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Rhizomatic Abstraction: Composing Music to Investigate Memory Patterns Among Listeners

An Expected Introduction

What makes an experience memorable, and what is it exactly that we recall when we remember a moment in time? Memories of significant moments are accompanied by an emotional profile, which we have evaluated as either positive or negative. Emotion is a dynamic force that directly affects our everyday cognitive processes, such as attention (Vuilleumier 2005), learning, and memory (Phelps 2004). The experience of listening to, evaluating, and remembering music is inescapably intertwined with this process of emotional appraisal. So what do we, as listeners, recall after a listening experience? To understand this question, one must become acquainted with how we process aural stimuli.

In recent history, there have been inspiring developments in the realm of music and memory, including neurocognitive experiments that might not have been possible earlier. These experiments and research have opened the door to a common thought: Can composers utilize the information from this research in their compositional process, and, if so, to what degree? The implications of psychoacoustic and cognitive research on the creation of contemporary music are at the heart of the fixed-media electroacoustic sound installation entitled *Rhizome*.

Rhizome was inspired by Gilles Deleuze and Félix Guattari's *A Thousand Plateaus*, the introduction to which is titled "Rhizome." As they explain, "There are no points or positions in a rhizome, such as those found in a structure, tree, or root. There are only lines" (Deleuze and Guattari 1987, 8). This concept of a non-linear network is a core structural feature of *Rhizome*, purposefully used to elicit specific qualitative responses from listeners. To meaningfully convey the reasoning behind the construction of *Rhizome*, we must first examine the existing research into how and why we process and remember the sounds around us. I will therefore provide a brief exposition of research on expectation, consonance, dissonance, rhythm, and time in this context. I will then present the details of the listening experiment and the composition of *Rhizome*.

How We Work

When evaluating our cognitive functions, it is vital and inescapable to do so from an evolutionary perspective. The aspects that define cognition evolved to preserve life, adapting to external and uncontrollable forces to maximize the potential for survival. Any sensory input (even the most innocuous) results in some degree of emotion, both triggered and appraised by the subject, subsequently being rehearsed and encoded or discarded. At the forefront of any experienced stimuli is the expectation, or lack thereof, of its presence in our experience. As David Huron states in his seminal work *Sweet Anticipation*:

> The story of expectation is intertwined with both biology and culture. Expectation is a biological adaptation with specialized physiological structures and a long evolutionary pedigree. At the same time, culture provides the preeminent environment in which many expectations are acquired and applied. (Huron 2008, 8)

Huron identifies and distinguishes five emotional response systems that accompany our expectations. He calls the collection of these response systems the ITPRA theory, the purpose of which is to describe the biological function of each type of response to expectation (Huron 2008, 15). These responses form a timeline of before, during, and after the onset of the evaluated event, and in each response system there is some form of emotion or feeling present in the subject. The ITPRA theory systems can be described as follows:

— **Imagination Response:** Imagine all the possibilities of what may happen.

— **Tension Response:** Peak physiological arousal and attention in preparation for what we anticipate will occur.

— **Prediction Response:** Appraisal of whether our prediction was correct or not, and subsequent positive/negative reinforcement to encourage accurate formation of future expectations.

— **Reaction Response:** Fastest neurological response, which assumes an assessment of the outcome from a worst-case scenario.

— **Appraisal Response:** Full, complex neurological assessment of the true outcome. Outcome and results are then evaluated with positive/negative reinforcement (Huron 2008, 16).

The presence of these response systems is natural and inescapable anytime we dedicate our focused attention to a piece of music. No matter the genre, instrumentation, or venue, every listening experience we engage in is affected by the presence of our expectations and our responses to musical outcomes. It can be assumed that the emotional content of our response is fully appraised only after we have engaged in the Appraisal Response to the stimuli. The reason for this likely lies in the fact that our Reaction Response is hardwired to activate an incredible amount of physiological arousal, expecting the worst, but in the moments immediately following our Reaction Response, we can fully appraise what we have just experienced. Musical examples that take advantage of our Reaction and Appraisal responses have existed for hundreds of years, for example this well-known passage from Haydn's 94th Symphony, nicknamed "The Surprise":

