Detection of Emotional Changes with Harmony

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Abstract

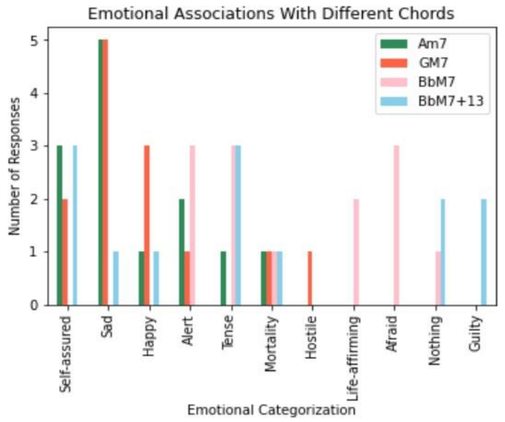
We describe novel techniques to detect and visualize harmony and chord progression changes in contemporary music. Creating surveys via Google forms, we embed musical chords and ask participants to describe how they feel by selecting an emotional term from a list developed from the PANAS-X (Positive and Negative Affect Schedule-extended form) manual and by categorizing their emotion as either positive, negative, or neutral. Survey data is collected to determine categorizations of emotional associations with the chords of a particular song; in this analysis, the song is “Best Part” by Daniel Caesar and H.E.R. Programs we write in the Python programming language are used to process the data and create visualizations, via the Pandas and matplotlib libraries. We made two surveys, in the first, we employ single-chord sound recordings, and for the second, chord-chord progression (CCP) recordings are embedded. We find that it’s complicated to categorize the chords or CCPs with one emotion as most had multiple terms as a maximum. We believe assigning of emotions to chords or CCPs will be simpler upon making similar surveys available to wider audiences. We plan to record for more songs to analyze the emotions associated with chord progressions of a significantly wider variety of contemporary music. We also plan to parallelize the program we create (to associate chords/ CCPs with emotions) with a harmonic detection algorithm.

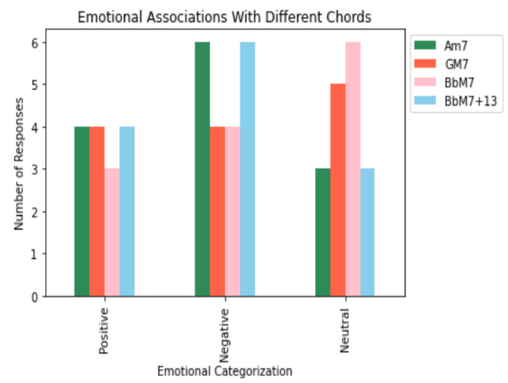
Methods

We record chords and chord-chord progressions (CCPs) on a grand piano using the Scarlett 2i2 Focusrite microphone. We upload these recordings to Youtube and embed those links in Google forms in which we use as surveys. The surveys consist of 4 question-sections; each section including the embedded link and 2 questions. The first question asks the participant what emotion they feel when listening to the chord and the second asks how they would categorize how they felt. The list of emotional term options were taken from the basic positive and negative emotion scales from the PANAS-X manual. We also find it important to add terms such as mortality, life-affirming, tense, and nothing. The term mortality is added as humans are thought of to always think of death and, as a control, we added the opposite of this which is life-affirming. The word tense is also added to the list as musicians intentionally add suspense or tension to their piece. Lastly, the term nothing is as a control overall. The second question is comprised of “positive,” “negative,” and “neutral” as categories.
We send these surveys out and gather the data upon receiving multiple responses. The data is downloaded from Google forms as an excel file. Columns irrelevant to our analysis, such as timestamp, are removed prior to import of data into Python. We then organize the data through dictionaries and turn it back into a readable data-frame by use of Pandas library. We then create visualizations of this data through matplotlib library.

Results

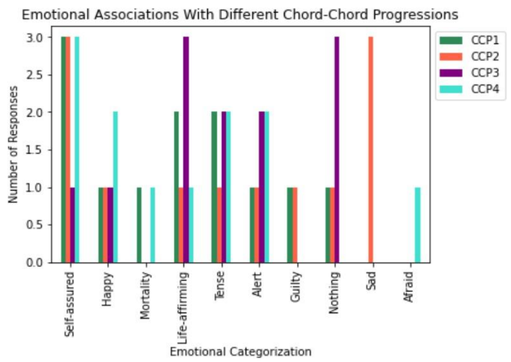
In **figure 1**, we see that the maximal response for the only minor chord in the song, A minor 7 (Am7) is sad. The other chord categorized as sad by the majority is G major 7 (GM7). The maximum for B flat major 7 (BbM7) is split between 3 terms: alert, tense, and afraid. The final chord, B flat major 7 + 13 (BbM7 +13) has maximum responses split between self-assured and tense. In **figure 2** we see Am7 is categorized as negative by the majority. The majority also categorize BbM7 +13 as negative. The other two chords, GM7 and BbM7 are both categorized as neutral by the majority of participants.

