

Layered Analysis of Irregular Facades via Symmetry Maximization

Submission ID: 0084

Supplemental Material

Table of contents

1. User study: Evaluation of façade retrieval

1.1 Introduction webpage

1.2 Survey webpage

1.3 A list of retrieval results used in the user study

2 User study: Evaluation of symmetry-driven decomposition

2.1 Introduction webpage

2.2 Survey webpage

2.3 A list of decomposition results used in the user study

3 User study: Evaluation of integral symmetry

3.1 Questions

3.2 Results

Section 1

User study:




Evaluation of façade retrieval

Welcome to our user study!

Please read this introduction before proceeding to the survey.

In what follows, you will be presented with three images of building facades (see the example below). Please choose which facade, A or B, is most **structurally** similar to the query facade on the top.

If it is too difficult for you to judge, please select "Unsure" as your answer.

	
<p>Which one is more structurally similar to above? By structure, we refer to the arrangement or organization of the basic elements of a facade.</p>	
 <input type="radio"/> A	 <input type="radio"/> B
<input type="radio"/> Unsure	

NOTE: By structure, we refer to the **arrangement or organization of the basic elements** of a facade, such as windows and balconies. Color, texture, styling, or other appearance attributes are not considered as structural characteristics. For example, the following two facades are similar in appearance in terms of color, texture and window/door styling, but they are structurally quite different.



In contrast, the following two facades are similar in terms of structure but different in terms of color/texture.



Are you ready? [Go!](#)

Similarity Comparison (1 / 20)



Which one is more **structurally** similar to above?
By structure, we refer to **the arrangement or organization of the basic elements of a facade.**



☐ A



☐ B

☐ Unsure

Next

Please select and then click 'Next'.

**A sample list of 25 comparisons of retrieval
results used as questions in user study 1**

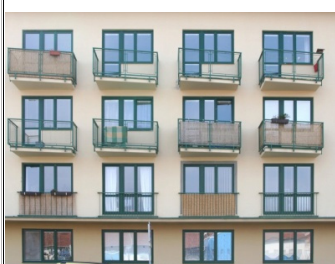
25 comparisons of retrieval results (questions in user study)

ID	Query	Ours	MSD	SIFT
1				
2				
3				
4				

5



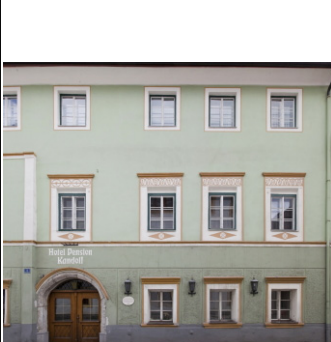
6



7



8



9







21				
22				
23				
24				
25				

Section 2

User study:

**Evaluation of symmetry-driven
decomposition**

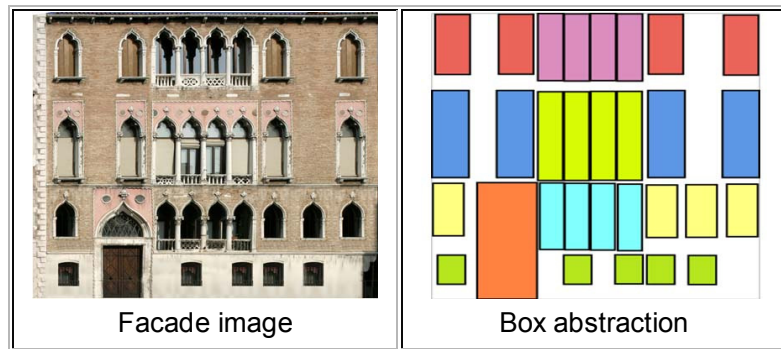
Welcome to our user study!

Please read this introduction before proceeding to the survey.

We are interested in structural analysis of building facades.

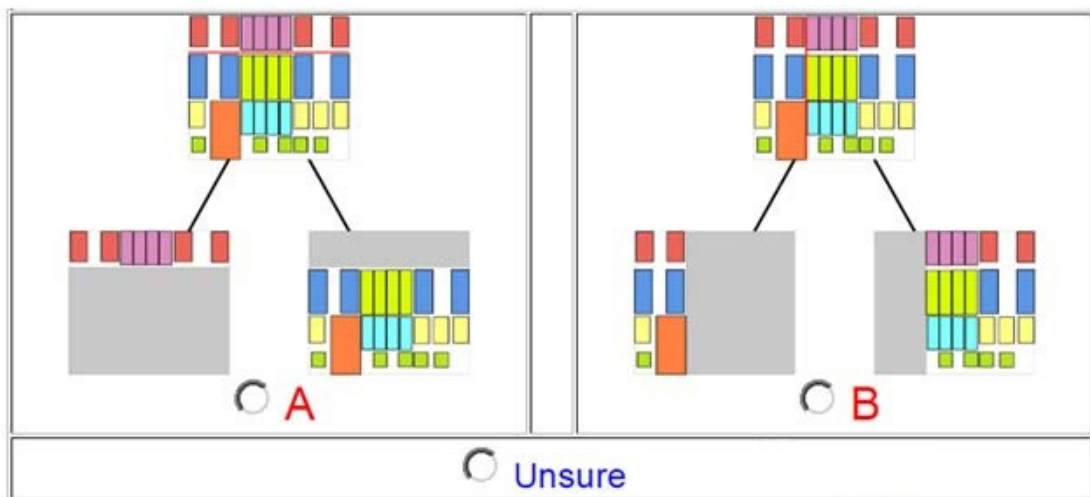
As a structural representation, the basic elements of a building facade such as windows, doors, or balconies, are abstracted as colored boxes. Boxes with the same color represent repeated elements.

Below is an example of a facade and its box abstraction:



For a given box abstraction representing the structure of a facade, you will be presented with two possible ways to decompose the structure into two substructures.

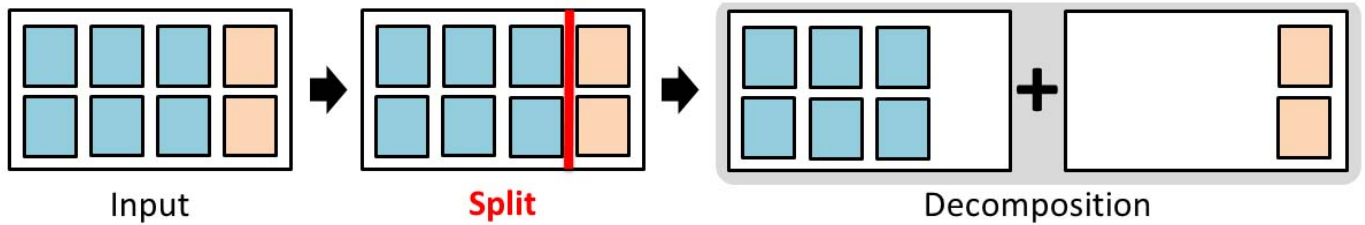
You will be asked to select which one, A or B, appears to offer **the best high-level explanation of the facade structure**:



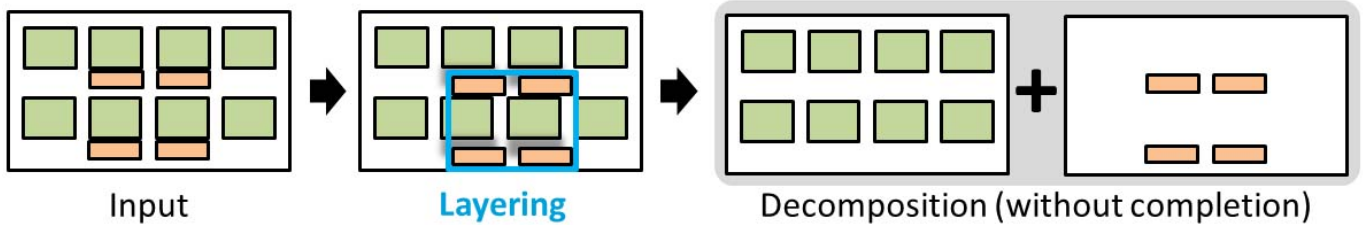
* If it is too difficult for you to judge, you can select "Unsure" as your answer.

Two types of decomposition operations are considered: split and layering.

