

Music and Data

Music 128

Fall 2020

Professor Mary Ann Smart

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Office Hours: Fridays 10AM-noon, and at other times by appointment

Sign up for office hours on Zoom via Google Calendar [here \(Links to an external site.\)](#).

Course Description

What does music have to do with data? Music is about feelings, memories, and moving your body, while data is raw information uninflected by emotion or experience. Yet any musical sound can be broken down as a series of data points measuring its physical properties, and songs can be understood as a collection of repeating and alternating musical elements. Streaming services like Spotify and Pandora aim to tag the emotional content of music to appeal to customers, and composers have recently created musical works by turning data about climate change into sequences of sounds. This course will explore the many connections between music and data through a series of case studies, from the eighteenth century to today. We'll engage creatively with essays and blog posts about music and data, learn to read and create data visualizations of musical content, and to analyze, modify, and create sounds with digital tools. The emphasis of the course is on the recent history of how data science shapes musical experience. Assignments include small weekly assignments (sometimes in groups), two hands-on data design/analysis projects, and a final paper. There will also be a midterm exam and a final, both designed as essay-based take-home exams to be written over a 24-hour period.

Learning Outcomes

By the end of this semester, you will be able to:

- compare the data content of different musical sounds using audio analysis diagrams such as spectrograms
- manipulate existing sounds and/or create new ones using sound design software
- evaluate data visualizations in terms of what questions they try to answer and how they organize data
- understand how musical features are identified and tagged in data analytics and critique the effects of this process on establishing genres and enforcing boundaries of genre, race, and class in the music industry
- explain how data analytics shape marketing and content production in the music industry

Materials

All readings, music to listen to, lecture videos, and other resources will be posted on bCourses. The easiest way to find what you need for each week's assignments is to follow the [Course Outline](#). The Outline contains a page for each week's lesson. If you click on those (or use <Pages> to go directly to that week's page) you'll find links to the reading, sound files, videos, and homework for that week's lesson. All readings and other materials for download can be found in the [Files](#) section of bCourses.

Weekly Schedule

The course is designed as a combination of work you can do on your own schedule and opportunities to come together as a group to discuss material. The work each week will consist of viewing a few short recorded lectures, reading one or two articles, a homework assignment (individual or in a group), and one synchronous discussion for the whole class. Instead of meeting three mornings per week, as listed the class schedule, most weeks we will meet together just once for a group discussion—usually on Mondays. The main discussion group will meet Monday at 10AM. If there's enough demand and we can make the timing work, I'll schedule an alternative discussion for students in other time zones. Each week's homework will be due Sunday at noon (California time).

Course Requirements and Grading

This course takes a project-based approach. You will have a small homework assignment to complete each week, based on an assigned reading (or a few short readings) and/or some music listening. There will also be two larger assignments, a final paper or project, and two essay-based take-home exams (midterm and final). Your semester grade will be calculated based on these requirements, as follows:

weekly or biweekly homework assignments, graded for completion (8)	16%
sound design project	11%
data visualization project	11%
midterm exam	12%
final paper or project	22%
final exam	18%
attendance and class participation	10%
total	100%

* All of the main assignments and exams must be completed in order to receive a passing grade.

Course Policies

Attendance and Participation

Attendance at our weekly (or slightly more than weekly) Zoom meetings is required. Students are allowed one unexcused absence over the course of the semester. If you have to miss a session, contact me ahead of time. I will be flexible and tolerant in excusing absences for good reasons. Participation in class discussion, activities in breakout rooms, and online forums is also required and will be graded. Attendance and participation together count for 10% of the semester grade.

Late Submission of Work

Because small assignments are due every week, it will be important to keep up and submit work on time. Missing one Sunday due date can make it difficult to catch up. However, it's important to me that every student submit all the work for the semester, and I'd rather receive an assignment late than not at all. So I'll be flexible about accepting assignments after the due date, if you contact me before the due date to request an extension. Depending on the

circumstances, late work may be accepted without a penalty or with a minor reduction in the grade (which will increase with time).

