Supplement: A Comparative Study of the Perceptual Sensitivity of Topological Visualizations to Feature Variations

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Abstract—Color maps are a commonly used visualization technique in which data are mapped to optical properties, e.g., color or opacity. Color maps, however, do not explicitly convey structures (e.g., positions and scale of features) within data. Topology-based visualizations reveal and explicitly communicate structures underlying data. Although our understanding of what types of features are captured by topological visualizations is good, our understanding of people's perception of those features is not. This paper evaluates the sensitivity of topology-based isocontour, Reeb graph, and persistence diagram visualizations compared to a reference color map visualization for synthetically generated scalar fields on 2-manifold triangular meshes embedded in 3D. In particular, we built and ran a human-subject study that evaluated the perception of data features characterized by Gaussian signals and measured how effectively each visualization technique portrays variations of data features arising from the position and amplitude variation of a mixture of Gaussians. For positional feature variations, the results showed that only the Reeb graph visualization had high sensitivity. For amplitude feature variations, persistence diagrams and color maps demonstrated the highest sensitivity, whereas isocontours showed only weak sensitivity. These results take an important step toward understanding which topology-based tools are best for various data and task scenarios and their effectiveness in conveying topological variations as compared to conventional color mapping.

Index Terms—Perception & cognition, computational topology-based techniques, comparison and similarity.

1 Sample Tutorial and Practice Questions

Pages 2-36 of the supplement contain an example of all of the web pages and trials seen for one single subject.

2 Demographics and Post-experiment Results

Pages 37-47 contain the summarized demographic information of participants and all answers to the post-experiment questions.

3 Statistics for Self-Identified Visualization Experts

The participant pool for our study comes from the general population instead of experts in scalar field visualization. Unfortunately, the scale of the experiment makes identifying enough experts difficult. The lack of expertise of the participant pool may have played a role in some of the results (e.g., lower accuracy for some methods). We separately evaluated the seven participants who claimed to be regular or extensive visualization users. Although this pool of candidates was not large enough to generate any statistical significance, we evaluated their answers separately. The results, shown in Table 1, were not noteworthy.

Table 1: Summary of the positional and amplitude variation trials from participants who self-identified as regular or extensive visualization users. Accuracy was measured as $N_{correct}/(N_{correct}+N_{incorrect})$.

Method	Var. type	N_{trials}	$N_{correct}$	$N_{incorrect}$	N_{unsure}	Accuracy
Color maps	Pos.	24	16	8	0	66.7%
	Amp.	18	8	9	1	47.1%
Isocontours	Pos.	24	14	10	0	58.3%
	Amp.	18	12	4	2	75.0%
Reeb graph	Pos.	16	5	11	0	31.2%
	Amp.	26	15	10	1	60.0%
Persistence diagrams	Pos.	20	16	4	0	80.0%
	Amp.	22	14	8	0	63.6%

- *T. Athawale and D. Pugmire were with Oak Ridge National Laboratory. E-mail: { athawaletm | pugmire }@ornl.gov*
- *B. Triana and T. Kotha were with the Department University of South Florida.*
- *P. Rosen was with the University of Utah. E-mail: paul.rosen@utah.edu*

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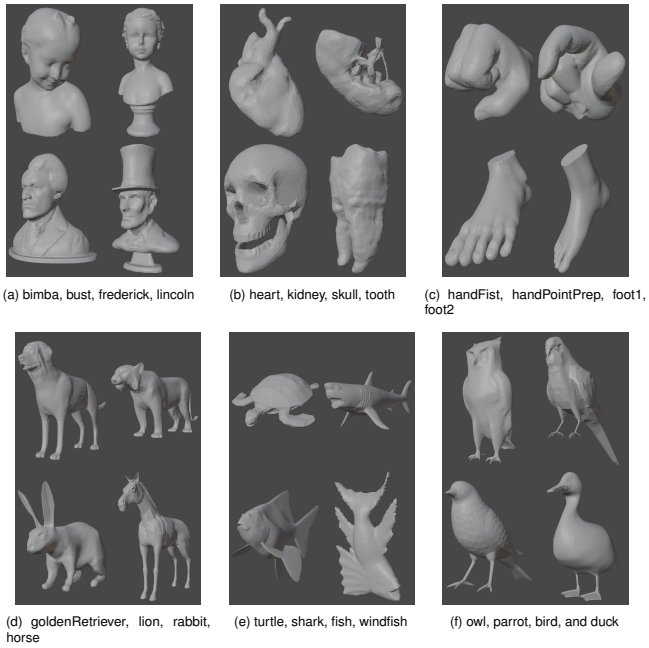

(a) bimba, bust, frederick, lincoln (b) heart, kidney, skull, tooth (c) handFist, handPointPrep, foot1, foot2

(d) goldenRetriever, lion, rabbit, horse (e) turtle, shark, fish, windfish (f) owl, parrot, bird, and duck

Fig. 1: 3D models used in experiment: (a) busts, (b) anatomical models, (c) extremities, (d) land animals, (e) sea animals, and (f) birds.

