Project Brief

Project Title: Exploring Emotional Sentience in AI-Created Music

Author: Neil Kale (human)

Date: 22 September 2019

Phrase 1

Can AI express emotional sentience through the music it creates?

Phrase 2

Musicality is spread throughout the natural world. However, humans alone use music to convey emotion. This stems from our ability to empathize. If algorithm-produced music can convey emotion, then the algorithm steps towards rudimentary sentience.

Background:

What defines sentience? The word derives from the Latin root *sentire* which means "to sense or to feel", and indeed sentience is to be "responsive to or conscious of sense impressions" (Merriam-Webster, n.d.). In other words, it's simply the ability to sense one's surroundings. However, a thermometer can sense the temperature around it, yet we wouldn't call it sentient. A light switch can sense whether it is on or off, hold that information, and even send it to a connected bulb. That said, it is still not sentient. Perhaps, what makes humans unique, and sentient, is not our ability to feel, but rather our ability to share feelings with others (Keltner et. al, 2019). By the status quo, computers aren't sentient (Allen, 2016). However, if AI can read human music that expresses emotion and machine learning allows AI to create unique compositions modelled on whatever it reads, then I believe that artificial-intelligence created music will propagate emotions as well. The purpose of this project is to explore whether AI can use music to express emotion as well as humanity can.

Humans express their emotions through a diverse set of mediums such as facial expression, speech, literature, music, and art. This project specifically focuses on whether algorithmic music compositions can induce an emotional response in humans. If so, an AI equipped with these algorithms is capable of propagating emotions, and we are one step closer to asking the question - "Can AI be sentient?"

There remains the question of whether these emotions are truly "its own" if the AI is merely selecting its emotion based off of an algorithm. However, I argue that humans also derive their emotions from internal algorithms, albeit extremely complicated ones. This doesn't reduce the value of human

emotions or sentience. In fact, it is all the more impressive that our complex emotions like love and happiness can arise from an algorithm, rather than spontaneously materializing.

If the human mind is a complex algorithm, then our emotional expression is also algorithmic. The great works of Mozart, Michaelangelo, Shakespeare, and Van Gogh were not spontaneous feats of creativity; they were algorithmically generated by the minds of their creators. The difference between AI and humans may simply be the complexity of their algorithms.

Ultimately, as we progress through the 21st century, the line between human and AI is fading. Advances in neuroscience are showing that we may be more algorithmic than we previously believed (Yayilgan & Beachell, 2006). Furthermore, machine learning is allowing AI to step closer to humanity than ever before (Shabbir & Anwer, 2018). This project enters the no-man's land (and no-AI's land) between humanity and AI, exploring what it means to be sentient as well as what it means to be human.

Project Definition:

The overarching question that this project aims to answer is, "Can AI express emotional sentience through music?" Humans express their emotions in many forms including art, literature, speech, facial expressions, and music. As a music lover, I will explore whether AI can match humans in expressing emotion through music.

I propose a series of hypotheses to test this question.

First, if a creative algorithm is trained or modelled on human music, then the resultant compositions will be indistinguishable from human compositions. Humans propagate their emotions through music (Juslin, 2013). Therefore, if a generative algorithm can produce music that is indistinguishable from that produced by humans, then the algorithm can allow an AI to convey emotions. Finally, one of the indicators of sentience is the ability to propagate one's feelings (Keltner et. al, 2019). If an algorithm allows AI to convey its emotions, then the AI is one step closer to sentience.

Experimental Design and Research Plan Goals:

Procedures:
First, compile 15-second to 1-minute samples of human-written and algorithm-written music. The samples will be MIDI files, to eliminate inconsistencies in human playing. The songs will encompass multiple genres including pop and classical. Second, develop and disseminate a survey testing whether humans can distinguish the human compositions from algorithmic compositions. The songs will be presented one at a time. While/after the song plays, the participant will be able to select one of three buttons: human, AI, indistinguishable. The responses will be compiled into a spreadsheet. See "Human Participants Research" section for a more detailed overview of the survey.

Risk and Safety:
The music shouldn't be played loud enough to cause auditory damage to a listener. To this end, participants will be able to control the volume of their device while taking the survey. Additionally, the

discord in some compositions may cause auditory discomfort to participants. To counteract this, the participant will be free to exit the survey at any time. Finally, to preserve participants' anonymity, personal data questions will be optional.