Academic Integrity

Collaboration and Independence: Reviewing lecture and reading materials and studying for exams can be enjoyable and enriching things to do together with one's fellow students. However, homework assignments should be completed independently and materials turned in as homework should be the result of one's own independent work. Some assignments, namely the preparation for the debate arguments, are meant to be done together in a group.

Plagiarism/Self-plagiarism: You must be original in composing the writing assignments in this class. To copy text or ideas from another source (including your own previously, or concurrently, submitted course work) without appropriate reference is plagiarism and will result in a failing grade for your assignment and usually further disciplinary action. For additional information on plagiarism, self-plagiarism, and how to avoid it, see the explanation [on this page](#)[Links to an external site.](#) (scroll down to "What is Plagiarism?")

Berkeley's honor code states "As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others." As a tool to promote academic integrity in this course, written work submitted via bCourses may be checked for originality using Turnitin. Turnitin compares student work to a database of books, journal articles, websites, and other student papers and provides students with an "originality check" that can alert you to content that is too similar to existing resources and that has not been adequately cited.

Semester Schedule

Week 1 (Aug 26, Wed.): Definitions and Concepts

Read: Gleick, "Talking Drums" from *The Information*

Listen/Watch: examples of talking drums, music for mechanical pianos (piano rolls), lip reading.

Week 2 (Aug 31): Data before Data--Histories of Music as Data)

Read: Loughridge, "[The Music of Man-Computer Symbiosis](#)" ([Links to an external site.](#)),

Brachetta, "[Musical Dice](#)" ([Links to an external site.](#)) on how Mozart's game works and [the web site](#) ([Links to an external site.](#)) that lets you play the game

Listen/Watch: Mozarcomposed with musical dice

Week 3 (Sept 9, Wed): Breaking Down Sounds into Data--Audio Analysis

Read: McAdams, Depalle, and Clarke, "Analyzing Musical Sound," 157-179 (note: most of this is pictures of spectrograms!)

Listen/Watch: Ravel, *Bolero* (beginning); Kraftwerk, *Die Roboten*

Supplementary or Background Reading: "[Seeing Sound: What is a Spectrogram?](#)" ([Links to an external site.](#))

Week 4 (Sept 14): Data Storage, Fidelity, and Lossiness (the CD)

Read: Burk, Polansky, et al, *Music and Computers: A Theoretical and Historical Approach*, section 1.1, "What is Sound?" ([Links to an external site.](#)) and section 2.1, "The Digital Representation of Sound" ([Links to an external site.](#)) and Sterne, "The MP3 as Cultural Artefact"

Listen/Watch: try to discern what is lost in the MP3 format

Week 5 (Sept 21): Vocal Synthesis 1--AutoTune, Vocoder, Vocaloid

Read: Lessley Anderson, "[Machine Language: How Siri Found Its Voice: Inside the Art of Making Computers Talk \(Links to an external site.\)](#)" *The Verge* (2013); and Nina Eidsheim, "Race as Zeroes and Ones"

Week 6 (Sept 28): Vocal Synthesis 2--AutoTune, Vocoder, Vocaloid

Read: Reynolds, "[How Autotune Revolutionized the Sound of Popular Music \(Links to an external site.\)](#)"

Listen/Watch: Laurie Anderson, Bon Iver; and compare performances with and without Autotune

Week 7 (Oct 5): Creating Music from Data 1--Digital Tools and Sound Design

Do: get familiar with sound design software

Week 8 (Oct 12): Review for Midterm and Creating Music from Data 2—More on Digital Tools

Read: "A Brief History of the Studio as Instrument: [Part 1 \(Links to an external site.\)](#); [Part 2 \(Links to an external site.\)](#); and [Part 3; \(Links to an external site.\)](#) and "[Grimes: 808s, Bird Calls, and Dentist Drills](#)" ([Links to an external site.](#))

Do: first stage of sound design project. Create a sound that has never been heard before, by manipulating musical parameters.

Due Friday, October 16: Midterm Exam (take-home).