Acknowledgments

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Experiment Introduction

Please review the following instructions carefully.

In this study we are evaluating perceptional differences of functions on 3D models across 4 different visualization types.

For the study you will need to:

- Answer demographics questions and 4 'warm-up' questions
- Answer 24 multiple choice questions, each of which has a maximum limit of 60 seconds.
- Complete a short post-quiz questionaire

To ensure that the experiment runs correctly, please make sure that the zoom level on your browser for this web page is at 100%.

Please answer all questions as quickly and accurately as possible.

Thank you for participating in our study.

IRB#: [redacted]

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Demographics Information

Please provide the following demographic information (if possible) to use as a datapoint for the experiment.

What is your age?

- ◯ under 18 years
- ◯ 18-24 years old
- ◯ 25-34 years old
- ◯ 35-44 years old
- ◯ 45-54 years old
- ◯ 55-64 years old
- ◯ 65+ years old
- ◯ Prefer not to answer

What is your gender?

- ◯ Female
- ◯ Male
- ◯ Identify as something different
- ◯ Prefer not to answer

Do you have corrected vision (i.e., do you wear glasses/contacts)?

- ◯ Yes
- ◯ No
- ◯ Prefer not to answer

How much experience do your have creating or using visualizations?

- ◯ 1 - None
- ◯ 2 - Minimal User
- ◯ 3 - Casual User
- ◯ 4 - Regular User
- ◯ 5 - Extensive User

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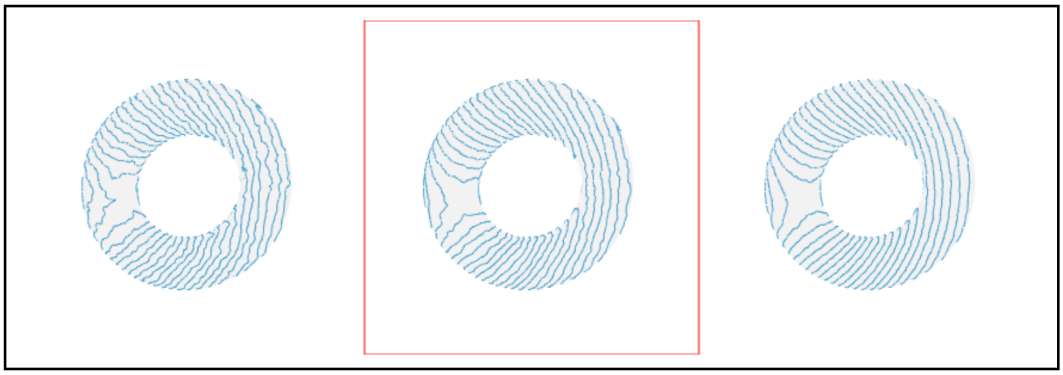
Tutorial

Each question will prompt you with *3 visualizations*. The **center-most** is the **baseline** visualization, with a **left**, and **right** visualization to either side of it.

Left-Option **Baseline** **Right-Option**

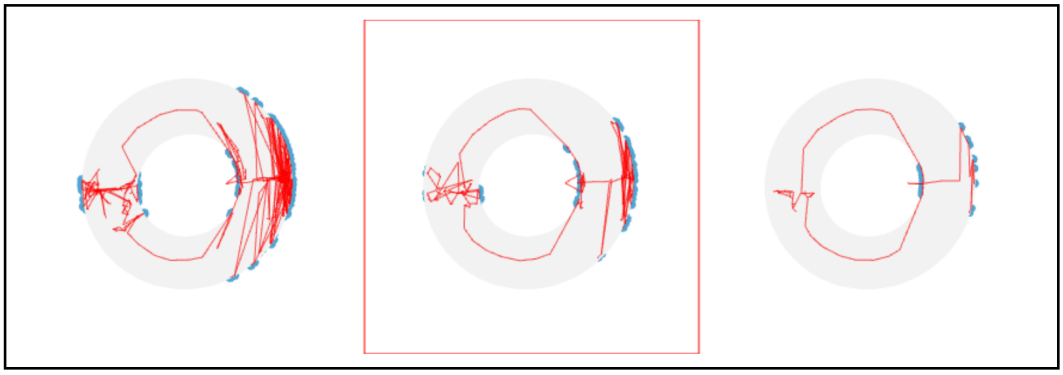


Got it

Tutorial

If 3D models are presented to you, you can *rotate the view window* by clicking and dragging with the **left mouse button** and also *zoom in and out* by using the **mouse wheel**. Some visualization types, will present you with a slider below the models to change the level of detail shown.