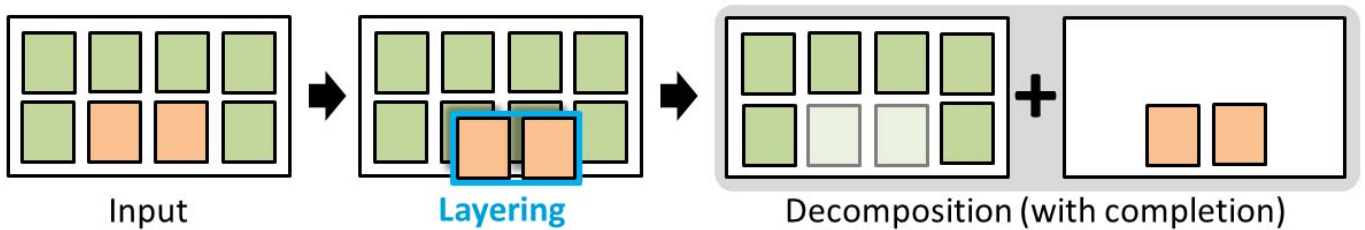
A split is a straight line passing through the bounding box of the facade, splitting the box abstraction into two subsets:



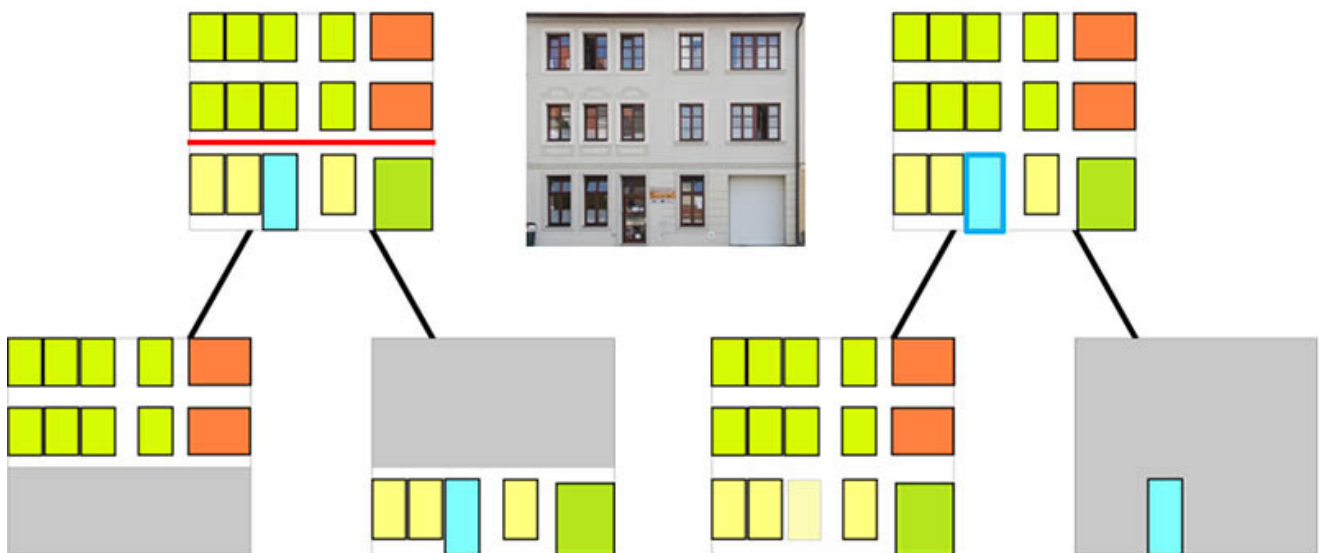
A layering decomposes the structure along the depth direction, forming two layers:

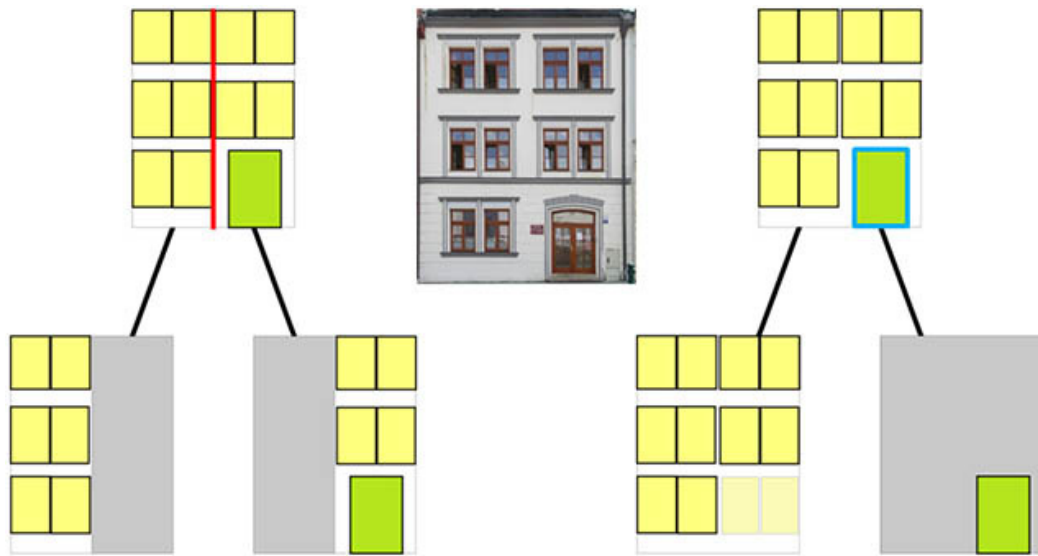


If necessary, the groups of boxes in the bottom layer undergo structure completion in a natural way following the perceptual principle of closure:



Below you will see two examples showing the alternatives in binary structural decomposition:

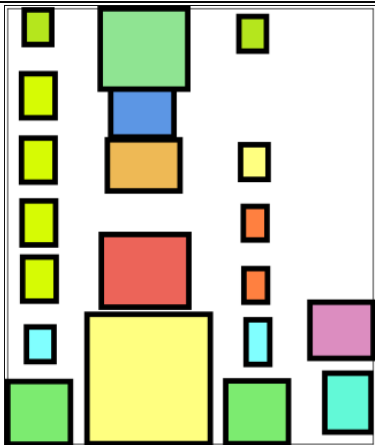




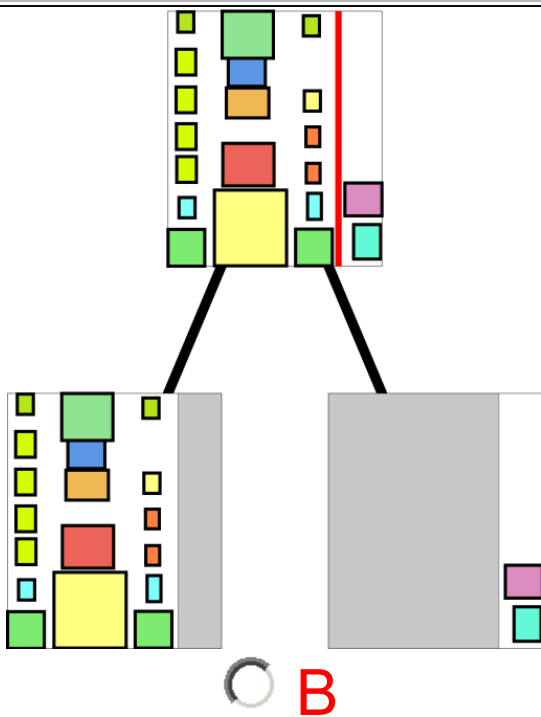
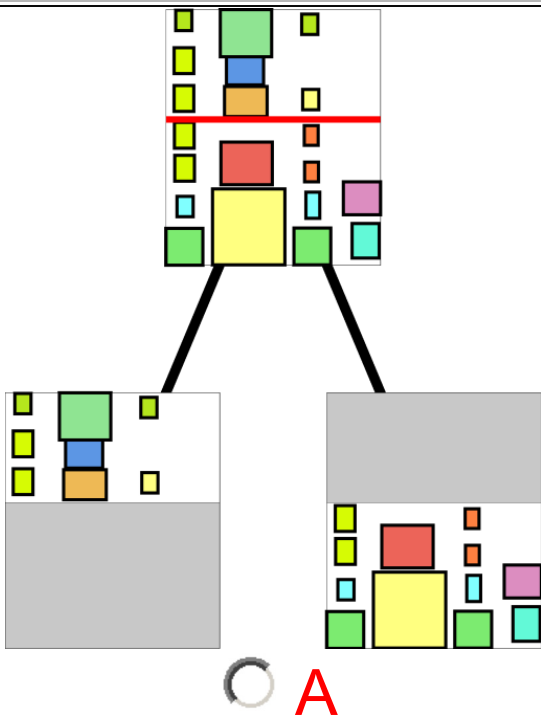
Example 2.

Are you ready? Go!

Decomposition Comparision (1 / 20)



The following shows two possible decompositions of the facade. Which one appears to offer **the best high-level explanation of the facade structure**?




