International Journal of Communication 8 (2014), Feature 2496–2503 1932–8036/2014FEA0002

Media, Hot and Cold

Introduction: Temperature is a Media Problem

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Temperature is a media problem, or so we are told by the United States Supreme Court. In *Kyllo v. United States* (2001), the Court ruled that the warrantless use of thermal imaging technology to detect marijuana-growing operations contravened the Fourth Amendment. In writing the majority opinion, Justice Antonin Scalia explained that the heat-sensing technology threatened the privacy of the house's female occupants. He wrote:

> The Agema Thermovision 210 might disclose, for example, at what hour each night the lady of the house takes her daily sauna and bath—a detail that many would consider "intimate."

How can we account for Scalia's comments? One analysis might look at the adoption of thermal technologies by police forces and how these technologies are used to diagnose normal and domestic thermal radiation. We could ask how it is that such basic thermal imaging can offend a famously pro-police Supreme Court Justice simply because the radiation of heat is a promiscuous phenomenon that might disclose more than is appropriate. Or we could ask how thermal technologies enter into a complex legal, disciplinary, and gendered semiosis of aberrant heat. A growing number of airports, for instance, use thermal imaging technology to monitor passengers and identify those with elevated temperatures—those who might be sick.

This is the ethos of "Media, Hot and Cold," this special selection of papers in the *IJoC,* which grapples with the questions implicated by the ever-radiating temperature of bodies, spaces, and things. Beginning with a pun on Marshall McLuhan's famous formulation of hot and cold (and sometimes cool) media, these papers look at the intersections of temperature and media studies, a full 50 years after the publication of *Understanding Media* (1964). We took McLuhan's metaphors perhaps more literally than they were intended in order to argue that the intersection of media and temperature is a significant—if significantly ignored—research avenue in the 21st century.

"Media Hot and Cold" is the title of the second chapter in *Understanding Media* (McLuhan, 1964), sandwiched between "The Medium Is the Message" and "Reversal of the Overheated Medium," the latter being further evidence of the importance of temperature metaphors in his system of ideas. But was it only a metaphor? Certainly, there is nothing actually hot about the waltz, or nothing especially hot about the waltz that would make the telephone seem colder. But at other times McLuhan's toying with temperature tilts away from the metaphorical. He writes, for instance,

> Whole cultures could now be programmed to keep their emotional climate stable in the same way that we have begun to know something about maintaining equilibrium in the commercial economies of the world. (p. 30)

McLuhan's blend of systems theory and temperature metaphors makes sense: A climate is a calibrated system, and "equilibrium" in that system is all too fragile. Likewise, cybernetic thought (also enjoying a heyday in 1964) imported the concept of homeostasis from biology, and homeostatic systems require a regulated temperature. Any musician who has tried to tune an instrument knows this. During winter, musicians let stringed instruments heat up to room temperature before tuning them. During summer, increased humidity can also change their behavior. For years, electronic instruments were particularly susceptible to temperature, changing their tuning as they grew hotter from use. Indeed, the first commercial product called Auto-Tune was not the now-ubiquitous voice-adjustment software, but instead a feature that allowed for temperature-calibrated tuning of electronic synthesizers in the 1970s. Western music and its descendants thus assume regulated temperatures in its most basic aesthetics, and today every purchased piece of consumer electronics is accompanied by specific instructions as to optimal operating temperatures. In their most basic operations, media technologies always assume a certain degree of hot and cold.

Temperature is therefore already implicated in many of the fundamental aspects of our media systems. Treating hot and cold as "just" metaphors chills the potential that temperature-focused problematics can hold. This special section follows the conjunction of temperature and media. As conceptions of temperature suffuse our understandings of living organisms, technical infrastructures, or the visualization of data, temperature tempers the discursive formulations around both global catastrophe and meticulous self-management.

Far from suggesting that "temperature studies" ought to exist as a subfield of media studies, this collection of essays pursues how temperature *already* appears as an active problematic in a range of cognate fields. By bringing these research threads together, we are asking: How do we talk about temperature as a vector of research in its own right?

In the simplest sense, temperature is a quality assigned to changes in brute facts: The water is boiling. The water is still. The water is frozen. In turn, these observable states are captured by measurement. Hasok Chang (2004) describes how the "invention of temperature" was no less than the fixing of water's three states to one particular scale. Temperature is also a means of describing the subjectivity of sense experience. John Locke employed his lukewarm-bucket-of-water experiment to argue that heat was not a property of water, and used it as a basis for distinguishing primary and secondary qualities (1690/1959).[1] These three dimensions of temperature—fact, measurement, and experience—and the inextricable links among them, return throughout the texts in this collection, although these authors are able to move far beyond the mundane attributes of water.

Contributions

One stream of work in this issue offers both definitions of temperature and a history of attempts to understand it. As Nicole Starosielski writes, "Temperature is a mode of environmental description attuned to the speed and rhythm of movement, the densities of substances, and their sensory effects." Building on this definition, Starosielski details four ways that temperature animates communication and media studies: the taking of a medium's temperature, the conductivity of particular media and communications technologies, the analysis of phase transitions, and as a material property and product of media ecologies. As the other contributions to this volume illustrate, Starosielski's typology offers a robust map for future work on temperature and media.

In their contributions, Brent Malin and Alice Christensen describe a blooming of 19th-century temperature research in psychological, physical, and psychophysical experimentation. Malin traces the 19th- and 20th-century trajectory of the science of emotions, beginning with the Italian scientist Angelo Mosso, whose self-probing connected his temperature to his emotional state. Malin describes the intertwined relationship of temperature and media technology research in psychology by tracking twinned processes: the "overheating" of citizens through information overload and the "cooling" of researchers, whose appropriation of media technologies enabled new kinds of rationalization. Christensen reveals that Ernst Weber's (1846) foundational work in psychophysics started with Weber's investigations into the sense of touch and temperature. Before bodies were considered sources of light and sound in their own right, Weber reckoned with the implications of a human body that is always its own kind of thermometer.

The weather channel, as the crystallization of a particularly familiar fusion of temperature-media, forms the backdrop of our most ordinary socializing (Sturken, 2001; Vincent, 1997). For countries where extreme temperatures are part of daily life, weather forecasting and weather talk can become part of the national or regional character (Berland, 2009). Against this ordinary backdrop, however, climate change and its capricious consequences are seemingly the inevitable outcome of planned obsolescence and waste. In the early 21st century, weather and temperature are the material grounds of our eschatological hypotheses, with visualization and data conversion software acting as the means of grappling with these hypotheses. Jody Berland compares cold weather to noise: "Bad weather is weather that makes itself audible, that introduces noise to the body's interface with the world, that threatens to demolish the discipline of everyday routine with no reason or need to explain" (2009, p. 241). Certainly natural disasters and climate change are reminders of human hubris and the limits of our agency, but as Berland suggests, so too is every freezing winter and scorching summer.

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[1] Put one hand in a bucket of hot water and the other in a bucket of cold water, then move them both to a bucket of lukewarm water. One hand will register as hot, the other as cold. Locke argues this showed that the idea of heat could not reside *in* the water, like shape or size could.

Another stream of contributions to this issue takes up questions of temperature representation and its effects. Lisa Parks describes how reading temperature—*pace* Justice Scalia—is now a precondition for decision making for military and law enforcement officials. Drained of the "visible light indicators" of race, class, and gender, drone-mounted infrared sensors have codified and re-stratified the "visible" world through the detection and classification of body heat. Marita Sturken, who coined the term "weather media" more than a decade ago (2001, p. 163), describes the representational politics of coloring the world according to temperature fluctuations. Sturken identifies a trajectory from community weather watchers, to Doppler radar images, to satellite data, and finally, to the self-representation of being in weather archived in social media. Rafico Ruiz's "Iceberg Media" chronicles the new industrial attempts to track, transport, and harvest icebergs. As the products of deteriorating polar regions, icebergs are a danger to shipping lanes, while at the same time they represent a potential supply of potable water; as such, they operate at the nexus of new communication infrastructures, emerging markets, and environmental collapse.

The language of temperature has long structured how we stratify space and the people who occupy space. Sometimes the language is metaphorical, as in English-language depictions of emotion: We lose our cool, we boil with anger, and then we simmer (Lakoff & Kövecses, 1987); or after World War II, when jazz musicians slowed their tempos, played behind the beat, and emphasized melody over phrasing to develop a "cool" alternative to "hot" jazz. Sometimes the language is judgmental or even explicitly chauvinistic, as when Claude Lévi-Strauss designated some societies "hot" (in Western Europe) and others "cold" (non-Western ones) (1991/1995). For other thinkers, mean differences in average temperatures are the grounds for massive social differences: Jean-Jacques Rousseau (1781/1998) argued that language emerged in hot countries as dance and moved to cold countries; Montesquieu (1748/1949) believed that warmer countries were lazy, while cold countries were efficient; and Henry Miller described in *The Air-Conditioned Nightmare* (1945) how heating is a basic comfort and artificial cooling is snobby. Some medieval canonists and theologians believed that sexual difference was a result of temperature difference—men were hot and women cold—and these differences manifested in physical attributes and behavior (Salisbury, 1996). Contemporary research into the connection between temperature and work efficiency applies this style of thinking while burdening it with different political baggage: Cornell researchers (Lang, 2004) adjust office thermostats and conclude warm workers are more productive than cold ones, while NIH researchers fiddle with room temperatures in attempts to quantify and improve sleep quality (Reynolds, 2014). As a focus in a growing area of research on the "science of comfort," the ergonomics of temperature sculpts workplaces and homes.