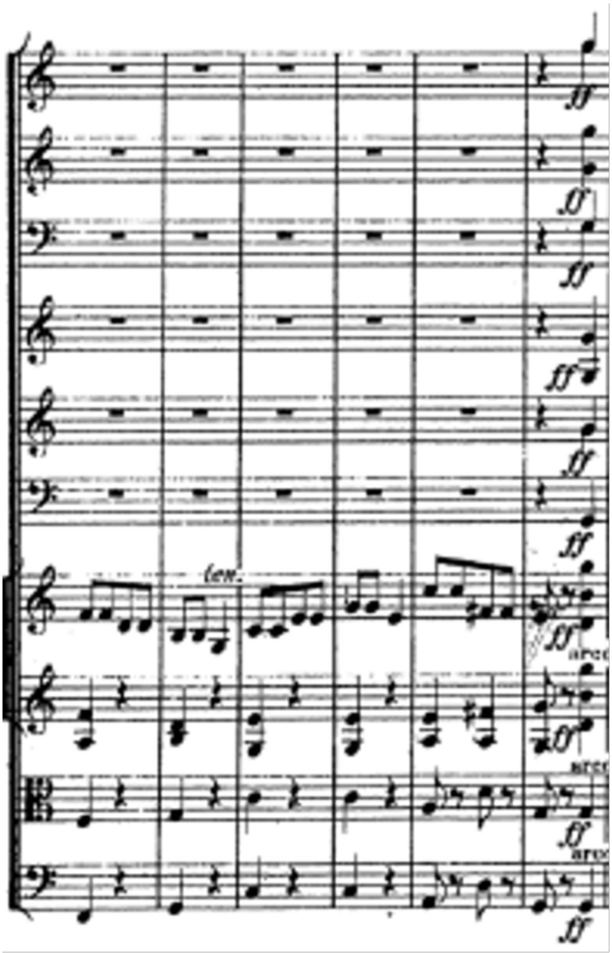


Figure 1: Measures 11–16 of Haydn's Symphony No. 94, Movement II Andante. Copyright Edition Peters.

There is no doubt why this symphony received its nickname. In the Andante movement, Haydn boldly subverts the expectations of the listener by inserting a fortissimo G major chord utilizing the full orchestra. This moment is particularly potent as it is preceded by a pianissimo string section, which itself is preceded by the first phrase cadencing at a piano dynamic level. Therefore, where the audience may expect a continuation of the already established diminuendo echo pattern of the original phrase's cadence, they are instead delivered the first instance of the full orchestra used in the movement at a fortissimo dynamic level. Was Haydn aware of the rapid Reaction Response, which is triggered by a surprising event and originates in the thalamus (Huron 2008, 19)? The answer is likely yes and no; the basic principles of tension, expectation, and fulfillment have been an integral part of constructing formal solutions and frameworks in Western classical composition for hundreds of years. What is new is our understanding of these phenomena through the perspective of neuroscience. Regardless, what is clear in this example is the composer having an intended audience response and utilizing his experienced human cognition to create an incident so subversive that it is the namesake moment for the entire symphonic work.

This Haydn excerpt is an obvious and neat example of composing with cognition in mind, with particular regard for expectation and the emotional effects of its subversion. However, the context in which a living composer shares their work contains a multifaceted collection of differences from when Haydn first shared his "Surprise" Symphony with late-18th-century London. Composers now, and only more so in the future, have a nearly unquantifiable amount of sounds, technologies, and venues that they can use to communicate their works to an audience. This sheer amount of sonic capability yields massive opportunities for the modern composer to subvert, redefine, and tease the expectations of the attentive listener. This wealth of creative materials also calls into question the manner in which the composer may approach the structuring of the piece, wherein every option is accompanied by procedural challenges and yields consequential effects upon the listener's experience.

Additionally, it is now also known that the brain can respond to the onset of an event that does not occur (Snider and Large 2005, 117–126). This indicates that the vast breadth of sonic and formulaic capabilities available to modern composers possesses equal importance in their absence as when they are expected. Physiological arousal emerges during the Tension and Reaction responses and has a great impact when expectations experienced consciously or unconsciously (Meyer 1956, 24) are appraised as unfulfilled or incomplete. This means that within all the sonic capabilities available to composers, there are also innumerable options for subversion, which can be just as or more impactful than the fulfillment of audience expectations.

Now that the role and importance of expectations upon our emotional responses to stimuli has been established, we can examine the qualities and aspects of music itself from a similar perspective. For any composer instructed in the Western classical tradition, terms such as melody, pitch, consonance, and dissonance are commonplace and mandatory in the discussion of theory and analysis. However, analyzing the phenomena of consonance and dissonance through a psychoacoustic lens yields a broader situational understanding that extends beyond the dogmatic constrictions of functional harmony and theory.

Melody often has prescribed dramaturgical and hierarchical importance in classical music (Forte 1979, 203), but within the context of psychoacoustics, it is plainly defined as experiencing a sequence of pitches as one gestalt (Radocy and Boyle 2003).

Melodies are seen as coherent units rather than separate tones (Tan, Pfordresher, and Harré 2010, 74). In *Psychology of Music*, Siu-Lan Tan, Peter Pfordresher, and Rom Harré further analyze the constituent elements of melody: pitch, interval, contour, harmony, and key. Since *Rhizome* exists outside the realm of melodically driven, harmonically functional composition, we need only briefly discuss the definitions and significance of consonance and dissonance within psychoacoustic research and general cognition.

