Emergent Formal Structures of Factor Oracle-Driven Musical Improvisations

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17 June 2011
International Conference on Mathematics and Computation in Music

The Mimi Project:
Multimodal Interaction in Musical Improvisation

- Inspired by the **OMax** project at IRCAM – a little sister of the OMax brothers
- Implemented by Alexandre François using his Software Architecture for Immersipresence (SAI)
- **Mimi 1.0**: by François, Chew, Thurmond [ACMCIE], premiered at 1st MCM meeting, Berlin 2007, on a Seiler piano
- **Mimi4x**: by François, Schankler, Chew [IMIDA, IJART], installation for high-level structural improvisation
- **Mimi 1.5**: by François, Schankler, Chew, featured in concerts: PiE, etc.

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Mimi demonstration

Question

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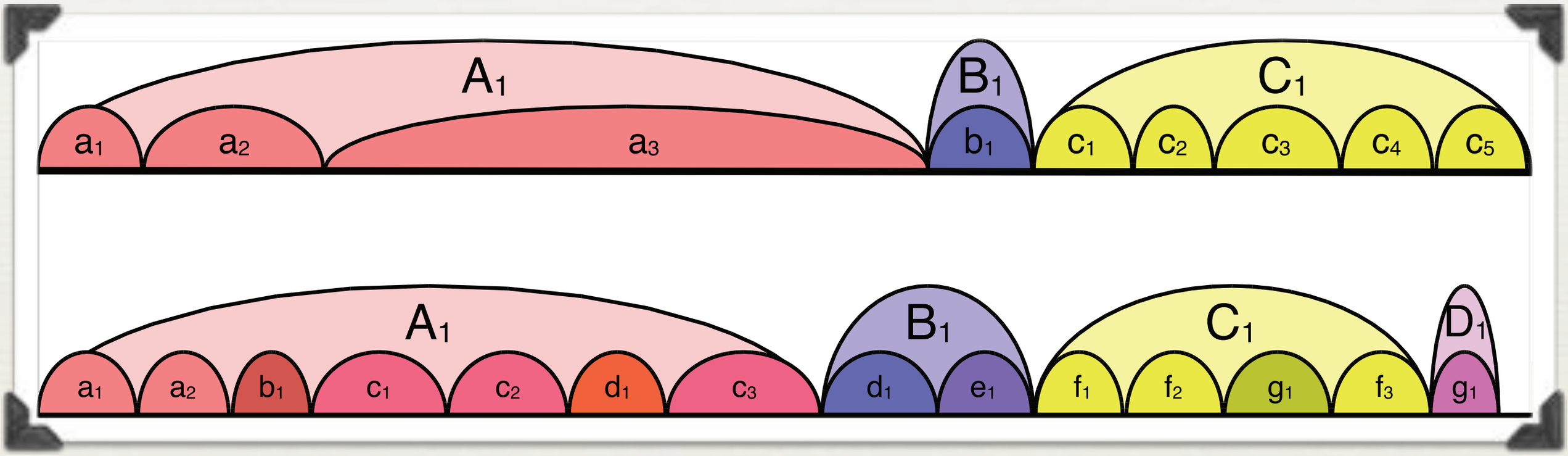
- When a human improviser interacts with Mimi, what kinds of structures emerge?
- Do the performer and a listener perceive the structures differently?

Experiment

- Isaac performed three improvisations with Mimi
- The sessions were recorded
- The recordings were analyzed by (1) the performer, Isaac, and (2) a skilled listener, Jordan
- The annotations were compared

