

## Comparing the Cognition of Abstract and Representational Structures in Electronic Music

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### Abstract

In this paper, we compare the cognitive processing of abstract and representational structures in electronic music by discussing the results of a listening experiment conducted to gather both in-the-moment and after-the-fact accounts of a listener's experience with a work of electronic music. We focus on two works that, while sharing various structural similarities, adopt significantly different sonic vocabularies. With this study, we aim to understand the type of conceptual associations that electronic music may evoke, and how these associations shape the listening experience. We first offer an overview of existing listener-based studies on electronic music. We then describe the works used in the current study, offering details about compositional programs, underlying themes, form, material and technique, and compare the works at various structural levels. We outline the aims and the method of the listening experiment, and present its results. Finally, we offer a discussion of these results, focusing on the experiential implications of whether an electronic music piece is primarily abstract or representational; these include where the listener situates themselves in relation to the piece, whether the listener is aware of their "listening self", and how narrative meaning is mediated.

### Introduction

As the electronic medium opens music to any and all sounds, the communication between the composer and the listener no longer depends upon a culturally established language of music. Electronic music therefore prompts a unique set of questions pertaining to music perception. The research into what listeners hear in electronic music has a robust history. Composers (e.g., Smalley 1996), musicologists (e.g., Demers 2010), and researchers (e.g., Bridger 1989) have utilized a variety of methods to inquire into the perceptual qualities of experiencing works in this genre. A growing number of researchers today are conducting listening experiments to explore these qualities. In this vein, we have previously presented our findings pertaining to the formation of diegetic affordances (Çamcı and Meelberg 2016), and a gesture-event model of narrativity in electronic music (Çamcı 2016).

In this paper, we focus on two works of electronic music, which were composed in tandem using vastly different sonic vocabularies. Although both works utilize purely synthetic sounds, one of the works stem from the composition of a narrative while the other work relies on a performance-based exploration of perceptual structures such as variations in pitch and amplitude. With this study, we aim to understand the factors that contribute to the cognitive processing of abstract and representational structures in electronic music, and how such structures shape the listening experience.

We describe a study, where 36 subjects were asked to provide both after-the-fact and in-the-moment descriptions of their experiences. We analyse the in-the-moment descriptors on a timeline of the musical track that they correspond to. We then compare descriptors between subjects, and contextualize these within the after-the-fact accounts of the works. We also offer a comparison of these descriptions with the compositional intents underlying these works.

We find that, despite their structural similarities, the difference in vocabulary stemming from compositional intent has a significant impact on how listeners describe their experience of these works. There is a strong preference towards representational descriptors for the piece that emerge from a narrative. We offer an in-depth analysis of how various narratives outlined by participants corroborate in terms of actors, settings and events, and how these relate to the composer's program. Conversely, the work that explores more abstract structures has primarily yielded perceptual and affective descriptors. Comparing the results for the two works, we look at higher-level implications of whether an electronic music piece is primarily abstract or representational; these include how meaning is mediated, whether the listener adopts a first- or third-person perspective towards the piece, whether the listener is aware of their "listening self".

### Related Work

Artists and researchers have adopted a variety of methods to explore the perceptual and cognitive processes involved in electronic music listening (Zattra 2005). A majority of these studies rely on expert analyses: for instance, the composer Simon Emmerson describes a discourse grid for electroacoustic music consisting of a *mimetic discourse*, which evokes imagery external to the musical material, and an *aural discourse* based on sound objects which are free of such associations (Emmerson 1986). Similarly, the composer Suk-Jun Kim offers a framework to analyze the emergence of sound-images in electronic music, where *perceiving* and *imagining* function as the two primary processes of listening (Kim 2010). In another study, the composer Gary Kendall adopts an event-schema model to analyze electroacoustic music, and concludes that there is a continuity between the cognitive processes involved in electroacoustic music listening, and those that give rise to meaning in everyday experiences (Kendall 2010).