German physicist and physician Hermann von Helmholtz published the first edition of his foundational work *On the Sensations of Tone as a Physiological Basis for the Theory of Music* in 1863. In this work, Helmholtz provided a scientific approach to gauging the extent to which simultaneously sounding tones (called a harmonic interval) sound pleasing or displeasing through the comparison of their partial tones (Helmholtz 1954). He covers a breadth of information regarding vibrations (frequencies), partials (harmonics), and the qualities resulting from the combination of tones, such as the "order of consonances in respect of harmoniousness" (Helmholtz 1954, 284):

> [T]he minor Second C Db and the major Seventh C B, which differ from the Unison and Octave by a Semitone respectively, are the harshest dissonances in our scale. Even the major Second C D, and the minor Seventh C Bb, which are a whole Tone apart from the disturbing intervals, must be reckoned as dissonances, although, owing to the greater interval of the dissonant partial tones, they are much milder than the others. (Helmholtz 1954, 285)

Helmholtz was the quintessential forerunner of an approach to consonance and dissonance as subjective phenomena influenced by the physics of each fundamental tone and its corresponding partials. A later work, R. Plomp and W. J. M. Levelt's *Tonal Consonance and Critical Bandwidth*, reinforced and expanded on the findings of Helmholtz. Plomp and Levelt argued that intervals are evaluated as consonant due to frequency differences exceeding critical bandwidth (Plomp and Levelt 1965). This critical bandwidth refers to a range of frequencies that evoke a similar response in the auditory system (Tan et al. 2010, 33). The tonal intervals that correspond to frequencies of about a quarter of this critical bandwidth were appraised as being the most dissonant (Plomp and Levelt 1965, 560).

So, instead, it seems that our auditory system responds similarly (e.g., with a similar cochlear response) to frequencies close to one another; frequencies that evoke a similar response are said to fit within the same critical bandwidth. In some cases, this "shortcut" of the auditory system can influence our perception of music. The most prominent example of this is musical dissonance (Tan et al. 2010, 33).

These studies are significant in their analysis of physiological reactions to isolated relationships between pure tones, but, as we know, there is a greater amount of information present in the tones one experiences in a concert setting. The loudness (or intensity) of tones, their complexity (timbre), and their context within the total duration of a piece and of themselves are all consistently present factors in any tone communicated during a piece of music. These characteristics, along with an individual's cultural background and personal physiology, point to the inevitable degree of subjectivity in any individual's appraisal of an interval as consonant or dissonant. Nonetheless, the physiological implications of the abovementioned studies give us a foundation

for how a composer may understand consonance and dissonance outside the setting of functional harmony.

Now that we have touched upon the foundations of consonance, dissonance, and single-event-based expectation within the context of psychoacoustics and cognition, we can move deeper into the discussion of how we experience these elements in time. When dealing with the concept of musical time, it is necessary to explain its components, in this case to highlight the role cognition has on our perception of rhythm and the absorption of musical information through time.

As with consonance and dissonance, one may find it deceptively difficult to confidently pinpoint a concise definition of the term "rhythm." Tan et al. define rhythm as "the time pattern created by notes as music unfolds over time. More specifically, rhythm is a set of time-spans that elapse between note onsets... Importantly, it is *onsets*, and not note durations, that determine rhythms" (Tan et al. 2010, 96).

This definition permits the analysis of rhythm as the ratio of time between note onsets, avoiding any dramaturgical or emotional influence upon its definition. In its essence, rhythm creates time (Epstein 1995) through our processing of its presence into pattern(s) and our association of onsets and our expectations of structure. The pattern of onsets and their ratios to one another has a direct effect not only on the listener's expectation(s) but also on their accuracy of pitch content evaluation. In one test, listeners were presented with a "standard" tone and instructed to retain it in their memory (Jones, Moynihan, MacKenzie, and Puente 2002, 313–319). Following this, a series of "distractor" tones were presented. Lastly, the listeners were presented with a final "comparison" tone and asked to determine whether or not the pitch of the "comparison" tone matched the "standard" tone. Listeners in this experiment were most accurate in judging the pitch of "comparison" tones, which occurred at expected moments in time, and least accurate with those presented at unexpected moments in time (subverting the established rhythm of the distractor tones). It is worth noting that this tendency dissolved when the rhythm of the "distractor" tones was irregular. Thus, the subversion of rhythmic expectation can directly affect the accuracy of a listener's recollection of previous information and unfolding tonal relationships because the listener uses rhythms to target attention to forthcoming points in time (Jones 1976).

