Maths+Music
Video 2:
Creating Sequences

Lesson objectives:

Understand that processes that include random events lead to unpredictable outcomes, and that sequences created from processes that include no random events ('deterministic systems') have rules that describe how they are generated. Identify that travelling in a straight line, over a square grid, is a process that includes no randomness, and show how a sequence could be created from this process. Appreciate that periodic sequences formed this way can be described musically as 'polyrhythms' and experiment with performing these polyrhythms as a class.

Keywords:

- Predictability
- Random
- Deterministic ('Not Random' is the important concept)
- Polyrhythm

Part 1:

Events that are 'predictable' are those where the outcome can be known before it happens. Random events lead to outcomes that are unpredictable, and sequences created from random events are likely to be aperiodic. 'Deterministic systems' (processes that involve no randomness) have rules that determine the outcome of the process, making them predictable.

The periodic sequences in Video 1 were created using deterministic systems:

- Turning a light switch on and off. The rules are:
    - If the light is off when you press the button, the light will turn on.
    - If the light is on when you press the button, the light will turn off.
- Days of the week. The rules are:
    - Sunday follows Saturday, which follows Friday, etc.

The aperiodic sequences in Video 1 were created from random events:

- Flipping a coin
- Colour of cars passing you on the street

Exercise 1:

Think back to some of the periodic and aperiodic sequences you created or discovered in the last video.

Were those sequences made from deterministic systems or random events?

If you made those sequences longer, would you be able to predict what would come next?

Some of the suggested examples from Video 1:

<u>Periodic sequences / Deterministic Systems:</u>
Traffic lights
- We know there is a rule for traffic lights, but do we know exactly what it is?

Rhyming schemes in poems
- What is the rhyming rule? Look at limericks, or other poem forms.

Hours of the day, days in a months/year
- Can we learn a rule to remember the number of days in each month?

<u>Aperiodic sequences / Random Events (or, unpredictable events: out of our control):</u>
Weather each day
- We try to predict it, but are we always right? Perhaps talk about weather that *is* periodic and deterministic e.g. Seasons. Why do seasons appear in order?

Dice roll
- Where and why do we use dice rolls?

Football/sports results
- Talk about betting as an industry based on likelihood of different outcomes. How predictable are sports matches?

Part 2:

We can set up a deterministic system (process that includes no randomness) by travelling in a straight line over a fixed grid of squares.

We can turn the journey along this path into a sequence by writing down:
- 'A' every time we cross a vertical line (in the video, 'A' stands for 'Avenue')
- 'B' every time we cross a horizontal line ('B' stands for 'Boulevard')

We can choose different paths, which should lead to different sequences, by:
- Starting at a crossroads, where 4 squares meet

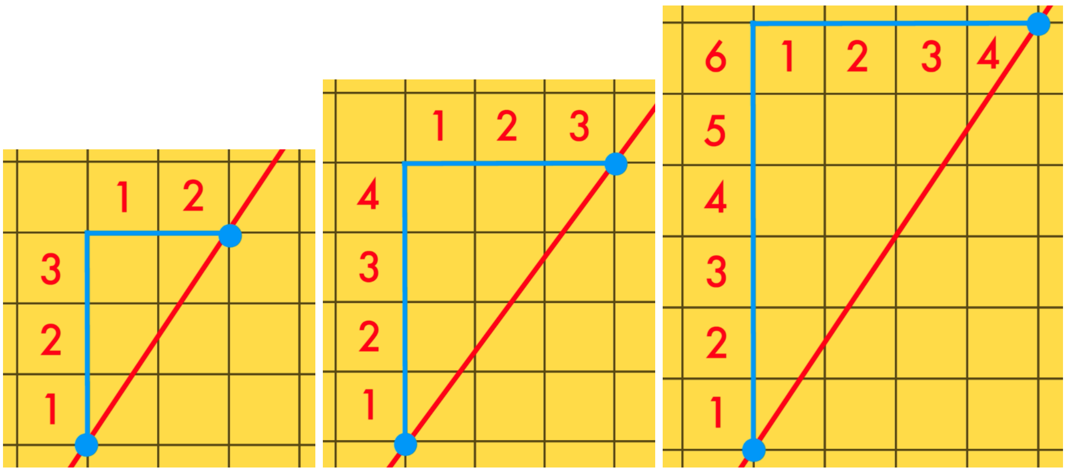
- Counting up some squares and along some squares to the right, to reach another crossroads.
- Drawing a line between these two crossroads and continuing off to the edge of your paper.