Left-Option **Baseline** **Right-Option**



Minimum Detail Maximum Detail

Got it

Practice Instructions

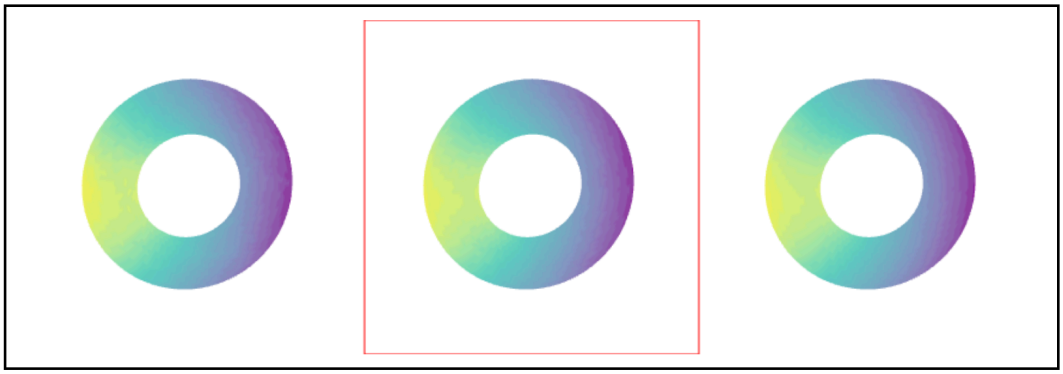
In this next section, we will be giving you 4 practice questions, one for each type of visualization you will encounter. Click on the next page button to proceed when ready.

Next Page

Practice Question

The following visualizations are **Color-Maps**. They display colors based on the underlying data distribution, with *light being higher values*, and *dark being lower values*. To proceed, click the **left** or **right** button to indicate which visualization is the most similar to the baseline. If not sure, click **Unsure**.

Left-Option **Baseline** **Right-Option**



Left Unsure Right

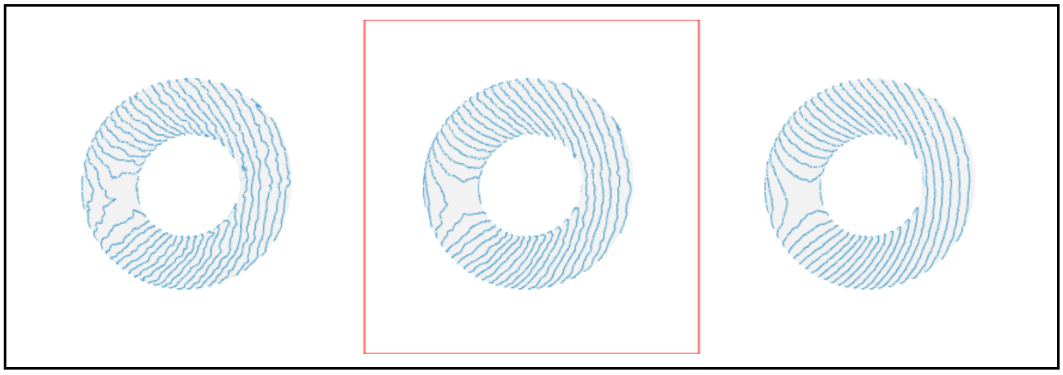
Here's some tips to help: Make sure to look for hotter or colder spots for each figure, and see how well you can match them with the baseline. You can also check to see if certain spots are stronger or weaker than the baseline.

Next Page

Practice Question

The following visualizations are **Iso-Contours**. They display *rings* which are formed at *various height levels* in the data range, much like a *geographical survey map*. To proceed, click the **left** or **right** button to indicate which visualization is the most similar to the baseline. If not sure, click **Unsure**.

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

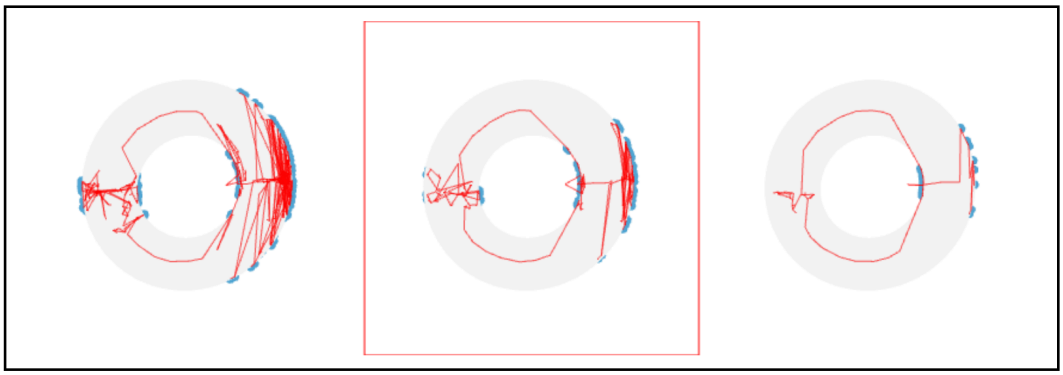
Here's some tips to help: Take note of how the rings form a pattern following the form of the model. Based on how the pattern flows, you can get a sense of how the data is being distributed at each level of the data range. You may need to rotate your view of the models to get a really clear view of the difference.