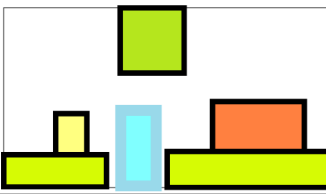

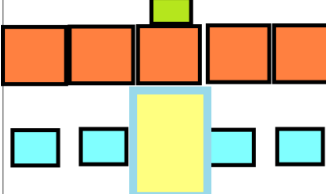
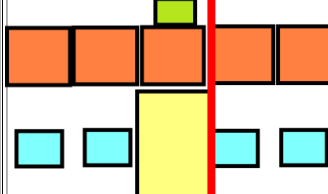

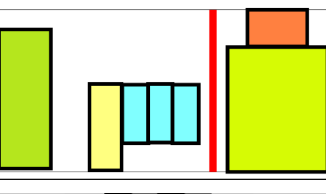
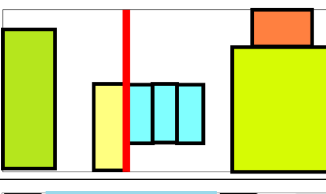

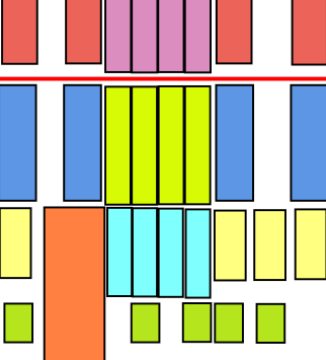
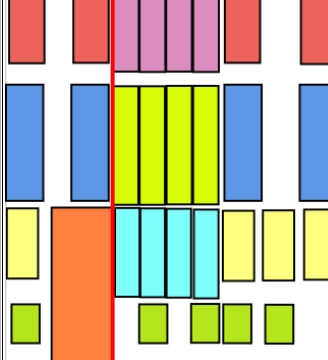
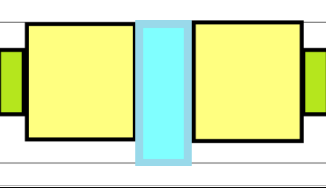
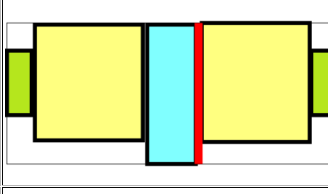





☐ Unsure


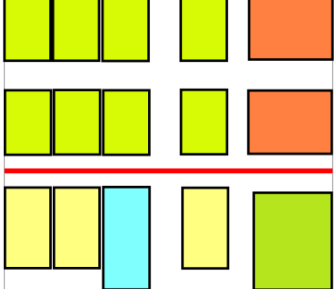
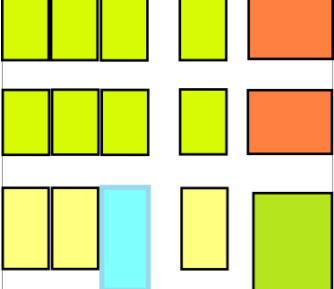
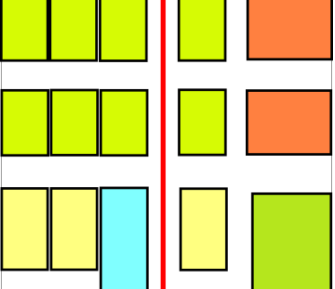

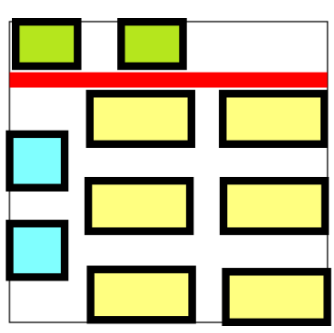
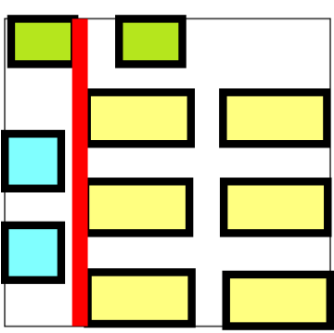
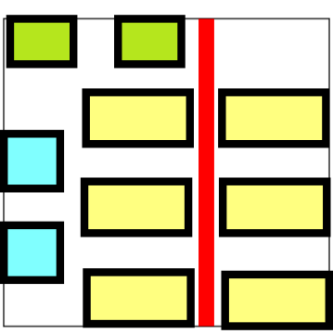

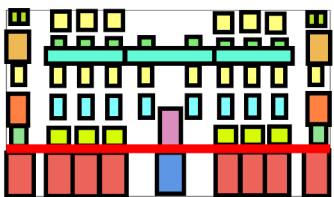
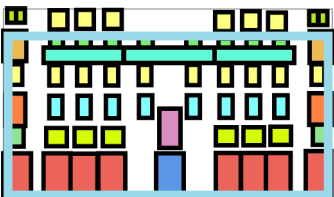


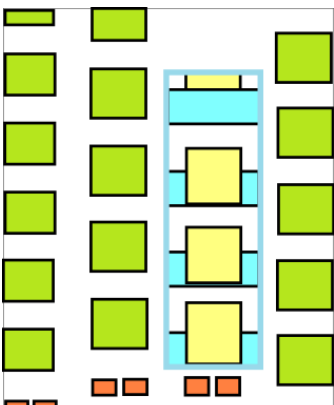
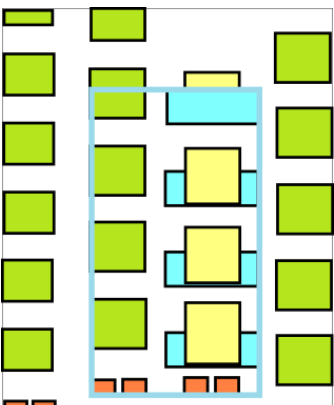
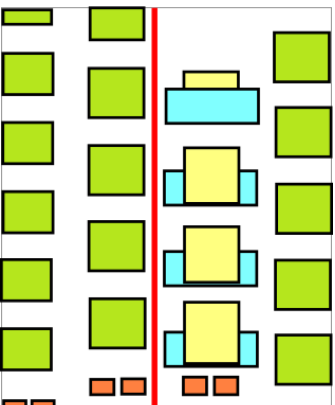

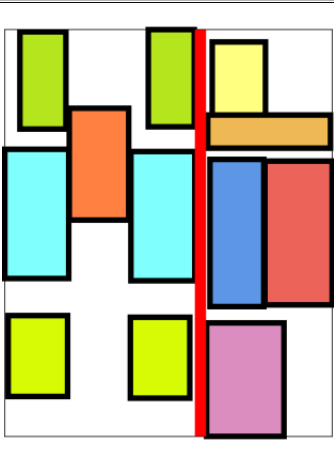
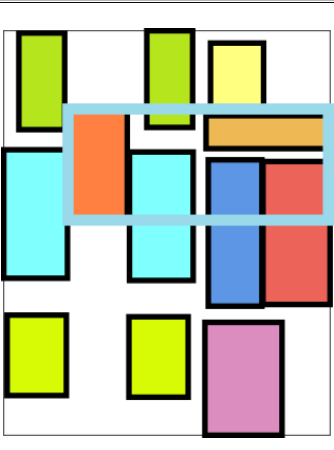
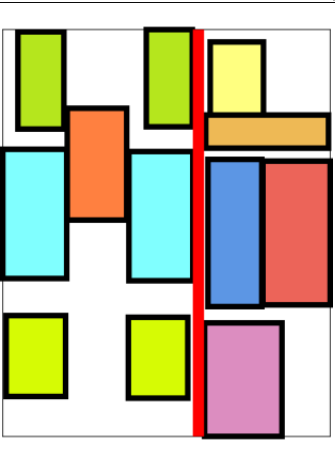

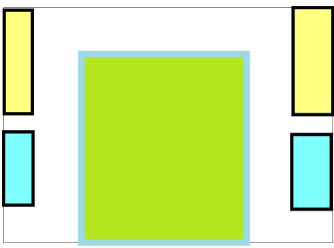
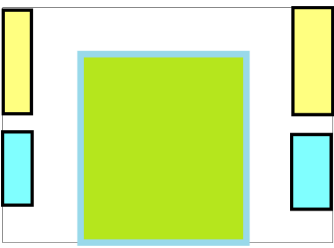
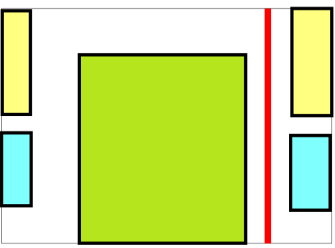
Next

Please select and then click 'Next'.

**A sample list of 25 comparisons of
decomposition results used as questions in
user study 2**

25 comparisons of decomposition results (questions in user study)

ID	Facade	Ours (NIS)	Norm. Global Sym. (NGS)	Graph-Cut Seg (GCS)
1				
2				
3				
4				
5				
6				
7				
8				

				
9				
10				
11				
12				
13				
14				

				
15				
16				
17				
18				
19				



Section 3

User study:

Evaluation of integral symmetry

Symmetry Comparison Test

In the following slides, you are given 46 pairs of structures: A & B, please choose the one you think is more symmetric according to your perception, and also rate the confidence about your decision.

Which is more symmetric? A or B ?

Confidence:

1 – unsure

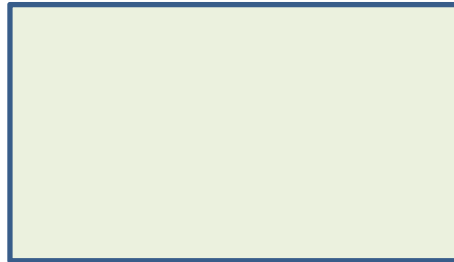
2 – randomly guess, maybe the choice is wrong

3 – probably,

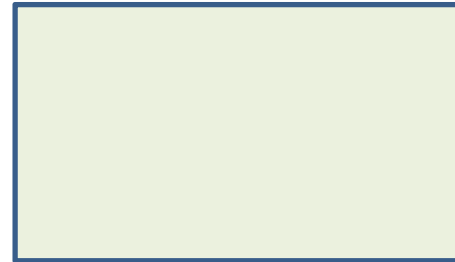
4 – likely, it should be

5 – absolutely

Example



A



B

A
5

Now we start...