Data Analysis:

For each composition, statistical analysis will determine whether there is a significant difference between the number of people who believed that the song was written by a human, and the number who believed that it was written by a robot. The analysis will also look at the total percentage of correct responses for human pieces, and the percentage of correct responses for algorithmic compositions. A comparison can also be done between songs of different genres. Additional analysis could include dividing the responses by participant demographics to determine whether certain groups chose the correct response more often than others.

Discussion of Results and Conclusions:

Humans use music to propagate their emotions. Therefore, if this survey finds that certain algorithm generated pieces are indistinguishable from human creations, those algorithms could allow AI to convey its emotions to humans. The ability to propagate one's feelings to others is one indicator of sentience which suggests that AI could possibly reach that mark . Furthermore, the question arises: Which algorithms correlate to which emotions?

If the survey determines that algorithmic pieces are distinguishable from human pieces, it can be concluded that algorithms can't induce emotions via music in the same way that humans can. By studying the timestamps on when people made their decisions while listening to the songs, I may be able to determine what allowed people to distinguish. Perhaps there is a fundamental aspect of emotional expression via music that AI will never be able to capture; however, I believe that the difference will reduce over time as technology advances.

Future Extensions:

If I have the opportunity, I would like to run this experiment with music ensemble members at WPI. This would allow me to test whether there is a correlation between music experience and ability to discriminate between human and AI music.

Given time, I would also like to directly measure how people are emotionally affected by AI-written music. One possible method would be having people listen to short samples of human created music, and select, off of a list of basic emotions, which emotions are evoked while they listen to that piece. I could feed those samples into an algorithm which can extend them (One such example is Google Magenta), and see whether when those same participants listen to an extended piece, or samples thereof, they select the same emotion/s for it that they selected for the original sample which created it. Another possible method is to utilize an EEG scanner. Participants will wear the scanner while listening to human written pieces and algorithm written pieces. The scans will be overlaid to see whether brain activation differs between the two data sets.

In the future, I could also run similar surveys and/or EEG scans for human/algorithm-created artwork, literature, speech, or facial expressions. These are all other methods which humans use to express emotion. Determining whether algorithms can replicate one more effectively than another might provide valuable insight into how algorithms evoke emotion, as well as into how we humans perceive it.

Human Participants Research

The survey population is Juniors attending the Massachusetts Academy of Math and Science. These students will be recruited via word of mouth and a notice posted to the school library bulletin board.

The first portion of the survey collects personal data such as age and experience with music. After that, the participant is instructed to listen to pieces of music, which will be played to the entire group, and, if possible, discern whether the piece is written by a human or a robot. The pieces will play one at a time.

During each piece, the user will select one of three options - "human-written", "robot-written", "indistinguishable". The piece will only play once. Once the user is satisfied with his/her response, he/she can submit, and the next piece will play. I may run multiple iterations of the survey, each with different pieces. Each participant may only take each iteration once. The survey should take no longer than 10 minutes, and the participant is free to exit at any time.

The risks and corresponding countermeasures, as stated in the experimental design, are as follows: Prolonged exposure to loud music can cause hearing damage. To prevent any risk during experimentation, a test sound will be played prior to testing, and lowered until all participants are satisfied. The volume of the music will not exceed the volume of the test sound. Additionally, the discord in some compositions may cause auditory discomfort to participants. To counteract this, the participant will be free to exit the survey at any time.

One benefit is that participants who enjoy music might enjoy this exercise. Additionally, being able to differentiate between AI and human created forms of emotional expression may become a vital skill in the future. Already, telling "deep fakes" apart from real videos of celebrities and politicians is important to prevent misinformation. As AI becomes more emotionally sophisticated, it may become difficult to differentiate between a real Beethoven symphony and an algorithmic "deep fake". This survey serves as a practice round for would-be connoisseurs of human music.

Any personal data collected by the survey will be anonymous. There will be no name, email, or phone number attached to the data. Moreover, it will all be collected online. The data may include: age, gender, economic background, and/or experience with music. The data will be stored in an Excel spreadsheet linked to my WPI Microsoft account. The account is password-locked, and the only people with the password are me and the school tech administrator. I will keep the data after the study has concluded, in case it is needed for future research.

I will inform participants about the purpose of the study, what they will be asked to do, that their participation is voluntary and they have the right to stop at any time through a mandatory informed consent form which will outline all of that information as follows.

Informed Consent Form

I am asking for your voluntary participation in my science fair project. Please read the following information about the project. If you would like to participate, please sign in the appropriate area below.