The exam will be released on bCourses at noon on Thursday, October 15. Answers must be submitted by Friday, October 16, at midnight. The exam consists of short-answer questions, two listening questions, and one medium-length essay. The entire exam is designed to take 90 minutes to complete.

Week 9 (Oct 19): Creating Music from Data 3: Sonification

Read: Nelson, "[To Understand Big Data, Convert it to Sound \(Links to an external site.\)](#)"

Listen/Watch: Matthew Kenney's [sonification of polar ice levels \(Links to an external site.\)](#); Alvin Lucier, *Music for Solo Performer*; Peter Ablinger, and the Sonic City project

Do: work on sound design projects, [due Sunday November 1 at noon](#)

Week 10 (Oct 26): Data Visualization 1

Read: Brownstein, "[Attempts to Map Music \(Links to an external site.\)](#)"

Listen/Watch: browse and compare the gallery of data visualizations in [the Tableau \(Links to an external site.\)](#) gallery (focus on the highlights listed on bCourses)

Do: work on sound design projects, due Sunday November 1 at noon

Week 11 (Nov 2): Data Visualization 2

Read: map of African American Entertainers in German Lands before the Jazz Age (Links to an external site.), and the essay on context and data for this map (Links to an external site.)

Wednesday November 11, Veteran's Day (no class or office hours)

Week 12 (Nov 9): Data Analytics, Streaming, and Marketing 1

Read: Brian Moon, 'How Data is Transforming the Music Industry (Links to an external site.)' and Ratliff, "On the Waves: Linking," from *Every Song Ever*; Loughridge, "Listening in an Age of Musical Plenty (Links to an external site.)"

Week 13 (Nov 16): Data Analytics, Streaming, and Marketing 2

Read: Eriksson, et al, "How Does Spotify Package Music?" from *Spotify Teardown*; and Drott, "Why the Next Song Matters"

Listen/Watch: Mark Montgomery French, All Your Favorite Music is (Probably) Black (Links to an external site.)

Week 14 (Nov 23): more on Visualization and Streaming

work on data visualization assignments, due Tuesday, November 24 at midnight

Thanksgiving Break, Nov 25-29

Week 15 (Nov 30): Final thoughts & Work on Papers/Projects

final projects due December 11, midnight

Final Exam (take-home) due December 14, midnight

ASSIGNMENTS

Week 1: Drums that Talk and Defining Data and Information

Read the first chapter of James Gleick's book *The Information*, on "Drums That Talk," and answer the following question in a short paragraph. You can download the reading in [Files: Week 1](#).

In this chapter Gleick describes two main communication systems, African talking drums and the telegraph. He begins by suggesting that they're quite similar, but eventually insists that they're very different. On p.9 of the PDF he writes: "the obvious analogy led people astray. They failed to decipher the code of the drums because, in effect, there was no code."

How do talking drums encode information differently from the telegraph? What is the smallest unit of meaningful information in each case, and what processes are needed to convert words or ideas into units (bits) that can be transmitted over long distances? What does Gleick mean when he says that for the drums "there was no code."

Week 2: Musical Dice Games and Early Algorithmic Composition

Your assignment this week is to record a brief (min. 90 second) video comment on the idea of algorithmic composition, as used in the musical dice games of the 18th century. The assignment is in several steps.

Step 1: Before you start, prepare by watching Professor Smart's lecture videos on early musical robots and musical dice games and reading [this short article \(Links to an external site.\)](#) by Guillermo Brachetta. (Stop at the section titled "My Version.")

Step 2: Next, go to [this web site \(Links to an external site.\)](#) and explore the possibilities of the game presented there. The actual units of music are different from the ones used in the "Mozart" dice game, but the rules and the process are the same.

To get a sense of what kind of music this kind of randomization can produce, first click "generate another song" and "play song" a couple of times. Listen to the music that is produced. Do all the melodies sound the same? Do you like some better than others?