Results

Recording #1



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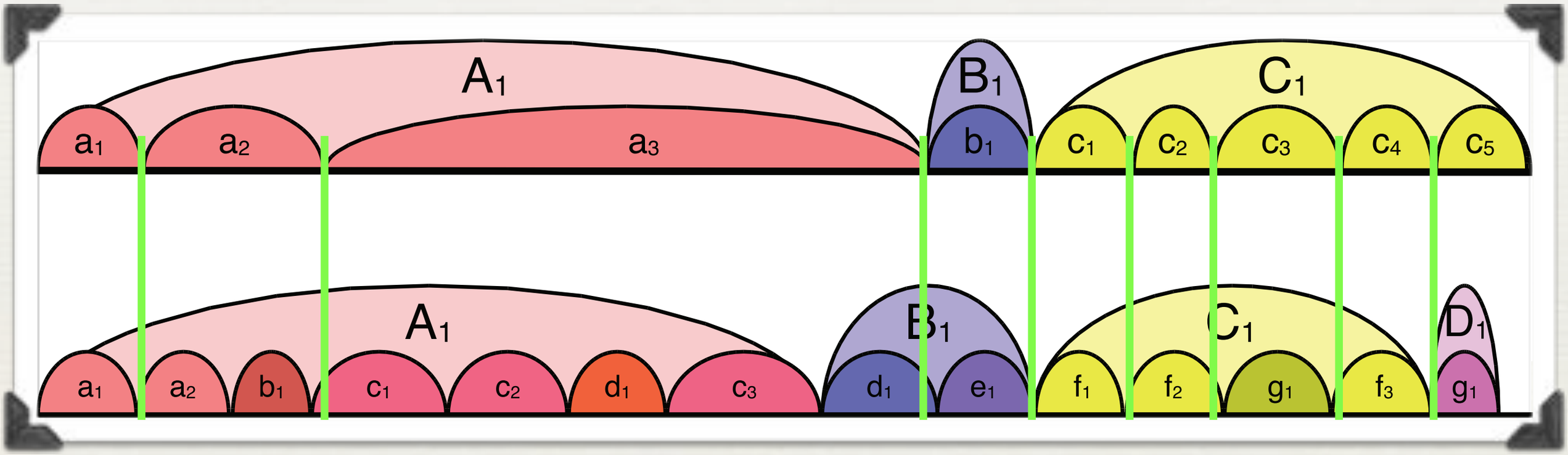

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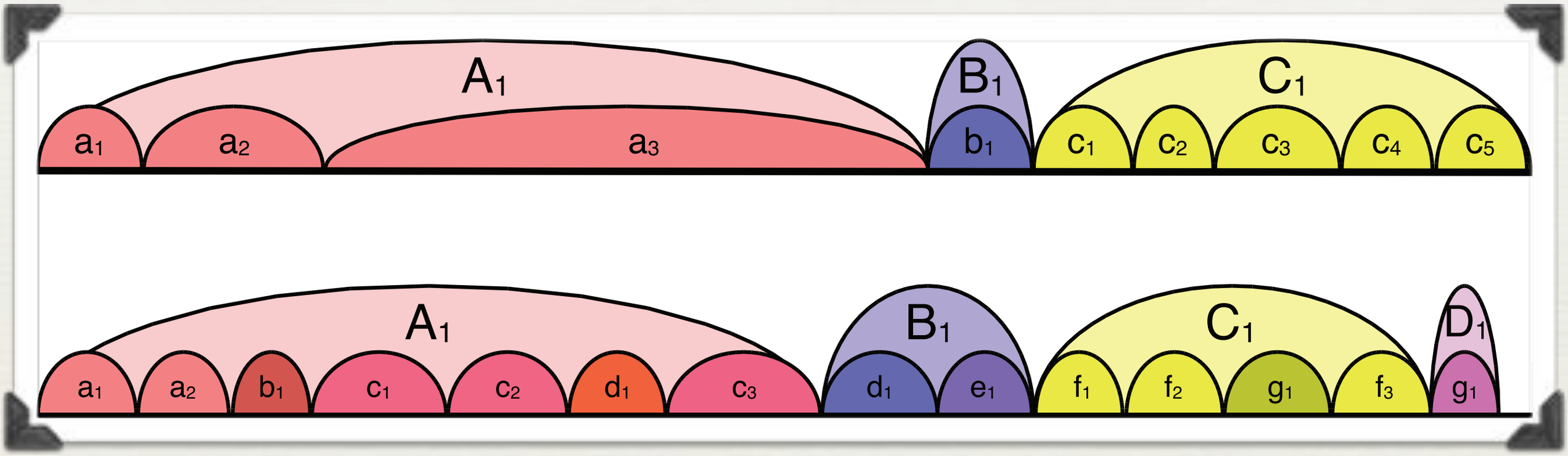
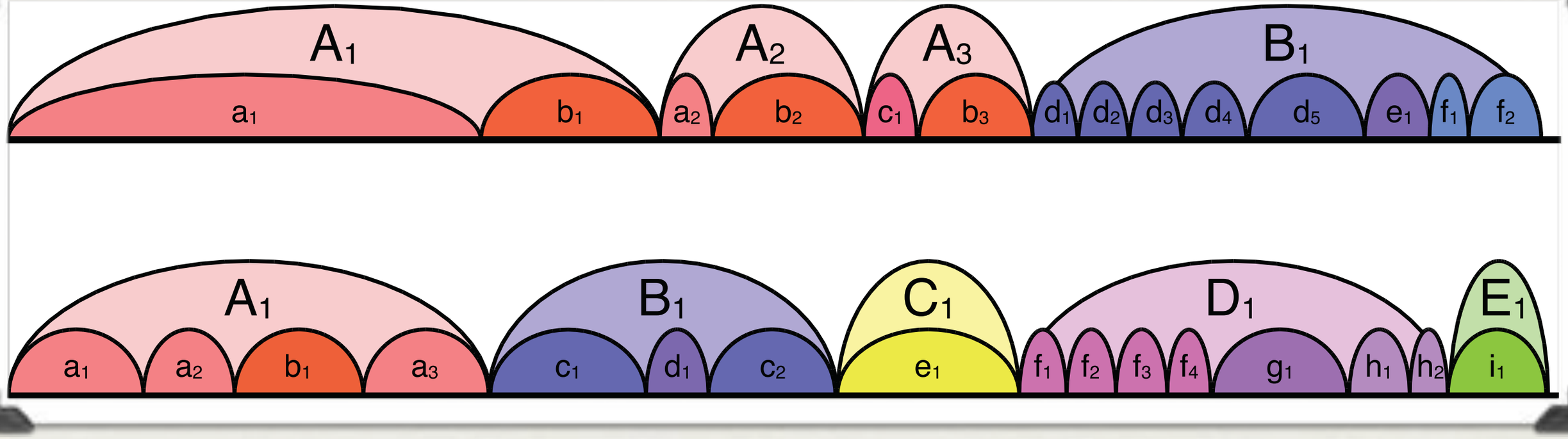


