believed that young women's hands allowed for easier fabrication of electronic components.

> The typical maquila want ad [in the 1960s] specified that prospective employees must be between the ages of seventeen and thirty (often younger), be single without dependents, have completed primary school, but have no more than one year of secondary school, be available to work any shift and be a resident of the city for more than six months. (Cowie, 1999: 119)

Companies in semiconductor and computer-parts assembly such as Fairchild, Litton Industries, Texas Instruments and National Semiconductor recruited women who could devote themselves fully to their work. By the 1970s–1980s, 77% of maquila workers were women, with about 66%–75% of them being between the ages of 16 and 24 (Cowie, 1999: 155). While we might be tempted to interpret the movement of semiconductor assembly operations to zones of depletion with a large labor pool of women and people of color as circumstantial, it is a persistent feature of racial capital. Latinas were enrolled in these efforts.

Soon after the BIP was put into operation in 1965, a range of semiconductor and computer parts manufacturers established a presence in the borderlands. They were drawn by friendly regulatory arrangements and the differentiating logics of racial capitalism. Litton set up a 3000 square foot plant in 1966 to make magnetic memory cores for computers, while a Fairchild official explained that the company sought to take advantage of lower labor and reduced freight costs for its heavier components to maximize profits (Lawson, 1967). Howard Boysen, who worked at Fairchild and opened the Tijuana plant in the late 1960s, went on to found International Manufacturing, Engineering and Consulting, which helped design *maquila* operations that maintained US leadership with Mexican managerial and technical teams under it. From 1967 to 1986, IMEC was said to have processed a market value of over $12 billion in high technology (electronics) products (Sklair, 1989: 79, 90–91). This arrangement entrenched networked asymmetries around whose knowledge was prioritized and whose was non-essential in the extraction of value. In 1973, Mexico had surpassed Taiwan and Hong Kong as the principal site for US electronics assembly operations. Two years later, electric and electronics manufacturers represented more than half the total investment ($35.1 million out of $63.7 million) made by all *maquila* industries (Grynbaum, 1975: 12–13). Searching through the artifact collection at the Computer History Museum in California shows a range of computer products, all 'Made in Mexico' from 1969 until the early 2000s – from Xerox mouses, calculators and Apple keyboards to circuit boards and Atari joysticks. Much of the information infrastructure networking the global village, from joy to work, was assembled through export manufacturing systems like the *maquiladoras* in Mexico.

In networking the interior architecture of computer semiconductors, the strain of women's bodies was soldered into them. Women working in semiconductor assembly at

maquilas have spoken of the tediousness of their labor, which affects their bodies. To live with the toxicity of semiconductor assembly – from the release of toxins to the making of vulnerable bodies – meant there was a differential exportation of harm entangled with electronics manufacturing (Precarity Lab, 2020: 24–31). During an interview with the North American Congress on Latin America, a non-governmental organization interested in interrogating US empire, a woman described her relative's experience working with semiconductors in Tijuana: 'Her job was to wind copper wire on to a spindle by hand. It was very small and there couldn't be any overlap, so she would get these terrible headaches', an effort that led her and other women to acquire glasses 'to help their failing eyes' (cited in Grynbaum, 1975: 13). Women developed migraines and failing sight as a result of their work. The embodiment of toxicity was already wired into semiconductors in the 1970s, a time of growth for the computer industry with the popularization of the personal computer. The network architecture of computing technologies relied on the reification of embodied asymmetries that treated women's labor as non-essential and disposable.

Treating certain populations as disposable is a process shaped through racial and gendered imaginaries (Gidwani and Reddy, 2011; Mbembe, 2021; Tadiar, 2013; Wright, 2006; Yates, 2011). The articulation of transatlantic slavery is a paradigmatic manifestation of this process. In considering Black bodies as commodity producing commodities, Black life was imagined as delible and disposable for the attainment of value – Black life itself was value (Johnson, 1999). This is not to say that racial imaginaries were exclusively understood through the logic of capital. Black racialization, Wang (2018: 88) shows, 'proceeds by way of a logic of disposability *and* a logic of exploitability'. Racialization is not merely a rational maneuver for actors invested in a profit motive, but a structure of feeling organizing capital itself (Robinson, 1983). Some populations are construed as external to the internal cohesion of a given collectivity. They are externalities to the process of boundary making that shape individuals into groups, groups into communities. Tying things together produces stratifications of value that position entities in relations of inferiority and unevenness; gendered and racial formations position their bodies at the disposal of others. Managing some populations as surplus means, in other words, 'they are subject to "obsolescence" and can be discarded' (Mbembe, 2021: 31). The racial fabrication of expendability, like in the cases of readily available Latina/o/e labor, is made through, and makes possible, networked asymmetries.

