

Emergent Formal Structures of Factor Oracle-Driven Musical Improvisations

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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

- ♦ When a human improviser interacts with Mimi, what kinds of structures emerge?

Question

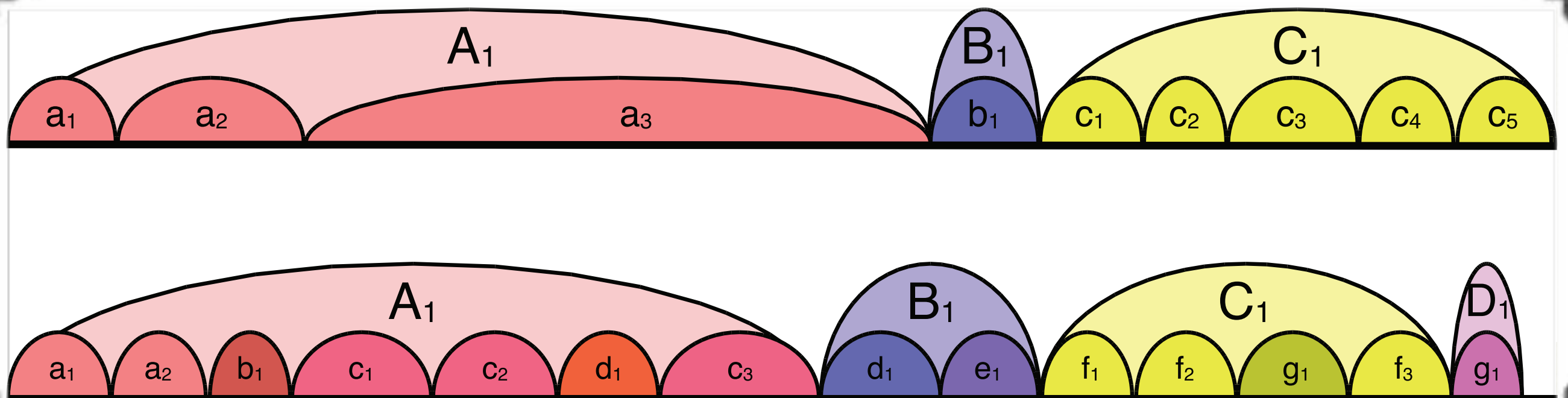
- ♦ When a human improviser interacts with Mimi, what kinds of structures emerge?
- ♦ Do the performer and a listener perceive the structures differently?