The paradigm of comparing tone onsets to interpret musical timing goes beyond the boundaries of any fixed pattern or ostinato figure. As composer Gérard Grisey explains in his article "Tempus ex Machina":

> I believe the composer who wants to give time a musical value must focus on this point. It is no longer the single sound whose density will embody time, but rather the difference or lack of difference between one sound and its neighbor; in other words, the transition from the

> known to the unknown and the amount of information that each sound event introduces. In his class, Olivier Messiaen said that it was necessary to have at least two sounds, or a silence and a sound, so that there would be music! (Grisey 1987, 258)

It is through this method of assessing how listeners interpret musical time that we can unlock a creative space to explore how they experience and define time within a musical context. Grisey continues:

> Thus, for example, an unexpected acoustic jolt causes us to skate over a portion of time. Sounds perceived during the ensuing moment of readjustment—a moment which is necessary for us to regain a relative equilibrium—no longer have anything like the same emotional or temporal value. This jolt… which leaves a violent impression in our memories, makes us less likely to grasp the shape of the musical discourse… On the other hand, a series of extremely predictable sound events gives us ample allowance for perception. The slightest event acquires importance. (Grisey 1987, 259)

Although this interpretation is proposed by the composer from his personal creative viewpoint, it broadly implicates aspects of research regarding cognitive responses to music that we have explored thus far. According to Huron's ITPRA theory, when we experience a completely surprising moment, we engage at least two systems of response: Reaction Response and Appraisal Response. The Reaction Response is immediate, involuntary, and as quickly as possible ensures that we are physiologically aroused by the situation. In the moments directly following this reaction, we engage in a clearer and more detailed appraisal of what we have just experienced. I believe it is this cognitive process that leads to Grisey's concept of "skating over time," as our systems automatically dedicate time to sorting the surprising/unexpected information before reengaging focus on new incoming information. This event creates a landmark in the listener's mental landscape of their experience while simultaneously pointing to how our attention and processing can be uneven, privileging the processing of emotional and surprising moments (Öhman, Flykt, and Esteves 2001).

Musical pieces that engage our system through the timing of sounds that are not overtly tonal are also of interest. Drummers can express a wide range of emotions simply through the use of onset patterns, void of any overt tonal variation (Jones 1976). The fact that unpitched percussion performances can engage our senses on the same level as a work for orchestra highlights the considerable importance of not only pitched onsets but any sonic onset, both of which can shape our concept and remembrance of the piece.

Our memory of listening experiences is thus influenced by our physiological reactions to expected/unexpected events, our perception of consonance and dissonance, and the organization of sound material into elements such as

rhythm. Unexpected moments leave a notable landmark in the memory of the listener, regardless of how they are valenced, and result in an immediately subsequent window in time in which our system is unable to deeply analyze successive stimuli. How we perceive and categorize pure tones as consonant or dissonant has a strong basis in the relationship between the partials of both tones but ultimately is a continuum that is subjective to the context of the piece and to the individual experiencing it. How we recall the musical time of a work is largely defined by the amount of tone/event onsets present, whereby our system attempts to categorize any rhythmic structures it deems present. This, in turn, further influences our expectations of the temporal placement of future onsets, our attention to which can be effectively guided or misguided by our expectations.

It is from these main points that the concept for *Rhizome* materialized. How can a composer utilize these cognitive processes, patterns, drawbacks, and insights in their work in a similar way as if they were employing standard compositional devices rooted in the Western classical tradition? What if the composer, rather than utilizing standard Western classical formulas such as the sonata form, constructed their series of sonic events according to the memory trends of listeners? How many sonic situations and approaches might arise from composers utilizing this data, and how might it provide them with a broader compositional scope? I believe the answer begins with experimental composition, and, in the case of *Rhizome*, through a sound installation wherein participants would be provided with surveys that they would fill out following their listening experience.

Composing *Rhizome*

Rhizome contains 10 minutes of sonic events composed of 60 individual samples, comprising a spectrum of sounds from purely acoustic raw recordings to entirely synthesized sounds. Of these 60 samples, I appraised seven of them as being resolutely consonant, with three more being undefined but leaning toward consonant. I classified 18 sounds as resolutely dissonant, with 13 more being undefined but leaning toward dissonant. I evaluated the remaining 19 as being purely indeterminate. I appraised the sonant quality of the samples by gauging the relationships of coherent fundamental tones and harmonics, the degree of any perceptible tonal center, the degree of tonal ambiguity, the amount of indeterminate sound, and the noisiness of the sample.

Rhizome's 10 minutes of material is arranged to be perceived as having no true beginning or ending. This is done through a series of compositional choices. The first creative choice is the lack of sample repetitions (besides two low subwoofer pure tone resonances) as repetition is foremost among memorable devices within any type of music (Storr 1992, 21–22). Next, a high amount of diversity among sample characteristics, relative lack of melody, and complete lack of any melodic repetition avoids the standard organization of sounds

employed by the brain (Levitin 2006, 14). The goal was to predispose the piece as being only as long as the listener chooses to experience it, meaning the listener could have a coherent listening experience no matter when they enter or exit the sound installation. The 10-minute length was essential for me to keep track of the length of time each listener spent within the sound installation, to note if they experienced any repetitions of sound samples. Ultimately, all participants except one stayed longer than 10 minutes, meaning nine participants experienced a repeated hearing of certain samples. Since our ability to hear repetition lends a sense of order to a work of music (Tan et al. 2010, 80), keeping track of this was of the utmost importance.