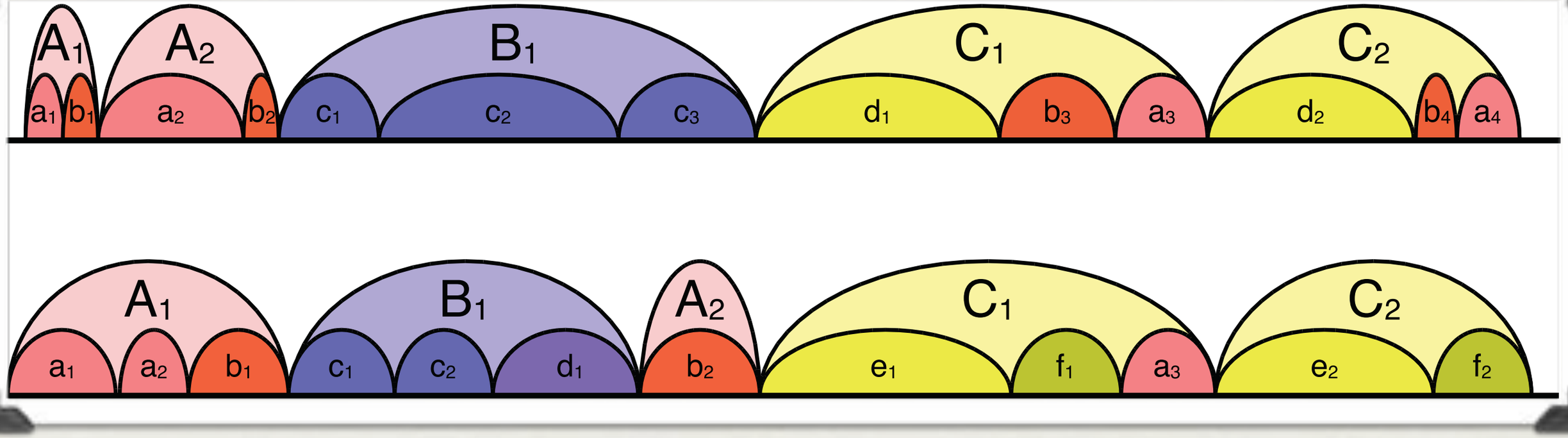
Results

Recording #2



Results

Recording #3



Results

- Boundaries in small-scale analyses tend to be closely aligned
  - Interpretation of boundaries was similar
- Labels in large-scall analyses tend to coincide
  - Large-scale organization is similar

Evaluation

- Visual comparison reveals many similarities, but these judgements are subjective.
- Four empirical evaluation metrics were considered:
  - Boundary precision and recall
  - Pairwise precision and recall
  - Average cluster and speaker clarity
  - Rand index

