

Math/Music: Aesthetic Links

Some Examples of Symmetry in Music

1. **Transposition** (Translation)

- Ballpark organ music
- *Symphony No. 5 in C minor*, Ludwig Van Beethoven
- *Stars and Stripes Forever*, John Phillip Sousa
- *Adagio for Strings*, Samuel Barber

2. **Retrograde** (Vertical Reflection)

- *Lean on Me*, Bill Withers
- *The Musical Offering*, Johann Sebastian Bach
- *Hallelujah Chorus* from the *Messiah*, George Frideric Handel
- *Piano Sonata No. 41*, “*Minuet and Trio*” in A major, Joseph Haydn (reused in *Sonata No. 4 for Piano and Violin* as well as his *Symphony No. 47*)

3. **Inversion** (Horizontal Reflection)

- Many of the fugues written by Johann Sebastian Bach
- *The Musical Offering*, Johann Sebastian Bach
- Opening of the march *The Thunderer*, John Philip Sousa
- *Mikrokosmos*, Book 6, BB 105: No. 141, *Subject and reflection*, Béla Bartók

4. **Retrograde-inversion** (180° Rotation)

- *Ludus Tonalis* (“Game of Tones”), Paul Hindemith, (final movement is equivalent to the first movement rotated by 180°)

5. **All of the above**

- *Játékok for piano I, Hommage à Eötvös Péter*, Georg Kurtág, (see music excerpt on top of page 105 of the text). This piece is symmetric under *both* a horizontal and a vertical reflection, and therefore also has 180° rotational symmetry.

6. **Pieces featuring symmetry types 1, 2 and 3**

- *Hungarian Rhapsody #2*, Franz Liszt
- *I Got Rhythm*, George Gershwin
- Many twelve-tone pieces of Arnold Schoenberg