The imbalanced proportion of sounds sourced from acoustic and/or potentially familiar sources to synthesized sounds was done with the purpose of exploring whether the relative scarcity of the acoustically sourced sounds would contribute to their being highlighted more often within the listener's experience. Within these acoustically sourced sounds, I created a roughly equal mixture of consonant and dissonant samples. This was done to examine whether the pure emotional response to the presence of sounds with potentially familiar sources would be more or less potent than the effect of the appraised consonance or dissonance of the sound content itself. These samples included: a solo female voice, a chaotic improvisatory choral passage, a sample with a quasi-liturgical style female singing with organ drone, an orchestral hit, a room-tone recording, and two solo organ samples (sample 1 here; sample 2 here). How often would the audience respond that their most vivid recollections were of the acoustic samples? Would the relative consonance or dissonance play a further role in which sample(s) are recalled? Or on the contrary, would any of the most unfamiliar/deeply synthesized samples trend among the listener's vivid memories due to their striking timbres, volume levels, or lack of predictability? Would these unusual sounds become even less focused due to their prevalence and lack of repetition?

Dissonant	Undefinable	Consonant
31	19	10

Figures 2A and 2B: The Logic file and categorization of samples for *Rhizome*.

The use of silence also presented opportunities for exploring the memory trends of listeners. Placed non-formulaically throughout the work are pauses between sounds at moments that I expected to be notable or inconspicuous. Since silence can sometimes feel just as conceptually "loud" as moments of high volume (Margulis 2007), I wanted to incorporate the use of unexpectedly

long silences to determine if they would contribute to accentuating the succeeding sample. The average length of pauses between samples in *Rhizome* is between three and six seconds, with purposefully longer ones approaching or reaching 10 seconds in length. Along with their hypothetical accentuating quality, I was particularly curious about how these silences could help shape the musical time perceived by listeners. I never placed the silences symmetrically with one another in order to ensure they could not overtly recommend any type of form to the listener. This was done further to avoid patterns of regularly timed events or synchronizing trends.

Designing the Experiment

Rhizome was constructed as a sound installation, which was delivered in two formats. Both setups utilized a 4.1 sound system located in an acoustically untreated room, the Gothic Tower of the Academy of Performing Arts in Prague.

In the first format, the composition was allowed to loop continuously for two time windows, each totaling 50 minutes. During these windows, listeners could enter and leave the space at will, staying to experience the installation for however long they desired. Upon exiting, these listeners were provided with a questionnaire that gathered basic demographic information and provided the following questions:

— Do you have prior formal music training? If so, indicate your level of experience and/or how long you are studying/have studied.

— What did you expect coming into this experience?

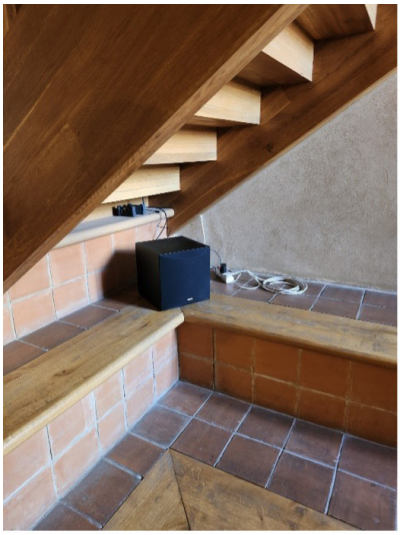
— How would you describe what you listened to?

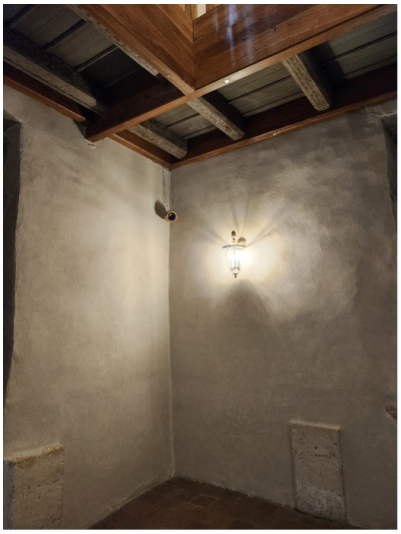
— What do you think the meaning or idea of the sound installation is?

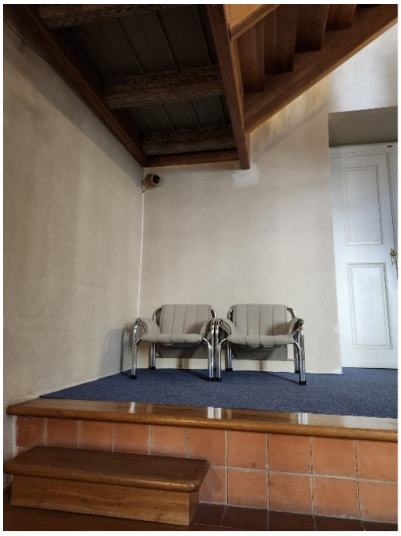
— What emotions did you experience throughout the listening experience?