Boundary precision and recall

Annotation

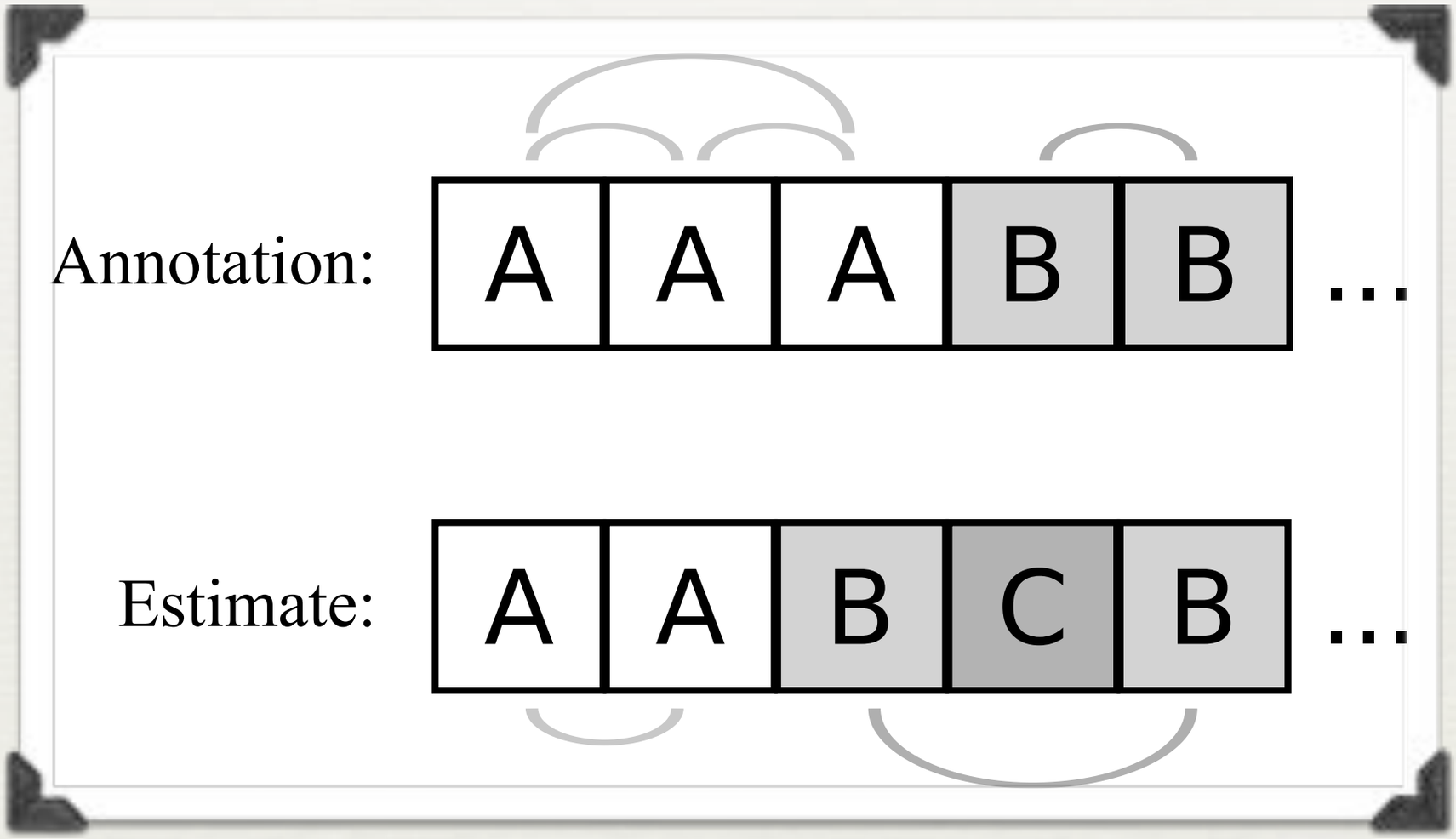
Estimate

Precision: 3/8 = 37.5%

Recall: 3/5 = 60%

f-measure: 2pr/(p+r) = 46%

Pairwise precision and recall



Precision: 1/2 = 50%

Recall: 1/4 = 25%

f-measure: 2pr/(p+r) = 33%

Baselines

- Empirical comparisons more or less meaningless without some baseline for comparison
- Many baseline strategies were used; the best-performing one placed 10 boundaries randomly throughout the piece and assigned segment labels randomly

Boundary f-measure ± 1 second	Performance 1		Performance 2		Performance 3	
Scale:	Small	Large	Small	Large	Small	Large
Ann1 - Ann2	**0.27**	**0.29**	**0.28**	**0.40**	**0.39**	**0.53**
baseline - Ann1	0.02	0.01	0.02	0.00	0.05	0.03
baseline - Ann2	0.02	0.01	0.02	0.01	0.04	0.04

Boundary f-measure ± 6 second	Performance 1		Performance 2		Performance 3	
Scale:	Small	Large	Small	Large	Small	Large
Ann1 - Ann2	**0.74**	**0.50**	**0.65**	**0.40**	**0.82**	**0.85**
baseline - Ann1	0.18	0.10	0.14	0.09	0.25	0.17
baseline - Ann2	0.24	0.15	0.13	0.10	0.29	0.17

Pairwise f-measure,	Performance 1		Performance 2		Performance 3	
Scale:	Small	Large	Small	Large	Small	Large
Ann1 - Ann2	0.47	**0.85**	**0.66**	**0.62**	**0.68**	**0.90**
baseline - Ann1	**0.50**	0.51	0.50	0.52	0.41	0.48
baseline - Ann2	0.34	0.50	0.40	0.43	0.36	0.48