Which is more symmetric? A or B ?

Confidence:

1 – unsure

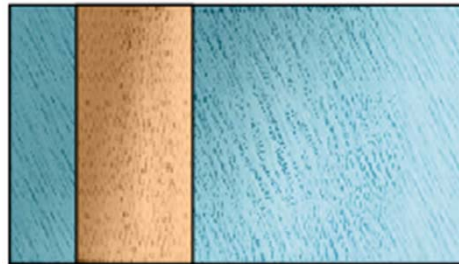
2 – randomly guess, maybe the choice is wrong

3 – probably,

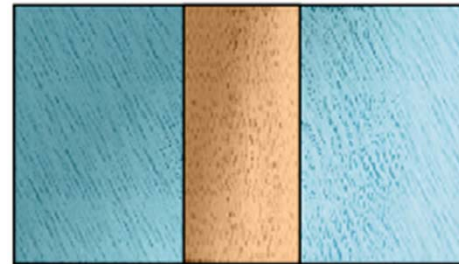
4 – likely, it should be

5 – absolutely

Pair 1:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

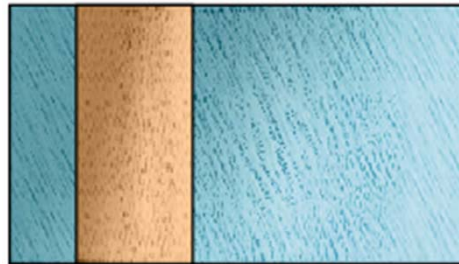
2 – randomly guess, maybe the choice is wrong

3 – probably,

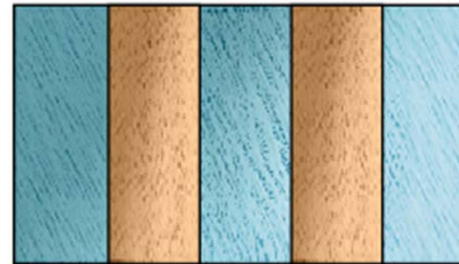
4 – likely, it should be

5 – absolutely

Pair 2:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

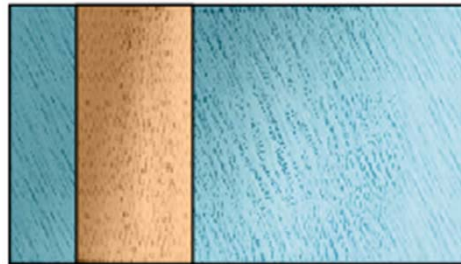
2 – randomly guess, maybe the choice is wrong

3 – probably,

4 – likely, it should be

5 – absolutely

Pair 3:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

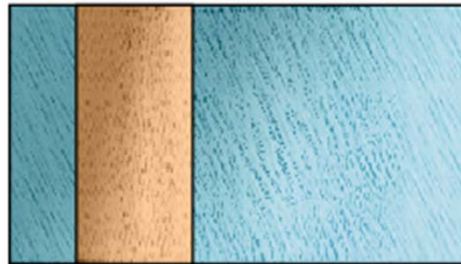
2 – randomly guess, maybe the choice is wrong

3 – probably,

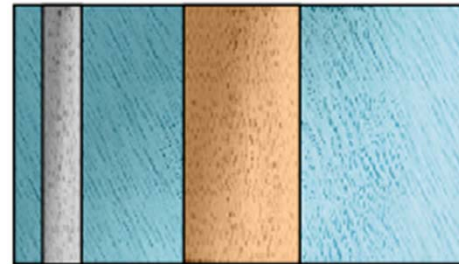
4 – likely, it should be

5 – absolutely

Pair 4:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

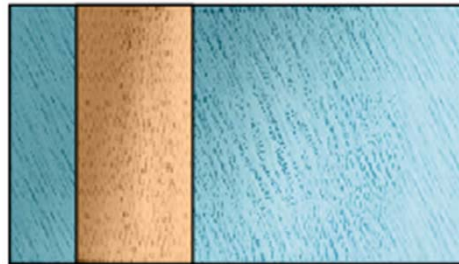
2 – randomly guess, maybe the choice is wrong

3 – probably,

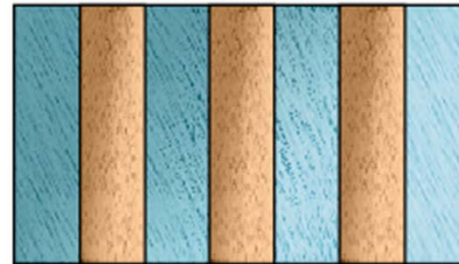
4 – likely, it should be

5 – absolutely

Pair 5:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

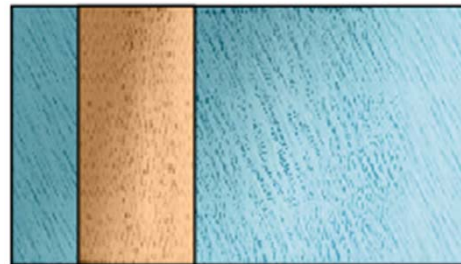
2 – randomly guess, maybe the choice is wrong

3 – probably,

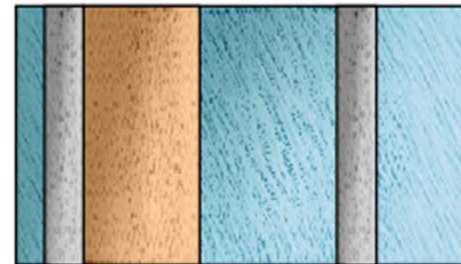
4 – likely, it should be

5 – absolutely

Pair 6:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

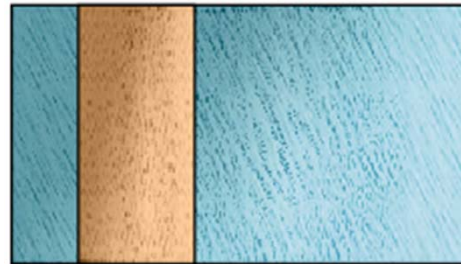
2 – randomly guess, maybe the choice is wrong

3 – probably,

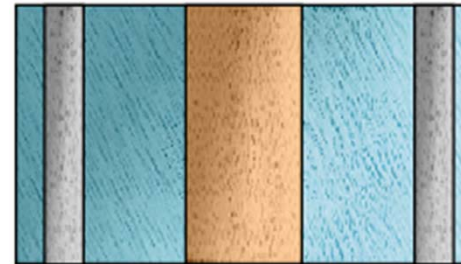
4 – likely, it should be

5 – absolutely

Pair 7:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

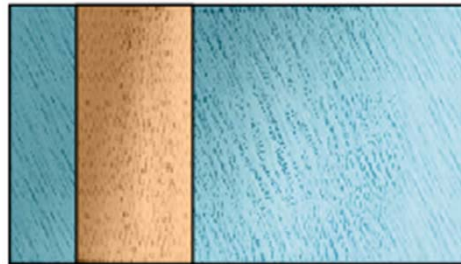
2 – randomly guess, maybe the choice is wrong

3 – probably,

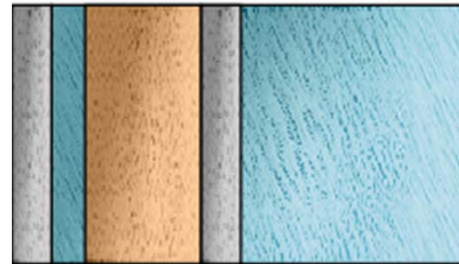
4 – likely, it should be

5 – absolutely

Pair 8:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

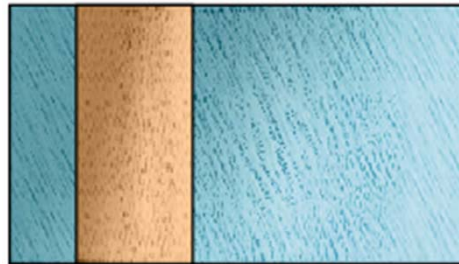
2 – randomly guess, maybe the choice is wrong

3 – probably,

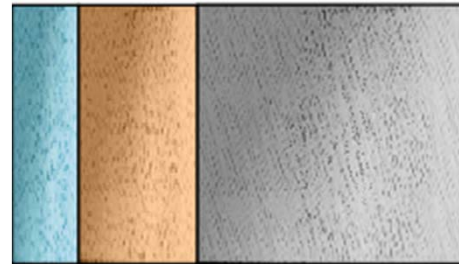
4 – likely, it should be

5 – absolutely

Pair 9:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

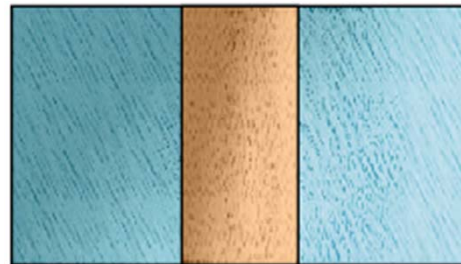
2 – randomly guess, maybe the choice is wrong