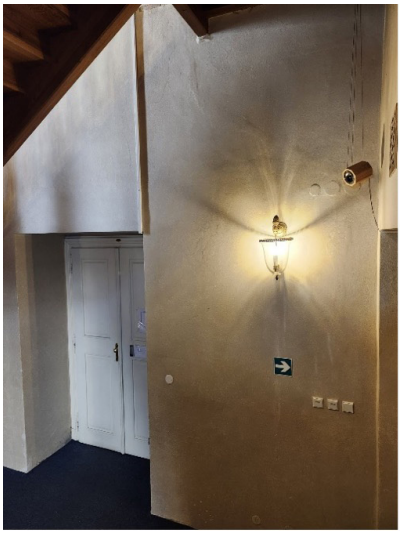
— Please describe the most vivid memories/moments of the listening experience, beginning with the strongest one(s) that remain in your memory.

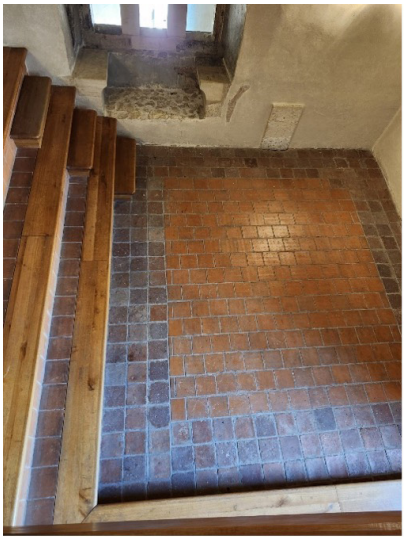
In the second format, three individual listeners were invited to experience the sound installation alone. They had the same freedom to exit the room at any point they desired, but all three experienced the work as beginning from the same point in time (the beginning of the sound file). Following their exit, the sound file was paused, and a one-on-one interview was conducted with each participant, ranging between 30 and 45 minutes. The amount of time each participant in both formats spent inside the tower was recorded by me as I stood outside the room, noting their entry and exit times.











Figures 3 to 7:
Photos of the AMU Gothic Tower.
Photo John Franek.

Both formats featured the same version of the composition. The length was chosen roughly with the lower end of concert works in the contemporary art music tradition in mind. This length enabled a greater likelihood of participants' experiencing the majority of the sound samples and opened the possibility of introducing repetition into the study of audience responses.

The Results

Of the 10 participants, six had achieved formal musical training ranging from a Bachelor's to a PhD degree in Music Composition or Music Theory. The remaining four participants all possessed some level of musical education between elementary/grammar school and some years of private instrumental study. The overview below of participant data features their educational background regarding music, length of listening sessions, and most vivid recollection(s). Instances of "University Degree" indicate a degree in Music Composition or Music Theory. For participants with multiple memory responses, the answers are listed in order of salience.

	Musical Training	Time Total	Most Vivid Memory
Participant 1	University Degree	13 minutes	Oscillators Pure Tones Voices
Participant 2	University Degree	17 minutes	Wide collection of synthesized content
Participant 3	Some private instrumental lessons	13 minutes	Solo woman's voice
Participant 4	Tonmeister degrees, instrumental lessons	38 minutes	High-pitched Sine Tones
Participant 5	General knowledge, instrumental lessons	27 minutes	Collection of synthesized content
Participant 6	Grammar school, basic knowledge	25 minutes	Solo woman's voice
Participant 7	University Degree	7 minutes	Presence of Vocals Raw quality of synthesized material
Participant 8	University Degree	13 minutes	Choir sample + loud sound
Participant 9	University Degree	19 minutes	Female Voice Synthesized Buzz High Pitched Sound
Participant 10	University Degree	14 minutes	Vocals + Ambient Noises Synthesized Effects Choir sample

Figure 8: Overview of Participant Questionnaire and Interview Responses.

Of the responses of the 10 participants, seven included the presence of a sample that contained the human voice, four of which (participants 3, 6, 9, and 10) indicated the same sample of the solo woman's voice. Each of these participants was present either from the beginning of the sound installation time window in the public format (3 and 6) or listened to the sound file from the beginning in an individual session (9 and 10). This indicates that all four of these listeners would have encountered this sample for the first time 13 seconds into their listening experience. Because of their respective times spent inside the installation, all of these participants would have experienced this sound sample twice. It is worth noting that Participant 9 did not realize that the sound installation had repeated until the presence of the solo female voice sample.

This particular sample is not only one of the few purely acoustic sound files in *Rhizome* but is relatively simple, containing only two notes a whole tone apart in a repeated gesture sung by a single female voice. In other words, this sample contains high consonance, familiarity, low complexity, and repetition. Like all other consonant samples, whether acoustic or synthesized, it is preceded and followed by dissonant synthesized samples. The other acoustic sample, which was specifically identified (participants 1, 8, and 10), was the chaotic and dissonant improvisatory choral passage. Among the rest of the sounds, both acoustic and synthesized, consonant and dissonant, no other sound sample was identified more than twice as among the most vivid memories of the listening experience of the participants.