Besides such studies that draw from expert analyses, there are also those, such as the one discussed in this paper, that derive perspectives from listener feedback. In the Intention-Reception Project, Landy and Weale investigate how revealing details about a work of electroacoustic music to the listener during the course of repeated listening sessions can

alter the listener's reception of the work (Weale 2006). The study shows that when inexperienced listeners are given dramaturgical information about a piece, they are able to use it to guide themselves through parts of the music that are problematic in terms of access and appreciation. In another example, the researcher François Delalande conducts a listening experiment with Pierre Henry's *Sommeil* to search for consistencies across listening behaviors (Delalande 1998). Based on testimonial analogies from 8 participants, Delalande outlines three types of listening behaviors: taxonomic listening, where the listener focuses on an overall structure; emphatic listening, where the listener focuses on in-the-moment affective perceptions of the work, and figurativisation, where the listener imagines moving and living things that the sounds suggest. In a study that evaluates the behaviours laid out by Delalande, the composer Elizabeth Lang Anderson finds that the listeners often display a tendency to either identify sound sources or label abstract sounds in a generalized manner (Anderson 2011).

### Listening Experiment

As evidenced in these studies, the practically unlimited sonic vocabulary of electronic music opens up a variety of considerations in music cognition that cannot be fully addressed with theories and techniques that apply to more traditional musical practices, therefore necessitating new approaches. Adopting one such approach, we conducted an exploratory listening experiment to evaluate the cognitive processing of abstract and representational structures in electronic music. Electronic music can be broadly defined as music produced using electronic instruments, such as computers, synthesizers, and samplers. There are numerous musical styles that fall under this definition, including Electronic Dance Music genres such as House, Techno and Trance. In this paper, we focus on electronic music compositions that follow an experimental tradition using "analog and digital technologies, concrete and synthetic sound sources, and systematic and intuitive composition strategies" (Roads 2015).

### Aim

With this study, we aimed to understand the ways in which the listeners interpret two works of electronic music differently on the basis of representationality. In a preliminary study, we evaluated our procedure and apparatus, and derived broad descriptor categories based on the responses gathered from the participants. In the main study, we explored how a listener's experience of a work is affected by the abstract and the representational elements in the work; to achieve this, we collected both after-the-fact and in-the-moment accounts of this experience.

### Stimuli

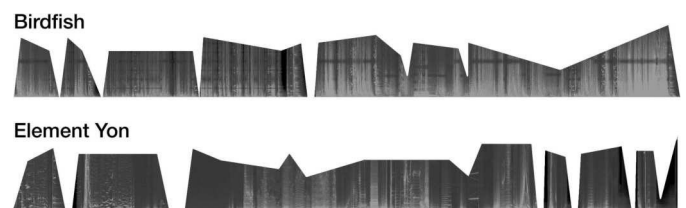
We focused on two works of electronic music composed concurrently by the author of this paper. Although the two works share many structural similarities, the compositional programs behind these works are significantly different. Furthermore, even though both works are composed using purely synthesized sounds, the processes applied to the sounds reinforce the differences in compositional aims. We chose to focus on the author's work to maintain an intimate dialogue

between listener feedback and the author's insights into these works. We attempted to address the conflicts this choice might create by concealing any information about the works from the participants of the study, and subjecting the analysis to peer review.

**Birdfish.** This piece narrates a story of aquatic organisms gradually evolving first into amphibians, and then into avian creatures. This predetermined narrative informed the composition process from beginning to end. The micro sound structures were created through various combinations of multiple synthesis and signal processing techniques. These processes were applied to achieve representational qualities that were intended to instigate visual references. The resulting structures, which range from few milliseconds to few seconds, were then micromontaged to fulfill the narrative arc. Overall, the composition of *Birdfish* was a non-real-time process that relied on complex sound collages rather than performed sections. The work exhibits a relatively clear motivic development, and a climactic ending signifying the transmutation of the creatures into avian form.

**Element Yon.** This piece explores the spectral and dynamic extremes of sounds that, in themselves, do not exhibit much textural or temporal complexities. Relying on markedly synthetic sounds, the piece explores how various contrasts in the domains of pitch and amplitude can be highlighted through macro structuring in the time domain. The piece is predominantly a result of performances with a subtractive synthesizer. The formal structure developed from these performances is intended to obfuscate a motivic progression in style of *moment form* (Stockhausen 1963).

