NETWORK SONIFICATION AND THE ALGORHYTHMICS OF EVERYDAY LIFE

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ABSTRACT

Today, public concern with the extent to which they influence people's routines, and how much they affect cultures and societies, has grown substantially. This paper argues that, by listening to networks, people can begin to apprehend, and even comprehend, the complex, ostensibly "magical" nature of network communications. One problem is that listening semantically to networks is incredibly difficult, if not impossible. Networks are very noisy, and they do not, for instance, use alphabetic language for internal or external communication. For the purpose of interpreting networks, I propose "tactical network sonification" (TNS), a technique that focuses on making the materiality of networks sensibly accessible to the general public, especially people who are not technology experts. Using an electromagnetic transduction device—Shintaro Miyazaki and Martin Howse's Detektor—TNS results in crowded sound clips that represent the complexity of network infrastructure, through the many overlapping rhythms and layers of sound that each clip contains.

1. INTRODUCTION

Jonathan Sterne claims that "[t]o think sonically is to think conjuncturally about sound and culture" [1]. Listening to sounds often invites cultural dimensions into our understanding of the various layers and dimensions of the environment we live in. Whether one listens to songs of birds on a clear morning, the hissing of tree leaves on a breezy day, the rhythms of waves on a sunny afternoon, or even the humming of machines on a busy day at the office, the soundscape offers different types of information about the space within which we happen to be at a given time. Although people do not necessarily always listen with intention, the—transdisciplinary—three modes of listening as defined by Michel Chion help determine the outcomes of a listening exercise. Causal listening, for instance, "consists of listening to a sound in order to gather information about its cause (or source)" [2]. While Stephen Barrass, in reference to Ludwig Wittgenstein, explains that "sonification could be considered a 'tool' rather than a 'representation of information'" [3], the sound itself in causal listening is a representation of an event, and the intent of listening is identifying the cause behind what we hear as opposed to mere sonic identification. Another mode is semantic listening, "which refers to a code or a language to interpret a message" [2]. In this mode, the sound acts as a message, and listening carries the intention of deciphering and making meaning of the sound we hear. This particular mode is more relevant to linguistics; within the context of this paper, semantic listening manifests as a gap between what people know about network communications and the possible information carried in these exchanges. To arrive at a semantic listening to network communications, there would need to be some sort of alphabetic/symbolic or linguistic exchange associated with the sounds of networks, which is not the case and thus makes semantic listening extremely difficult if not impossible. On the contrary, in reference to Pierre Schafer, Chion explains that reduced listening "focuses on the traits of the sound itself, independent of its cause and of its meaning" [2]. Reduced listening focuses on the sound as artifact, in an attempt to recognize its pure characteristics outside its potential causes; it allows the listener to pay close attention to the details of the sound in question, repeatedly, until the multiple aspects and events that characterize it are registered, and appropriately recognized and described. In its first stages, this project utilizes reduced listening, followed by an attempt at causal listening once the sounds are appropriately described as independent subjects of inquiry. Semantic listening however cannot be applied to network communications because they do not use symbolic language; it will nonetheless be occasionally addressed throughout this paper.

In the age of networks, technological devices communicate ubiquitously, leaving minimal tangible traces that people can perceive. These devices emit signals and messages; along with information, they communicate data that serves for their mere functioning—i.e. laptops and Wi-Fi routers are not constantly communicating "meaningful" information of interest to people, but it is necessary data for a device to access the internet. Although the electromagnetic (EM) waves that materially make these network communications possible are inaudible and invisible to people, they do exist within our environment. It is difficult to question the material presence of network communications, as well as their possible implications, especially given their ubiquitous status. Although we may not "decipher" the communications through sonification, it is important to listen to their rhythms, if only to learn about the material performance of technologies as they sustain our modern everyday life. Making concrete the physical presence of EM waves solidifies the fact that when technologies communicate, they do actually leave a trace, inducing more "modification of [the natural] rhythms . . . by means of human actions" [4]. Moreover, sonifying network communications materializes how human technological actions contribute to, if not interfere with, the natural soundscape, re-marking natural space.