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

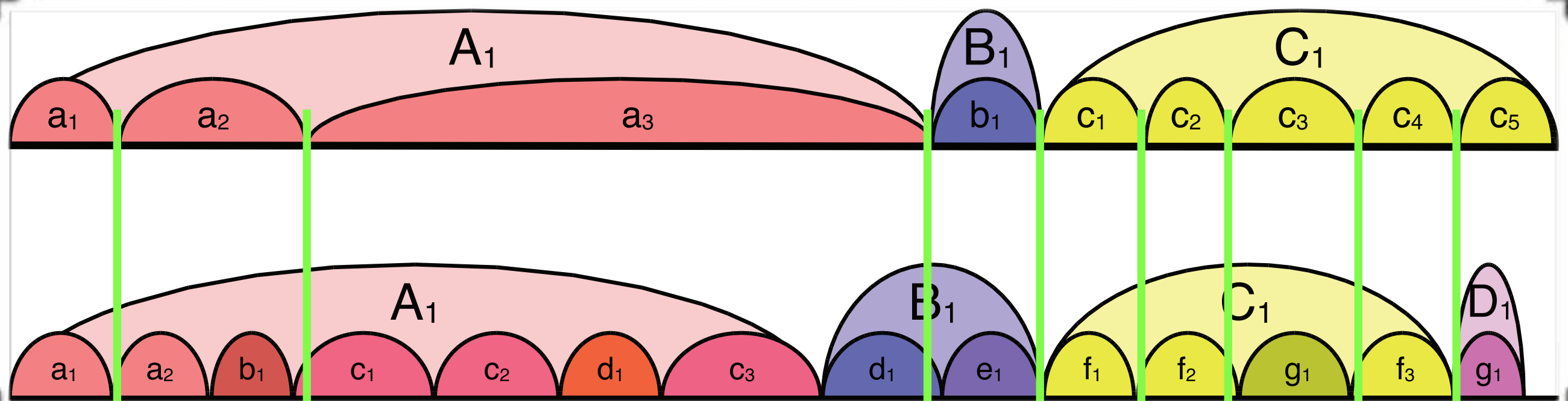
Results

Recording #1



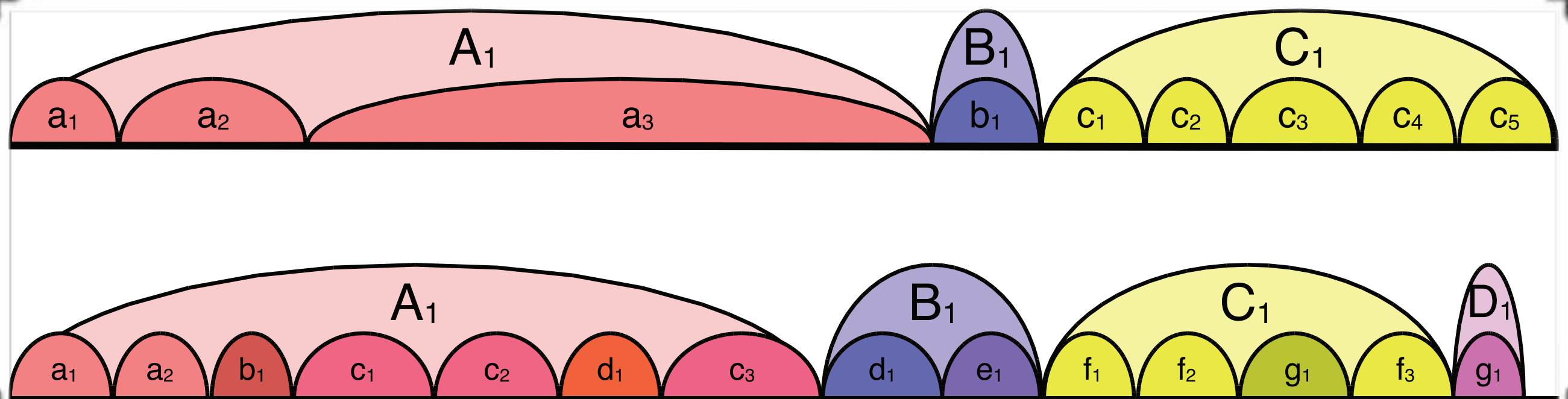
Results

Recording #1



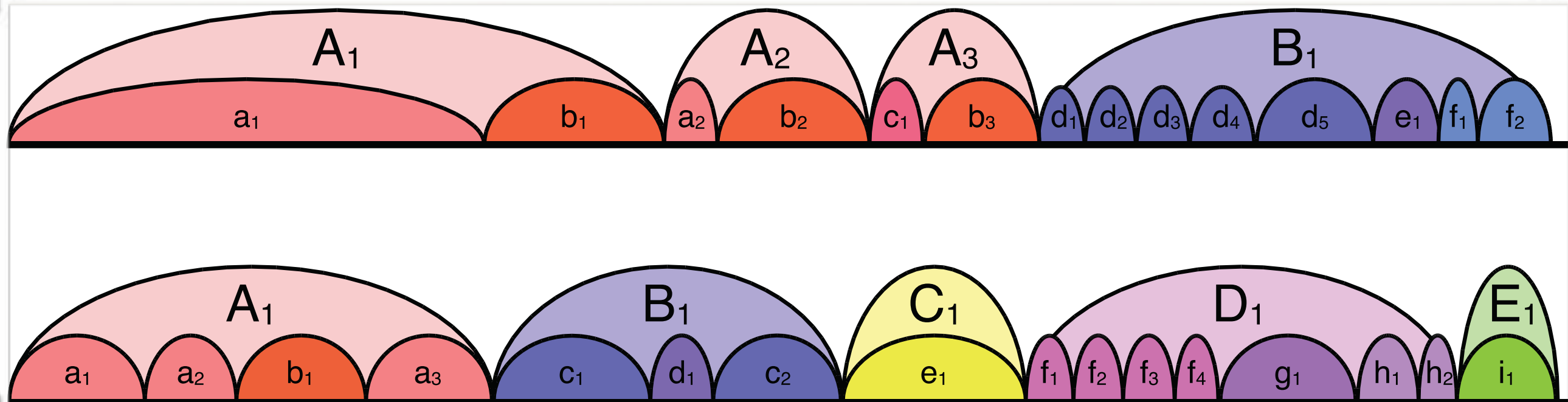
Results

Recording #1



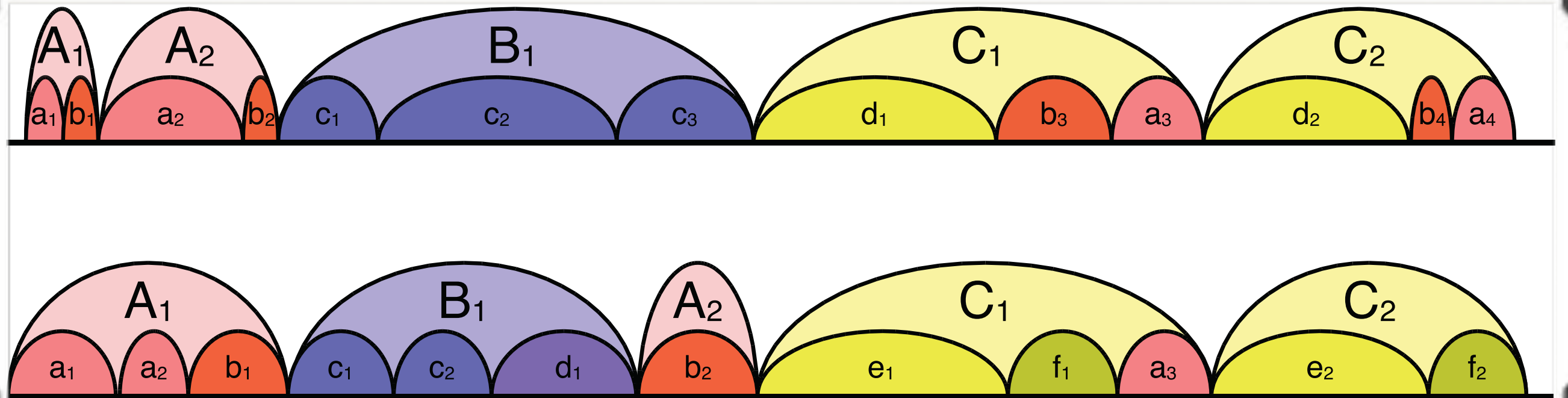
Results

Recording #2



Results

Recording #3



Results

- ♦ Boundaries in small-scale analyses tend to be closely aligned
 - ▶ Interpretation of boundaries was similar
- ♦ Labels in large-scale 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: $3/8$