Next click on some of the individual numbers. Try playing them through in numerical order. What kind of music is created when you do that? You could also try clicking backwards through one of the rows (e.g. 66, 19, 95 right to left on the top row), or vertically up or down (e.g. 25, 74, 1, 68 going down on the 4th row from the left). Can you make a tune that makes sense by doing this? Clicking all the digits in the last column on the right is especially interesting (66, 88, 21...)

Step 3: Once you done that, make a short video discussing one or more of the questions below. Your video should be at least 90 seconds in length.

Videos must be submitted in the [Media Gallery section](#) of our bCourses site. You can do this either by uploading a video you have made or by recording it right in bCourses. For either option, begin by clicking the blue "Add Media" button in the right corner of the Media Gallery page. Under "Add New" (right-hand corner), select either Media Upload or Express Capture. The media tools in bCourses have been overloaded this week. If you run into problems with Express Capture, try recording outside of bCourses and uploading. If you find that you can't upload at all, email me! (masmart@berkeley.edu)

Step 4: After you upload your own video, go to the Media Gallery and add comments (30-second video or short paragraph of text) on videos by two other students. Comments are due by Monday at midnight--the day after you post your own video.

Questions to address in your videos

- why do think musical dice games like this were so popular in the eighteenth century? what's the appeal?
- why can't you combine the numbered chunks of music in any order at all? Why do some orders sound so much better than others?
- is the music you can create with these games noticeably mechanical or lacking in inspiration or novelty? can you hear its soullessness? or does it sound pretty much the same as music composed by Haydn or Mozart?
- since these melodies aren't fully original and don't express the individual personality, inspiration, or feelings of the person creating them, should they really be called music?

Week 3: Transform, Distort, and Remake 10 Seconds of Sound

Your assignment this week is to take an existing sound recording and manipulate it to make something new. The final product that you hand in will consist of three things:

- 1) a recording of the original sound clip you began with;
- 2) a recording of the recording as you've transformed using digital editing software;
- 3) a short written account of what you were trying to do and how you did it.

Like the last two assignments, this one is due on Sunday--but at midnight, not noon.

You'll need to work on this in several steps.

1. If you don't already have one, download a copy of an audio editing program. There are many options, but Audacity is one that works on both PCs and Macs and is easy to learn. Another good option would be GarageBand, but to me its controls are less intuitive. You can download Audacity for free [here \(Links to an external site.\)](#).

2. Choose or create a short audio clip to work with. When I tried this out I used an excerpt of a piece by J.S. Bach that was only 8 seconds long. That's probably about the shortest your source should be. Aim for between 8 and 20 seconds. You can create a recording yourself (sing, play an instrument, record your dog barking) or import one from existing audio. Pick something you like and/or something that has special meaning for you.

3. If your recording already has a file name ending in aiff, wav, or mp3 you can skip this step. But you may find yourself with a recording in MP4 format, which doesn't work with either Audacity or GarageBand. If so, you'll need to convert it, and you need another piece of software to do that. Here's a free one that works well: [Switch Audio File Converter \(Links to an external site.\)](#).

4. Import your source recording into Audacity or GarageBand and start to play around with it. In Audacity, you'll especially want to use the Selection Tool (top panel, button marked with a capital I) and options from the Effects menu. Select a small portion of the sound file (a few seconds), then apply the effect--e.g. change the pitch of one section, or add an echo or a wahwah effect, or apply distortion. You can play with the possibilities until you find something you like. (When you **don't** like what it sounds like, just change it by selecting "Undo Effect" under the

Edit menu.) If you want information about how anything works, Audacity has a good online manual, which you can access by Google-searching terms (e.g. 'Paulstretch Audacity').

5. When you're satisfied with what you've made, export it as a WAV or mp3 file, and then upload it, along with your original, to bCourses.

6. Finally, add a paragraph explaining what you did and what kind of effect you were going for. This can be very casual and chatty, but should document your experience of doing the assignment.

* Feel free to contact me any time if you run into problems with any of these steps.