**Structural Comparisons.** The two works were composed concurrently over a 9-month period. Despite the differences in the sound production methods used in these works (i.e. signal processing and micromontaging in *Birdfish* vs. performance with a synthesizer in *Element Yon*), how these materials were sculpted at macro levels show distinct similarities between the two works. Figure 1 shows macro structures of these works, with the spectrogram of each work shown as color variations. The spectrum ranges of both works are similar; however, *Birdfish* utilizes broad-spectrum sounds while *Element Yon* articulates narrow-spectrum sounds from different parts of its spectral range. Both works utilize similar phrase lengths at the gesture level. Furthermore, the macro structures are also of similar length as seen in Figure 1. Another distinct similarity between the pieces is the use and the extent of silence in between structures.



**Figure 1.** Visual representations of the macro structuring in *Birdfish* (top) and *Element Yon* (bottom) with the X-axis denoting normalized durations. The spectrograms (X: time, Y: frequency) of the pieces are shown with colour variations, where brighter colour indicates higher intensity.

## Participants

The preliminary study was conducted with 12 participants (M=10, F=2, average age: 32). The following main study was conducted with 24 participants (M=18, F=6, average age: 28.6). Half of the participants listened to *Birdfish* while the other half listened to *Element Yon*. 4 participants in each group indicated that they had no musical background. The remainder of the participants consisted of students, educators, and professionals in the fields of sound engineering, sound art, and music composition.

## Procedure

Both the preliminary and the main studies were based on a two-section, between-subject design. The studies were conducted one listener at a time, and involved two sections. Each instance took approximately 20 minutes, and was administered on a personal computer with closed-back headphones. In the first section, the listener was asked to listen to one of the tracks in its entirety. No information regarding the piece (e.g., title, composer, duration, period) was provided to the listener in advance. Furthermore, the listener was not given a specific task besides listening to the work. Once the listening was completed, the listener was asked to provide their general impressions about the piece in writing; no restrictions were imposed upon the format or the length of this feedback.

Once the first section was completed, the listener was presented with a browser-based user interface to complete the second section of the study. This interface allowed the listener to type and submit descriptors in real time while they listened to the same track from the first section. Each descriptor was saved in a database with a timestamp.

## Results

The general impressions gathered from the first section of the study were analyzed both individually and in relation to the corresponding real-time descriptors from the second section. Furthermore, the real-time descriptors were analyzed both within piece and across the participants who listened to the same piece.

Birdfish	Element Yon
[water, bubble, splashing, sparkling, fluid, flow, liquid, waves, lake],	[wide spectrum, spectral, high frequency, low frequency, contrast],
[living, creatures, animal, amphibian, bird],	[electronic, oscillators, synthetic, abstract],
[slimy, worm, snail, squishing, insect, swarm],	[unpredictable, unstable, unclear, confusing, surprising, exciting],
[alien, Zerg, StarCraft, sci-fi, Star Wars],	[dangerous, scary, chaotic, argument],
[high tech, robots, electronic],	[painful, irritating, exhausting, annoying],
[granulating, grinding],	[relief, relieving, calm],
[metallic, blades, gong],	[slow movement, stable, still],
[sense of space, cave, water park],	[silence,
bass, dialogue	[science fiction, Tron]

**Table 1. Discourse analysis of the general impressions submitted for *Birdfish* and *Element Yon* with keywords, or keyword groups, that are consistent across 3 or more participants.**

A discourse analysis was applied to the general impressions to determine consistent themes and concepts. General impressions expressed in a multiplicity of formats (e.g. prose, list, drawing) are split into “meaningful sections” (Özcan 2012) in the form of keywords. These keywords were grouped across participants by semantic similarity as seen in Table 1. The format of the general impressions, and how frequently a format was used is seen in Table 2. Multiple formats used by a single participant (e.g. a word list and a drawing) were counted separately.

	Word list	Sentence list	Prose	Drawing
Birdfish	5	4	3	1
Element Yon	3	3	6	1

**Table 2. The rates of occurrence for the general impression formats for *Birdfish* and *Element Yon*.**

The number of real-time descriptors (RTDs) submitted for the two pieces can be seen in Table 3. The descriptors were primarily single words or 2-word noun phrases although a limitation was not imposed on word count. The categories produced from the analysis of the preliminary study were used as an initial guide to categorize these descriptors. Through an iterative process of thematic analysis, these categories were refined and expanded.