$= 37.5\%$

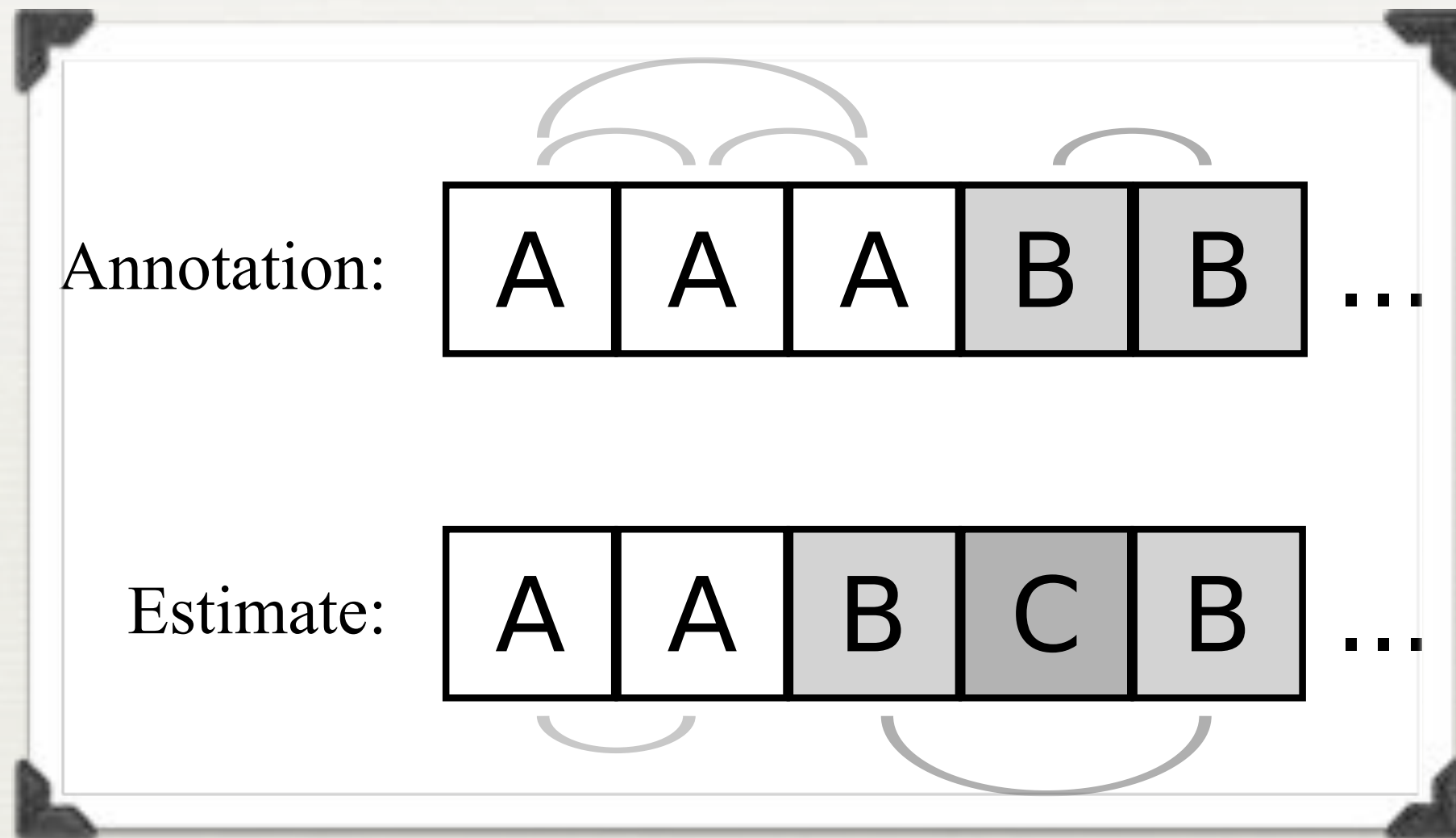
Recall: $3/5$

$= 60\%$

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

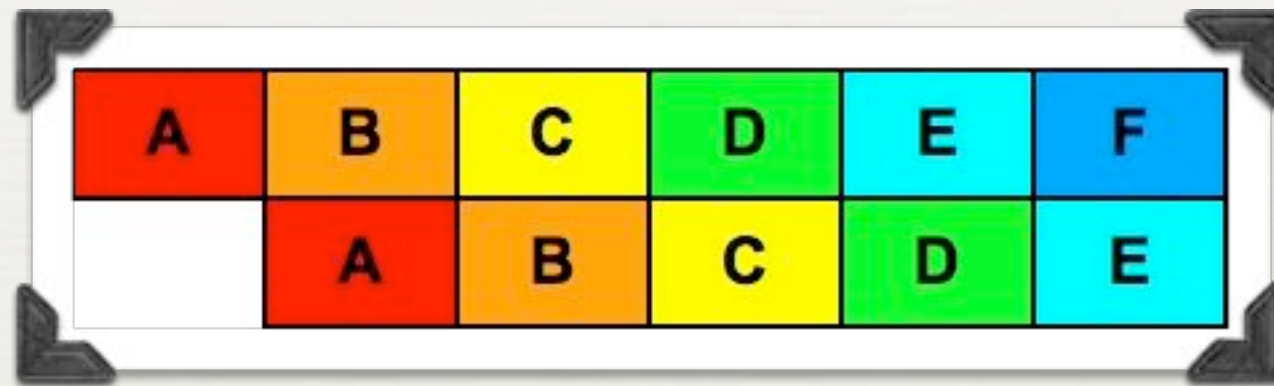
K -measure	Performance 1		Performance 2		Performance 3	
Scale:	Small	Large	Small	Large	Small	Large
Ann1 - Ann2	0.60	0.84	0.70	0.70	0.68	0.87
baseline - Ann1	0.56	0.53	0.55	0.56	0.44	0.51
baseline - Ann2	0.43	0.54	0.50	0.50	0.42	0.52