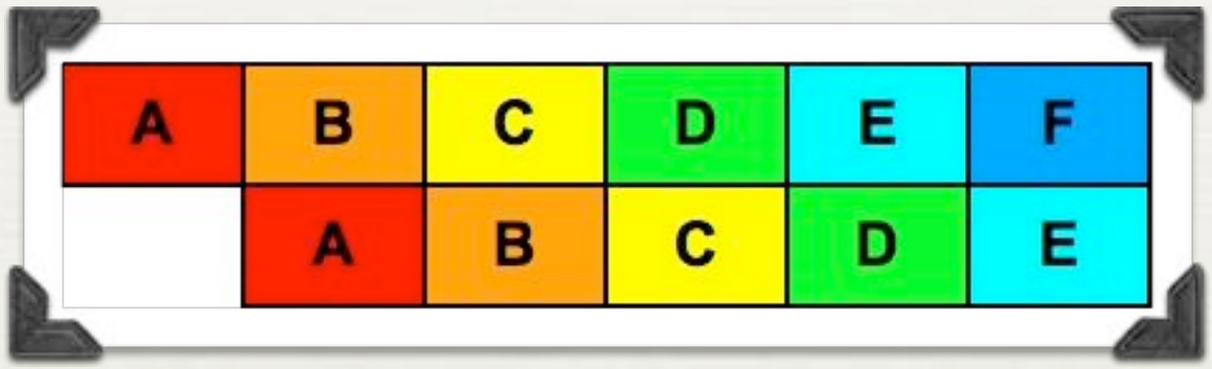
K-measure	Performance 1		Performance 2		Performance 3	
Scale:	Small	Large	Small	Large	Small	Large
Ann1 - Ann2	**0.60**	**0.84**	**0.70**	**0.70**	**0.68**	**0.87**
baseline - Ann1	0.56	0.53	0.55	0.56	0.44	0.51
baseline - Ann2	0.43	0.54	0.50	0.50	0.42	0.52

Rand index	Performance 1		Performance 2		Performance 3	
Scale:	Small	Large	Small	Large	Small	Large
Ann1 - Ann2	**0.70**	**0.90**	**0.88**	**0.71**	**0.87**	**0.93**
baseline - Ann1	0.67	0.63	0.76	0.59	0.68	0.58
baseline - Ann2	0.58	0.61	0.72	0.52	0.63	0.58

Question

- When a human improviser interacts with Mimi, *how* do structures emerge?

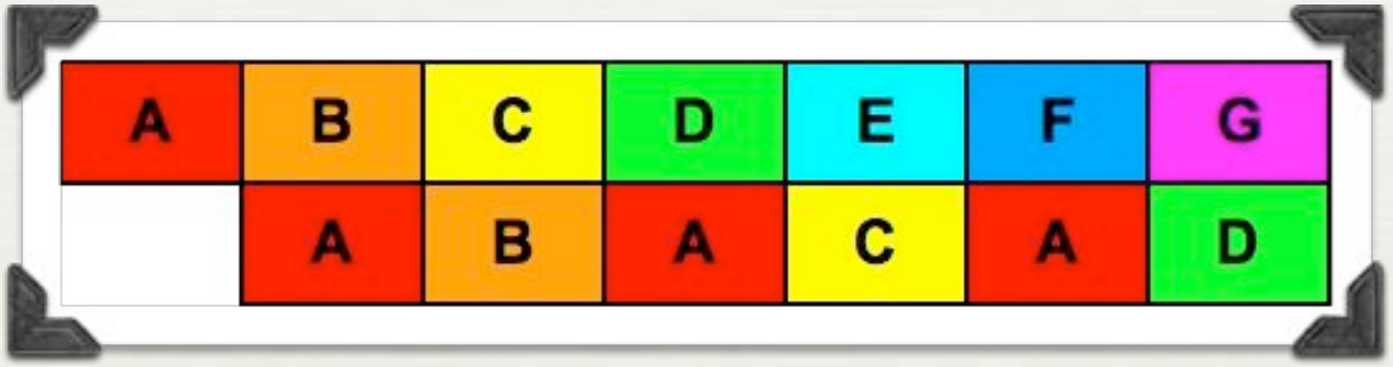
The Canon



- Mimi's actions are delayed by 10 seconds
- If no recombination occurs, together Mimi and the human performer create a canon at the 10-second level