In this section, Jessica Mudry brings us her exposition on "the calorie"—a peculiarly contemporary articulation of food, bodies, and exercise—with a hefty history. Mudry reaches back to 18th-century France for the work of Laplace and Levoisier (1780) and their guinea-pig-cum-*calorimetre*, and through 19th-century Germany, where Max Rubner used the calorie "to denote the amount of heat required to raise one gram of water, one degree centigrade." In spite of (or because of?) its roots in Enlightenment science, Mudry describes the picayune ways the calorie became a means of discipline and self-management.

Temperature is both a friend and foe of media technologies. Freezing old videotapes is a last resort for preventing the ferric oxide from falling off magnetic tape; "baking" audio tapes allows them to be played one more time for digital capture. The antagonistic relationship between extreme temperatures and consumer technology is turned on its head and turned culinary when freezing information and cooking it become the only way to save and use it. As the physical footprint and profile of home and mobile computing grow smaller and the "cloud" expands, individual users not only outsource data storage, they outsource heat management from their own devices to massive server farms that are hungry for clean air, cool temperatures, and cheap energy. This fact did not go unnoticed by a team of researchers at Microsoft who "argue that servers can be sent to homes and office buildings and used as a primary heat source" (Liu et al., 2011, p. 1). These "data furnaces," the authors claim, would recycle the heat already created by computing to reduce server costs for large tech companies while improving quality of service by "moving storage and computation closer to the consumer" (p. 1).

But heat has long been a limit of computing power. In 1968, Gordon Moore penned his famous essay that predicted that the density of transistors on a chip would increase by "a factor of two per year" (p. 83) (now erroneously called "Moore's Law" and often misquoted). He immediately followed this prediction with a section entitled "Heat Problem," arguing that "the heat generated by tens of thousands of components in a single silicon chip" (1968/1998, p. 84) was an engineering problem that had to be overcome but could be. As Rick Maxwell and Toby Miller write, by 2011 this was no longer the case:

> [T]he energy demands of the latest chip generation were reaching the limits of the electrical power supply, while the only way to avoid destructive heat levels was to create a kind of chip, known as dark silicon, on which some transistors were left unpowered while others were running. (2012, p. 28)

At least in the world of consumer computing, today's microprocessors no longer conform to Moore's so-called law. Innovations in processor power for desktop computing now focus on multiple cores, novel cooling systems, and applying coding efficiencies originally developed for mobile platforms.

Heat also shapes the most basic math of computing for media. One of the most important mathematical models in the history of physics and computing is the Fourier Transform—a method for converting signals to frequencies—which began as a theory of heat propagation. There is perhaps no better place to locate the articulation of media studies and temperature than with a mathematical model meant to represent the transformation, exchange, and processing of heat as a substance. This model subtends practically every one of our communication technologies in use today. For instance, every digital sound and video file operates according to the Fourier Transform and its mathematical descendants. In his contribution, Wolfgang Ernst, addresses the "technomathematical condition of present day media culture" through a media-archaeological investigation of the Fourier Transform and the history of signal processing. He offers a reading of the Fourier Transform as a fundamentally sonic phenomenon, framing the history of the separation of signal from noise and the conceptions of time that still shape signal processing technologies today.

In a quote usually attributed to Mark Twain, Charles Dudley Warner, editor of the *Hartford Courant*, wrote that "everybody talks about the weather but no one does anything about it" ("This weather," 1897, p. 8). In this short overview—and in this special section—we hope to make clear that people are doing things about temperature. Many people are doing many things about temperature: Some hope to manage it, others try to predict it, still others use it to imagine their cultural worlds. Jody Berland begins her chapter on the weather with the claim that it mediates between physical and social bodies. We end our essay by extending her claim. As this issue goes into production, one of us (Jonathan) prepares for doctors to again heat up his body with a heavily regulated radioactive material in a chase after renegade cells—a diagnosis that only exists because of advanced imaging technologies. As in nuclear medicine, so it is in the world in general. Temperature not only mediates between physical and social realms, it is the point at which their difference is at once organized and annihilated.

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International Journal of Communication 8 (2014), Feature 2504–2508 1932–8036/2014FEA0002

IJoC Media, Hot and Cold

The Materiality of Media Heat

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It is not surprising that temperature has been used so often to conceptualize media and communication, both colloquially—from freeze-frames to WiFi hotspots—and across media and cultural theory. Temperature is a mode of environmental description attuned to the speed and rhythm of movement, the densities of substances, and their sensory effects. As we inhabit an increasingly volatile climate, and the language of hot and cold filters ever more extensively into descriptions of media and culture, the stakes for reflecting on these metaphoric transfers are raised. The following paragraphs chart four ways that temperature has animated media and communications studies. The last of these, a new materialist consideration of media's heating and cooling, reveals the profound effects that media temperature has on global infrastructure and environmental conditions.

First, we might think about *taking a medium's temperature*. Perhaps the best-known example of this approach is Marshall McLuhan's (1994) distinction between hot media such as cinema, which are high definition and affective, and cool media such as television, which require more interaction and engagement. For other scholars, the photographic has been that which freezes time (enacts a "spatiotemporal standstill"), thus described in terms of cold and ice (Alter, Koepnick, & Langston, 2013), and the cinematographic has been aligned with fire (Wollen 2003). The implicit question here is ontological and at times diagnostic: What temperature is a medium? Or, what temperature is a culture? In this approach, a medium or society appears as an organism unto itself, one whose momentum, affect, and relationships can be charted using the indices of temperature. Although this kind of analysis rarely registers the actual transmission of heat, it nonetheless uses everyday embodied interactions with the environment as a basis for imagining media.

A second way that temperature has permeated the analysis of media is vis-à-vis thermodynamics and information theory–influenced descriptions of the *conductivity of particular media and communications technologies*. Influenced less by the experiential dimensions of temperature—our perceptions of hot and cold—than by the correlation between heat and information, media with high levels of content transmission are seen as conductive, generating heat and intensity. This approach is rooted in Claude Shannon's theory of information, which advanced thermodynamics-inspired concepts such as entropy in the description of communications systems. In considering media culture, the language of thermodynamics can help to describe the extensive transformations of a technological modernity—one that is heating up, increasing in entropy, and ultimately moving toward a "heat death" (Parisi & Terranova, 2000). In contrast, cold in this paradigm is used to describe the inability to transmit. Günther Selichar's photography project, *Screens, cold*, which depicts a number of blank, nonfunctioning screens, operates in this mode. For a medium, to be cold is to be *off*, to lack the ability to transfer information. Rather than an ontological question—whether a medium is a hot or cold one—this is a question of capacity: Any given technology might be more or less conductive, and thus conducive for the movement of information as heat.

A third approach to temperature—the analysis of *phase transitions*—is more often used in the characterization of culture than media. This genealogy can be traced back to Marx's phrase "all that is solid melts into air," which draws upon the process of boiling to describe the coming revolution. Here, the transitions of phases—of states of matter—brought about by temperature changes form an apt set of metaphors to describe the process of media and cultural change. For an example in popular media discourse, the failure of Facebook's initial public offering was widely referred to as a "meltdown"—a transition that helped to illustrate the dissolution of what had previously appeared as a solid structure. Writing about technological change, Gillespie, Boczkowski, and Foot (2014) use a story about glass's malleability at different temperatures to explain the variable rates of media transformation. Media scholars have also used "transduction" to describe the process by which media and other objects effect changes of state—the language of temperature resonates here as well (Helmreich, 2007; Mackenzie, 2002). If taking a medium's temperature invokes an environmental imagination to naturalize certain media ontologies and a thermodynamics-inspired model of communication helps us to see those media as not simply hot and cool but varying in conductivity, this mode draws from temperature to explain how media crystallize in different figurations as they morph over time.

More recently, temperature has been taken up as a material property and product of media ecologies. Here, hot and cold are used less to characterize individual media technologies or register their conductive capacities than as a gauge for understanding *how media shape the equilibrium of their surrounding environments*. Data centers and computer systems generate enormous amounts of heat, which in turn form one of the greatest threats to communications systems. One network manager reflects: "An invisible enemy lurks within computer networks and communications equipment. The enemy is not a hacker, virus or worm, but something that appears much more innocuously: heat" (Mordick, 2006, p. 34). Increases in processing continue to generate heat, and as Gordon E. Moore observed in the 1960s this could result in a "heat problem" if computers become small enough, though this has been less memorable than Moore's law about the acceleration of computer growth (Maxwell & Miller, 2012). An attention to the generation and redistribution of this heat connects media to the energy infrastructures on which they depend, and, in turn, to the intensification of global warming (Carruth, 2014; Cubbitt, Hassan, & Volkmer, 2011; Starosielski, 2012).