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

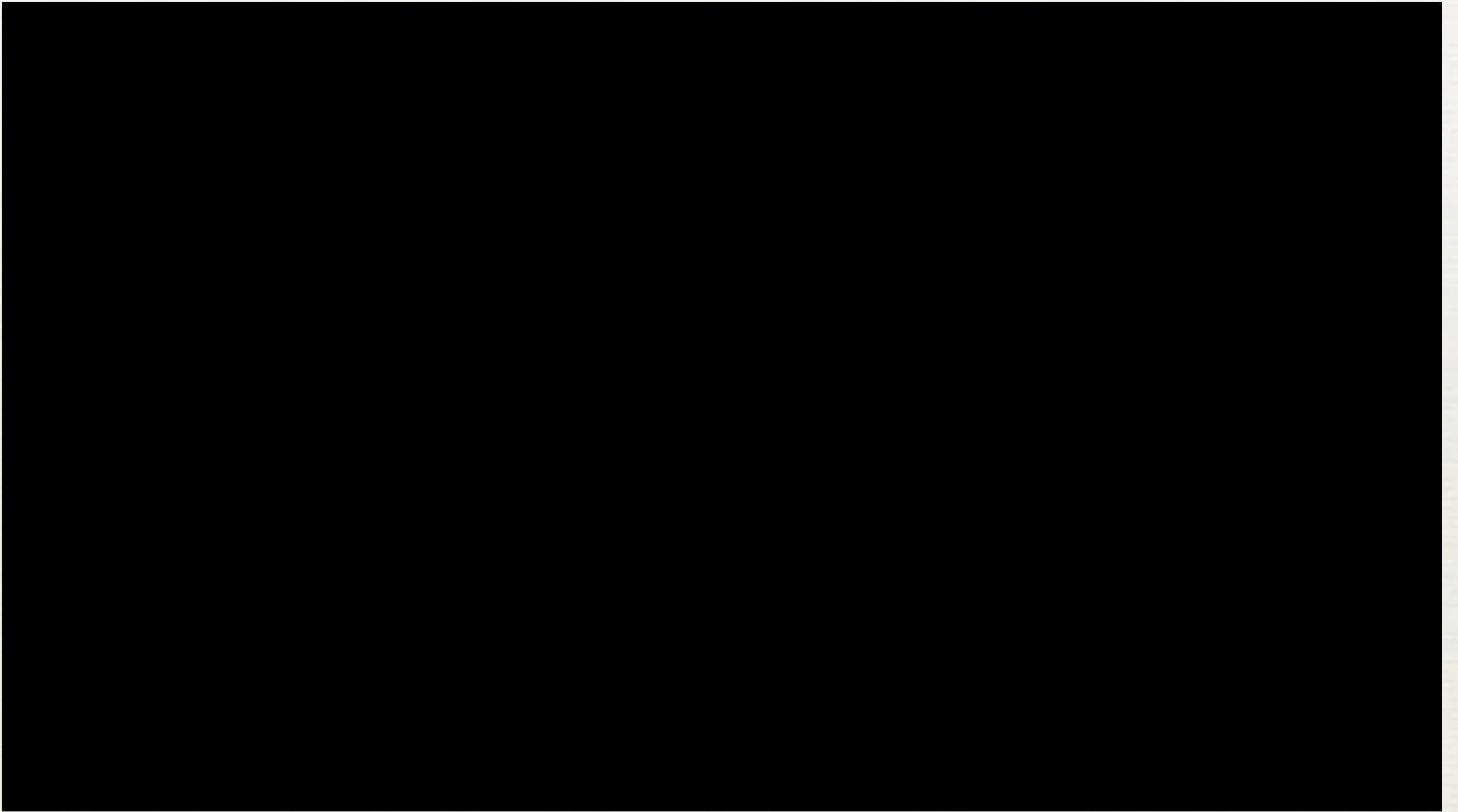
- ♦ When a human improviser interacts with Mimi, *how* do structures emerge?