Weeks 4 and 5: Design a Listener Test for Digital Recording

This week's assignment is a bit of an imaginative exercise. I encourage you to take it in a direction that interests you and to have fun with it. The main goal is to use and think about some of the concepts and terminology connected to digital audio recording and perceptual audio coding, discussed in this week's recorded lectures ([Part I](#) and [Part 2](#)). If you feel very confident with these concepts, go ahead and propose something very technical, even with graphs, if you like. If these ideas are newer to you and you don't feel you've grasped all the details, that's OK too--choose one or two ideas and design a test that focuses on the audio qualities of a song you know and love.

The Prompt:

You are working with a team that is developing the next audio format, which aims to be portable and cheap to produce but also high quality. Describe a listening test you might design to check the effect of your digitization. Your test should be conceived with the idea in mind that the idiosyncrasies of human hearing and human taste are integral to any storage or playback technology.

Some questions to consider:

- what kind of music, or what specific song or piece, would you use? why?
- who would you hire as testers? how much experience would they have and what kind? why?
- what instructions would you give them? what kinds of distortion, lossiness, or fidelity would you tell them to focus on when they listen?

Week 6: AutoTune and Vocoder Listening Quiz

This quiz is organized around four Youtube recordings. Each question will point you to a particular point in the Youtube video (using the time stamp). You will probably want to listen to these short passages several times each while answering the questions. Like our other weekly assignments, everyone who completes the quiz will get full points, so there's no penalty for wrong answers. But doing this carefully will give you practice listening to vocal synthesis effects that you'll need for the midterm exam in a few weeks and for your own projects.

Week 8: Learning about Sound Design with the Ableton Tutorial

1. Work through the first several sections of Ableton's "Learning Synths" tutorial, which you can find [here \(Links to an external site.\)](#). It shows you the various parameters of sound, step by step, and (crucially) shows what it sounds like when you change just one parameter in isolation, or two parameters at a time. Note that this isn't what actual **music** ever sounds like, because it almost never happens that frequency changes without amplitude or the envelope also changing, and, similarly, it almost never happens that amplitude changes without the color (timbre) of the tone also changing.

Take this slowly and be deliberate about. When there's a circle inside a rectangle, take the time to understand completely how the sound changes when you move the circle straight up, straight down, diagonally, etc.

The tutorial is long, but it's also easy and fun. This week you should do the first six sections. Those sections are: Getting Started, Making Changes, Synth Basics, Envelopes, LFOs, and Oscillators. (Stop before "Filters"; we'll do some of that later.)

2. Answer five questions about what you did in the tutorial and what sounds you heard, in the Quiz [here](#).

3. Download [the free 90-day trial of Ableton Live \(Links to an external site.\)](#), in preparation for making your sounds and music next week and the week after.

Sound Design Project with Ableton

Due November 1

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The goal of this assignment is to create a short piece of music using Ableton Live. You'll submit a recording of the piece and a one-page statement explaining how you created it. Both should be submitted through the file upload function in bCourses. The assignment is due by midnight on Sunday, November 1.

The piece you create should be 32 measures long and should be creative and well-constructed. Your piece can be in any style or genre, but it should use novel and interesting sounds and it should use repetition and contrast in ways that make sense to the ear and the brain. Think about the form and style of a typical pop song, or of a minuet by Bach or sonata by Mozart. All of them feature short sections of interesting music that repeat, and the repetition is part of what makes the music enjoyable and memorable. This means that your work will involve designing some original melodies and sounds, but not 32 measures worth of completely new material.

You can approach this assignment in different ways depending on how much experience you've had with Ableton or other sound engineering and composing software, and your work will be graded accordingly. Beginners should concentrate on mastering the software controls and making sounds and music that you like. If you have more experience, you can push yourself to do something beyond what you've been able to do before.

To get started, download [the free 90-day trial of Ableton Live](#), if you haven't done this yet. If you haven't used Ableton before, you'll probably need a tutorial to get started making a track. Here's one that I found useful as a starting point, but there are many others to choose from: [Link \(Links to an external site.\)](#)

But even more useful are Ableton's own help screens. Activate them by clicking "Help View" under the Help menu. This will open up a panel on the right side of the window with guides and lessons. You can click through them as needed, or move ahead to specific lessons by clicking anywhere in the table of contents.