The analysis of material media environments has also been concerned with the expansive cooling infrastructure needed to dissipate communications heat. Andrew Blum (2012), quoting a Facebook infrastructure director, reports of our media systems: "This has nothing to do with clouds. It has everything to do with being cold" (p. 258). The need for cooling is shaping the geography of global Internet distribution, relocating some of its nodes to the colder climates of Oregon and Scandinavia. Cold climates shelter signals in more ways than just offsetting heat. Cold weather keeps Hewlett Packard's computer equipment safe from thieves as it moves through Central Asia (Bradshler, 2013); the cold, hard ground keeps fiber optic cables safe from local public works projects. This is not a strictly digital phenomenon: Archives also need to be cooled, and our ability to access media history via nitrate film, for example, is dependent on extensive temperature control. In a related vein of media research, climatic zones, including the cooled archives of digital content, the development of "polar media" across the Arctic regions, and the regulation of heat inside museums, have come to define a new set of parameters for analysis (Domínguez Rubio, 2013; Hogan, 2013; Krapp, 2009).

Research on media's materiality—from media archaeology's excavation of artifacts to platform studies' investigation of hardware—has focused attention on the technologies, objects, and artifacts that undergird media culture. A materialist consideration of media heat offers a different take on the "materials" of media studies. Tracking media heat, we cannot simply view matter as discrete, determinate, and solid—a firm substructure—but rather, as Coole and Frost (2010) advocate in their introduction to the new materialisms, we must see it as a relational, lively force. Heat exchanges are not confined to communications systems, but move across and through infrastructure, ecologies, and bodies. Whether the burning of fossil fuels or the calories of laborers, the cooling of hard drives or movie theaters, such exchanges can help us to better understand how media both enfolds and gives rise to a set of broader environmental relations and conditions for life.

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International Journal of Communication 8 (2014), Feature 2509–2512 1932–8036/2014FEA0002

IJoC Media, Hot and Cold

Anal Probes and Overheated Media: The Physiological Roots of Contemporary Media Research

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The mid-to-late-19th-century Italian scientist Angelo Mosso took an autobiographical approach to physiology, employing a range of instruments to measure his own bodily changes. In one especially personal example, Mosso reported that "his own thermometer-measured rectal temperature changed with his spontaneously evoked emotion" (Dror, 1998, p. 173). As invasive as this approach might sound, it is indicative of a central trajectory within the transition from 19th- to 20th-century social science, with important implications for the history of media studies. Mosso was situated between traditions of spiritualism—which saw self-reflection as an essential component of understanding—and an increasingly scientific psychology that used presumably objective technologies to extend, and in many cases critique, this personal approach. Mosso's position between these two traditions likely explains his relative comfort utilizing scientific technologies on himself.

Early media and communication research arose at a similar moment, and the precise nature of Mosso's transitional climate had especially strong implications for the study of media (Malin, 2014). Like Mosso, 19th-century psychologists—who would become some of the first media researchers—had made heavy use of introspection, both reflecting on their own psychological states and having their research subjects do the same. As the kind of recording technologies that Mosso used to measure his own physiology became more prevalent, social researchers increasingly saw introspective accounts as problematic. Technologies of physiological measurement were given more and more authority over the body until introspective accounts came to be seen as completely untrustworthy. Whereas people were likely to misunderstand their bodily processes, researchers believed that physiological measurements bypassed a person's distorted perceptions and got to an inner truth of the body.

If for Mosso his rectal temperature provided a data point that helped him reflect on his emotional states, for these later researchers that temperature was the emotional state itself. The idea that emotions were bodily temperatures being drawn out by technologies was especially persuasive for early researchers on media technologies. The film, radio, and phonograph records of this period were celebrated for their abilities to provide scientific data on people's emotions even as they were denigrated for their impact on the wider public (Malin, 2009). Christian Ruckmick, who contributed one important monograph to the Payne Fund Motion Picture Studies, praised the emotion-reading power of the psychogalvanometer, which was essentially a lie detector that measured a variety of physiological changes and then recorded them on film. At the same time, Ruckmick argued that films themselves produced a "profound mental and physiological effects of an emotional order," resulting in "unnatural sophistication and premature bodily stimulation" (Dysinger & Ruckmick, 1933, p. 119).

Ruckmick's research, like that of psychology more generally, was influenced by a broader concern about overstimulation that increasingly saw the emotional pressure of modern life—and emotion itself—as dangerous to the public. Walter Lippmann's (1922, 1925) worries about "disenchanted man" were premised on the idea that information overload had created a world of overheated citizens who were too exhausted to participate in public life. Whereas earlier 20th-century psychologist Hugo Münsterberg (1916) had celebrated the new emotional stimulations of the movies, Ruckmick and his peers saw the emotions of the new media age as dangerous to both audiences and psychology itself. The use of emotion-measuring technologies in the laboratory was an attempt to bypass psychologists' own emotions, which were seen as antithetical to a truly objective social science. Measuring a subject's emotions through various technological means, these researchers presumed, allowed psychology to free itself from the messiness of emotional connection and intimacy. For Ruckmick, the psychogalvanometer engaged deeply with people's emotions so that he didn't have to, leaving him to observe the emotions of the new technological age from an appropriate—though equally technologized—distance.

To the extent that media technologies have continued to be seen as especially emotionally stimulating, their paradoxical effects—as overheating the public and cooling down the media researcher—have maintained a prominent place in the history of media studies. Even so reflective a thinker about technology as Marshall McLuhan could fall prey to this implicit thread of physiological reduction. That such distinctions between hot and cool media and oral and literate culture are premised on an unexamined concern for the emotional power of advancing technologies becomes clear when looking at the larger corpus of McLuhan's work, especially as articulated in the posthumously published *Laws of Media* (McLuhan & McLuhan, 1988). Here, the distinction between oral and literate culture becomes especially physiological, as McLuhan and his son Eric drew on recent brain scan research to show how the oral culture of the ear—which they favored—affects the brain more positively than the literate culture of the eye. Ironically given their professed goal of understanding media technology, however, they failed to consider the implications of a technology central to their claims: the brain scan itself. As did Christian Ruckmick, they treated this research technology as an objective observer charting the impact of the technological march forward.

Today, when digital technologies such as the MRI are regularly employed to understand the emotional impact of such digital technologies as the Internet, it remains important to be mindful of this persistent thread of anxiety about the emotional stimulation of new technologies. Claims about how digital technology is making us smarter (Johnson, 2006) or dumber (Carr, 2011) need to be read against the longer history of seeing the primary impact of new technologies as the heating up of people's physiological processes. The connections between Mosso's anal probe, Ruckmick's psychogalvanometer, McLuhan's brain scan, and the digital images of the MRI are not so faint as they might first appear. Each approach assumes the fundamentally physiological nature of emotional effects and the unique access of technologies to those emotional processes. However, something important was lost in moving forward from Mosso's research, which assumed a radical self-reflexivity at odds with these later studies. Despite being the product of the laboratory technologies he employed, the temperatures Mosso measured were still deeply personal and firmly located within his own bodily experience. For Ruckmick and later media researchers, the bodily heat of emotion was increasingly seen to come from without—generated, it seemed, by the distant power of an impersonal, technologized, mass culture. Alongside this imagined mass culture, these researchers lost sight of their own personal position within the technologies and emotions they explored—overlooking how the psychogalvanometer or brain scan were implicated in the same cultural resonances they attributed to the technologies that were the targets of their analysis. In order to avoid perpetuating these same physiologically reductive views, contemporary media research will be well served by recovering elements of Mosso's radical self-reflexivity, however difficult and uncomfortable that may be.

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International Journal of Communication 8 (2014), Feature 2513–2517 1932–8036/2014FEA0002

IJoC Media, Hot and Cold

Making Sense of Temperature in Early Psychophysics

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How do human bodies sense the hotness and coldness of things? Not like a thermometer does, answers Ernst Heinrich Weber in *Tastsinn und Gemeingefühl* (*Sense of Touch and Common Feeling*) (1846). A thermometer registers the "heat of the mercury" at any given moment, while the human body instead registers changes from its "zero point" (the temperature of the body or skin) as positive and negative magnitudes.

Sense of Touch and Common Feeling was originally published as part of a series of articles on physiological topics edited by Rudolph Wagner. The text expands considerably upon Weber's earlier Latin treatise on the tactile sense, *De Tactu* (1834), and is, generally speaking, more theoretically ambitious than the earlier work. While the first half of *Sense of Touch* presents research on the effects of weight, pressure, and temperature on the nervous system of the skin, the second half of the text interrogates the connection between mind and body in the context of *coanaesthesis* (i.e., generalized feelings that cannot be attributed primarily to an external source such as pain, hunger, etc.).[1] It would be hard to overstate the importance of Weber's 1846 text for the subsequent development of the disciplines of experimental psychology and sensory physiology (Ross & Murray, 1996). Indeed, Gustav Fechner referred to his former mentor Weber as the "father of psychophysics" (1860, p. v), stating that in the "classic investigations" of *Sense of Touch*, Weber had laid out the basic categories of psychophysical inquiry. Among other things, *Sense of Touch* describes Weber's influential two-point discrimination test and provides the fullest description of what came to be known as Weber's Law.[2] It also elaborates considerably on Weber's investigations, first described in *De Tactu*, of the human body's response to hot and cold stimuli.