	Birdfish	Element Yon
Piece duration	4’40”	3’45”
Total number of RTDs	334	170
Average number of RTDs per participant	27.83	14.16
Average number of RTDs per minute per participant	6.05	3.77

**Table 3. Total and average numbers of real-time descriptors (RTDs) for *Birdfish* and *Element Yon* per participant and minute.**

The resulting descriptor categories are *source*, *concept*, *location*, *affective*, *perceptual*, *onomatopoeia*, and *meta descriptors*. *Source* category includes descriptors that can be prepended by the phrase “the sound of”. These descriptors can indicate objects (e.g., “water”, “bugs”), actions (e.g., “friction”, “explosion”), and musical sources (e.g., “piano”). *Concept descriptors* can be objects or actions; however, they do not refer to sounding objects or phenomena in themselves but might refer to concepts that *imply* such phenomena (e.g., “war”, “science fiction”). *Location* descriptors define imagined spaces other than the one inhabited by the listener (e.g., “jungle”, “cave”). *Affective descriptors* can indicate emotions experienced by the listener (e.g., “curious”, “relief”), binary appraisal of an experience (e.g., “nice”, “cool”), or affective qualities that the listeners attribute to an object (e.g., “weird”, “exciting”). *Perceptual descriptors* denote auditory (e.g., “bass”, “silence”) or non-auditory (e.g., “deep (cave)”, “dark (forest)”) perceptual qualities. *Onomatopoeia descriptors* include words that are formed from sounds (e.g., “boom”, “ding”). Finally, *meta descriptors* refer to the track itself rather than the listener’s experience of it (e.g., “counterpoint”, “granular”).



Once the emergent categories were determined, the category membership of each real-time input was assessed through forced-choice categorization. If a descriptor consisted of multiple words and noun phrases, it was split up into its constituents that would fall under a category individually (e.g. “computers underwater” broken into “computers” and “underwater”). The categorical distribution of the descriptors for the two pieces can be seen in Figure 2. According to this figure, more than half of the descriptors submitted for *Birdfish*, are source descriptors (55.96%). On the other hand, the most salient categories for *Element Yon* are *concept* (28.64%) and *perceptual descriptors* (22.39%).

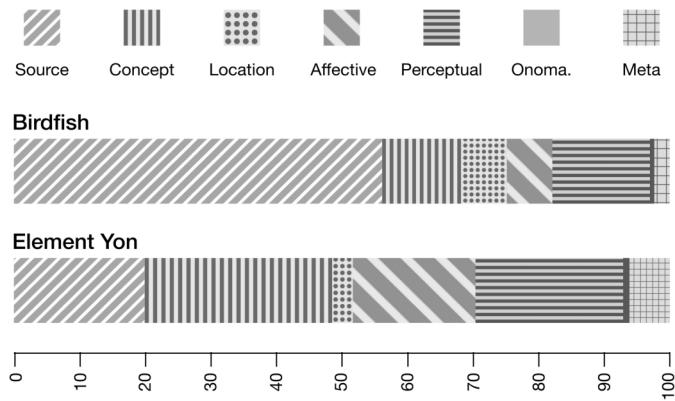


Figure 2. Categorical distribution of real-time descriptors submitted for *Birdfish* (top) and *Element Yon* (bottom).

## Discussion

The results conform to our expectation that *Birdfish*, which is composed of complex sound sources based on an underlying narrative, would prompt listeners to describe their experience in terms of sound sources and visual imagery. With *Element Yon*, which is composed of spectrally generic sounds performed with a synthesizer, the listeners seem to have focused more on the perceptual qualities of their experience, and the abstract concepts these qualities have prompted. Furthermore, the prominence of affective descriptors used to describe *Element Yon* points to a tendency to reflect upon the affective experiences these perceptual qualities have instigated. The noticeable difference in the *location descriptors* category for each piece is consistent with the narratively charged feedback received for *Birdfish*: when describing their experiences, the listeners identified both actors and the environments these actors would be situated in.