Networks rely on algorithms that dictate the events of emitting, receiving, and processing EM waves amongst devices, to make their communications possible. Shintaro Miyazaki explains that

> we are surrounded by infospheres consisting of vast electromagnetic (EM) networks created by assemblages of antennas, satellites, cables and other bits of communication technology for data transmission intermingled with computational

devices of data processing and storage such as smartphones, laptops, netbooks or tablet computers [5].

The world we live in has come to accommodate "infospheres" that are essential for communications not only between people (in virtual ways), but more deliberately between technologies themselves, even outside the direct human needs for them: at extended times, technologies communicate with each other, without a *direct* purpose of serving for human needs for communications or everyday operations. These infospheres are infrastructures that physically surround us, and involve people in the techno-environment simply by sharing the same space. However, the inaudible nature of eventful EM waves makes it difficult for people to acknowledge their existence, let alone try to understand them (semantically for instance), or question their effects and consequences. To that end, "[d]ata sonification [presents as] a method of exploring processes in spacetime terrains such as bodies and landscapes" [6]. Sonifying networks can situate their communications and EM waves exchange within a tangible spatio-temporal experience. Further, Alberto de Campo defines "*Sonification or Data Sonification*" as "the rendering of […] data into (typically non-speech) sound designed for human auditory perception" [7]. Being able to listen to the sounds that the technological devices produce, even when not purposefully designed, provides a new approach to recognizing what rhythms network events contribute to the space-time continuum of our everyday life. Sterne explains that "sonic imaginations rework culture through the development of new narratives, new histories, new technologies, and new alternatives" [1]. Using sound as a method to tell new stories about historical and technological events allows a new understanding of the cultures around these systems. (Re)visiting the sounds that technologies produce in the silence of their communications, promotes a new discourse around the infrastructures of networks—and the performances of algorithms—within the existing cultural manifestations of power and control. Given that networks electromagnetically communicate at dedicated ranges, and since these ranges overlap at times, the sonifications in their changing volumes and rhythms are an example of how technological systems adapt within our everyday environments—utilizing the natural energy that is EM Waves—to maintain their processes and/or connections.

Michaela Palmer and Owain Jones explain that "sonification artefacts or events retain temporal and performative dynamics within themselves as they play in time" [6]. Sounds, as heard and listened to in time and space, interact with the continuum in a way that is performative, through the rhythms that they carry and implicate on any given soundscape. Sonic artefacts in and of themselves have features that represent the nature of networks, particularly in their spatio-temporal performances that represent an integral part of algorithms. Miyazaki explains that "[w]hen an algorithm is executed, processes of transformation, and of transduction from the mathematical realm into physical reality, are involved" [8]. The algorithm is processed in a way that reads and calculates mathematical commands, and executes them into the physical reality of the software and—more importantly in the context of this paper— network that it defines, through EM waves or hardware, respectively. This feature of algorithms—mathematical translations into EM waves—highlights their performative nature, in that they participate in a process that gets applied into, and contributes to the physical reality of networks. Listening to such processes makes tangible the physical execution of algorithms and the physical nature of networks, permitting a better understanding of how networks and their algorithms work and rebrand the rhythms of our societies. Listening to networks and their communications is another form of representing the rhythms that people inscribe in their space [4], reconfiguring the natural space within which they live. Because the subject of study is naturally inaudible to the human ear, this research utilizes Michel Chion's [2] listening modes, to guide the case study. More specifically, the sonifications, foreign to the everyday soundscape, require a particular attention to the individual sounds for the listener to understand the complexity of the subject. These modes of listening stage the study as a two-step-approach, first engaging with the sounds as object of study, before moving on to investigate the networked soundscape.

2. LISTENING METHODS (MODES)

2.1. Reduced Listening

I use reduced listening to describe the sounds in a way that is independent from the settings that surround and lead to the production of the sonic outcome. Using raw/literal language to describe sonic events could be helpful in—potentially—identifying what is "meaningful" and what is "noise", if only through what is aesthetically described as positive versus negative. However, R. Murray Schafer explains that "[n]oise pollution results when man does not listen carefully. Noises are the sounds we have learned to ignore" [1]. This definition may suggest that by exercising reduced listening on transduced EM waves of network communications, one cannot describe sounds as noise, given that we do not normally hear them, let alone have been trained to ignore them. Therefore, reduced listening does not by itself engage in identifying/classifying sound from noise, since its main purpose is to describe the sounds we hear regardless of their meaning or cause. However, reduced listening potentially helps in distinguishing sound from noise in the causal listening stage.