[1] On the history of medical theories of coanaesthesis, see Daniel Heller-Roazen (2007), particularly pages 237–251. Coanaesthesis, as Heller-Roazen summarizes it, was in all its forms "the name of both the solution and the difficulty: the cipher of that sense by which animate beings dimly feel they are alive" (p. 250).

[2] That is, as the level of a given stimulus varies, the smallest change one can perceive depends on the foregoing/baseline level of stimulus and that the ratio of these two quantities ("just noticeable difference": baseline stimulus) is a constant. Weber described this relationship in the context of his experiments on sense of pressure, in which weights were used as stimulus. The name for this relationship between stimulus and response—Weber's Law—was given by Fechner. (He went on to suggest a revised, logarithmic relationship, calling this revision the Fechner-Weber Law.)

In *Sense of Touch*, the faculty is further subdivided into three kinds of awareness: sense of location on the body (*Ortsinn*), sense of pressure (*Drucksinn*), and sense of temperature (*Temperatursinn*). Short passages summarize experiments in each of these domains. In addition to two-point discrimination tests, a range of stimuli of varying pressure and temperature were applied to different parts of the body. Weber explains to the reader that sense of touch arises through the presence of peripheral nerves in the skin and that these nerves are distributed unequally along the skin's surface. Thus, for each of the three subsenses of location, pressure, and temperature, Weber creates a kind of empirical atlas in which the effects of stimuli on different parts of the skin's surface are noted.

The section on "sense of temperature" (*Temperatursinn*) begins with introductory remarks in which the human body is compared to a thermometer (as described above). Because we have a source of heat (*Wärmequelle*) within us, Weber explains, hot and cold are felt as positive and negative magnitudes from this fluctuating zero point. Similarly, in *De Tactu* (1834), he states that hot and cold are felt as "positive and negative numbers" (p. 170). But Weber's introductory remarks on "temperature sense" also mark an important shift from his explanation in *De Tactu* of the mechanism by which we sense heat. In *De Tactu*, Weber lays great emphasis on the fact that our assessment of temperature is an act of "estimation." He describes a two-step process: first, the touch-organ (*organo tactus*) perceives heat or cold. Then, using this information, we judge the temperature of objects. This judgment is an act of estimation, not of perception, Weber stresses.[3] Twelve years later, in *Sense of Touch*, Weber omits the concept of estimation, instead claiming that the body senses temperature directly.

Weber outlines experiments that have allowed him to quantify and map the human body's sensitivity to temperature. First he presents a series of experiments in which a hand was placed in water of varying temperature.[4] The resulting sensations of hotness and coldness and their alterations over time are described. For example:

> If I dip my hand into water with a temperature of 12½°C for one minute, and then into water of 18°C, I have a feeling of warmth in the latter for several seconds, but after this a feeling of cold sets in that lasts as long as the hand is submerged. (Weber, 1846, p. 551)[5]

The frequent failures of the human body to perceive temperature accurately are also addressed. Why do we often misperceive hot and cold objects? Why do we often "not perceive temperature *correctly*"? (Weber, 1846, p. 551, emphasis added). For these failures, Weber provides two explanations. The first is that we perceive hot and cold differently depending on how well a given object conducts heat. Thus a cold wooden stick seems less cold to us than a metal rod of the same temperature. The second is that the heat of our skin is variable, because of changes in blood flow, for instance, or prolonged exposure

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[3] "Aestimari a nobis temperiem dico, non percipi" (Weber, 1834, p. 113).

[4] Weber generally gives temperature measurements in both degrees Celsius and Réaumur, though he sometimes presents only one or the other.

[5] All translations from *Sense of Touch and Common Feeling* are my own. Weber moves freely between first-person narration and a more impersonal third-person voice in descriptions of his experimental results.

to extreme temperature. Nevertheless, Weber notes that, among other findings, most individuals seem to be able to perceive a temperature difference as small as 2/5° Réaumur.[6]

In his final remarks on temperature sense, Weber describes the variable sensitivity of different parts of the skin to temperature. Hot and cold seem to make a "stronger impression" (Weber, 1846, p. 552) on the left hand than on the right. He speculates that this might be caused by a thinner epidermis on the left side. Weber presents a detailed atlas (in words) of the body in terms of its variable temperature sensitivity. Two experimental apparatuses are described. In the first of these, two vials were filled with oil and fitted with caps that held a thermometer in place. These vials were warmed or cooled in water, wiped off, and then placed on two different parts of the skin. In the second set of experiments, a large metal key was heated and cooled; the cylindrical end of the key was then placed in contact with two locations on the skin, switching back and forth between the two locations repeatedly. In order to heat or cool the key, Weber used two methods: in some cases, the key was dipped in a mercury bath of known temperature; in others, the key was laid on a "very cold stone slab" in front of a window where the temperature was displayed until the key "took on the temperature of the slab" (Weber, 1846, pp. 554–555). In this way, Weber determines, for instance, that

> the sensation of change in temperature is much duller on the tip of the nose than on the side of the tip of the nose; sensitivity increases quite a bit on the nostril, and is greatest on the lower margin of the outer part of the nostril. (1846, p. 555)

Yet, reflecting on the legacy of psychophysical research some 60 years later, Ernst Cassirer points out in *Substance and Function* that "it is a long way from the immediate sensation of heat to the exact concept to temperature" (1910/2003, p. 142). In a section devoted to critique of the foundational assumptions of psychophysics, he argues that "the indefinite stronger and weaker of impression offers no foothold for gaining fixed numerical values" (p. 142). In his critique of the slippage between concepts of heat and temperature, Cassirer claims that in experiments such as Weber's, sensations as such were not measured, but "only the *objects* to which we relate them" (1910/2003, p. 142). Even if sensation were indeed measurable by such mediation, Cassirer goes on, this tells us little about perception, because

> even granting this assumption, it is clear that the physicist . . . has nothing to do with sensations of warmth or contact, but only with temperature and pressure. None of these concepts however can be understood as a simple copy of the facts of perception. (1910/2003, pp. 141–142)

The underlying assumption of mediation between feelings of hot and cold and thermometric quantities may not be justified, or even if it could be, does not provide real insight into perceptual experience. Weber's description of temperature "estimation" in *De Tactu* allows the separation between the conceptual realms of heat and temperature, between perception and estimation; the more radical "temperature sense" in *Sense of Touch*, however, elides any human experience of heat that does not concern the "positive and negative numbers" of a temperature scale.

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[6] 1° Réaumur = 1.25° Celsius.

Weber's sensory physiological experiments in *Sense of Touch* and Cassirer's critique of 19th-century investigations of the *qualia* in *Structure and Function* share a central figure: the thermometer. While Weber initially insists that human sense of temperature operates differently than a thermometer does, he nonetheless necessarily uses the thermometer as the standard against which the human ability to sense temperature is measured (Hess, 2000). Sensations of hot and cold are assumed to exist along a theoretical scale that can be aligned with a thermometric scale (in both *De Tactu* and *Sense of Touch*), inaugurating a psychophysical program that aligns "objectively" measured stimuli and "subjective" sense. For good reason, then, Cassirer selects the thermometer to stand in for a larger critique of psychophysics. A glass tube with etched markings in which the volume of mercury (or alcohol, or water, in the long history of thermometer production and calibration [Chang, 2004]) expands to indicate rising temperature and contracts as temperature falls—what does the process of expansion and contraction in this tube necessarily have to do with other phenomena of heat and their measurability? Cassirer asks. Cassirer insists on the utter incommensurability of a length of mercury with the "indefinite stronger and weaker" of feeling hot or cold; as far as he is concerned, since the Weberian notion of *Temperatursinn* begins and ends with the thermometer, it makes no sense at all.

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International Journal of Communication 8 (2014), Feature 2518–2521 1932–8036/2014FEA0002

IJoC Media, Hot and Cold

Drones, Infrared Imagery, and Body Heat

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For decades, planes and satellites have remotely sensed the earth's surface, transforming objects and sites into temperature data. Over time, this data has been used to understand the thermal properties of material phenomena and to generate heat signatures for objects ranging from nuclear power plants to glaciers. Within this planetary regime, the earth has been codified as a set of absolute temperature values such that military strategists, meteorologists, and earth scientists have built careers on perceived repetitions, variations, and/or anomalies in these values. In the current world order, temperature taking usually precedes decision making, and officials have invested enormous faith in the capacities of sensing instruments tasked to "see" electromagnetic radiation that is imperceptible to humans.

In recent years thermal infrared sensors have been loaded onto unmanned aerial vehicles or drones, which fly at lower altitudes than planes and satellites and can hover over particular sites for extended periods, yielding high-resolution imagery. The Predator and Reaper drones used in U.S. counterterrorism and targeted killings are equipped with infrared sensors that enable remote pilots to monitor and track heat-bearing objects on the ground in real time. As drones fly above territories, their instruments "see" through clouds and darkness and sense infrared radiation emitted from objects on the earth's surface. Once this radiation is detected, it is encrypted and converted into data and transmitted to earth stations where it can be processed by computers and rendered as rasterized displays that correlate pixel qualities with temperature values. FLIR, one of the world's largest manufacturers of infrared instruments, boasts that its infrared cameras are designed to "to show a thermal world not visible to the unaided eye."