3 – probably,

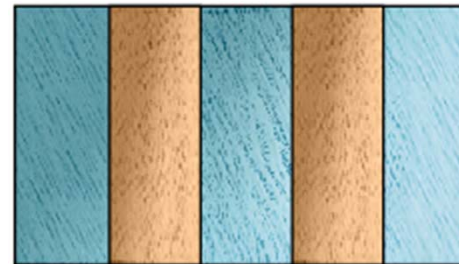
4 – likely, it should be

5 – absolutely

Pair 10:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

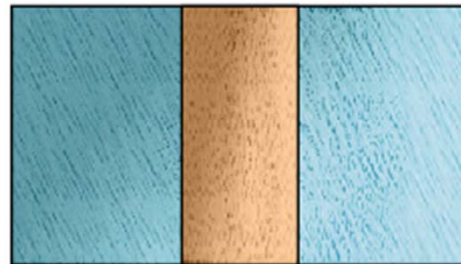
2 – randomly guess, maybe the choice is wrong

3 – probably,

4 – likely, it should be

5 – absolutely

Pair 11:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

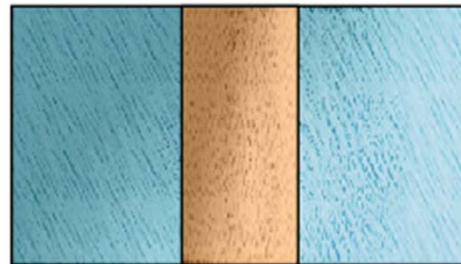
2 – randomly guess, maybe the choice is wrong

3 – probably,

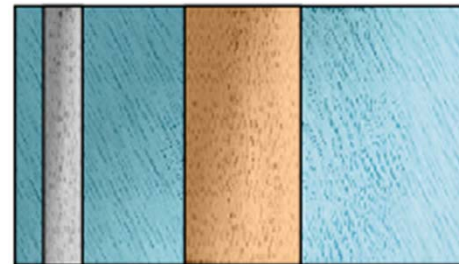
4 – likely, it should be

5 – absolutely

Pair 12:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

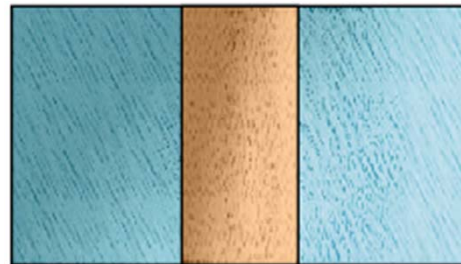
2 – randomly guess, maybe the choice is wrong

3 – probably,

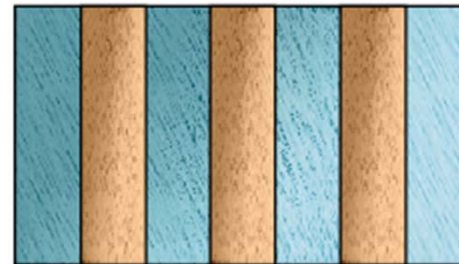
4 – likely, it should be

5 – absolutely

Pair 13:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

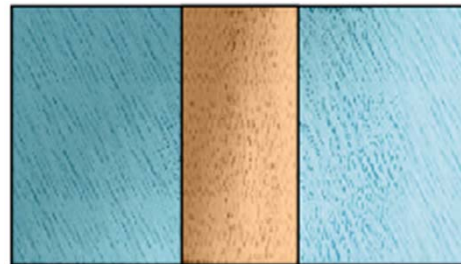
2 – randomly guess, maybe the choice is wrong

3 – probably,

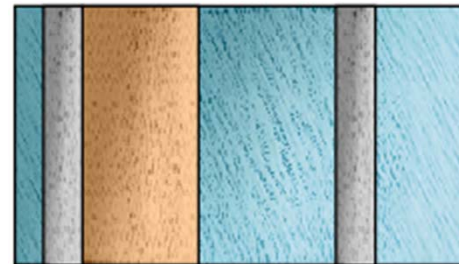
4 – likely, it should be

5 – absolutely

Pair 14:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

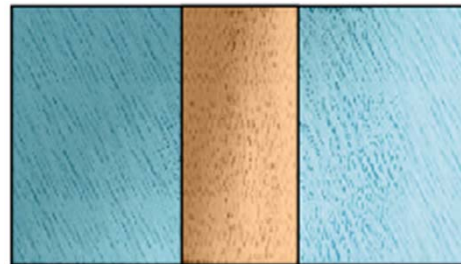
2 – randomly guess, maybe the choice is wrong

3 – probably,

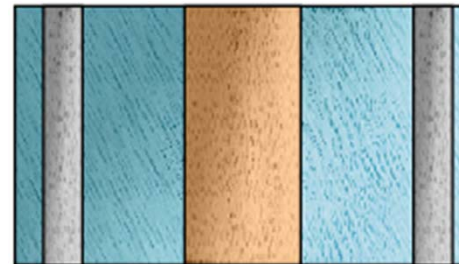
4 – likely, it should be

5 – absolutely

Pair 15:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

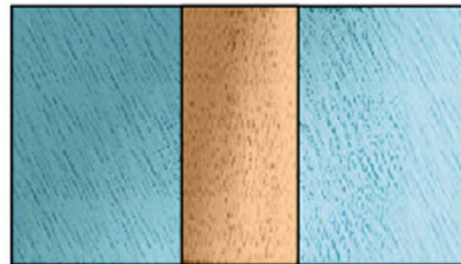
2 – randomly guess, maybe the choice is wrong

3 – probably,

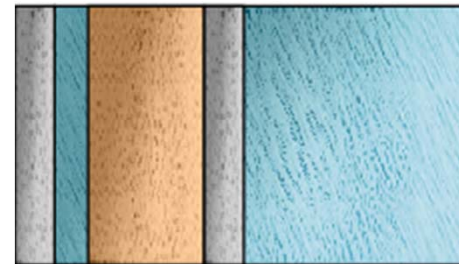
4 – likely, it should be

5 – absolutely

Pair 16:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

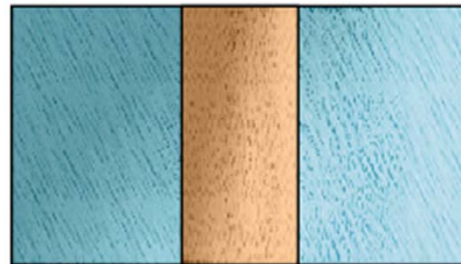
2 – randomly guess, maybe the choice is wrong

3 – probably,

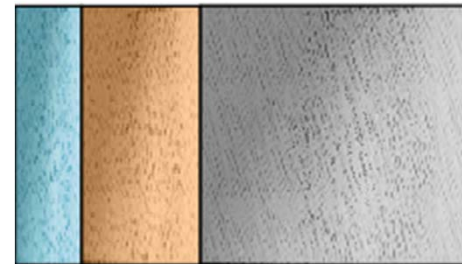
4 – likely, it should be

5 – absolutely

Pair 17:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

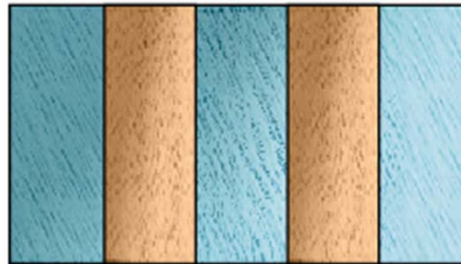
2 – randomly guess, maybe the choice is wrong

3 – probably,

4 – likely, it should be

5 – absolutely

Pair 18:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

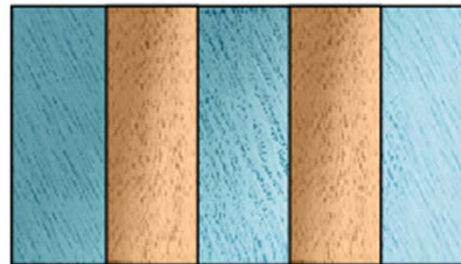
2 – randomly guess, maybe the choice is wrong

3 – probably,

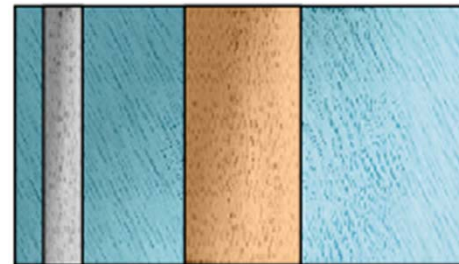
4 – likely, it should be

5 – absolutely

Pair 19:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

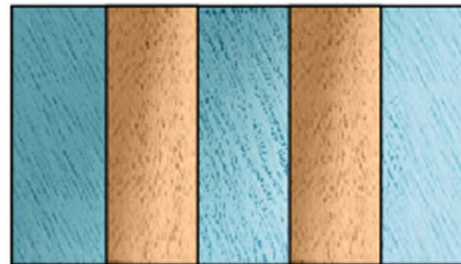
2 – randomly guess, maybe the choice is wrong