Five of the 10 participants reported that they felt "calm and relaxed" during the listening experience. These participants had a mixture of university-level and amateur musical training. Only Participant 6 expressed "fear" as one of the emotions experienced throughout the listening. Participants with prior experience of attending sound installations commented that they were expecting something akin to past installations they had attended. Participants without prior experience of attending an installation all commented that they had no specific expectations for what they were going to experience. Participants' concepts of the meaning of the installation and descriptions of what they listened to were entirely subjective and unique to each responder.

Summary and Conclusions

The findings of this experimental composition project both confirmed and subverted my expectations about the audience's reactions to and memories of the work. It seems that the state of constant abstraction, flux, and lack of predictable music content influenced a generally relaxed, meditative reaction among the listeners. Although there was a general trend for university-educated listeners to approach the experience from an analytical point of view, this calming, introspective, and pensive experience was reported equally among participants with and without conservatory training. The absence of dramaturgical and hierarchical musical elements, which usually guide our

expectations, such as melody (Levitin 2006, 115), overt repetition, and form (Tan et al. 2010, 77), in conjunction with consistently juxtaposing samples with disparate sound sources, influenced the introspective quality of the experience for the listeners. However, calculated moments where I expected surprise among the participants did not trend among the self-reported memories of the participants. It was rather the moments of familiarity or simplicity, particularly the rather gentle solo female voice sample, that trended most frequently among the self-reported recollections of the listeners. This trend is seen to be equally present in the groups with and without conservatory-level training.

The experiment gave rise to a handful of ideas, the further elaboration and explanation of which will require follow-up experimental research. One aspect I consider to be highly influential upon the results lies in the balance of sound types in the work. With such a notable majority of synthesized sounds, distinctly unique, and leaning away from generally prescribed consonance, I have summarized that the weight of this type of musical data led to an emotional and personal highlighting of the samples utilizing the human voice. Additionally, I believe that this notable majority of varied synthesized sounds contributed to a diminished effect upon their notability within the audience's recollections. Perhaps the limbic systems (Jäncke 2008) of the participants were engaged in a higher level of activity upon the recognition of this human voice, inspiring a mental note of reprieve among the more common onsets of unfamiliar sounds.

At present, I am left to ponder whether the responses to the same work would have included relaxation if the human voice was removed. If the work possessed the same sample sounds and order but lacked the presence of the human voice, would the listeners have reported the same level of meditative relaxation? Further, it was the simplest of the samples using the human voice, which was specifically recalled, raising the importance of complexity in this equation. I suggest that there may be a "consonance of alleviation" experienced by listeners in this context, in which the familiarity of the timbre caught their attention, and the relative simplicity of the musical information being shared added to the reprieve their systems felt in the context where they were unable to predict what sound would come next.

It is worth noting that all of the listeners who reported this sample heard it twice, whether or not they realized that the piece had looped. It is of great importance, though, to note the nearly equal presence of the discordant choir sample among the audience responses. Since it contains a great deal of discordant sonic information in a short amount of time, deeply contrasting with the content of the solo female voice sample, its rate of presence within audience responses leads me to believe that the rare but present human voice within the piece was particularly memorable. What if such a compositional technique were applied to a 30-minute orchestral work? For example, what if, at one or two points during a 30-minute work for orchestra, every other instrument came to rest, and the only sound was that of a single human voice? Might such a moment rate highly and commonly among the vivid memories of the audience members?

Among the synthesized content, two participants responded with a vivid recollection of the sine tones used in the work, which are fundamentally the simplest of all the synthesized content regarding aural information. This speaks to an already well-known principle of cognition in which an instance of less or simpler information is easier to recall than a moment of complex information. I find it quite possible that I, as the creator of the work who experienced each sound many times, may have appraised some sounds as "simple" when indeed their synthesized nature alone provided the listener with much more to process than I anticipated. The synthesized content also displayed the beautiful subjectivity of the personal tastes of audience members. The sheer diversity in participant responses among their memories of synthesized sounds displays quite succinctly the breadth of subjective, unique responses humans can have to their reception of information and experiences.

Rhizome has verified to me that one of the finest opportunities for experimentation and audience evaluation lies in the qualitative study of audience memory following a focused listening. This is one of the greatest gifts for composers as the vessel for our research becomes our composition itself, a concept that implicates the extent to which artists can create a meaningful work, whether it is performed in the concert hall or used to conduct qualitative research (two concepts that are not mutually exclusive).