In addition to being used for general aerial reconnaissance, infrared imagery is used to monitor, track, and target—or, in the parlance of U.S. special operations, to "find, fix, and finish"—particular sites, objects, or bodies on earth. In such contexts, infrared imaging reorganizes the visual field as a hunt for heat, and the "drone stare" is fixed on heat-bearing objects such as guns, missiles, explosives, tanks, antiaircraft vehicles, trucks, power generators, and people (Wall & Monahan, 2011). During the past decade, infrared imagery has been used to locate and kill Osama bin Laden and Anwar al-Awlaki as well as thousands of alleged terrorists and civilians in Pakistan, Yemen, and Somalia. In the United States, law enforcers have used airborne thermal infrared sensors to patrol U.S. borders, bolster urban and rural policing, and find and apprehend Boston bombing suspect Dzhokhar Tsarnaev.

In such situations, aerial systems are calibrated to detect and visualize infrared emissions such that human bodies pop out in the visual field as blotches of light or dark stasis or movement (depending on image processing selections). As such, bodies are not only easier to see, but easier to track and target. Within this visual regime, surveillance practices are extended beyond epidermalization (Browne, 2010;

Fanon, 1967), personal information gathering (Lyon, 2002), and biometrics (Gates, 2011) as infrared imagery isolates suspects according to the heat waves emitted by their bodies. While other systems of human differentiation and observation are organized around skin color, personal data, and/or facial recognition, aerial infrared imagery turns all bodies into indistinct human morphologies that cannot be differentiated according to conventional visible light indicators of gender, race, or class. Seeing according to temperature turns everyone into a potential suspect or target and has the effect of normalizing surveillance since all bodies appear similar beneath its gaze.

At the same time, however, it is important to point out that temperature data have become visible precisely so that they can be made productive within existing regimes of power. Even as it displaces the visible light registers of ethnic/racial difference, drone-based infrared imagery reinforces already existing power hierarchies by monitoring and targeting certain territories and peoples—such as those in Pakistan, Yemen, Somalia and along the U.S.-Mexico border—with greater frequency and potency. These areas are designated as geopolitical "hotspots" that need to be pre-emptively contained. Strategies of ethnic/racial differentiation do not disappear within an aerial system of temperature-based visuality; rather, they are restructured along a vertical axis of power and recodified through systems of social sorting, remote sensing, and computational imaging. Certain peoples' territories, movements, and profiles are scrutinized, tracked, and targeted from the air day after day, month after month, year after year. As drones circle above, they reorganize surveillance as the aerial harvesting of body heat and movement, which not only alters peoples' everyday dispositions to the sky, but also produces vertical affects such as intimidation, fear, rage, revenge, injury, and death. Surveillance, then, shifts from a system of decoding the visible markers of difference on individual bodies to one that uses body temperature data to differentially apply vertical administration.

Perhaps what the thermal image ultimately reveals is how deep the compulsions of extraction and control run and how forcefully they need to be staged and reasserted. Though infrared imagery encodes light or dark blotches as "hot," it is important to point out that these images are not "heat photos." They are computational images or data visualizations. As Alex Galloway explains, "any visualization of data must invent an artificial set of translation rules that convert abstract number to semiotic sign" (2012, p. 83). Because of this, he continues, "any data visualization is first and foremost a visualization *of the conversion rules themselves*, and only secondarily a visualization of the raw data" (ibid.). If this is true, what are we really looking at when viewing infrared imagery? The thermal image is not only a visualization of an algorithm (assuming this is what Galloway means by conversion rules); it can also be understood as rendering more macrolevel *conversion rules* such as the implicit mandate of science and militarism to transform the imperceptible into a rubric of human experience and the body into a target.

These conditions suggest the need for further historical and critical investigation into what Jeremy Packer calls the "radiographic episteme," which he describes as "all that can be known through the reflective conditions and characteristics of radio waves and the environment" (2013, p. 189). Studying the "radiographic episteme" would involve exploring the detection systems, knowledge formations, communication practices, and mediations that have taken shape in relation to a broader range of the electromagnetic spectrum, beyond that of visible light. Work on such a topic requires engaging with the tensions between visibility/invisibility as well as the dynamics of camouflage that Hanna Rose Shell (2012) eloquently elaborates in *Hide and Seek*. It also involves considering the different types of media analytics and deliberative practices that have historically emerged within intelligence agencies (Hinsman, 2014). Engaging critically with a broader range of the electromagnetic spectrum and radiographic episteme is bound to expose how contingent visualization is and has always been.

Just as practices of visibility/invisibility and racial/ethnic differentiation shift within a temperature-based visuality, so do tactics of resistance. A plethora of counter-thermal imaging practices has surfaced in recent years in response to increasing drone use, imploring people to do everything from relearn how to "bird watch" (code for watch for drones) to experiment with deflective and insulating materials—such as glass, wool blankets, rugs, tin foil, and synthetically designed fabrics—in efforts to trap or hide heat, even if temporarily, so that it cannot be detected when drones are hovering above. New York artists Adam Harvey and Johanna Bloomfield even released a drone-proof clothing line called Stealth Wear made of nickel metalized fabric, and a German company has designed a special outfit called Ghost, which makes the body invisible to infrared sensors. And while fashion designers, libertarian survivalists, civilians, and militants devise schemes and materials to evade aerial thermal infrared sensors, FLIR has just released the first personal thermal imager designed for smart phones. The antics of the thermal mediascape have just begun.

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International Journal of Communication 8 (2014), Feature 2522–2524 1932–8036/2014FEA0002

IJoC Media, Hot and Cold

Seeing the Temperature in Weather Media

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How do weather media tell us about the temperature? We can trace the trajectory of the consumer's relationship to weather information from the local to the national to the global and back to the individual. In each case, weather media situate us, the weather consumer, in relation to temperature, weather phenomena, and space.

While in its most prosaic form one's situation within weather begins with the simple act of going outside, feeling the temperature, and looking at the sky, weather media have for the last half-century defined weather as a technological event. With the rise of weather media as a genre of cable television that began with the emergence in 1982 of the 24-hour Weather Channel learning about the weather became mediated and technologically inflected in entirely new ways. Thus began an era in which consumers received weather information through a satellite view of the world, looking, as Jody Berland once wrote, not up but down (Berland, 1996). Thus, the mediated experience of weather was altered by situating the viewer within a particular location according to that site's view from space. This point of view is so normalized that we rarely consider the fact that it situates us within weather from an enormously distanced viewpoint, visualizing the weather as an atmospheric system rather than something that happens on the ground. In this context, the weather watcher is asked to have a high level of literacy in weather imaging, data visualization, and data assimilation.

In the proliferation of weather images taken from space, the primary aspects of weather that are registered by the viewer are atmospheric—clouds, rain, snow, storms, etc. There are two kinds of images that predominate: satellite photographs and weather radar images, commonly known among meteorologists and their consumer audiences as Doppler Radar images. This nomenclature comes from the phenomenon known as the *Doppler effect*, which relates to how wave frequencies change when the source of those waves is moving relative to a person or object. *Doppler radar* measures the speed of detected objects within a defined field. While the Doppler effect is applied in many contexts, the rise of consumer weather media has resulted in its correlation in the public imagination specifically with the weather, aided by the way that weather newscasters fetishize the Doppler Radar in their broadcasts. *Pulse-Doppler radar* uses radio waves to register atmospheric activity and energy, such as precipitation, storms, and fog. Such weather visualization has the effect of conveying the sense that not only is the weather measurable and predictable, but that it can be controlled through technology.

Which brings me to the question of temperature. A satellite photograph and a Doppler Radar image do not represent temperature. Mapping the temperature involves data input from numerous on-the-ground measuring sites and translated into a map. This kind of data visualization through the conversion of data into representational form has a long history as a means of making data more understandable if not instantly readable. Graphs, maps, pie charts, and other data conversion conventions have evolved into increasingly complex digital forms of 3D modeling. The visualization of temperature data has a long history of graphs and charts in which temperature is rendered into gradations of color, most obviously red for heat and blue for cold.

The representation of temperature offers a complex set of challenges to weather media. As climate change continues to alter the world's temperature, the visual representation of temperature becomes more important in enhancing the public's understanding of the climate. Weather media is produced with an intended short attention span, so long-term weather phenomena do not fit well into the temporal framework of weather media coverage—which tends to be consumer-oriented along the lines of: What will the weather be today? Heat and drought, arguably two of the most devastating weather problems worldwide, tend to be underplayed in weather coverage precisely because they do not make for good TV, are long-term phenomena, and are not easily seen in satellite photos.