3 – probably,

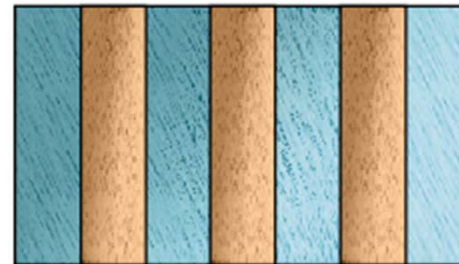
4 – likely, it should be

5 – absolutely

Pair 20:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

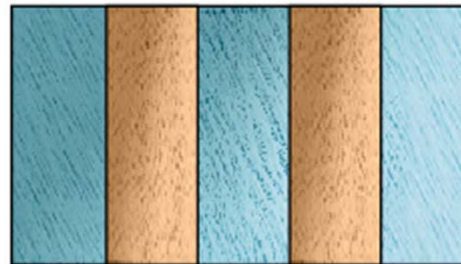
2 – randomly guess, maybe the choice is wrong

3 – probably,

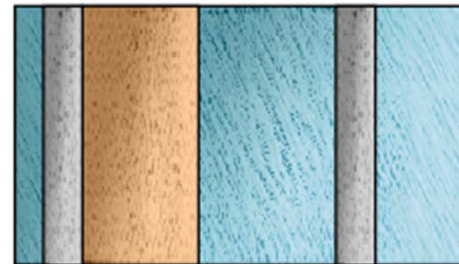
4 – likely, it should be

5 – absolutely

Pair 21:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

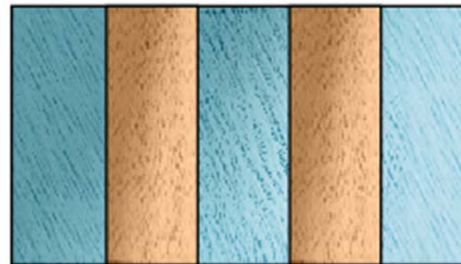
2 – randomly guess, maybe the choice is wrong

3 – probably,

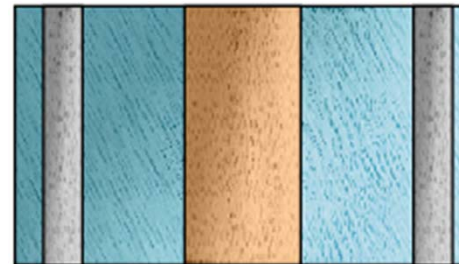
4 – likely, it should be

5 – absolutely

Pair 22:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

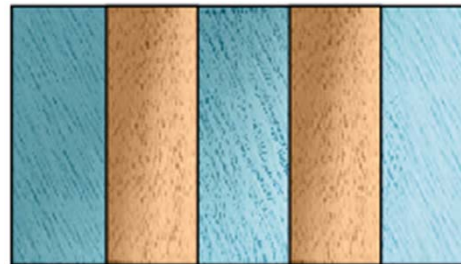
2 – randomly guess, maybe the choice is wrong

3 – probably,

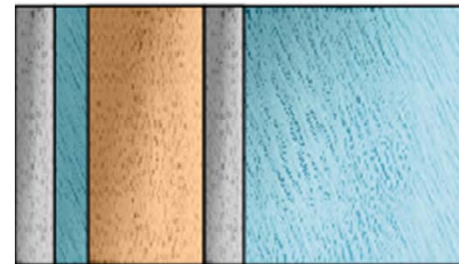
4 – likely, it should be

5 – absolutely

Pair 23:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

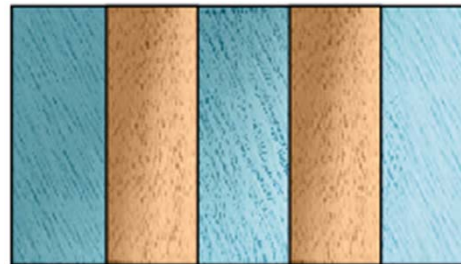
2 – randomly guess, maybe the choice is wrong

3 – probably,

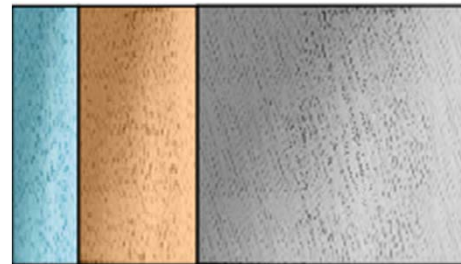
4 – likely, it should be

5 – absolutely

Pair 24:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

2 – randomly guess, maybe the choice is wrong

3 – probably,

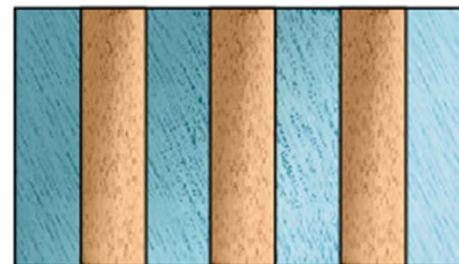
4 – likely, it should be

5 – absolutely

Pair 25:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

2 – randomly guess, maybe the choice is wrong

3 – probably,

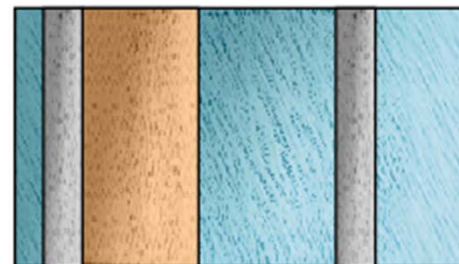
4 – likely, it should be

5 – absolutely

Pair 26:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

2 – randomly guess, maybe the choice is wrong

3 – probably,

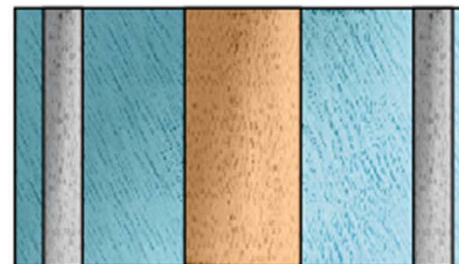
4 – likely, it should be

5 – absolutely

Pair 27:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

2 – randomly guess, maybe the choice is wrong

3 – probably,

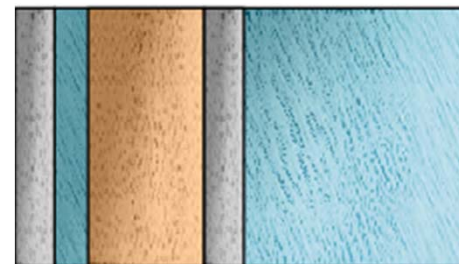
4 – likely, it should be

5 – absolutely

Pair 28:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

2 – randomly guess, maybe the choice is wrong

3 – probably,

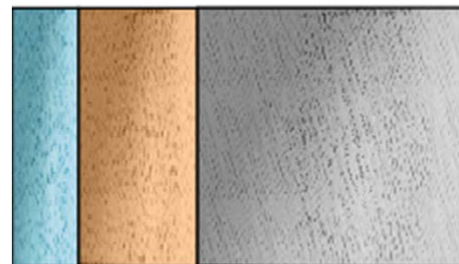
4 – likely, it should be

5 – absolutely

Pair 29:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

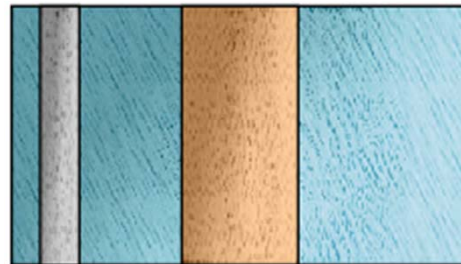
2 – randomly guess, maybe the choice is wrong

3 – probably,

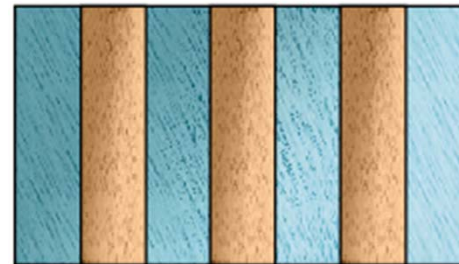
4 – likely, it should be

5 – absolutely

Pair 30:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

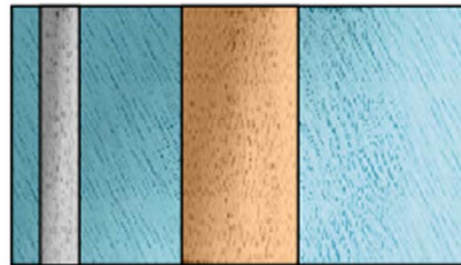
2 – randomly guess, maybe the choice is wrong

3 – probably,

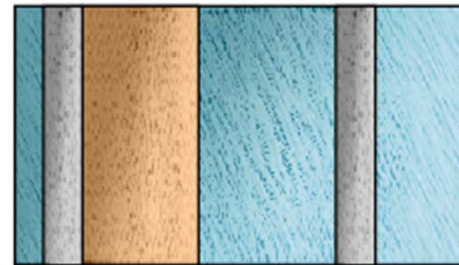
4 – likely, it should be

5 – absolutely

Pair 31:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

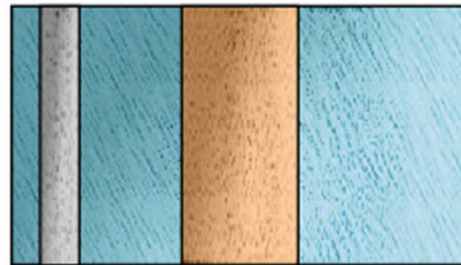
2 – randomly guess, maybe the choice is wrong