Networked asymmetries are intersectionally produced. Where upper-class light-skinned Latinos like Rosenblueth were integrated into the realms of knowledge work and were partially recognized for their labor – even if in the role of background figures or plot devices – Mexican women were mostly hidden from view, their bodies blending into the machine of industrial computer fabrication. Rosenblueth was integrated into a hemispheric supply chain of knowledge workers who were not only trained in higher learning institutions, but were also responsible for research and teaching in these institutions. Mexican women workers in the *maquiladoras*, on the other hand, were not allowed to perform Rosenblueth's (geopolitical) boundary crossing. Race, class and gender shaped their immobility as disposable labor for what slowly became Silicon Valley's 'lateral networks of ethnicized' labor (Ong, 2006: 125). Latinas were treated as ideal for the low-wage and toxic work of semiconductor assembly. Race and gender co-shape one another

in redrawing hemispheric boundaries of inclusion and exclusion in the Americas as to what bodies could enter the circuits of knowledge production and computer fabrication. To think about the making of Latina/o lifeworlds is to broach sociotechnical and hemispheric entanglements.

The documentary film *Maquilápolis* (Funari and De la Torre, 2006) provides insight into the kinds of lifeworlds made through women of color feminisms. The film explores what it means to live with and against sociotechnical arrangements such as the one produced through the maquila system. The film relies on the self-documentary practices of *maquila* women workers who document their experiences and struggles in the northern Mexican borderlands. The women record their interactions with family in their improvised homes, walks around their neighborhood and the environmental degradation of their communities resulting from the operation of electronics plants, and their attempts to organize workers, sue operators and fight against their exploitation. In its opening scene, the film depicts the relation between the bodies of female workers and the racial violence of capital and technoscience. Lined up shoulder to shoulder, the uniformed women move their hands and arms synchronously as industrial music occupies the soundscape. They attach invisible components with one hand as the other holds the piece in place. Once done, they move the piece down the manufacturing line. The process starts again.

In this scene, their bodies become the factories that produce modern technology – the successful blurring of boundaries in human-machine configurations, a cyborg arrangement within zones of depletion. The nonexistence of the electrical and electronic components that later appear in the film reverts the process of alienation at the heart of the capitalist mode of production. The *maquila's* labor is no longer hidden by the sheer expanse of commodity and supply chains. Working bodies stand in place of the vast fabrication lines; they stand next to each other, out in the open air and outside of the shell of the factory. Their bodies are a synecdoche for the factories that produce as much as are produced by the persistent reconfigurations of human-machine relations. Working bodies are the 'contemporary interweavings of nature and artifice' that Suchman (2007: 275) invited us to recover. They are the articulation and experience of living with/against toxicity, of a pain that, as Sandoval (1994: 76) reminds us, results from 'the union of machine and bodily tissue'. Rather than follow the designers of computing, the film shows the imperial reach of the research and development lab as it enrolls Mexican women laborers. And even though these workers take these manufacturing jobs with the dream of a better life, they come up against the reality of the toxicity of electronic components, the development of unsanitary living conditions by the failures of the Mexican state to protect its citizens, the everydayness of misogyny and the hardships of low pay. *Maquilápolis*, shot and written by the workers themselves, is an effort to flip the script of the machine of capital and technoscience. The film shows Mexican women as the bridges, the invisible infrastructure of modernity. It offers a glimpse into the enactment of networked asymmetries, even as the film works against the absent presence and expendability of *maquila* workers.