Temperature maps are invariably reductive, based on the notion that color is the best way to depict temperature. Thus, projections of rising world temperatures are invariably represented as a flattened global map with blue bands at the top. Purple is the coldest, gradating into blue, then light blue, yellow, green, and then red, changing in the extreme to maroon red. Here other color codes seep in—the coding of severe terrorist risk as red on the terrorism index; the air quality index where orange is unhealthy for some, red unhealthy for all, and maroon very unhealthy. So normalized are these codes that we rarely even think to analyze them. Is it the blue of ice and the red of fire that initially inspired them? Some of the weather temperature maps are soft and comforting shades of yellow and green, but most increasingly signal alarm through their color gradations. They trend toward red, in particular those depicting forecasted rising temperature heighten a sense of alarm—the dominance of red trending toward maroon is a key factor in this sense of anxiety and crisis. The threat of high temperature thus reads much more alarming than that of cold and is easily correlated with the threat of violence.

Weather temperature maps may be visualized by digital means, but they are decidedly analog in their visual aesthetics, with temperatures rising and falling on a continuous graphic scale, for instance. Significantly, the digitalization of weather media has meant that mobile and social media have expanded if not eclipsed the dominant role of television weather media. Here, we move from the global or national scale of the television or web map, which situates the viewer in a perspectival position in space, looking down on the world, to the individualized, mobile consumer whose weather and temperature system is a world of one. Hence, with the proliferation of apps that provide consumers with personalized weather data, the weather consumer is situated not within a mapped landscape, but on their mobile phone, with location and numerical temperature. Today my iPhone reads, "New York, Mostly Sunny, 21**°."** Ironically, these digital data are stripped down, providing a quick snapshot of daily weather reduced to crude icons of sun, cloud, rain, wind, and snow. This sends the message in its instant availability that it provides all that one needs to know as an individualized weather consumer.

As weather becomes increasingly extreme and unpredictable, it has become one of the most prevalent topics of discussion on social media. This includes sharing images of mobile phone temperature readings (often juxtaposed with readings from other, usually warmer, places around the world) and the more recent phenomenon (in particular during the cold weather of the winter of 2014) of the "weather selfie"—images in which people photograph themselves in notable weather contexts (most commonly dressed in layers for extreme cold). The weather selfie is also a way for social media users to distinguish their weather from that of their social network, in particular if they are vacationing in an alternate weather universe, so to speak. We have thus moved from measuring temperature as a community practice, with local weather watchers, to the consumer experience of the national and global television weather map, seen from space, to the representation of weather and temperature as individualized and handheld: weather temperature as a networked unit of one.

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International Journal of Communication 8 (2014), Feature 2525–2530 1932–8036/2014FEA0002

IJoC Media, Hot and Cold

Iceberg Media

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Potable water is emerging as one of the most important natural resources of the 21st century. Under increasingly widespread conditions of water scarcity, various corporate and state actors are turning to North Atlantic icebergs as a potential water source to address a future with fewer and more expensive sources of water. While icebergs have long been a part of commercial and cultural life on the Arctic and subarctic waters of the North Atlantic, the accelerated pace of glacial melt due to anthropogenic climate change is increasing both their frequency and availability (Conkling, Alley, Broecker & Denton, 2011; Cruikshank, 2005). What I want to do here examine such a "natural" resource as an iceberg in order to reveal substantive questions for media theorists and historians that lie at the politicized interface of frontier capitalist economies and the processes of environmental change in the 21st century.

Icebergs are relational and emergent natural resources that signal how a complex ecology of ethical, political, and socioeconomic issues can be raised when conventional forms of water provision reach their limit. They are also problematic objects for media theorists and historians as icebergs signal a host of relationships between natural resources and the set of practices and protocols associated with communication. This focus is generative of new ways of thinking about how extractive industries rely on processes of communication—from transportation corridors to networks of resource accumulation and distribution to mobile labor pools—that are themselves supported by a range of more conventional media technologies such as modeling software applications.

The relations that icebergs point to contain both a politics of representation as well as a politics of mediation around the ownership and exploitation of circulating natural resources, unsustainable global agricultural irrigation practices, and resource use and demand in metropolitan social formations. It is in this sense that icebergs constitute the central node in what could be thought of as a "media environment" that subtends and supports the ground of the extractive resource industries.

From the screens tracking the locations and movements of North Atlantic icebergs via satellite technologies to the different types of modeling software for forecasting and simulating the transportation of icebergs to drought-prone regions of the world, my aim is to start to view these emerging (cold) media environments and the issues that they raise as being of disciplinary concern to media theorists and historians (Barney, 2011; Buxton, 2013; Van Wyck, 2010). This trade in predictive and virtual environments is grounded in the processes and contestable politics of a reconceptualized understanding of "the environment" that extends its boundaries to the media technologies that re-present and mediate its proximities, distances, and temporal registers. "Control of information technology," as Jody Berland writes, “shapes the parameters of communication, knowledge, and memory, and determines the proximity to and nature of power itself” (2009, pp. 76–77). To which I would add, the control of natural resources shapes practices and protocols of communication, knowledge, and instrumental-technical foresight, and determines the proximity to and power of nature itself.

Getting icebergs on the move, and, to a degree, marginally integrated into the realm of possible extraction, has of late sparked a substantial amount of public interest of the tech-utopian variety (Brown, 2011; Harris, 2011; Madrigal, 2011). This has largely focused on expanding the realm of the possible through human technical achievement and expertise, and rarely, if ever, evinces a great deal of political-ecological awareness as to the underlying causes of water overconsumption across the Western world. For example, in the relatively long history of moving icebergs via sailboat, tugboat, or ocean current, one of the more recent episodes, though it stretches back to the early 1970s, revolves around the figure of Georges Mougin, a French engineer and the technical director of Iceberg Transport International (ITI). Beginning in the 1970s, Mougin undertook a series of modeling experiments to test the (economic and physical) feasibility of towing an iceberg from Antarctica to Saudi Arabia. Prince Mohammed al Faisal, the nephew of King Khalid of Saudi Arabia, founded and backed ITI and was at the time in charge of its desalination water program (Iowa State University, 2009. Through a series of conferences at Iowa State University that began in 1977, Mougin and his group worked to devise ways of testing various potential materials and scientific scenarios that could assure the timely and cost-efficient transportation of icebergs across the Atlantic and beyond. By the time they began their simulation work on actual icebergs, using those of tabular shape because they presented the best properties in terms of solidity, interest in the project had dropped off, particularly on the part of the Saudi Arabian government. Thus, Mougin had to wait until the late 1990s to relaunch the project.

At that time, he had revised the pilot project in an attempt to forecast the possibility of towing a large tabular iceberg from the coast of Newfoundland to the Canary Islands. For Mougin, the project had begun to creep into the realm of the possible again after seeing the documentary *Khufu Revealed* (2009), which tells the story of the reconstruction of the Keops pyramids using 3-D simulation technologies designed by the French company Dassault Systèmes (Harris, 2011). Dassault is a major player in the world of corporate digital simulations, and, in partnership with Mougin, have taken up his pilot project and rechristened it IceDream (Dassault Systèmes, 2012). The crucial factor in the simulations is the prediction of the iceberg’s melt rate. Using newly designed 3-D modeling software that incorporates nearly real-time meteorological and oceanographic data, largely collected and transmitted via satellite, the goal is to create a reliable drift model that could forecast the iceberg’s potential route and its associated costs. Dassault claims that a multimillion-ton iceberg could be transported to the Canary Islands with the aid of a single tugboat in 141 days. As an *Engineering and Technology Magazine* profile of Mougin’s project contends,

> There are no longer any major obstacles to understanding iceberg transportation for use as fresh water. Powerful simulation technologies combined with accurate knowledge about sea currents and other ocean and weather data have enabled complete and accurate study of the technical challenges without needing to invest in pilot projects or expensive, and unrealistic physical prototypes. (Harris, 2011)

For Mougin, the next step is to yet again simulate the towing with a tabular iceberg of a smaller size. Here, the value of repetition, of remodeling, returns. In this sense, media environments signal how such practices of modeling are making icebergs available at the interface of societal understandings of simulation and its role in capitalist economies that are benefiting from such processes of anthropogenic environmental change (equally across climate as ocean composition and currents) (Heymann, 2006; Winsberg, 1999).

Yet Mougin is, to some degree, a latecomer. Icebergs, and the potential they hold as a source of water for the dry or drought-ridden regions of the world, constitute a little-know touchstone in historical and contemporary debates on the ethical and ecological limits of the extractive industries. Actors in that industrial world of extraction have, for well over a century, sought to move icebergs from their points of origin, calving off of glaciers in both the Arctic and Antarctic, to lucrative markets in Chile, California, and Saudi Arabia, among others. In 1949, John Isaacs, newly arrived at the Scripps Institution of Oceanography, floated the idea of towing an Antarctic iceberg to southern California (Berhmann & Isaacs, 1992, p. 49). Isaacs' scheme stemmed from thinking through how to move large quantities of water from one location to another, an abiding preoccupation in his part of the world. In a 1956 interview with the *Los Angeles Examiner*, Isaacs speculated on the constant and most problematic aspects of the scheme: variables. Whether it was melt rate, tow speed, current drag, or the cost analysis between fuel and water, it was the calculability of the variables that had to be worked out. In the interview, Isaacs gave the somewhat outlandish example of moving an 8 billion ton iceberg with a length of 20 miles, a width of 3,000 feet, and a depth of 1,000 feet. Isaacs predicted that getting the iceberg from the Antarctic to San Clemente Island off of San Diego would take 200 days, with, in his mind, relatively modest power requirements:

> The energy necessary to reclaim such a quantity of water from the sea would be equivalent to that of tens of thousands of atomic bombs, whereas the energy needed to tow the iceberg here would be equivalent to only one or two. (Behrman & Isaacs, 1992, pp. 50–51)

Isaacs' idea would prove to have a certain idiosyncratic longevity. It was picked up intermittently over the following decades, in part spurred along by the rising cost of oil and the concomitant awareness of the value of adjacent natural resources such as potable water.

