Group ID: 8-22
Project Title: Golden Dedley
Group members: Ang Yong Heng (2O1) and Goh You Yi (2A1)

Project Work Written Report (Final draft)

1. Our project idea

Music has been around for hundreds of thousands of years, ever since the days of the first civilisations. It has always played an important role in everyone's lives.

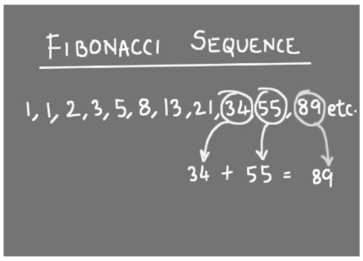
Our project idea is to discover the relationship between the golden ratio, Fibonacci sequence and music. These studies investigate mathematical patterns such as the Fibonacci Sequence and the Golden Ratio as they apply to the composition of modern music and/or classical music. We want to offer students a solution to compose music using the golden ratio and the Fibonacci sequence.

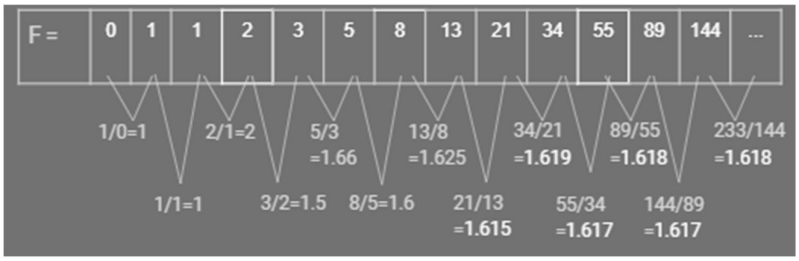
It was quite common for mathematicians to be skilled in music; e.g. Pythagoras. The combination of mathematician and musician is not a coincidence, but rather, it is an indication of the close relationship that mathematics and music share.

Our findings showed that more than 80% of the popular songs apply the Fibonacci Sequence and Golden Ratio, which were probably the most effective compositional tools for musicians.

2. Literature review

- Fibonacci Sequence and Golden Ratio
  - The Fibonacci Sequence is an infinite series of numbers that follows a pattern in which each subsequent number is the sum of the previous two numbers; i.e., {1, 1, 2, 3, 5,8, 13, 21, 34}. If any adjacent Fibonacci numbers are divided by each other {2/3 or 21/34}, a Fibonacci ratio is formed, and as the ratios move further along in the sequence, the ratios converge to 1.618, the golden ratio.





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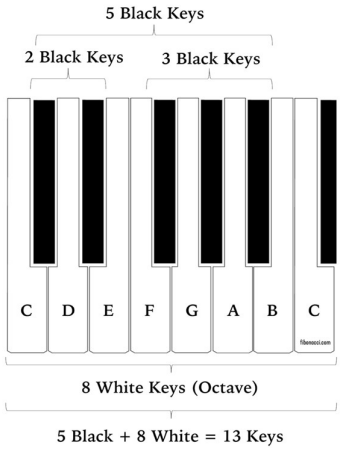
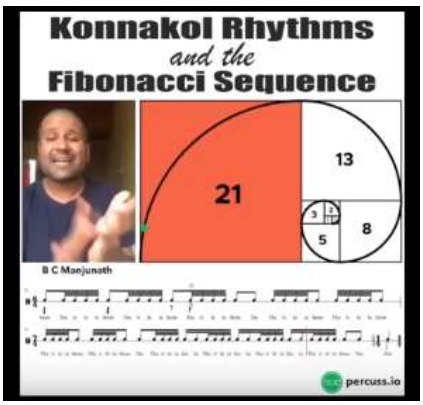
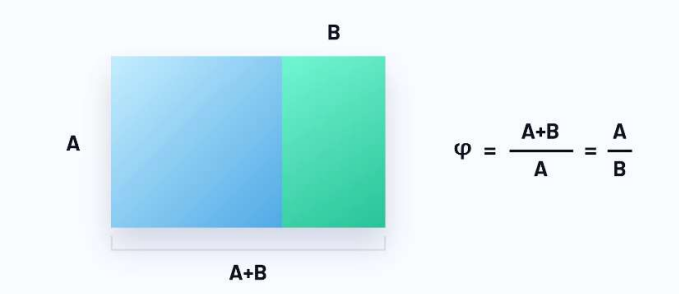




Fibonacci Sequence in Music

- The Golden Ratio



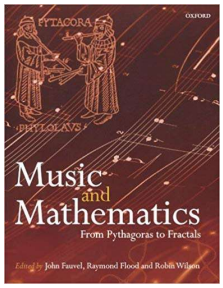
$$\varphi(\text{Phi}) = 1.618034...$$

- Summary of article 1 (The math behind Beethoven's music)
  - The first article talks about how examining Beethoven's use of both consonance and dissonance in his pieces of music can help us begin to understand how he added the unquantifiable elements of emotion and creativity to the certainty of mathematics.