The other thing you'll want to do to help you understand what you're doing as you use Ableton is to turn on the Info View. Do this by clicking the grey triangle that appears in the bottom left corner of the window. When the triangle points up, it opens a small window there that explains the controls. Whenever you hover the cursor over a window or a control the Info View window shows information about what it does.

Next, follow the instructions in the first 5 or 6 minutes of the Youtube tutorial, which should get you to the point where you've created a melody and/or some chords. You should be able to go on from there to add new sounds and music and then to copy, modify, and play around with the music you've created to build your composition out to 32 measures.

Any sounds or sound sources are OK to use in this assignment. You can import recordings of everyday sounds or of yourself or someone else playing or you can work with the sound library in Ableton.

If you run into any hitches or obstacles with either the creative part of the assignment or with Ableton, get in touch and I'll try to help!

Ideas for Final Project

Your final project is due December 11 and can take any form you choose. I'm hoping that you'll pick up on something we've discussed this semester and take it in a direction that interests you.

Final projects can take the form of a piece of music or sound design, a software project, a visualization or sonification of some data, or an essay researching and/or interpreting some aspect of music and data. If you choose an essay format, the essay should be 1500-2000 words. If you choose a more practical project, your submission should be accompanied by a short explanation of what you did and how (500-700 words).

Everyone must submit a one-page proposal for the final project by November 8 (Sunday at midnight).

To get you started, here are a few topics and approaches that would work for the final project. Feel free to use or adapt any of these, or to come up with something completely different.

1. Create your own sonification. To do this, you might start from the FAQ on [Data-Driven DJ's web site \(Links to an external site.\)](#), where he talks about both the technologies and the data sets he uses. He uses only open-source technology, including ChuckK, Audacity, and Python, and publicly available data sets, including from the US Census, the United Nations, the World Bank, and NYC Open Data. To do this, you'd need to have some programming ability.

2. Write a proposal to a company like Apple or Amazon for how they could make their synthesized voices more inclusive, less normatively white, and (possibly) more human. This would involve research voice synthesis to find out how it's currently done and also researching the criticisms of voice synthesis, especially in relation to race and exclusion. You could frame

your argument as a proposal for change, but to be convincing it would have to be backed up by extensive research.

3. Write a proposal to Spotify or Apple Music about how to improve their recommendation algorithms. This would work in a similar way to #2, making a proposal for improving the system but backed up by research. You could also frame this as a policy proposal to a government agency about why these companies should be regulated more, or as a piece of long-form journalism (for *Wired* magazine, or *Pitchfork*, or *Slate*) about how music streaming services invade our privacy or how they promote the careers and sales of some artists and music genres at the expense of others.

4. Create an ambitious data visualization, or write an essay comparing and analyzing several visualizations. To make a visualization you could build your own data set (by analyzing or counting features in a song, or a number of songs) or you could use freely available data, like the [Million Song Dataset \(Links to an external site.\)](#).

5. Create a sound art piece using [Pure Data \(Links to an external site.\)](#) or Ableton Live. You could aim for a more modern version of an abstract piece like Hugh LeCaine's piece *Dripsody* (which synthesized and manipulated sounds of dripping water) or something more like a pop song or dance music. Aim for standard pop song length, about 3 minutes.

6. Do a data analysis of your own listening habits on Spotify, or those of other people you know. You can request your listening history data from Spotify, but getting into a form you can use is complicated: see the detailed instructions in [this article \(Links to an external site.\)](#).

7. Write a research essay about some aspect of the history of music and data, such as early music composing machines or the development of musical automata or the player piano. As a starting point, here's [a good short article \(Links to an external site.\)](#) about some women who used technology to create music, including 19th century computer pioneer Ada Lovelace. [This virtual museum of imaginary musical instruments \(Links to an external site.\)](#) contains many historical instruments that used data in various forms.