The below analysis does not assume that aesthetics are enough to separate sound from noise, and is open to outcomes that may not necessarily conform to expectations. The questions to keep in mind as one practices reduced listening are: what is at stake when the sound is completely separated from its cause and meaning? What does it mean to listen with the pure intention of describing the sonic object and event? What are the advantages of acousmatic listening in the context of networks? The descriptions below attempt at answering these questions, taking into consideration the possibility that a more accurate understanding may unfold in the next sections, and further research—and projects—may be necessary. To arrive at the most detailed description possible, within the constraints of this project, I listen to clips multiple times, with careful pauses as necessary; repeated listening allows me to hear particular details and events that may have gone unnoticed in the first few times, as I get acquainted with the sound clip being studied.

2.2. Causal Listening

I use causal listening in an attempt to understand the causes behind the particular sonic events and/or noises. I do not claim that I have exact and accurate determinations of what particular technological event or algorhythmic command causes a specific sound. However, I suggest that practice in identifying causes behind particular sounds can lead to a better understanding of the technologies investigated, and to making networks more accessible to the general public. More specifically, I focus on causes behind the rhythms that we hear, as well as interesting sonic event points—i.e. brief sonic moments. Chion urges that:

> We must take care not to overestimate the accuracy and potential of causal listening, its capacity to furnish sure, precise data solely on the basis of analyzing sound. In reality, causal listening is not only the most common but also the most easily influenced and deceptive mode of listening" [2].

Given the nature of causal listening, people may be inclined to assume particular causes to be associated with a given rhythm or sonic event, which in turn leads to deception; this phenomenon is mostly due to the fact that the sounds we hear can be affected by the environmental soundscape within which they exist.

Although I use causal listening to better understand technological processes, I do not argue that this practice is enough to truly comprehend the material investigated. In the context of the listening exercises below, causal listening is guided by the descriptions provided by the artists, though I also introduce some observations of my own. I start by presenting what the artist explains about the particular sound clip—if any information is available—and continue to conduct my own causal analysis. I focus on event points and event patterns, and try to understand what they could mean. The reduced listening descriptions are referenced when attempting to interpret said event points and patterns (during the causal listening descriptions).

2.3. Semantic Listening

In its original methodological planning, this project imagined the use of semantic listening to be at the heart of the Tactical Network Sonification technique. Chion explains that semantic listening "is purely differential" [2]. Within the context of linguistics, Chion notes that "semantic listening often ignores considerable differences in pronunciation . . . if they are not *pertinent* differences in the language in question" [2]. Consequently, having a basis for differential analysis is particularly important in semantic listening. For example, it would be ideal to have a basic semantic knowledge of sounds within network communications, to be able to learn which sounds are noise and which ones are meaningful. Note that the difference between causal listening and semantic listening is that the former identifies the cause—action, element, command—that resulted in a particular sound, while the latter would identify what the sound itself means—for example, (hypothetically) that a given sound means that one machine is sending location data to the network receiver. Before giving up on semantic listening, I tried to explore ways of acquiring a set of sounds that are important within networks. To do so, it appeared important to have recordings of networks as they sound individually: every network has its own sounds, which in an infrastructure may be muffled or overridden. It was technically—and theoretically—impossible to separate networks within a system into separate entities.

Additionally, given the nature of contemporary networks, the soundscape of separate networks would be different than that of the same network within the whole system. Due to the fact that networks operate and communicate around each other, the EM emissions accommodate and account for all the active networks with a system. As such, listening to networks separately and outside of their infrastructure would practically defeat the purpose, because it changes the conditions and circumstances that produce particular algorhythmics. That said, networks are crowded and multi-layered, which in turn means that I could not reliably identify a set of sounds as a basis for semantic listening. This project thus acknowledges that practicing semantic listening of networks, is not feasible, even if listeners were to try and find meaning beyond the linguistic codes and symbols.