3 – probably,

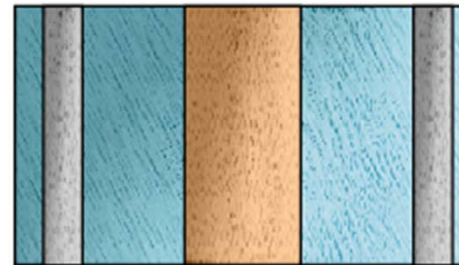
4 – likely, it should be

5 – absolutely

Pair 32:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

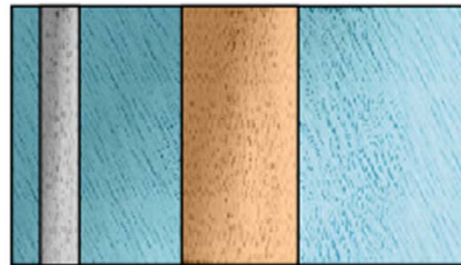
2 – randomly guess, maybe the choice is wrong

3 – probably,

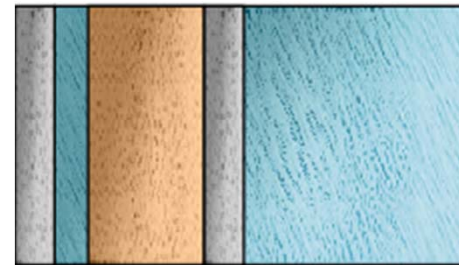
4 – likely, it should be

5 – absolutely

Pair 33:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

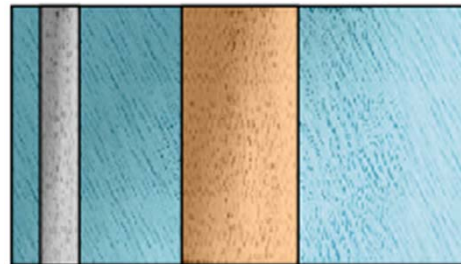
2 – randomly guess, maybe the choice is wrong

3 – probably,

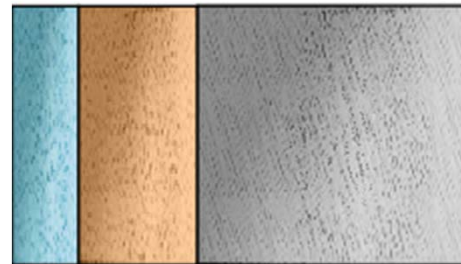
4 – likely, it should be

5 – absolutely

Pair 34:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

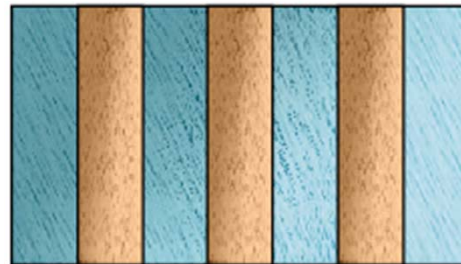
2 – randomly guess, maybe the choice is wrong

3 – probably,

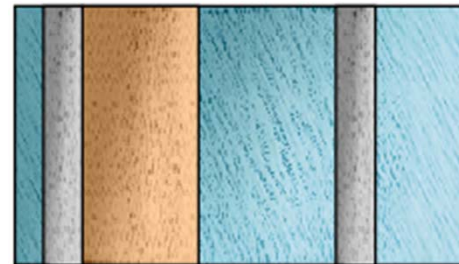
4 – likely, it should be

5 – absolutely

Pair 35:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

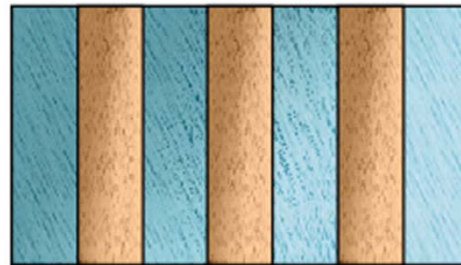
2 – randomly guess, maybe the choice is wrong

3 – probably,

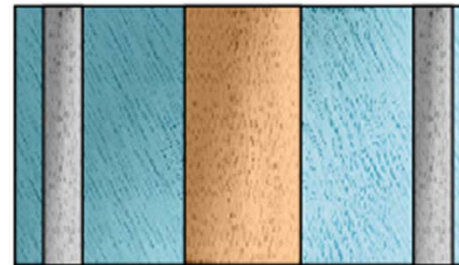
4 – likely, it should be

5 – absolutely

Pair 36:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

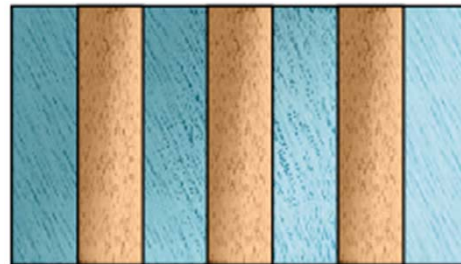
2 – randomly guess, maybe the choice is wrong

3 – probably,

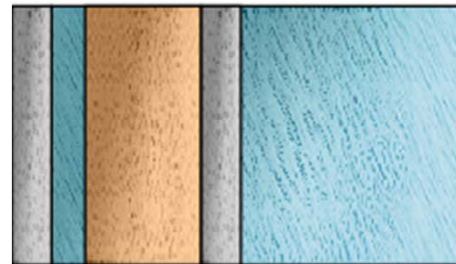
4 – likely, it should be

5 – absolutely

Pair 37:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

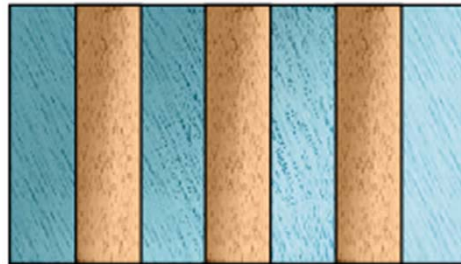
2 – randomly guess, maybe the choice is wrong

3 – probably,

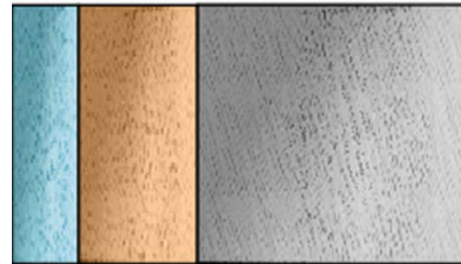
4 – likely, it should be

5 – absolutely

Pair 38:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

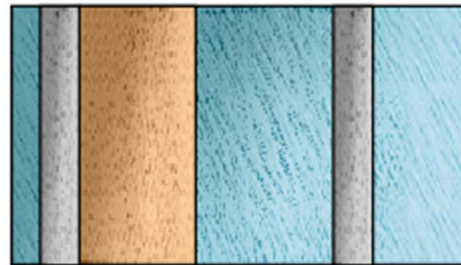
2 – randomly guess, maybe the choice is wrong

3 – probably,

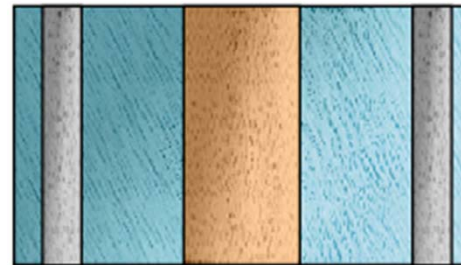
4 – likely, it should be

5 – absolutely

Pair 39:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

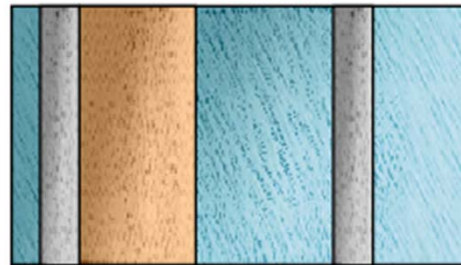
2 – randomly guess, maybe the choice is wrong

3 – probably,

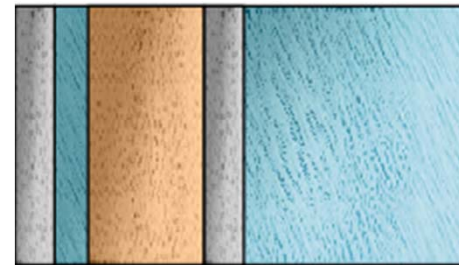
4 – likely, it should be

5 – absolutely

Pair 40:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

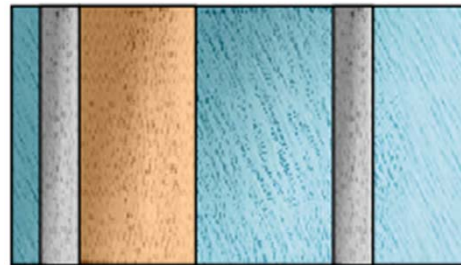
2 – randomly guess, maybe the choice is wrong