In the early 1970s, Wilford F. Weeks of the U.S. Army Cold Regions Research Laboratory at Hanover, New Hampshire, and William J. Campbell of the U.S. Geological Survey examined the "manna" or "madness" of towing Antarctic icebergs to the arid regions of the world. Weeks and Campbell were the first to formalize the calculability of Isaacs' variables through towing tests (Weeks and Campbell, 1973a, 1973b). Soon after, John L. Hult and Neill Ostrander, a pair of physicists working for the Rand Corporation in Santa Monica, published a report that addressed the now very real possibility of approaching Antarctic icebergs as a water resource at a scale available for the world as a whole (Hult & Ostrander, 1973). In their report, which was prepared for the National Science Foundation, Hult and Ostrander also recalculated many of Isaacs' variables, winnowing them down and coming to the conclusion that, in their estimation, the cost of provisioning water from Antarctic icebergs would be half of that of piping water to southern California by aqueduct from the Colorado River (Behrman & Isaacs, 1992, p. 52).

What this longer history of getting icebergs on the move and integrated into the world's need for fresh water shows is that media environments also telescope into the past, into an analytical world of oceanographic algorithms, early satellite imagery, and paper reports. The practices and protocols of communication embedded within these media environments are made manifest by examining the relationships that natural resources reveal through their place in contingent understandings of ecologies and economies.

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International Journal of Communication 8 (2014), Feature 2531–2534 1932–8036/2014FEA0002

IJoC Media, Hot and Cold

Burning Man:
Heating, Eating and Doing the Calorie

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We're gonna fire up your metabolisms with some warm-up squats! Let's burn off that extra helping of ice cream![1]

Exercise. Metabolism. Heating. Eating. Making the body a fire pit for burning food through exercise seems normalized in myriad gyms and exercise programs. Dressed in lycra in a windowless gym, nobody questions that they are actually burning off their dessert by jumping and sweating alongside a cadre of other delinquent eaters. The relationship between ridding the body of ice cream through the squeezing of one's gluteal muscles which in turn revs up one's metabolic rate seems somehow natural. Food goes in and, in order to prevent it from being stored as fat, we are expected to get rid of it by doing things: running, jumping, working, playing, sitting, sleeping, and just being. Before the thousands of mobile device apps for tracking eating and doing there were, and still are, pedometers, food diaries, and weight loss and exercise tracking clubs and groups to monitor how much food we burn, and how fast we burn it. There are myriad metaphors for this exchange. We "earn" a slice of pizza after a long swim, and we "treat" ourselves to a handful of candy after mountain biking—but that which we are managing, monitoring and controlling in the body, and through food, is heat.

The communication between food and the body happens through an equilibrium equation where bodies negotiate units of heat through food and exercise. This equation is now part of our sociocultural infrastructure. Food labeling policies, exercise tax credits, insurance policy standards and international health indices all turn our attention to an idealized and reductive relationship of heat exchange between food and the body. Objectively, the body is the apparatus that experiences thermodynamic heat exchange. The commonplace unit for the exchange is the calorie.

[1] The question becomes, then, how to categorize food and the body? If, as McLuhan writes: "a hot medium is one that extends one single sense 'in high definition,'" (1964, p. 36) is food such a medium in communication with the body? In the current reductive model of communication through calories, yes. The body is scarcely participatory, receiving food to be metabolized. A more comprehensive model of food in policy, and public discourse could make food "cool." To think of food in the context of personal history, culture or place, it becomes more than just units of heat. In these cases food becomes a "low dimension" moment of gustation, where a bite of ice cream becomes a memory of summers at the cottage, a trip to the county fair, or, simply, Florence, Italy. The eater decides what a food will become, in a scientific model of eating, food already *is*.

Codified in policies around the world, the trope of the calorie looms large on boxes of cereal, printed on restaurant menus, and measured by treadmills, elliptical machines, and wearable monitors. Sometimes we celebrate the calorie's absence. Food packaging trumpets the lack of calories: "Low-calorie brownies!" "No-calorie sodas!" We learn that eating calories is bad. Exercises and workouts celebrate the abundance of calories—"1,000-calorie workout!" "Burn major calories in less time!" "How to burn more calories when you sleep!" We know that expending calories is good. The calorie mediates communication between our food, our bodies and our activities and it turns into heat everything we eat and everything we do. Literally and figuratively, the calorie is hot.

Metabolic Determinism

Measuring the heat of the body is centuries old. In the 18th century French chemists Antoine Lavoisier and Pierre-Simon Laplace measured a guinea pig's exuded heat when trapped in an ice-insulated pot. Their *machine,* (which only later became *le calorimetre*) helped them establish the fact that heat phenomena could be both instrumentalised and measured in a living body. There is no mention in their 1783 treatise on heat, *Memoires sur la chaleur,* if they ate the guinea pig (Lavoisier & Laplace, 1780).

A century or so later, German chemist and physiologist Max Rubner used the word 'calorie' to denote the amount of heat required to raise one gram of water, one degree centigrade (Widdowson, 1955). Using respiration calorimeters to measure the caloric output of animals, and bomb calorimeters to measure the calories contained in foods, Rubner and others applied a law of isodynamism to the human body: to maintain a steady weight, calories *in* should equal calories *out*. These early ideas of heat were integral to arriving at a physico-mechanical relationship between eating and heating the body (Rubner, 1902).

Nineteenth-century nutrition scientists like Rubner and Max Pettenkoffer in Germany and Wilbur Atwater, Edward Rosa and Francis Benedict in the United States, who were inspired by the operations of mechanical technologies like steam engines, offer an explanation for the cultural transformation of the calorie from a unit of measuring heat to a unit of analyzing food, people and activities. For them, the parallels between machines or systems and humans were striking. In 1928, Dr. Benedict writes in *The Scientific Monthly*:

> One of the first things learned in the study of vital activity was that heat is not produced solely to keep the body warm…As the boiler, in order to produce power, must give off a large amount of heat, so is human heat production likewise necessary in order to furnish motive power for human activities. (1928, p. 9)

We call human combustion "metabolism," yet in both boilers and our bodies, we want a high rate of thermogenesis; we shovel potato chips into our mouths instead of coal into a firebox; we do Zumba instead of raising and lowering a piston to turn a flywheel.

Indeed the calorie affords us a new perspective on the body: we get to see, be and do, heat. Calorified foods, metabolisms and activities allow us to be the mediating technology in which potential energy is turned into kinetic and in which food or fat is turned into fire. Bodies turn pizza into pushups, butter into burpees, and muffins into marathons. This means, however, that this equation of calories can be used as a quantitative judgment of our body's efficiency, and eating and exercise become our embodied measure of that efficiency. The efficient body runs hot, and burns calories through quotidian activities: shoveling snow, having sex, and vacuuming; or through nominated exercise: running at a speed of 5.2 miles per hour, using an elliptical machine, or doing a boot camp aerobics class (Harvard Heart Letter, 2004). Statements like: "I run because I love to eat" become obvious when there is a relationship between food and doing, and that relationship is one in which the body is a site of caloric negotiation.

Every time we "play with our children with moderate effort" for 30 minutes in order to "burn off" our snack of 21 almonds, we dutifully obey the first law of thermodynamics (Harvard Heart Letter, 2004). These models and technologies, and the designation of the calorie as the structuring trope for eating and doing, allow us to parse heat and temperature; they also encourage particular ideas about food, eating, and human metabolism. To say someone is "hot!" is both a judgment about their physical attributes—the size of their breasts, the ripple of their abs, or the symmetry of their face— and an assessment of their metabolism. As we idealize low waist-hip ratios, body mass indices, and body fat percentages, we reinforce the physiological roots of what it means to be "hot." As such, the word calorie becomes a structuring unit in the communication about food and bodies. To understand categories of food and bodies in such a way (e.g., scientific and technological), we need to be calorically literate: we need to be able to parse a menu in New York City, to consume food responsibly according to our activity levels, and to understand our bodies through a metabolic determinism that circumscribes how "hot" we can be. The calorie becomes a structuring concept of the management and moralization of our body. When it comes to embodied calories, it's cool to be hot.

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International Journal of Communication 8 (2014), Feature 2535–2539 1932–8036/2014FEA0002

IJoC Media, Hot and Cold

Fourier('s) Analysis: "Sonic" Heat Conduction and Its Cold Calculation[1]

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The techno-mathematical condition of present-day media culture has triggered the discursive interest in temperature-related subjects. We can deal with signal processing either with "hot" imagination-driven theories, which concentrate on its discursive effects, or by a "cold" analysis of its underlying nondiscursive techno-mathematical structures. The "ice-cold" resonates with the media-archaeological research method itself, as a Nietzschean "passion of distance" (Nietzsche, 1886, p. 227).

