Mind the Tempo:

Children’s conceptions of temporal symmetry

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Discussion Points

● The Researcher and the Study
● What is “temporal symmetry”
● Relevant Literature
● Methodological Considerations
● The Tasks
● Analysis Findings
● Further Study
● Conclusion & Questions
As a drummer and physicist, I have always been interested in time, motion, and pattern

...but mathematicians don't like time!

There is an odd relationship between mathematics, the metaphors we use, and the models that are employed...
The Study

Research Aim

Investigate perceived and externalized differences between figures with ‘symmetry,’ those with no ‘symmetries,’ and those that (by their deep connection with physical objects in the ‘real’ world) are taken (by me) to possess “temporal symmetry.”

Temporal symmetry is therefore a ‘primitive domain’

What is “temporal symmetry?”

Symmetry in “pure” math involves no time, yet the metaphors…

…I suggest it as a means for linking the abstract/Gestalt with the concrete/dynamic
 Relevant Literature

- Noether (1918)
  - Fundamental importance of temporal symmetry in physical laws
- George Lakoff and Rafaël Nuñez (2000)
  - Mathematics comes from mind and body
- Bazzini (2001)
  - Calls for more research in physically-oriented mathematics experiences

 Methodological Considerations

- Primarily qualitative
  - Not causal or broadly generalizable
  - Descriptive, interpretive and exploratory
- Two participants used
  - Attend same school
  - Difference in grade level = difference in formalized symmetry instruction
  - Difference in age (8 and 10)
  - Similar SES and cultural background
Tasks performed on “keyboard” with mallet(s) were video- and audiotaped.

Main data sources for triangulation:
- How they play
- What they say
- Presence of tempo

Basis for Inference
Findings – How they played…

- **Similarities**
  - Used one mallet, though given two
  - Used multiple notes/pitches
  - Pitch patterns same on #1 (“stairs”), #2 (“crown”) and #9 (“feet”)
  - Both played tasks 8 and 9 immediately
  - Oriented the keyboard “properly” (piano)
  - Oriented the tasks the same to start
    - Orientation change did not affect tempo
Findings – How they played… (cont.)

- Differences
  - Older student – more time before playing
  - Pitch patterns on other 6 tasks – **widely**
  - Younger did not change tasks 1-5 when orientation changed, but did on tasks 6-9
  - Older changed for every task change
  - Older used volume differences (for shape)

Analysis Findings – Tempo…

<table>
<thead>
<tr>
<th>Task Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 8</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Age 10</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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“Tempo” was both observed and measured with a metronome during analysis
Both between 40-120 bpm and <5% variation
Findings – What the older said…

- Stairs – “line, step..” then “same on both sides”
- Crown – “isn’t symmetrical” because all the sides are not the same
- Flower – “turning doesn’t matter, it’s the same”
- Semi – “not the same” so it “sounds different”
- Feet – stayed on the same two notes “because the footprints don’t go up”

Findings – What the younger said…

- Stairs – “like a person walking on the keyboard, they go from low to high then…”
- Crown – “like fingers sticking out”
- Flower – “it’s a flower and a flower keeps on growing… until the flower opens”
- Semi – “goes up then comes back down”
- Feet – Played a “person walking up the steps leaving footprints behind”
Findings – Interesting...

I play two versions of what they did for flower and stairs – one with tempo, the other without

Me – “Are those the same?”

Older – “Pretty much the same thing.”

Younger – “Yes.”

Findings, cont.

- Tempo is subconscious, but it may reflect an awareness of geometrical symmetries
- Temporal symmetry
  - Younger had more concrete object, time, and motion references
  - Both were quick to play and describe tasks 8 and 9 (bubbles and feet) in those terms
Further Study…

- What would musicians do on their “native” instruments?
- Developmental/age relationship between the way people perceive temporally symmetric phenomena?
- What other modes of representation could show temporal symmetry?
- Useful in regular and special education classrooms (tactile and kinesthetic learners)?
- Mind/body connection between mathematics and science modes of reasoning/thought?

Questions & Comments