The Canon

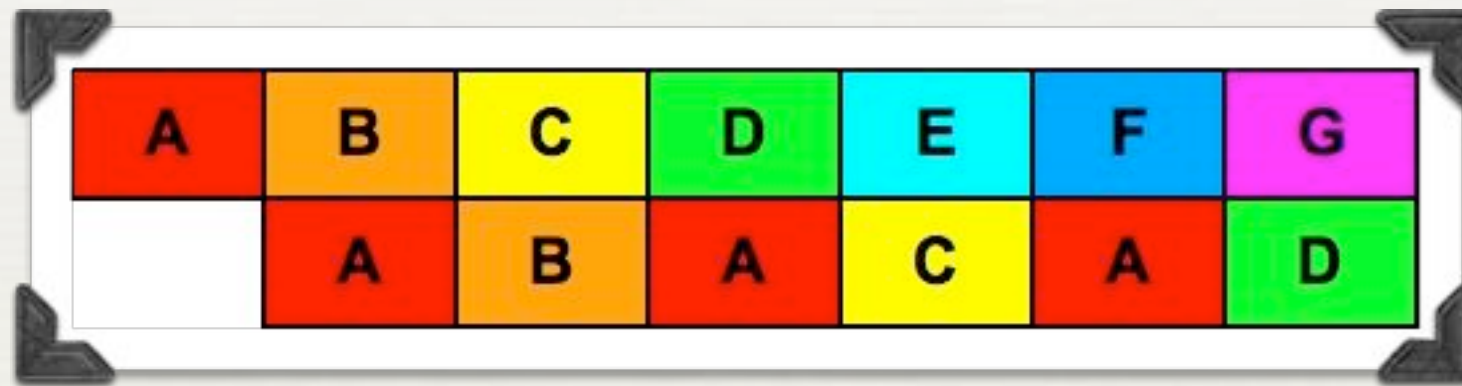


- ♦ Mimi's actions are delayed by 10 seconds
- ♦ If no recombination occurs, together Mimi and the human performer create a canon at the 10-second level