3 – probably,

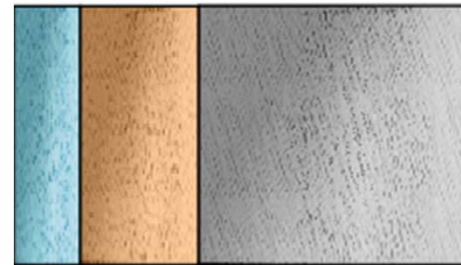
4 – likely, it should be

5 – absolutely

Pair 41:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

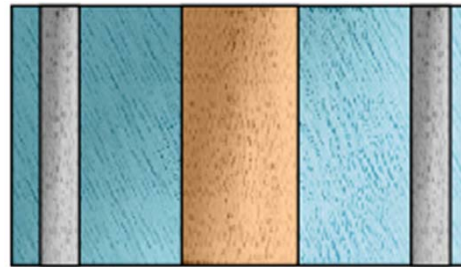
2 – randomly guess, maybe the choice is wrong

3 – probably,

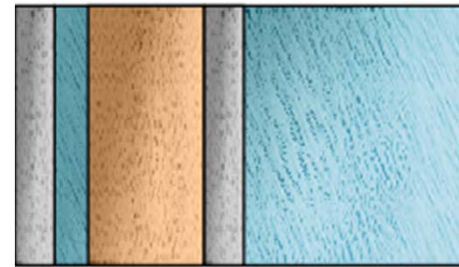
4 – likely, it should be

5 – absolutely

Pair 42:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

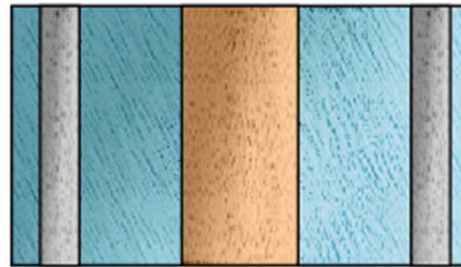
2 – randomly guess, maybe the choice is wrong

3 – probably,

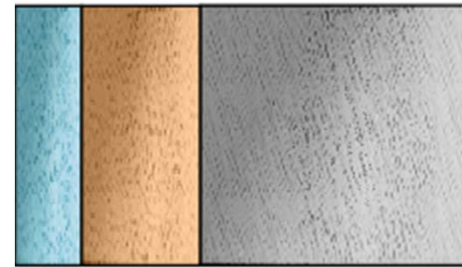
4 – likely, it should be

5 – absolutely

Pair 43:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

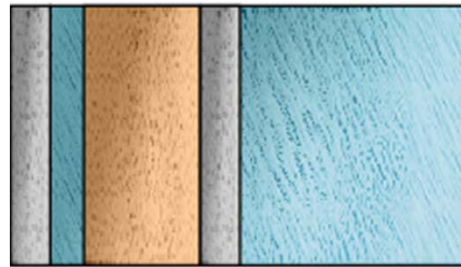
2 – randomly guess, maybe the choice is wrong

3 – probably,

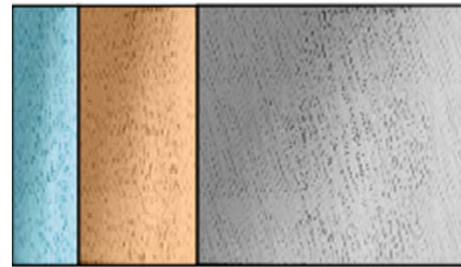
4 – likely, it should be

5 – absolutely

Pair 44:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

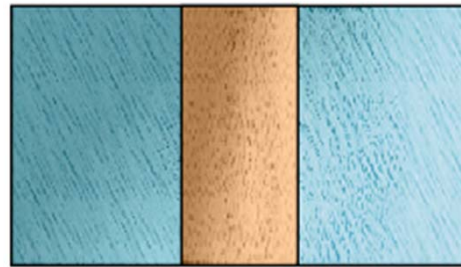
2 – randomly guess, maybe the choice is wrong

3 – probably,

4 – likely, it should be

5 – absolutely

Pair 45:



A



B

Which is more symmetric? A or B ?

Confidence:

1 – unsure

2 – randomly guess, maybe the choice is wrong

3 – probably,

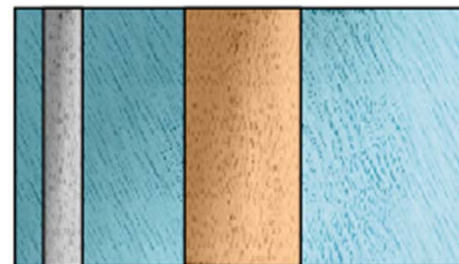
4 – likely, it should be

5 – absolutely

Pair 46:



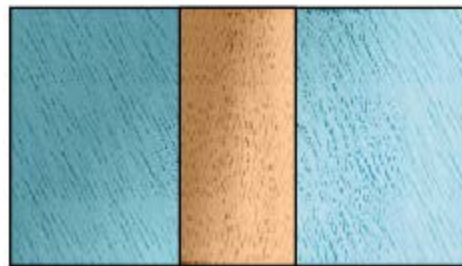
A



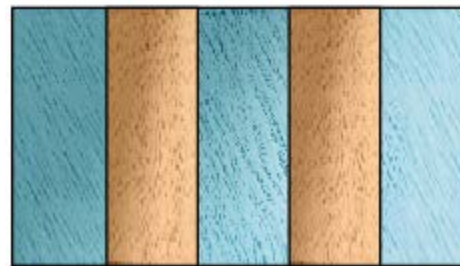
B



0.38397



0.614426



0.50453



1.0



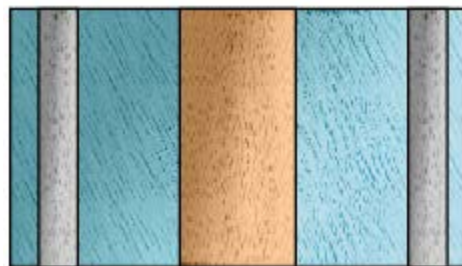
0.346327



0.506029



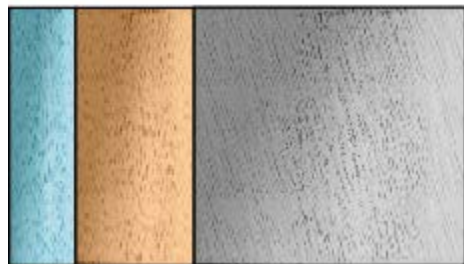
0.288031



0.385239



0.23054



0.320094



1.0

Integral Symmetry
computed by our measure.

Testing Results

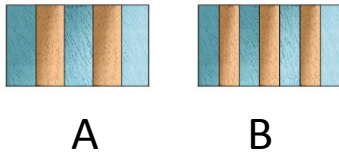
15 users participated in our testing.

Each of them are asked to tell which of two patterns is more symmetric and provide a confidence value (from 1 to 5).

The confidence value serves as a vote on the comparison.

The following slide show the results of voting.



















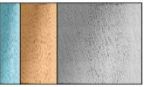
For example, in the table, at cell (3,5), we have (18,25).



It means, for the test of this pair, 18 votes are given to A, and 25 votes are given to B.

And our measure chooses B (indicated by red color).

Results of the user answers.

									
	0,74	0,74	0,71	19,20	0,72	22,11	1,62	26,6	38,3
		36,18	23,29	68,0	43,4	70,0	47,10	71,0	72,0
			22,31	68,0	18,25	68,0	45,8	69,0	72,0
				62,5	32,18	69,0	46,17	67,0	66,3
					0,69	23,15	0,66	29,7	32,8
						72,0	53,6	71,0	70,0
							0,70	20,15	28,5
								66,0	71,0
									24,10
									

Totally, our measure return 2380 right answers, and there are 2692 votes.

So the accuracy = $2380/2692=88.4\%$

Here are some patterns that can not be clearly clarified.

A

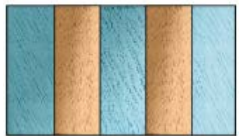
B



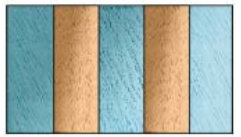
19 votes to A, and 20 people B.
Our measure chooses A.



23 votes to A, and 29 votes to B.
Our measure chooses B.



22 votes to A, and 31 votes to B.
Our measure chooses B.



18 votes to A, and 25 votes to B.
Our measure chooses B.



23 votes A, and 15 votes B.
Our measure chooses A.



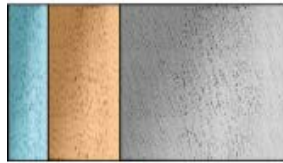
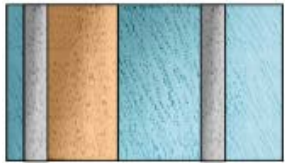
20 votes A, and 15 votes B.
Our measure chooses A.



24 votes A, and 10 votes B.
Our measure chooses A.

For very symmetric, or very asymmetric patterns, our human visual system can not always give a consistent evaluation.

Our measure consistent with the user observations in most cases except the following two cases in our testing:



28 votes to A, and 5 votes to B.
Our measure chooses B.



24 votes to A, and 10 votes B.
Our measure chooses B.