3. CASE STUDY USING THE DETEKTOR

Using Miyazaki and Martin Howse's Detektor, a Focusrite Scarlette 2i2 audio interface, and the Sonic Visualiser software [9], I recorded five, approximately fifteen-minute-long sound clips at the Humanities Computing and Media Centre (HCMC) in the McPherson Library building at the University of Victoria. I have received consent from the centre personnel, as well as ethics approval, to conduct and share these recordings. To maintain a semi-controlled environment, I recorded on Tuesdays and Thursdays, from 1:00 pm to 1:15 pm, while situated in the same cubicle. The HCMC is an open-space computer lab, with twelve computer stations in its main area (ten Dell computers with UNIX operating system, and one Apple computer with an Apple operating system—iOS). These stations are occupied by a fluctuating number of research assistants and project primary investigators. The main area also has a table at its centre, where individuals work on their own laptops (that run on various operating systems). In another area, there are two Dell computers and two Apple computers, with Unix and Apple operating systems, respectively. The area in which I was situated at the time of the recordings has one Apple computer with an Apple operating system, in addition to a number of screens that could be connected to personal laptops via VGA or HDMI chords. The lab operates within the premises of the university library, and is therefore within the connection range of its Wi-Fi. Given the diversity of the HCMC environment, I was only able to record the number of people present at the time of each recording, allowing for the possibility of a person coming in or out (without being noticed or recorded as present). Further, I noted my own personal devices that I have running, in proximity to the Detektor, at the time of the recordings. Given the lack of material for causal listening (as will be addressed below), I will present reduced listening descriptions of each session, and will then discuss causal listening collectively. Semantic listening remains outside of the scope of this section, given the complexities of the sounds recorded, and the—purely—assumptive narrative that such an analysis would risk attributing to the communications processes recorded and discussed. This paper does not aim at making human meaning out of technological communications, but to propose a way to accept mechanic sounds as meaningful performances in our lived spaces.

3.1. Reduced Listening

3.1.1. HCMC Session 1 (Clip can be accessed at https://soundcloud.com/tracey-el-hajj/hcmc-session1)

During this session there were seven people in the space. The devices running in close proximity to the Detektor were: a laptop, a screen, a Bluetooth mouse, Bluetooth headphones, and a cellphone. Listening to this session, I have identified thirty events; I assume that some similar events have gone unnoticed or undiscernible under the various competing sound layers, which you might be able to identify as you listen carefully. Some of the noted events are patterns or underlying layers of sound that are dominant in the session. Given the repetitive nature of sounds and events recorded, I refrain from describing them individually, though I attempt to describe what they sound like and approximate the number of times these events occur.

There are approximately seven types of events, most of which occur multiple times, at different volumes and intensities; you might find that some events simultaneously embed other types of events within them. The first type of events is a buzz that sounds like the cellphone-interference we hear through external speakers (when our phone rings). This event happens around fifteen times, at different volumes, intensities, and lengths. The second type of events is an intense buzz; it occurs three times in total. The third event recorded is one that is more or less a dominant pattern in the session, consisting of a rather monotonous buzz that fluctuates in volume. The fourth type involves events that sound like scratchy interruptions of more consistent layers. This type occurs approximately three times. The fifth type of events is one that embeds a number of rhythmic occurrences: one-second-long minimal events that happen almost every second; though not very regular in terms of collective rhythms, their individual rhythms are more or less maintained. This type reoccurs twice. The sixth type of events is one of a scratch—low frequency—that is approximately one second long. This event reoccurs once. The seventh type of events is a very subtle change in the beeping, or constant whistle, and is a one-time occurrence. The beeping, or constant whistle, as you hear throughout the clip, presents as a predominant sound, along with a hum. These two sounds are mostly consistent, though they are—at times—interrupted by other dominant sounds and other not so dominant events.