Canon-like forms

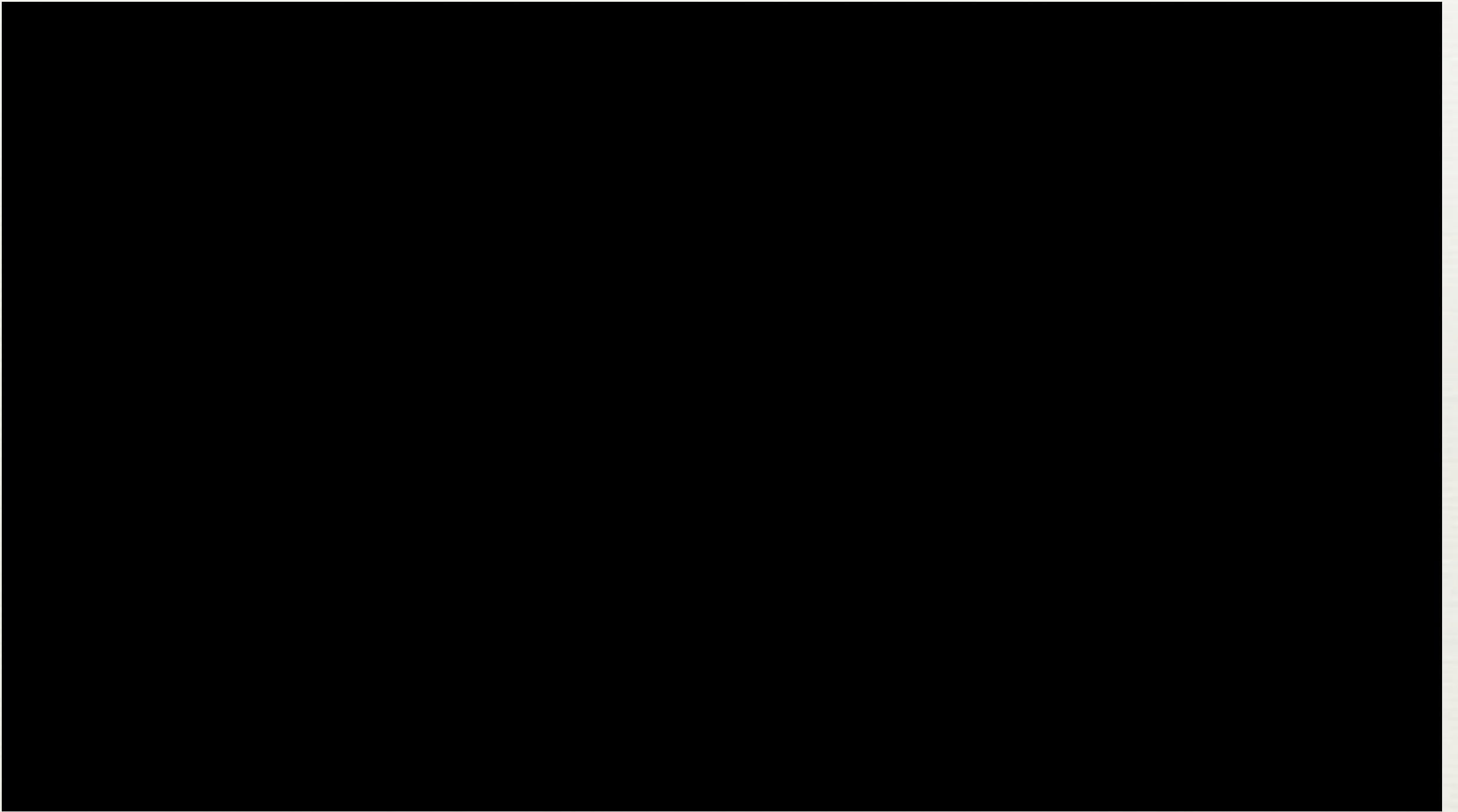


The Rondo

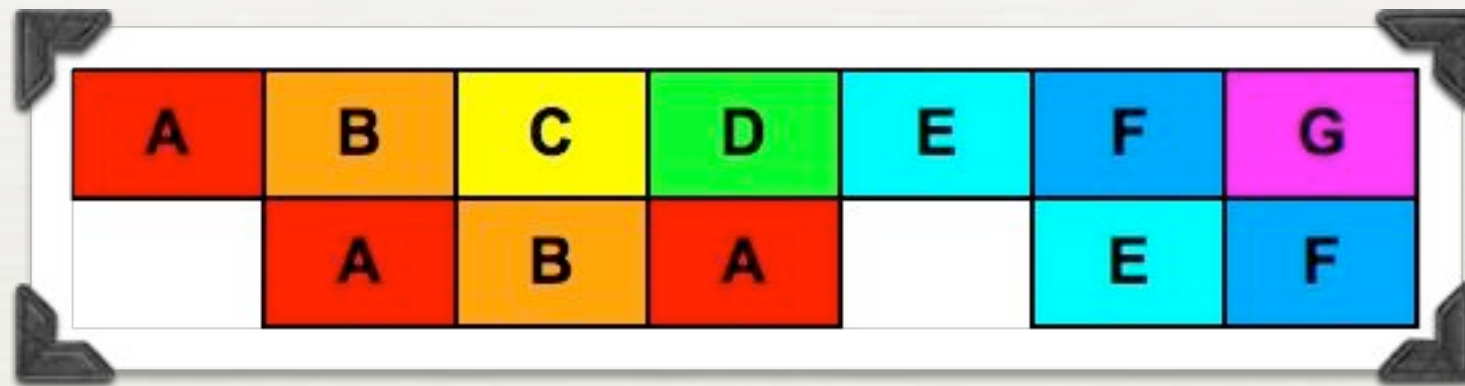


- ✦ Mimi may revisit pieces of musical material, creating a sense of return
- ✦ If Mimi is continuously learning, material learned earlier is more likely to be heard again than material learned later