Purpose of the project: To determine whether AI-produced music is indistinguishable from human-produced music, and, in turn, whether AI can convey emotions to humans via music.

If you participate, you will be asked to: Listen to a series of excerpts from musical pieces, and classify each piece as one of the following: human written, algorithm-written, indistinguishable.

Time required for participation: 5-10 minutes

Potential Risks of Study: As with any music, playing these samples at high volume could cause hearing damage. Please keep the volume at a comfortable level.

Benefits: If you enjoy music, you may enjoy this exercise. Additionally, being able to differentiate between AI and human created forms of emotional expression may become a vital skill in the future. Already, telling "deep fakes" apart from real videos of celebrities and politicians is vital to prevent misinformation. As AI becomes more emotionally sophisticated, it may soon be difficult to differentiate between a real Beethoven symphony and an algorithmic "deep fake". This survey serves as a practice round for would-be connoisseurs of human music.

How confidentiality will be maintained: The data collected in this survey is nameless and faceless. The personal data that you share can't be tied back to you in any way. Furthermore, all data which you share will be stored in a password-protected account. It will only be accessible to me, my project mentors, and the project supervisor.

If you have any questions about this study, feel free to contact:

Teacher/Adult Sponsor/QS/DS: Phone/email:

Voluntary Participation:

Participation in this study is completely voluntary. If you decide not to participate there will not be any negative consequences.

Please be aware that if you decide to participate, you may stop participating at any time and you may decide not to answer any specific questions.

By signing this form, I am attesting that I have read and understand the information above and I freely give my consent/assent to participate or permission for my child to participate.

Adult Informed Consent or Minor Assent
Date Reviewed & Signed: _____
Research Participant Printed Name: _____
Signature: _____

Parental/Guardian Permission (if applicable)
Date Reviewed & Signed _____
Signature (Required for all subjects under 18 years): _____
Parent/Guardian Printed Name: _____

Survey Questions

Overview:

The official survey will exist as an online form linked to my school website. It will be locked by a code that is only available to the registered survey participants. The first page will collect personal data such as age and experience with music. After that, the participant is instructed to listen to musical pieces and, if possible, discern whether the piece is written by a human or a robot. The pieces will play one at a time. During each piece, the user will select one of three options - "human-written", "robot-written", "indistinguishable". The piece will only play once. Once the user is satisfied with his/her response, he/she can submit, and the next piece will play. I may run multiple iterations of the survey, each with different pieces. Each participant may only take each iteration once. The survey should take no longer than 10 minutes, and the participant is free to exit at any time.

Note on the Music:

The list of pieces is not yet finalized, however, a list of the potential pieces is attached.

Demographics
1.) Musical Experience (Pick zero, one or more)
 a.) Group Ensemble
  i.) Chorus
   (1) 0-2 years
   (2) 2-5 years
   (3) 5-10 years
   (4) 10+ years
  ii.) Band
   (1) 0-2 years
   (2) 2-5 years
   (3) 5-10 years
   (4) 10+ years
  iii.) Orchestra
   (1) 0-2 years
   (2) 2-5 years
   (3) 5-10 years
   (4) 10+ years
 b.) Lessons
  i.) Instrumental
  ii.) Voice
 c.) Interest in Music Overall
  i.) Likert Scale ranking from -5 (Strongly Dislike) to 5 (Strongly Like)
2.) Gender
 a.) Male

b.) Female

c.) _____ (fill in the blank textbox)

d.) Prefer not to say

3.) Age Range

    a.) Under 12 years old

    b.) 12-17 years old

    c.) 18-24 years old

    d.) 25-34 years old

    e.) 35-44 years old

    f.) 45-54 years old

    g.) 55-64 years old

    h.) 65-74 years old

    i.) 75 years or older

4.) Ethnicity

    a.) White

    b.) Hispanic or Latino

    c.) Black or African American

    d.) Native American or American Indian

    e.) Asian / Pacific Islander

    f.) Other

5.) Education

    a.) No schooling completed

    b.) Nursery school to 8th grade

    c.) Some high school, no diploma

    d.) High school graduate, diploma or the equivalent (for example: GED)

    e.) Some college credit, no degree

    f.) Trade/technical/vocational training

    g.) Associate degree

    h.) Bachelor's degree

    i.) Master's degree

    j.) Professional degree

    k.) Doctorate degree

Music Questions:

1) If possible, predict whether this piece of music is:

    a) Human-written

    b) Algorithm-written

    c) Indistinguishable

Pre/Post-Music Questions:

The Discrete Emotion Questionnaire (see attached) will be completed, in digitized form, at the beginning of the experiment, and again after each song. For brevity, redundant descriptors such as "mad" and "pissed off" may be removed since "angry" conveys the same emotion.