3.1.2. HCMC Session 2 (Clip can be accessed at https://soundcloud.com/tracey-el-hajj/hcmc-session2)

During this session there were eight people present in the room. The devices running in close proximity to the Detektor were: a laptop, a screen, a Bluetooth mouse, Bluetooth headphones, and a cellphone. Music was streaming onto the headphones. In this session, similar sound events as those of session one are detected. When you listen to the track, you may notice that the underlying whistle is almost the same. The hum—also noted in session one—becomes audible to a certain extent, when other sounds quiet down, but is not as prominent as the hum heard during the first session. Further, there are intermittent high-pitched beeps, as well as subtle changes in rhythms more consistently noticeable in session two than they are in session one. Nonetheless, there are three notable events you will hear during this session. The first event is rhythmic, with three extended buzzes, somewhat beat-like. The second event is a buzz that is similar to the first type of events detected in session one (a buzz that sounds like the cellphone-interference); this event occurs numerous times throughout the session. The third event is one that is similar to the second sonic event of this session, though longer; this buzz is also muffled by more dominant sounds. Listening closely to this session, you will notice that it has a number of minor events that prove difficult to distinguish and individually group or even detect.

3.1.3. HCMC Session 3 (Clip can be accessed at https://soundcloud.com/tracey-el-hajj/hcmc-session3)

During this session there were six people in the space. The devices running in close proximity to the Detektor were: a laptop, a screen, a Bluetooth mouse, Bluetooth headphones, and my phone. You will notice that this session has very steady rhythms and sounds, but is also rich in subtle and minor events. As you listen, pay attention to a number of event types noted here, and notice how some of them occur at multiple instances. The first event consists of three beeps—more accurately described as high-pitched whistles—of approximately one second length each. The second event is a brief scratchy buzz that is rather common throughout the session—and is also present throughout other sessions. The third type of events is an intensified buzz, that is higher in volume than others previously detected. This event reoccurs approximately three times. The fourth type of events is an intensified whistle that becomes more like a high-pitched beep. As you will hear, this event is notably repeated at least three times. The fifth type of events is one that is similar to the first type from session one (and second in session two—a buzz that sounds like the cellphone interference people would hear through external speakers when a phone rings). You will notice that this type is not as markedly common in this session (noted only twice). At a few points in this session, a loud multitude of simultaneous indiscernible events is noted. This event is extended in length, and imposes a sense of competition between the sounds in question. Towards the end of this session, a similar type of events occurs, though some of the sounds can be identified: intense high-pitched loud scratches, and intermittent whistles/beeps that are of a rhythmic nature. By the end of this session, you will have noticed that it also features repeated sounds that change in volume and intensity, which determines whether or not they are notably heard.

3.1.4. HCMC Session 4 (Clip can be accessed at https://soundcloud.com/tracey-el-hajj/hcmc-session4)

During this session there were thirteen people in the lab space, two of whom were in the small cubicle, with a third person coming in at minute nine. The devices running in close proximity to the Detektor were: a laptop, a screen, Bluetooth headphones, and a cellphone. The Bluetooth mouse was intentionally turned off for the entirety of this session. You will hear that the sounds in this session are clearer and less crowded than previous sessions; it seems that a layer of sound—predominant in previous sessions—is missing in this recording, which is allowing for clearer results. However, this clarity you experience does not guarantee a straight forward and individual identification of sonic events, as you will notice. Further, similarly to the previous sessions you have listened to, session four has events that are dominant throughout the recording (buzzes, whistles, and hums) and others that occur occasionally and are disruptive in their nature. The first type of events is multiple buzzing sounds that are limited in length (one second long each). The second type of events is an intense static buzz, similar to the first type of events in session one (second type in session two and fifth in session three). This type notably reoccurs approximately four times. The third type of events is an intense high-pitched buzz, which is also common in previous sessions. You can count this event approximately three times, and will notice that it is sometimes interrupted by scratches. The fourth type of events is a change in volume and overall noises, where one can notice a drop in both pitches and frequencies. The fifth type of events is a louder scratchy staticky buzz. This event reoccurs around two times. As you will hear, this session features numerous interruptions in the overall rhythms and patterns of its sonic events.