- Summary of video 2 (The Golden Ratio and Fibonacci Sequence in music)
  - Since the beginning of time, Phi (also known as the golden ratio) has inspired the world around us. Have you ever noticed how some pieces of music just seem to make sense? From the notes and chords to the phrasing and dynamics, they can all feel like they were meant to go together. Many people believe this is not a coincidence but the golden ratio in action. This YouTube video

explores and proves that the relationship between the golden ratio and Fibonacci sequence in music is relevant.

- Summary of book 3 (Music and Mathematics: From Pythagoras to Fractals by John Fauvel, Raymond Flood and Robin Wilson)
  - This book explores the physical, theoretical, physiological, acoustic, compositional, and analytical relationships between music and mathematics.



3. Our methodology

In order to develop our project, we read books on the relationship between math and music and we did research on the relationship between the golden ratio, Fibonacci sequence and music. Our research findings are that the golden ratio is a special number found by dividing a line into two parts so that the longer part.

- If you take the inverse of phi, which is 0.618, and multiply it by the length of a song, that point is called the Phi moment of the song by music theorists. This moment is usually when the climax of the song comes in or the rhythm of the song changes. The Phi moment has been found in many popular pieces of music, such as “In My Feelings” by Drake and “Under Pressure” by Queen and David Bowie. However, it is highly doubted that composers have calculators by their sides when composing a song.

  When we took the song “Perfect Strangers” by Jonas Blue, whose Phi moment is at 2:07 of the song, as an example to try and test the relevance of the Phi moment, we found out that the rhythm of the song changed exactly at that second of the whole song. When we took another example, “The Nights” by Avicii whose Phi moment should be at 1:58, we found out that the rhythm of the song changed at that moment as well.

  One of the most interesting findings is that the Phi moment does not only apply to English songs. In the Japanese anime named Tokyo Ghoul, its opening, “Unravel” by TK, also has the Phi

moment occur at 0:55 of the song as the rhythm of the song changes entirely at this point of the song. However, the Phi moment is not always present in songs due to the different genres of music.

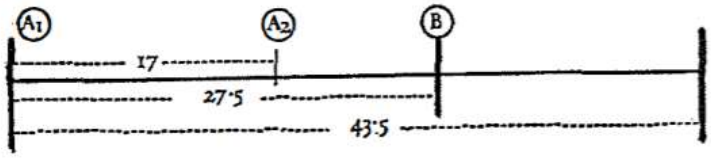
Below are the songs that we have used to test for the presence of the Phi moment in songs.

Song Title	Length of Song	Phi Moment	Applicable?
1. Perfect Strangers by Jonas Blue	207 seconds	207s x 0.618 = 127s	Yes
2. The nights by Avicii	191 seconds	191s x 0.618 = 118s	Yes
3. **Unravel (Japanese song) by TK**	90 seconds	90s x 0.618 = 55s	Yes
4. Shape of you by Ed Sheeran	264 seconds	264s x 0.618 = 163s	No
5. Sugar by Maroon 5	302 seconds	302s x 0.618 = 186s	Yes
6. Earth by Lil Dicky	432 seconds	432s x 0.618 = 266s	Yes
7. Better by Khalid	251 seconds	251s x 0.618 = 155s	Yes
8. High hopes by Panic! At the Disco	197 seconds	197s x 0.618 = 121s	Yes
9. God's plan by Drake	220 seconds	357s x 0.618 = 220s	Yes
10. Bounce by Marshmello	200 seconds	200s x 0.618 = 123s	Yes
11. Heaven by Avicii	305 seconds	305s x 0.618 = 188s	No

- In Mozart's "Sonata for two pianos", the third movement is structurally proportioned by the golden ratio. The principal theme, 43.5 measures in length, is divided into three sections: A1+A2+B.

Location of the B section	**43.5 x 0.618 = 27.5**
Location of the A sections	**27.5 x 0.618 = 17**

- Likewise, the A sections also have a phi relationship with each other. Both A sections together total to 27.5 measures, and 27.5 x 0.618 = 17, thus making Ai 17 bars in length.



4. Conclusion

In conclusion, from the results gathered, the Fibonacci numbers and the golden section appears to be the most effective compositional tool that has been utilized by musicians. Without mathematics, it would be harder to measure rhythm and relative pitch in music, and it would also be more difficult for musicians to be able to compose and read music. The research problems that we faced were that there was a lack of original songs for us to do testing for the presence of the Phi moment, and as we had a lack of music background and were entirely new to music, we had to learn more about the fundamentals of music first before we started on the testing of songs. If we were to do this project again, we would start doing the testing of songs earlier in order to find more song samples. One possible method that we could use to extend the project would be to create a piece of music using the Phi moment.

5. References

- http://www.openculture.com/2016/04/the-math-behind-beethovens-music.html - article 1
- https://www.youtube.com/watch?v=9mozmHgg9Sk – video 2
- Music and Mathematics: From Pythagoras to Fractals by John Fauvel, Raymond Flood and Robin Wilson – book 3