Rondo-like forms

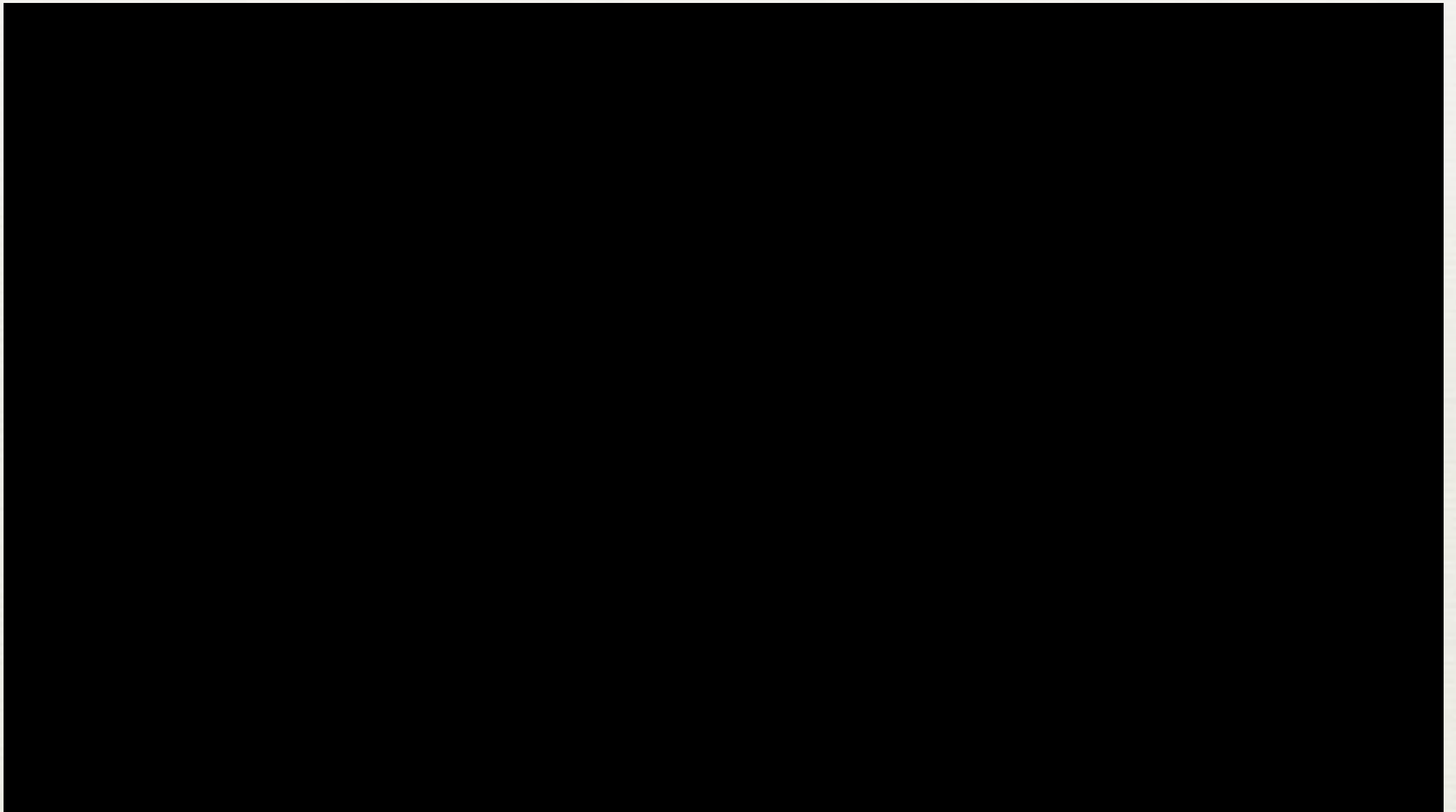


Large-scale formal divisions



- ✦ 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 rythmiques found in the music of Stravinsky and Messiaen, but always immobile

Rhythmic cells

A musical score for bass clef, 4/4 time, featuring five rhythmic cells labeled A through E. The score is organized into four systems, each containing two staves. The first staff of each system contains measures 1-4, and the second staff contains measures 5-8. Measure numbers 5, 8, and 10 are indicated at the start of their respective staves. Rhythmic cells are defined by brackets and labels: Cell A (measures 1, 5, 9, 13), Cell B (measures 2, 6, 10, 14), Cell C (measures 3, 7, 11), Cell D (measures 4, 8, 12), and Cell E (measures 13, 14). Each cell consists of a triplet of eighth notes. The key signature changes from one flat (B-flat) to two flats (B-flat and E-flat) after measure 8.

5

8

10

Rhythmic cells

A musical score for a single melodic line in bass clef, spanning 14 measures. The score is divided into four systems, each containing two staves. The first staff of each system contains measures 1-4, 5-8, 9-12, and 13-14 respectively. The second staff of each system contains measures 5-8, 9-12, and 13-14 respectively. The score is composed of rhythmic cells labeled A through E, which are defined by brackets and letter labels above the notes. Cell A is a triplet of eighth notes. Cell B is a triplet of eighth notes. Cell C is a triplet of eighth notes. Cell D is a triplet of eighth notes. Cell E is a triplet of eighth notes. The score includes various musical notations such as eighth notes, sixteenth notes, and rests. The key signature has one flat (B-flat), and the time signature is 4/4. The score is presented on a white background with black musical notation.

5

8

10

Rhythmic cells

A musical score for a single melodic line in bass clef, spanning 14 measures. The score is divided into four systems, each containing two staves. The first staff of each system contains measures 1-4, 5-8, 9-12, and 13-14 respectively. The second staff of each system contains measures 5-8, 9-12, and 13-14 respectively. The score is composed of rhythmic cells labeled A through E, which are defined by brackets and letter labels above the notes. Cell A is a triplet of eighth notes. Cell B is a triplet of eighth notes. Cell C is a triplet of eighth notes. Cell D is a triplet of eighth notes. Cell E is a triplet of eighth notes. The score includes various musical notations such as eighth notes, quarter notes, and rests, as well as key signatures (one flat) and a common time signature. The measures are numbered 1, 5, 8, and 10 on the left side of the staves.

1

5

8

10

A B C D A

B A A B

A A A B

C D D E

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!