The general impressions of *Birdfish* were largely in the form of either word and sentence lists enumerating imagined sound sources, or visually-oriented narratives that recounted a story involving sound sources. The general impressions of *Element Yon* were mostly concerned with concepts, such as “flow”, “hollowness”, “contrast” and “heaviness”, and affective appraisals such as “exciting”, “curious”, “calm” and “annoyed”, as well as the physical qualities of sounds, such as “loud” and “bass”. Impressions of this piece that relate to objects or environments were also highly conceptual, such as “big magnets”, “gravity”, “circus-like”, “a dark metro station”. One participant expressed that “no images came to [their] mind”.

This result can be explained by the dominance of representational imagery in *Birdfish*, which brought about

impressions that relate more to the descriptions of objects and actions. With *Element Yon*, the participants, besides having less to say as evidenced in Table 3, were more inclined to reflect about their affective experience. These results suggest that, despite the structural similarities between these pieces, the sheer difference in how the synthetic sounds were perceived impacted the appraisal of the works on cognitive, perceptual and affective levels.

The collation of the *object* and *action* descriptors under the *source* category was motivated by previous work on sound categorization. In an experiment conducted by Guastavino on the categorization of environmental sounds, the participants often used the source of a sound as a metonym to describe a *sound event* (2007: 55). In another experiment, Dubois et al. similarly found that either source or action descriptors were used by separate participants to classify the same acoustic phenomenon (2006: 867). This behaviour was apparent in the current study as well: for instance, in *Birdfish*, the same gesture was described as “water” and “boiling” by different participants. In another example, the descriptors “fly by” and “bird wings” were used by separate participants to denote the same gesture.

## Identifying a Narrative

As shown in Figure 2, *Birdfish* has commonly prompted source descriptors. This was mirrored in the descriptor lists provided in the general impressions for this piece. However, in addition to such lists, the general impressions have also consisted of narratives provided in prose form. Below are two excerpts from such general impressions:

I heard robotic bugs moving around being commanded by more intelligent robotic beings. There was water, stepping into water, robotic dialogues and also progress made by the robotic bugs in their task. The dialogues were robotic but they had emotion.

The sounds heard and experienced by a baby in its mother’s womb prior to birth, and its eventual coming to earth.

Although the characters and the settings in these two impressions are entirely different, a similar narrative progression can be identified. Furthermore, while the real-time descriptors by these listeners largely adhere to their own general impressions, the similarities in the narrative arcs are evident between listeners in the descriptors that coincide on the timeline of the piece, such as “giving orders” and “talking”; “big cheers” and “volcano”; and “project successful” and “space silence”.

Such narrative structures were much less common in the general impressions submitted for *Element Yon*. From a compositional standpoint, this work can be characterized as consisting of “unstructured musical sequences” (Deutsch 1980). The impact of this quality is apparent in the real-time descriptors, such as “exhausting”, “chaotic” and “confused”. Furthermore, in their general impressions, one participant stated that “sounds without a rhythm made [them] curious but at the same time they were really exhausting”. A moment in the piece which this participant marked as being “exhausting” was marked by another participant as “I repeat and repeat but you don’t get it”. The latter participant had already elaborated on this section in their general impressions when they likened

their experience to witnessing a redundant argument between people. The lack of temporal or spectral patterns has therefore created a sense of futility in the listener's mind.

**Signs of life.** Intonation can be indicative of meaning for both humans (Gussenhoven 2002: 47), and other vocalizing animals (Amador and Margoliash 2013). Even with synthesized sounds, pitch modulations that emulate intonation cues can be expressive of emotion (Scherer and Oshinsky 1978). The rapidly modulated high-resonance filter sweeps used in *Birdfish* were commonly identified by the participants as bird sounds. Similarly, the gestures consisting of rapid frequency modulations of monophonic lines in *Element Yon* were suggestive of an organic origin within the abstract sound-world of the piece. This was evident in descriptors such as “crying”, “scream”, “I guess he is trying to tell us something”, “communication”, and “conversation” submitted by 5 different participants.