Women of color have long been positioned as an unacknowledged, world-making infrastructure. Moraga and Anzaldúa's (1983) co-edited *This Bridge Called My Back*, a project of women of color feminisms, theorized them as 'bridges', as the backbones in

the making of radical lifeworlds – that is, in knowledge practices, community building and emotional labor for liberation. Feminists of color in *This Bridge* described how the labor of BIPoC folks is embedded within technologies and infrastructures, and how these communities maintain lengthy engagements with technique – not merely as subjects of biopolitics – as participants in their design and development. The stories told by Mexican workers in *Maquilápolis* echo women of color feminisms' tending to the heterogeneous infrastructural labor of racialized populations, of women and the working class. However, instead of sustaining the same structures of oppression impacting their lives, of bridging their present disposability to their future one, these women-built networks of contestation, consciousness-raising and community-building.[8]

Race and gender are network formations. In her analysis of the 'network' as technical matter and analytical maneuver, Chun (2016: 53) proposes attention to 'habitual connections', arguing that networks rely on continual repetitions that simultaneously make connections action-able and imagine-able. Race and gender draw things together by putting entities in relation to one another and by refracting their relations through a peculiar worldview that assigns essential attributes to bodies and populations. Race and gender are codes, techniques of distinction that must be habitually enacted to produce difference.[9] Critical race digital studies scholar and trans theorist Cárdenas (2016) proposes that we understand race and gender through algorithmic analysis, 'to visualize and articulate multiple locations of intersection and combinations of elements in movement', to reveal their articulation of differentiation and subjection. Race and gender structure relations and practices by making them programmable, conducive to a kind of automaticity that prescribes certain populations to perform distinct roles and actions and hold specific positions. Though, as the *maquila* workers of *Maquilápolis* show, their networked entanglements also produced other futurities – of standing in solidarity with each other, of relating with/against their disposability and of creating new possibilities for themselves and other women workers like them.

Information flows work through race/gender and/as technology. Mexican women laborers in *Maquilápolis* negotiate the ways the maquiladoras position their racialized and gendered bodies as assembling nodes in the making of information lifeworlds. Dealing with the toxic environment of the maquiladora system – the environmental toxicity of semiconductor assembly, *Maquilápolis* offers their producers a moment of encounter to tell their stories, organize and take collective action in redrawing the networked asymmetries enrolling their working flesh.[10] Their bodies were, even if temporarily, no longer non-essential knowledge of the *maquila* system, but bridges toward liberation.

Conclusion

The history of modern computing and information infrastructures cannot be told without an examination of race/gender and/as technology. Race and gender are network formations that make/enact asymmetries through bodies and knowledges treated as non-essential and disposable. Differential relations inscribe and prescribe; that is, they order actors and actants in lasting, even if fluid, arrangements. In the histories recounted above, the maintenance of functioning collectives – be that of the Cybernetics Group or of the

maquiladoras – relied on making some bodies essential. Their vitality was necessary to sustain the machinations of larger sociotechnical arrangements. The articulation of non-essential knowledge and the treatment of peoples as disposable simultaneously divided, connected, exploited and fostered these communities.

Non-essential knowledge and disposability are the materialization of the logics of racial capitalism. As a relatively privileged light-skinned Mexican man, Rosenblueth gained access to the white spaces of US academia and science from where he made a range of contributions – intellectual as much as through community building. His relative privileges did not protect him, however, from ongoing discrimination as both Mexican and Jewish. Rosenblueth's labor was enrolled for the development of US scientific education and research in the early 1930s, which led him to contribute to cybernetics in the 1940s even if, paradoxically, his intellectual and organizing contributions were treated as non-essential in historical accounts. That is, US cybernetics and the stories told about it afterward, especially in STS, prioritized the merit and value of certain kinds of bodies only to the point that they reproduced the hegemonic order of things and beings. Mexican womens' labor at the *maquilas*, similarly, fell under the spell of the commodity fetish. Alienated from the fruits of their labor, their knowledge, experiences and stories did not fit the neat narratives of creative destruction told about Silicon Valley and US computing. They could not be listened to either, as the boundaries of the laboratory – a historically privileged site in STS as much as a site for the making of privilege and difference – prioritized some bodies over others in the production of modern electronics and computing. Mexican women were enrolled in experimental modes of governmentality – special economic zones, export-industrialization – as much as they were responsible for making new experimental modes of governance in 'the world computer' (Beller, 2021).