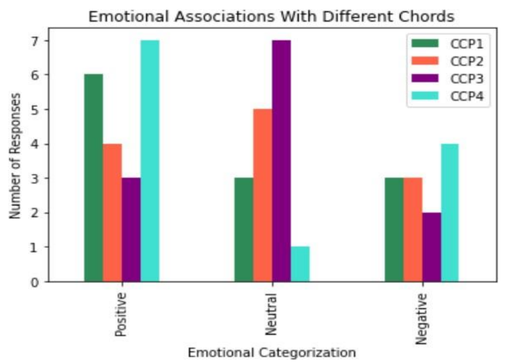




Left: Figure 1: Emotional responses to different chords. The different colors are associated with the different chords; Am7 stands for A minor 7, GM7 is for G major 7, BbM7 is for B flat major 7, BbM7+13 is for B flat major 7 +13. **Right: Figure 2:** Categorization of emotions to different chords. The different colors represent the different chords; Am7 stands for A minor 7, GM7 is for G major 7, BbM7 is for B flat major 7, BbM7+13 is for B flat major 7 +13.

In **figure 3** we see the majority respond to the first and fourth chord-chord progression (CCP) in the same manner; they feel self-assured. We see that the second CCP is interpreted as either self-assured or sad by the majority. Most participants say that the third CCP makes them either feel nothing or affirmed in life. In **figure 4** we see that the first and fourth CCP is perceived as positive by many. On the other hand, the majority of participants categorize the emotion they feel with the second and third CCP as neutral.





Left: Figure 3: Emotional responses to different chord-chord progressions. The different colors represent the different chord-chord progression (CCP).These are inclusive of all chords in the song, unlike survey 1 where 1st chord is home key and listened to optionally. CCP1 represents chord DM7 followed by Am7, CCP2 is Am7 followed by GM7, CCP3 is GM7 followed by BbM7, and CCP4 is chord BbM7 followed by BbM7+13. R**ight: Figure 4:** Categorization of emotions to different chord-chord progressions. The different colors represent the different chord-chord progression (CCP) . CCP1 represents chord DM7 followed by Am7, CCP2 is Am7 followed by GM7, CCP3 is GM7 followed by BbM7, and CCP4 is chord BbM7 followed by BbM7+13.

Conclusions

When interpreting results found in **figures 1-4**, we see that some of the emotional responses don’t align with the categorization responses. We see this for chords GM7 and BbM7 in the first survey. While most agree that GM7 makes them feel sad, most categorize the chord as neutral. As for BbM7, most participants associate the chord with tense, afraid, and alert, but majority categorize the chord as neutral. When looking at data from survey 2, we see that only one person associates CCP2 with feeling of ‘nothing,’ but when it comes to the categorization of CCP2, most respond with neutral. This is interesting because 5 people say it’s neutral when we find that all emotional terms, except for nothing, are either positive or negative terms, so theoretically 11 responses should be distributed amongst the positive and negative categories. This is also true for CCP3; only 3 respond with nothing but 7 categorize this chord-chord progression as neutral. We believe this either may be due to human error—in which one may think they clicked for the desired answer but choose something different—or this just further proves how complex human emotion truly is.

Future direction

In the case that participants are incidentally choosing answers they don’t mean, we are to incorporate visuals next to choices to help aid against this. We plan on recording chords/ chord-chord progressions for more songs expanding the variation in chords for analysis. Additionally, we plan on obtaining approval from Salisbury University’s Institutional Review Board for testing with human subjects; this allows us to gain a larger audience and thus record data for a much larger sample size. We presume a larger sample set will have one maximal response for each question making it easier to categorize the chords or CCPs with one emotional term. After we create a program that associates the different chords with their respective emotional terms, we plan to use parallel programing, using this program with a harmonic detection algorithm.

Acknowledgements

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References

1. C. Humphries, *The piano handbook*. San Francisco, Ca: Backbeat Books, 2002.
2. D. Watson and L. Clark, “THE PANAS-X Manual for the Positive and Negative Affect Schedule -Expanded Form.” [Online]. Available: https://www2.psychology.uiowa.edu/faculty/clark/panas-x.pdf
3. J. Grus, *DATA SCIENCE FROM SCRATCH : first principles with python*. 2019.