Temperature is increasingly being referenced in academic discourse.[2] Long before the awareness of climate change and Jacques Derrida's *Archive Fever*, McLuhan (1964) drew a distinction between "hot" and "cool" media depending on the degree of sensual participation on the part of the user. Whereas across the humanities, temperature appears mostly as an image of force, in the nonhumanities temperature figures as a medium. In the technological engineering of communication, it was a decisive step when Shannon (1948) turned entropy—the key term in physical thermodynamics—into a probabilistic measure of the degree of information contained within a message, thereby transforming the physical theory of heat into "cold" mathematical analysis. Another temperature-related term that has gained ultimate importance is the Fourier transform, which is essential to understanding audiovisual signal processing today. Even if this techno-mathematical operation at first glance seems unrelated to "hot" and "cold" media, there is a link. Joseph Fourier started his mathematical operations which since carry his name with heat analysis—such as the flickering air above the Egyptian desert (Siegert, 2003, p. 242)—just like Norbert Wiener's idea to investigate harmonic analysis was inspired by the wave patterns on the Charles River that he observed looking out of his office at the Massachusetts Institute of Technology. What appeared like a *fata morgana* at first sight led to a most efficient computational tool.

In its simplest form, Fourier analysis decomposes complex periodic functions (such as those perceived as "sound") into the sum of simple sine and cosine waves counted in cycles per second (hertz) (Fourier transform, n.d.). Even in its initial conception, Fourier analysis provided a symbolic mechanism to master dynamic physical events by approximation: that is, by converting continuous events into discrete

[1] The following thoughts are part of a research focus on the nature of "sonicity" within technical media: implicit sound as object of knowledge.

[2] One example of this is the interdisciplinary conference "Archives of the Arctic. Ice, Entropy and Memory," which was organized by Susanne Frank and Kjetil A. Jakobsen at Humboldt University, Berlin, September 18–21, 2013.

numbers. By converting a function of time into a new function of frequency, the time domain of a signal is converted into discrete numerical values. As a result, the discrete-time Fourier transform facilitates digital storage and computation of real-world signals and their reperformance, since the operation can be time inverted. High-fidelity reconstruction of time signals is pragmatically essential for audio and video reproduction technologies today. But when the Fourier transform is understood in its epistemological dimension as well, it also inspires insights into the nonhuman nature of technological tempor(e)alities, which is of particular interest to the media archaeological sense of time (Goddard, 2014). Technological media time becomes progressively autonomous from the familiar cultural history. "Media cross one another in time, which is no longer history" (Kittler, 1999, p. 115). The Möbius strip–like entanglement between time and frequency, between analogue vibrations and discrete numbers, is the essence of a time mechanism that is both physical and symbolic at the same time (Miyazaki, 2012)From his research into the relations between heat conduction and abstract numbers, Fourier (1822) derived a general conclusion: "From several mechanical questions arise similar results, such as the isochronism of oscillations, the multiple resonances of sonorous bodies" [Plusieurs questions de mécanique présentent des résultats analogues, tels que l'isochronisme des oscillations, la rèsonnance multiple des corps sonores] (p. 15). His mathematical insight (which had been preconditioned by Leibniz's infinitesimal calculus) is implicitly sonic. Vibrating heat waves are indeed the cause of energy conduction within and between adjacent bodies. Very appropriately, the quanta of thermic wave energy within crystals are called *phonons*. "Second sound is a quantum mechanical phenomenon in which heat transfer occurs by wave-like motion . . . the wave motion of heat is similar to the propagation of sound in air" (Thermal conduction, n.d., para. 1.4).

When it comes to describing microdynamical processes, the language of both physics and electrical engineering frequently refers to terms taken from acoustics, since sonic articulations provide the chrono-poetical model to reflect microtempor(e)alities. Etymologically, Latin *temperare* is related to measured time (*tempus* as cut, as intersection) expressed by harmonic number ratios. The relation between the thermodynamic impulse of Fourier's analysis and "temperature" in music exists in the mathematization of vibrational events: the reversal of time into calculable frequencies like the "well-tempered" tuning of keyboard instruments as it has been developed in Johann Sebastian Bach's composition *Das wohltemperierte Klavier*. This may even result in a retuning of the sounds of the past: "Equal temperament is now universally accepted, but . . . historic temperaments are essential to unlock the emotional charge of earlier music" (Hafner, 2000, para. 1).

Whereas the acoustic signal "heats up" human aural perception, its mathematical analysis cools it down. The discursive fascination with the temperature metaphors of the "frozen" nowadays corresponds with the media archaeological: that is, techno-mathematical approaches such as the synthesis of the human voice that takes place as a coupling of materially refined electronics (*techné*) and mathematical analysis (*lógos*). Boris Yankovsky's Syntonfilm Laboratory in Moscow in the 1930s based its experiments with synthetic sound on mathematical analysis of the genuinely time-critical nature of sonic waveforms as temporal transitions, different from more traditional experiments based on previous sound recordings. Yankovsky's completely formal approach was suspended from any semantically "hot" imagination; artificial voices—resulting from techno-aesthetic "cool" analysis—were not meant to sound specifically human at all: "The final waveform would sound like a 'frozen' vowel" (Smirnov, 2013, p. 215). The techno-mathematical (analytic) approach to speech synthesis results in "cold" voices (Zakharine & Meise, 2013).

While the Greek vocal alphabet had been invented for the special purpose of recording the musicality of poetry (cultural recording as symbolical operation), the current digital code returns to first expressions of pre-Grecian writing that had been invented for *calculating* purposes (Schmandt-Besserat, 1992).

The Fourier transform brings a recorded voice event into the mathematical realm. In digital computing, fast Fourier transformation is the time-efficient algorithmic implementation of this operation, allowing for a kind of real-time speech analysis that only computing can achieve. At that moment, the machine is a better media archaeologist of sound than any human ear. Only by application of such technological tools can the microtemporal level of such events be explained. Therefore the cover of a book on the origins of the vocal alphabet (Figure 1) shows both an image of an early Greek inscription *and* the spectrogram of the same hexametric verse line spoken by Barry Powell, one of the most original scholars on that subject(Ernst & Kittler, 2006); see Powell (1991, 2002). What is meant to be revealed by this juxtaposition is the recursion of the alphabetic writing within spectrographic (alphanumeric) computation: Both techniques were invented for the analysis of the musicality of human speech.

Fourier's decomposition of temperature into harmonic sine waves reaffirms the occidental epistemology of a world ordered by Pythagorean numbers, but results in an overemphasized separation of sound from noise. Nonperiodic functions in fact cannot be derived from Fourier series; the real challenge, therefore, is thermal noise and thermodynamic stochastics. Culture turns from phonocentrism to mathematics—the cool jazz of media theory.

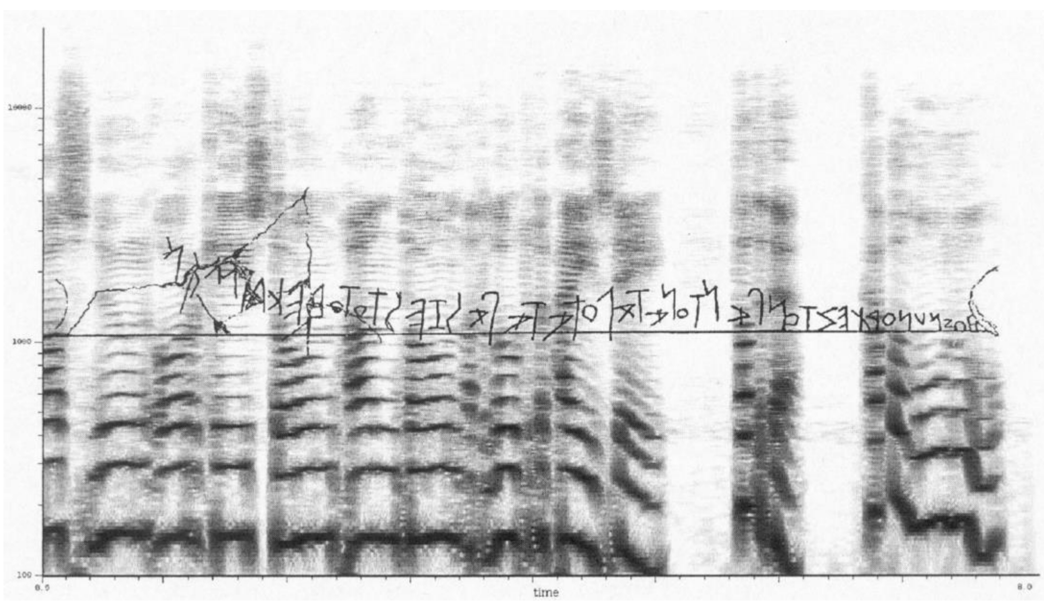

Figure 1. Cover of Die Geburt des Vokalalphabets aus dem Geist der Poesie. Schrift-Ton-Zahl im Medienverbund **[The birth of the vocalized alphabet from the spirit of poetry: Script-sound-number in their medial system].**

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