The opportunities for this type of experimentation can also only increase, as there is still much that has not been overtly discovered or fully developed about understanding our emotional and cognitive responses to music. It is, for example, still not clear whether the "emotions" associated with music are the same as emotions defined in the broader psychological sense (Juslin and Västfjäll 2008) or if music generates emotions only through extramusical associations (Konečni 2008). As neurocognitive research continues to illuminate the inner workings of our brains in response to aural stimuli, it seems only natural that there will be more opportunities for composers to explore approaches to composing with cognition in greater detail:

> Music is prophecy. Its styles and economic organization are ahead of the rest of society because it explores, much faster than material reality can, the entire range of possibilities in a given code. It makes audible the new world that will gradually become visible. (Attali 1985, 10)

It is my hope that this type of composition and experimental listening may be cultivated by individuals and communities around the globe. Experiments that stem from the approach used in *Rhizome* may give greater insight into the extent to which memory patterns are diverse or similar among communities.

However, music is unlike language in that the meaning of a foreign language is largely inaccessible to a non-speaker. By contrast, research suggests that music can communicate to the unschooled listener. At the same time, the intention behind music is not fixed. Ultimately, it may be that music binds humanity

together more effectively than language does, while at the same time acting as a vehicle for cultural diversity, just like language does (Tan et al. 2010, 298).

Rhizome is just one step in the journey of exploring the depth of the relationship between our cognition and its influence on our memory. *Rhizome* has provided results that I feel may illuminate some possible avenues for further exploration, particularly on the impact of the human voice on an audience member's memory and emotional reaction to a piece of music that lacks melody and repetition. The deeper that human memory and emotional responses to listening experiences are studied, the more we will determine whether any universal trends transcending culture and societal frameworks exist, and, if so, to what extent. Further, if it is the case that we may demonstrate that any universals exist, this will enable composers to explore new methods of approaching the composition of their musical works. This approach to composition has the potential to encourage fresh ways of approaching musical time, rhythm, and composition as a whole:

> The tree imposes the verb "to be," but the fabric of the rhizome is the conjunction, "and... and... and...." This conjunction carries enough force to shake and uproot the verb "to be." Where are you going? Where are you coming from? What are you heading for? (Deleuze and Guattari 1987, 25)

Within the medium of sound installations, a similar composition utilizing a different balance of samples with appraised consonant and dissonant qualities is a logical next step. In one hypothetical version, the dissonant samples may rank higher in audience recollections due to their greater scarcity. If this is the case, it may show that it is the rarity of less-expected sounds that contributes to their significance for audience recollection. Further, increasing or eliminating the presence of the human voice could lead to further insights into the capacity that familiar sounds and timbres can influence audience memory of a musical work employing synthesized sounds. The current version of *Rhizome* could be replicated with an equal presence of a different culturally common or familiar instrument, assessing whether it is the general familiarity of the sound source or the particular effect of the human voice that leads to this impact upon the listener's memory. It is in these further iterations and variations that we may clarify a deeper understanding of "memorability" among musical contents within a broader collection of sonic situations.

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Bio

John Franek is a pianist and composer who has had performances of his compositions throughout North America, South America, Europe, and Asia, including notable premieres with ensembles such as the Sofia Philharmonic, Janáček Philharmonic Orchestra, Moravian Philharmonic, Pardubice Chamber Orchestra, St. Petersburg Improvisers Orchestra, KLK Contemporary Ensemble, the Brightwork Ensemble, the Lontano Ensemble, FAMA Quartet, Trio Immersio, Syntax Ensemble, laug.sonoris, Hub New Music, Unassisted Fold, .abeceda and TACETi Ensemble. His music has been featured in the 2025 MicroFest Amsterdam, the Saint Petersburg International Contemporary Music Festival, the Grachtenfestival Amsterdam, and the International Computer Music Conference 2024. John's music has also received airtime on Český Rozhlas, Polish Radio, Concertzender and WPRB Princeton. Active as a performer, recording artist, and composer, John's output hosts a collection of acoustic and electroacoustic albums featured on the labels Navona Records, Da Vinci Classics, Edition Wandelweiser and Donemus Composer's Voice. As a sought-after soloist, John has performed on three continents, including concert tours throughout the United States. He is currently a PhD student at the Music and Dance Faculty of the Academy of Performing Arts in Prague.

Abstract

What makes an experience memorable, and what is it exactly that we recall when we remember a moment in time? What do we, as listeners, recall after a listening experience? To understand this question, one must become acquainted with how we process aural stimuli. In recent history, there have been inspiring developments in the realm of music and memory, including neurocognitive experiments that might not have been possible earlier. These experiments and research have opened the door to a common thought: Can composers utilize the information from this research in their compositional process, and, if so, to what degree? The implications of psychoacoustic and cognitive research on the creation of contemporary music are at the heart of the fixed-media electroacoustic sound installation entitled *Rhizome*, which is the subject of this study. It provides a brief exposition of research on expectation, consonance, dissonance, rhythm, and time, and presents the details of the listening experiment and the composition of *Rhizome*.

Key words: neurocognitive experiment – artistic research – psycho-acoustics – fixed-media installation – *Rhizome*

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