Canon-like forms

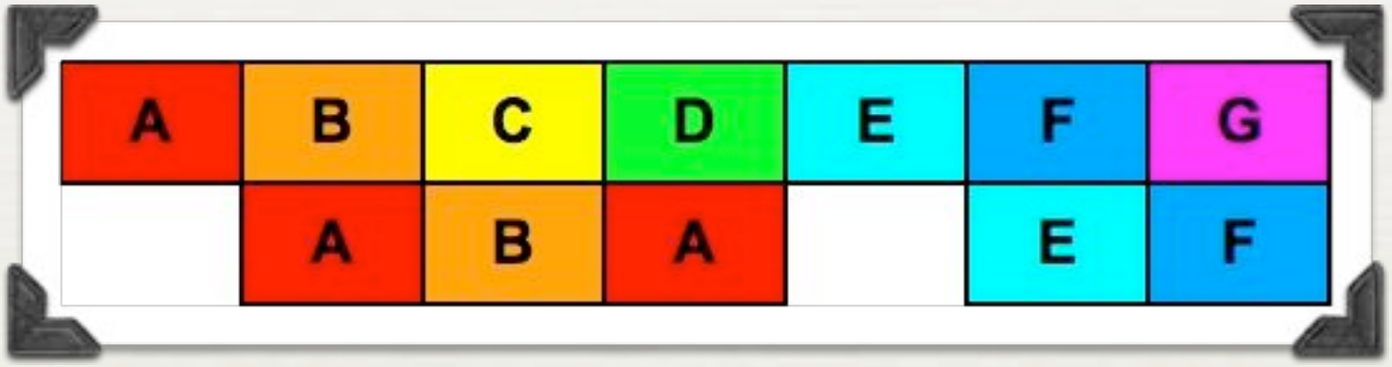
The Rondo



- Mimi may revisit pieces of musical material, creating a sense of return
- If Mimi is continuously learning, material learned earlier is more likely to be heard again than material learned later

Rondo-like forms

Large-scale formal divisions



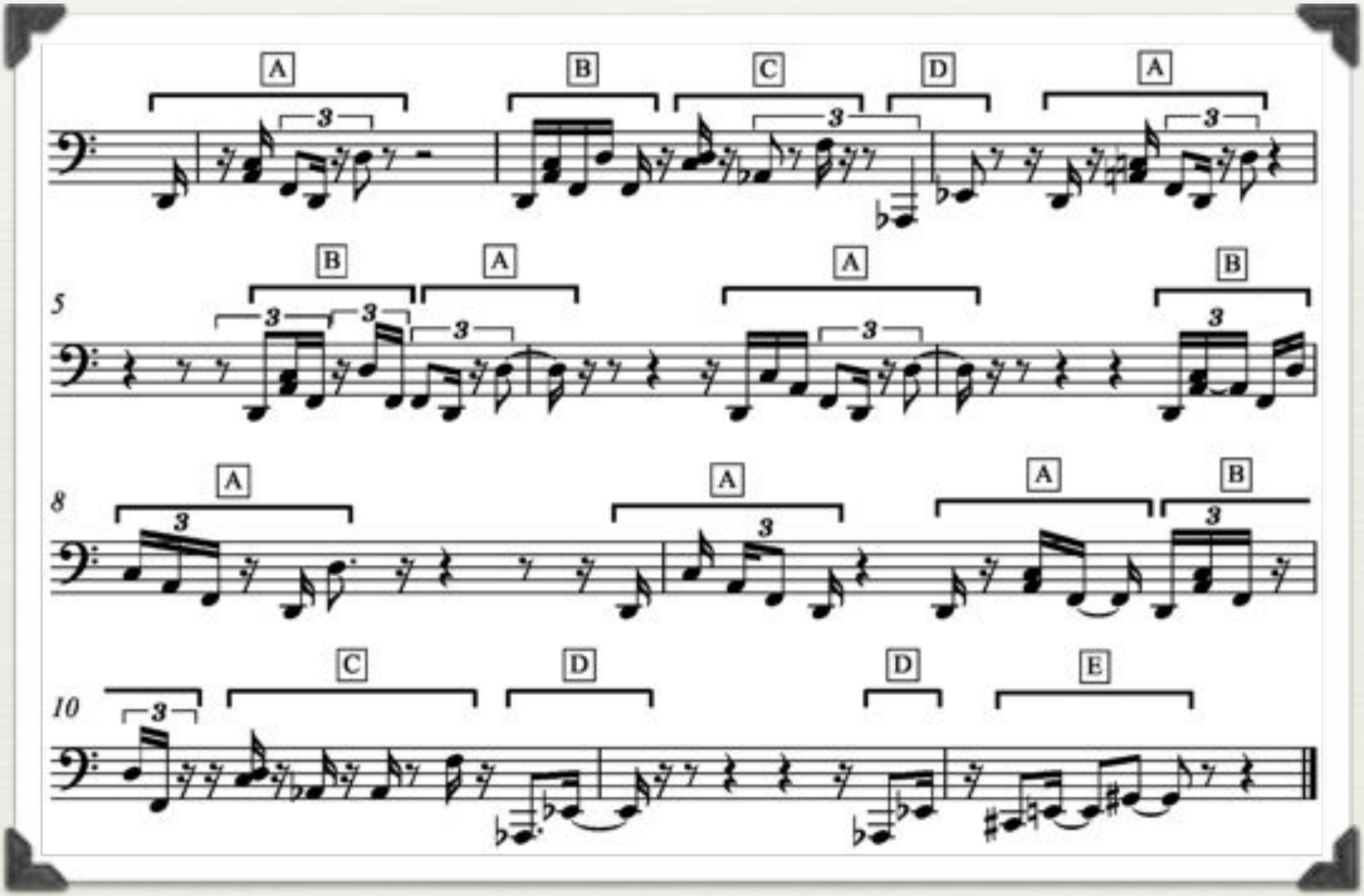
- Mimi's memory can be cleared, allowing the creation of large-scale formal divisions