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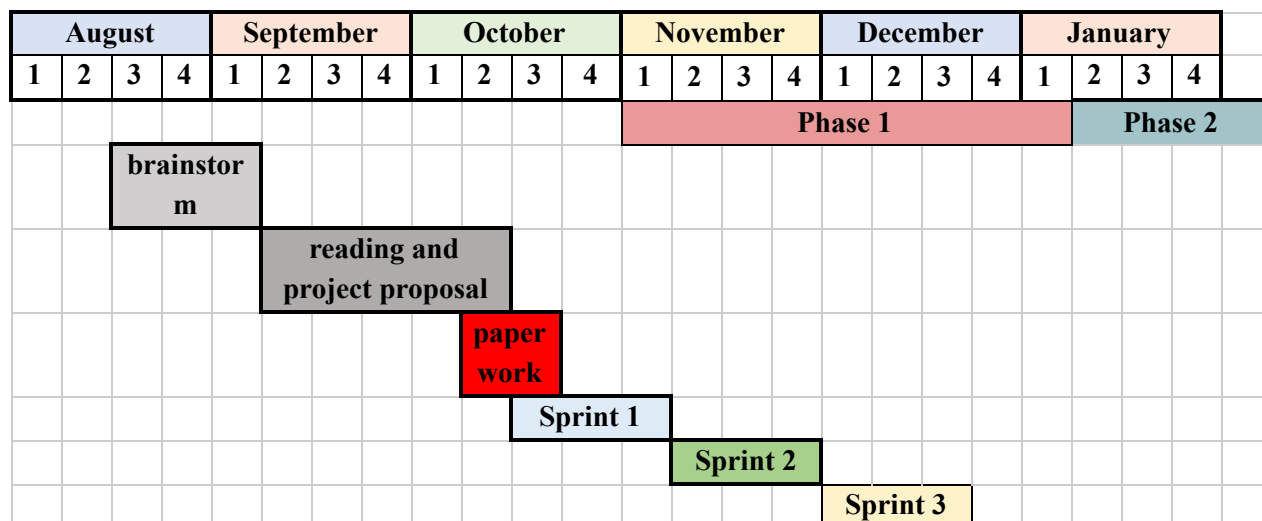
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Timeline: (with action steps identified- sub-deadlines will continue to evolve):

Rough timeline of major phases. As these phases get established, specific tasks under these phases will be defined further.

	August				September				October				November				December				January		
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4

Phase 1 (November 1 – December 4)

Phase 2 (January 1 – 4)

brainstorm (August 3 – 4)

reading and project proposal (September 1 – 3)

paper work (October 1 – 2)

Sprint 1 (October 3 – 4)

Sprint 2 (November 1 – 2)

Sprint 3 (December 1 – 2)

For more details on each sprint, refer to project schedule:

https://docs.google.com/spreadsheets/d/1Vuy0KP-ly2PjHhvifEes2WaTlER-IGfShL9vgSFvUmo/edit?usp=sharing

Background Knowledge Goals:

Date	Topic	Completed Date
9/22/2019	Classical music production by Robots	
9/22/2019	Classical music writing by Robots	9/30/19

Brainstorming Reflections:

Want to use to develop further?	Why?	Assumptions making with this idea	How can these assumptions be challenged?
Obtain existing models	My project relies on the use of existing algorithms in order to collect behavioral data about human response to those algorithms.	AI exist that can write complex musical pieces that can parallel human pieces.	Perhaps existing algorithms don't do the job as well as they should, or don't fit my specific requirements.

Real-time feedback for control	Interesting idea for my project.	I can video people's faces while they listen to the music / see their brain activity.	Cost of this procedure might be too high, and invasion of privacy?

Don't Want to Use	Why?
Shark food?	My project will not be attacked by sharks
Waterproof components	Most acoustic studies are best conducted on land

Budget:

Preferably use existing musical pieces so as to minimize production costs, and focus on analysis. Survey & Music distribution will be online, therefore zero cost for printing/mailing surveys and music. Ideally utilize data analysis tools available through WPI, however, if needed, software can be bought. There is no hard limit on budget, but cost should likely not exceed $1,000 without serious consideration and applying for external funding.