3.1.5. HCMC Session 5 (Clip can be accessed at https://soundcloud.com/tracey-el-hajj/hcmc-session5)

During this last session there were six people initially, and nine people by the time the recording was finished. The devices running in close proximity to the Detektor were: a laptop, a screen, a Bluetooth mouse, Bluetooth headphones, and a cellphone; however, I stopped using the mouse around minute eight to inspect whether or not its movement was affecting sounds, so you might hear the difference there. This session is louder than session four. Similar to all previous sessions, session five has events comparable in nature to previously described events. The first type of events noted in this session is a three-part buzz, with the third part more extended than the first two. This event reoccurs once, as far as is clearly audible. The second type of events is similar to the first, but is a two-part buzz as opposed to having three parts. As you listen, expect for at least five occurrences of this event, and listen for how it is sometimes disruptive of others. The third type of events is a brief intense buzz that is 0.5 second long. This event is more common in this session than in others, and reoccurs around twelve times at different volumes and intensities. The fourth type of events is a rhythmic high and low of buzzing, with which scratchy and staticky buzzing interferes. This event reoccurs at a particularly crowded interval in the session. This session also features the whistle that you will have also heard during all other sessions. It also has some exceptional and interesting events that are different from other sounds (even across sessions), which are nonetheless difficult to individually discern or accurately describe (I do not claim to have accurately described any of the sounds, given the complexities inherent thereto, as well as the intricacies of communicating sound through spoken and written languages).

3.2. Causal Listening

In this section, I cautiously discuss potential causes that may have contributed to the variations of sounds identified in the reduced listening descriptions. Given the capacities of the Detektor, I assume that the EM waves transduced fall within the ranges of GSM networks as well as Bluetooth networks (within appropriate ranges). However, I do not completely exclude the EM waves from Wi-Fi network, as I do not have definitive evidence that they completely fall outside of the EM range captured. Further, given the multiple layers of sounds resulting in the recorded sessions, I argue that attempting to associate particular sonic events and rhythms with particular technological events would be unreliable. The technological events that I am aware of and noted in the setting descriptions are limited to my personal devices, because: a) requesting reports on colleagues' workings and technological actions during the times of recording would be a breach of privacy; and b) there are many factors that seep through the recordings that are completely outside of my knowledge, including but not limited to the GSM network and other EM waves emitting devices that are not considered within the scope of this research.

Nonetheless, there is one factor that I am capable of commenting on. As noted above, one of the devices that I was using at the time of the recording was an Apple Magic Mouse, connected to my laptop via Bluetooth. Listening to the recordings, I had suspected that the traffic from the mouse may be overwhelming other sounds. When recording session four, I turned off the mouse. As per the reduced listening discussion, session four has clearer sounds, though not completely discernable. The difference in volume and layers between sessions one, two, three, and five, and session four suggests that the Bluetooth connection is louder and more dominant than other connections. Although I have taken note of some Whatsapp messaging events during the recordings, I have not noticed any particular sonic events that are unique to the messaging process or consistent with timing of the recording, therefore I will not make assumptions in this regard.

4. RESULTING AMBIGUITIES

The Detektor allows the transduction of EM waves produced by technologies and network communications otherwise inaudible and inaccessible to people. Practicing reduced listening at the initial stage of analysis allows a deeper understanding of the phenomena at hand, if only by paying attention to the intricacies of sounds, and the complicated nature of communications processes so abstract. Causal listening adds a layer to understanding sounds resulting from these silent events; however, as demonstrated above, causal listening fails in addressing the multitude of information, even those collected in the process of describing what the listening devices transduce. Semantic listening proves to be a nearly impossible task, given the lack of symbolic language in network communications, as well as the absence of differential material that would be essential in understanding the meaning of transduced sounds, as communicated between networked machines. That said, the incongruities in detail between reduced listening and causal listening result in various ambiguities that are problematic when attempting to study how technologies communicate within an infrastructure. These ambiguities also result from the multitude of sonic events that seemingly correspond to different types of connections, as showcased in the case studies, without knowing what sounds correspond to what technological events: for example, we cannot be sure of what sounds are particular to GSM versus Wi-Fi—if any. As Miyazaki explains,

> rhythmanalysis of wirelessness would examine the highly technical processes and rhythms happening in those agencements of information by conducting a media technologically enhanced rhythmanalysis and by creating a systematic ordering of the noises, beeps, blips and pulses . . ., not only [by] listen[ing] to them, but also . . . explain[ing] their becomings [5].