More large-scale formal divisions

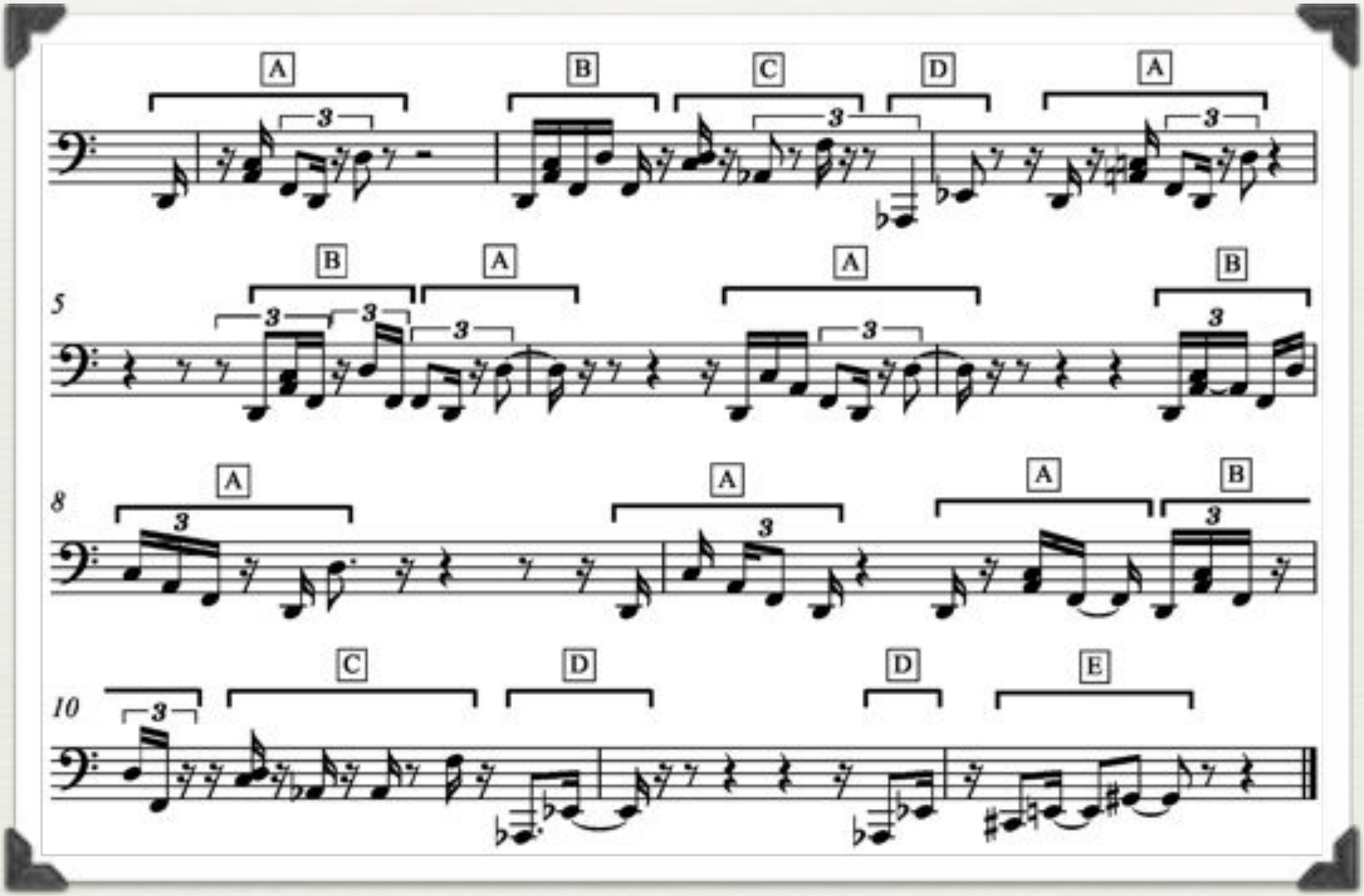
Rhythmic cells

- On a smaller scale, Mimi's performances exhibit similar structural tendencies
- Similar to personnages rhythmiques found in the music of Stravinsky and Messiaen, but always immobile