Exercise 2:

Find the sequences for these 3 paths:

1. Up 3 squares and along 2 squares (= Periodic. Period: BABAB)
2. Up 4 squares and along 3 squares (= Periodic. Period: BABABAB)
3. Up 6 squares and along 4 squares (= Periodic. Period: BABAB)
4. Choose your own start and end crossroads and write down the period. Is it the same or different to the sequences from parts 1-3?

NOTE: The sequences for the 1st and 3rd paths are the same. I mention this in the video after the exercise break. The reason is that a ratio of 6:4 (or a fraction of 6/4) can be simplified to 3:2 (or 3/2). This is a nice visual way to introduce or revisit simplifying fractions / ratios.



SOMETHING TO OBSERVE: The further along your path you travel before hitting the next crossroads, the longer the period of your sequence will be.

In the next video, we will be seeing what happens if the path *never* hits another crossroads (it creates a deterministic aperiodic sequence).

Part 3:

If we replace 'A's and 'B's with musical sounds, we can create 'polyrhythms' by travelling along our path. Matching the period, the musical pattern repeats every time you hit a crossroads.

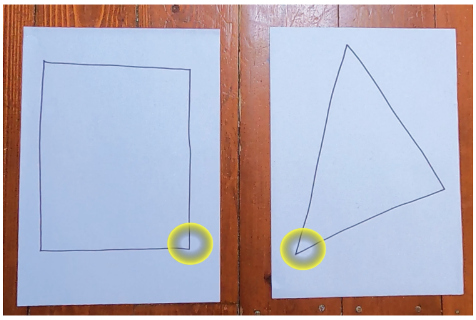
The 4-against-3 polyrhythm, which appears regularly in modern pop music, matches path number 2 (above), where we took 4 steps up, and 3 steps along, to reach the next crossroads. Musically, one sound plays 4 beats in the same amount of time as another plays 3.

Video Case study: Clean Bandit and Zara Larsson: *Symphony*
https://www.youtube.com/watch?v=aatr_2MstrI

Another example:
Skrillex and Diplo: *Where Are Ü Now* with Justin Bieber (from 1'09")
https://www.youtube.com/watch?v=nntGTK2Fhb0

Exercise 3:

A slowed-down version of the 4-against-3 polyrhythm can be performed by tapping around the corners of a rectangle and a triangle, and making a sound every time you get back to your starting point.



With a partner, or in a group, perform some of the polyrhythms linked to your paths across the grid. (3:2 and 4:3 are easiest, more complex patterns such as 5:4 or 8:5 can be used as a challenge.)

Draw shapes on a piece of paper that match the number of steps you took to reach the next crossroads on your path. (For 2 beat patterns, just use a line segment.)

Play a piece of music, or a drum beat, or a metronome, to keep everyone in time. Tap around the corners of your shape, making a noise every time you get back to the start.

Start at the same time as your partner. How many times do you travel around your shape before you and your partner next make a noise at the same time? How many 'beats' did it take?

ANSWER: If the ratio used is in its simplest form, the number of times you travel around your shape will be the same as the number of sides of your partner's shape. For example, for 4-against-3:

- Rectangle (4 sides) will complete 3 full cycles
- Triangle (3 sided) will complete 4 full cycles

The number of beats is given by the number of vertices times the number of cycles. In this example 4 sides x 3 cycles = 3 sides x 4 cycles = 12 beats.

(A possible extension is to investigate non-simplified ratios, e.g. 6:4 or 8:6. It should become clear that simplifying the ratio gives the number of cycles needed for the noises to match up. E.g. a hexagon needs 2 cycles (12 beats) when played against a square (3 cycles).)