The concept of networked asymmetries, informed by women of color feminism, feminist STS and critical race digital studies, contributes to the methodological frameworks of actor-network theory by attending to hemispheric and situated processes. As this article demonstrates, we must trace the differential rhythms that position entities in uneven, ambivalent and strategic relations. New understandings of imperial knowledge networks and information infrastructures become possible when we examine the work of Latina/o/es in cybernetics and computing. Cybernetics created just as much as it was created by a shifting matrix of actors, practices, and institutions shaped by and shaping the US empire. It also created new scientific practices in Mexico with ramifications as to how the nation-state ought to construct and imagine itself as modern – Rosenblueth's role in the founding of the Center for Research and Advanced Studies (Centro de Investigación y Estudios Avanzados) points us in this direction (Quintanilla, 2008).

A focus on networked asymmetries redraws the boundaries in stories of technoscience as we understand those whose backs were and remain the bridges of modernity, those who seek to build the infrastructures to exit their precarity. There is much we can begin to understand about Silicon Valley and computing if we consider the invisible, infrastructural labor of BIPoC. Latina/o/es were not alien nor foreign to electronics, cybernetics and computers. Instead, they were fundamental for their research and development, as their bodies were entangled with vast networked asymmetries. Their hopes, fears, joys and pains are soldered into the circuitry of the modern world. Their breath energizes the machines of our age.

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ORCID iD

Iván Chaar López https://orcid.org/0000-0003-4731-6013

Notes

1. Other works exploring Latina/o labor and Silicon Valley include Marez (2016) and Pitti (2003).
2. Throughout this article I use the term 'Latina/o/es' to name peoples who were born in and/or have a cultural connection to Latin America. The Spanish gendering 'a/o/es' points toward a visibility that recognizes women, men, and trans and gender non-conforming folks. I use 'Latina/o/es' whenever I am talking in broad terms and use a specific gendered form only when I knew the actors I write about might have used it. 'Latine' and 'Latinx' is part of an ongoing discussion about collective identification of trans and gender non-conforming folks. For more see: Vidal-Ortiz and Martínez (2018). For Latinidades see: Aparicio (2017), Del Río (2017).
3. Agard-Jones (2013), Benjamin (2016), Chan (2014), Mascarenhas (2018), Medina (2011), Medina et al. (2014), Murphy (2006, 2012, 2017), Parreñas (2018), Subramaniam (2014), TallBear (2013), Vora (2015).
4. Imperial formations are entangled practices, concepts, and bodies that articulate equivocal rules and areas of belonging and exclusion. Building on the work of Stoler (2016), I approach imperial formations as networked asymmetries to draw out relations producing differential treatments and shaping the contours of exceptions. Imperial formations, in other words, are fundamentally infrastructural.
5. For work in critical digital studies grappling with racial formation see: Amrute (2016), Benjamin (2019), Browne (2015), Chun (2009), Coleman (2009), Nakamura (2014).
6. Ong (2006) studies the establishment of export-industrialization factories in Malaysia during the same period. Simultaneous development of these points toward global structural adjustments in racial capitalism.
7. Cowie (1999) holds that RCA administrators stressed the same factors in moving manufacturing to Indiana, Tennessee and Mexico: labor docility and lower wages.

8. For a sharp analysis of *This Bridge Called My Back* as a networked pedagogy project see Adair and Nakamura (2017). For the contribution of Black feminism to intersectionality, power, and structures see Nash (2019).
9. Of interest here is Stone's (1994) work on bodies and electronic network prostheses as well as Cárdenas's (2016) theorization of the stitch in relation to algorithmic analysis and trans women of color. My thanks to Cass Adair for calling attention to these.
10. Ramírez (2019) and Beltrán (2020) also analyze how actors negotiate the dynamics of non-essential knowledge and disposability by examining the creative work of a folk artist who makes art with rubbished circuit boards and Mexican code workers hacking neoliberal logics, respectively.

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Author biography

Iván Chaar López is Assistant Professor in the Department of American Studies and the Principal Investigator of the Border Tech Lab at the University of Texas at Austin. He is the author of ‘Sensing intruders: Race and the automation of border control” (*American Quarterly*), ‘Alien data: Immigration and regimes of connectivity in the United States’ (*Critical Ethnic Studies*), and a coauthor of Precarity Lab’s *Technoprecarious* (Goldsmiths Press 2020).