Rhythmic cells



Rhythmic cells



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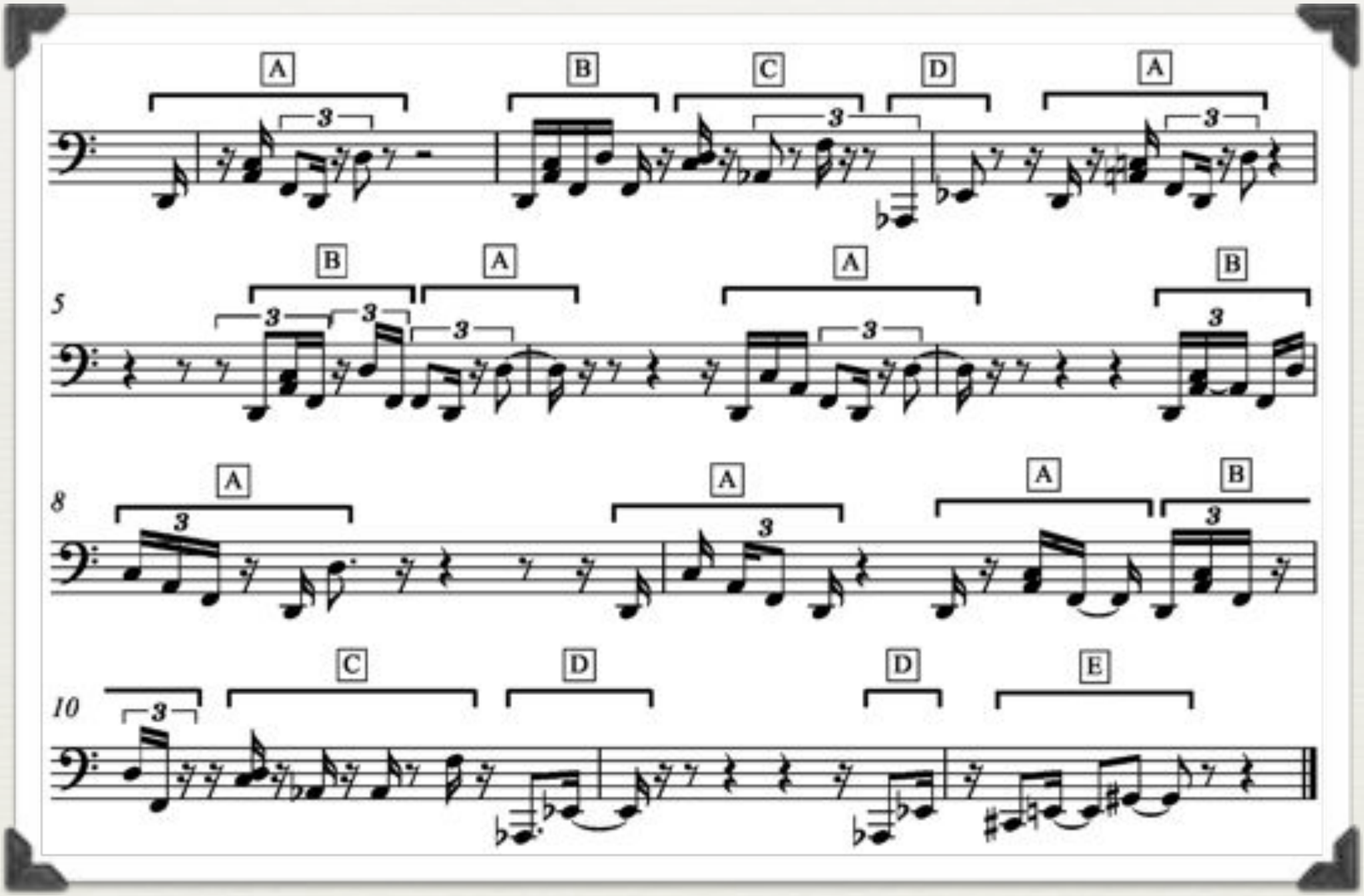

Summary

- Questions:
  - When a human improviser interacts with Mimi, *what* kinds of structures emerge, and *how* do they emerge?
- Answers:
  - *Familiar* structures (canon, rondo, etc.)
  - By virtue of Mimi's *programming*...

Thanks for your attention!