A rhythmanalysis of network communications requires an understanding of the information responsible for the happening of a given connection.

Further, it is essential that a rhythmanalyst has access to the "systematic ordering" of the particular sounds produced, to attempt a proper explanation of "their becomings" [5]. The problem with such an exercise is the fact that the listening device available at the time of this study transduces a wide range of frequencies, which is too broad for its purposes. As per the AD8313 (the transducer chip installed in the Detektor) data sheet [10], the wide bandwidth covered by the Detektor is 0.1 GHz to 2.5 GHz. Accordingly, it is rather difficult for one to determine what particular sound corresponds to what particular network, when the layers of sonification cover a multitude of networks simultaneously connected. It is also worth noting that the most advanced Wi-Fi technologies—currently on the market—function at a 5 GHz frequency range, which means that they remain outside of the transduction ranges of the Detektor. Given the prominence of Wi-Fi communications in the wirelessness of everyday life, leaving its EM waves outside of listening exercises possibly leaves out the most dominant traffic of network communications, and the most condensed of networks.

Peter Krapp argues that "[w]hen recurring noise patterns become signal sources as their regularity renders them legible, the systemic function of distortion doubles over as deterioration of message quality and as enrichment of the communication process" [11]. Correspondingly, noise and noise patterns gain significance—signal—when they become regularly repetitive, whereby failure—distortion—simultaneously affects the message as well as enhances communication. Reduced and causal listening, unlike semantic listening, do not attempt to make (human) meaning out of given sounds, but focus on apprehending—and eventually comprehending—the communicative process between technologies and amongst networks. If a listener is to cognize sound as noise until it acquires a pattern, they risk missing the brief yet significant technological happenings. However, having a crowded sound clip that is rich in both event points and event patterns, without a clearly organized network organization, confuses the output between sound and noise, and thus contributes to fictional—and possibly forceful—construction and attribution of meaningful signals. In other words, a rich sound clip does not necessarily suggest enhanced network communications, particularly because the range of transduced frequencies and their layering may induce patterns that are naturally corruptive to our understanding of the process.

The multiplicity of sounds and their collisions could be collapsing sound and noise, which defeats the purpose of reduced listening and interrupts causal listening. Notably, the presence of a multitude of signals is essential to wireless communication. Comparing wireless communication to wired communication, Adrian Mackenzie explains that "[i]n wireless communication, nearly all signals are marked by the presence of other signals. The situation is overwhelmingly relational in comparison to the relatively narrowly constricted flows of networks" [12]. Thus, based on the indispensable yet non-constricted signal traffic, I argue that attributing individual causes to individual sonic events is irrelevant in open environments; rather, an exposure to the acousmatics of an infrastructure allows for a sensible access to the rhythms inherent to the multitude of algorithms, which are at play—power play for one—in making network communications possible.

5. CONCLUSION

To perform reduced listening is to listen with the intent of creating words to talk about sounds, describing what we can hear, with as much detail as possible, without taking into consideration the causes behind the sounds produced. On the other hand, causal listening requires the listener to identify particular causes behind the particular sound events. As demonstrated above, performing reduced listening to sound clips of transduced EM waves results in interesting and exciting findings that lead us to expect a lot of information. However, when attempting to exercise causal listening onto the same sound clips, particularly those involving higher frequencies and waves of network communications, it remains difficult to identify exactly what sources are causing what sounds. Semantic listening remains impossible at this stage of the project, especially given the lack of knowledge that people have in making meaning of the transduced waves exchanged during streams of network communications.

The many layers of sounds and the various simultaneous rhythms are the result of the wide frequency range that the Detektor captures and transduces. Despite providing an idea of what network communications sound like in the ambient environment, the sonic congestion of the clips results in many ambiguities and raises various questions about the differences between the various types of networks. Exploring networks as a system of algorhythmic interactions allows people to approach network communications as a series of events, as they translate computational rules into vibrations that travel our ambient environment. These rules and algorithms are defined by a logic of power and control that not only regulates how the technologies we use and on which we rely communicate, but more importantly how *we* are to interact *with* and *through* them. As we hear them, our technologically realized actions produce and reiterate rhythms that redefine the natural space as inhibited by ubiquitous networks.

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