**Situating the narrative.** In *Birdfish*, medium to largely sized reverberations and low frequency rumbles are used to establish the sense of a large enclosed environment. These were addressed in the real-time descriptors that identify imaginary environments, which were often in agreement with preceding source descriptors submitted by the listener. A listener who had used such descriptors as “animal” and “water”, submitted “big huge cave” at a later point in the piece. Another listener who identified such sources as “factory noises” and “light saber”, described that same point in the piece with “spaceship”. Two different listeners marked another point in the piece with “dungeon” and “big spaceship” preceded by source descriptors that similarly conform to narratives that transpire in these environments. This indicates that sources and locations identified in the piece tend to reinforce each other's narrative prominence.

**Perceptually driven narratives.** In *Element Yon*, the frequency and damping characteristics of certain sounds instigated such descriptors as “metal balls getting bigger and smaller”, “high tone falls and hits the ground”. Here, distinctly perceptual qualities are situated within metaphors while retaining their embodied relationship with the listener. Another similar example is observed in the responses to high frequency gestures in *Birdfish*, which listeners characterized with such descriptors as “ice”, “glass”, “metal”, “blade” and “knife”. These metaphorical associations imply a cross-modal similarity between high frequencies and the sense of sharpness in terms of perceptual qualities.

### **Sense of a “listening self”**

Spectral and dynamic extremes, such as very high and very low frequencies that are distinctly loud or quiet, can make the listeners conscious of their listening selves. Almost half of the participants who listened to *Element Yon* expressed a form of annoyance with the high frequencies with such descriptors as “disturbing”, “annoyed” or “irritating”. Furthermore, three quarters of the participants marked the rests in the piece either by pointing out the pockets of silence themselves, or by describing the relief these induce. While *Birdfish* incorporates high frequency gestures comparable to those in *Element Yon*, only one participant used the descriptor “harsh high” to indicate a similar annoyance. Furthermore, although the silences are structured very similarly between the

two pieces, none of these silences were denoted as bringing relief in the context of *Birdfish*. This indicates a variation in engagement with perceptual qualities of a piece based on its representational characteristics. In an abstract work, where the listener is left to focus on the perceptual qualities of the work, same spectral extremes tended to draw an amplified recognition of one's act of listening.

Interestingly, the participants who listened to *Element Yon* wrote their general impressions mainly in first person (i.e. “I felt (...)” while the participants who listened to *Birdfish* commonly used a third-person voice (i.e. “(...) happened”). This, again, indicates a noticeable sense of listening self in response to abstract perceptual qualities in *Element Yon*, where the listeners have reported back on the ways in which such qualities had affected them. Conversely, the representational sounds of *Birdfish* prompted them to describe a series of events that they *witnessed* rather than *experienced*. This variation in voice suggests that the prominence of representational elements in a piece affects where the listeners situate themselves in relation to a piece. While with *Element Yon* the listeners tended to place themselves at the center of the experience, the listeners of *Birdfish* assumed the role of a spectator watching a narrative unfold at the core of the piece.

## **Conclusion**

The expansive sonic vocabulary of electronic music brings about unique considerations in music cognition; it can consist of sounds that are structurally generic, or as complex as everyday sounds. This acoustic variety leads to a wide range of listening experiences. In this paper, we investigated these experiences from a representationality perspective. We proposed a new experimental design for the study of the cognitive processes involved in electronic music listening. By focusing on two works that utilize contrasting sonic vocabularies, we explored the differences in how listeners perceive abstract and representational elements in electronic music. We believe that this form of inquiry bears significant potential to expanding our understanding of how listeners experience electronic music.

We found that the prominence of representational elements in *Birdfish* has prompted a majority of the listeners to recount their experiences in terms of descriptors pertaining to perceived sources, and narratives constructs. These accounts were mainly provided from the perspective of an outside viewer. We also observed that a narrative context can affect the recognition of sources and vice versa. On the other hand, the prominence of abstract structures in *Element Yon* has resulted in a preference towards conceptual descriptors. The listeners focused on perceptual qualities of their experience, and provided affective interpretations of these qualities. Furthermore, these listeners were more inclined to report on their experiences in first-person. When narrative constructs emerged, these were inherently informed by perceptual qualities, and were associated with the “listening self”. Despite the structural similarities between the two pieces, both the general impressions and the categorization of real-time descriptors displayed significant variations, indicating the ways in which abstract and representational structures in electronic music can impact a listener's experience.

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