Next Page

Practice Question

The following visualizations are **Reeb-Graphs**. They act as *skeletons* of the data. The **red lines** show the overall *trend of data movement*, and the **blue points** are *junctions*. To proceed, click the **left** or **right** button to indicate which visualization is the most similar to the baseline. If not sure, click **Unsure**.

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Here's some tips to help: Be sure to track how the edges travel in the model. Often different path trajectories may imply differences in the data, along with the locations of the blue dots. In the case of very messy graphs, try to observe how the red arcs and blue dots group together visually. Often very similar visualizations yield similar patterns.

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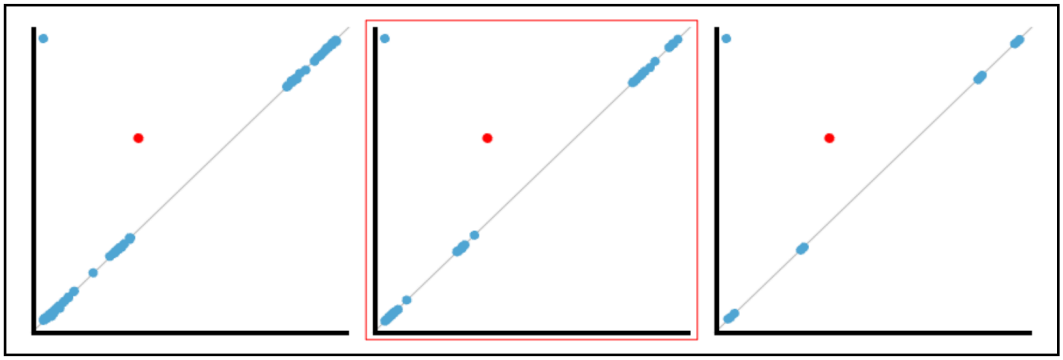
Practice Question

The following visualizations are **Persistence-Diagrams**. They describe *features* of the data, represented as *dots* on the plot. Points near the **diagonal line** are noise, you should look for differences that are farther away from the **diagonal line**. The dots may be either blue or red to indicate that they are a different feature type. To proceed, click the **left** or **right** button to indicate which visualization is the most similar to the baseline. If not sure, click **Unsure**.

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Here's some tips to help: Here the diagonal line is your friend. First check the distribution of points along that diagonal and see if you can spot immediate similarities. Then check for dots further away from the diagonal. From this you should be able to gauge how similar a chart is with the baseline.

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Experiment Instructions

Now we will proceed to the actual experiment. Please review the following instructions carefully.

The experiment consists of 24 questions, and you will have 1 minute to answer each one of them. Please answer questions as quickly and accurately as possible. If your answers are more accurate, you may receive a bonus. Good luck!

Next Page

Experiment Questions

Answer the question based on the 3 visualizations below.

57 seconds remaining

1 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**

Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

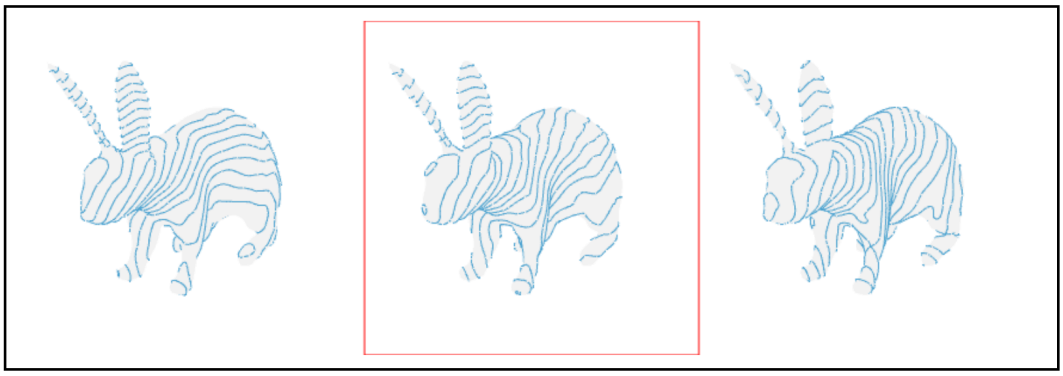
Answer the question based on the 3 visualizations below.

58 seconds remaining

2 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

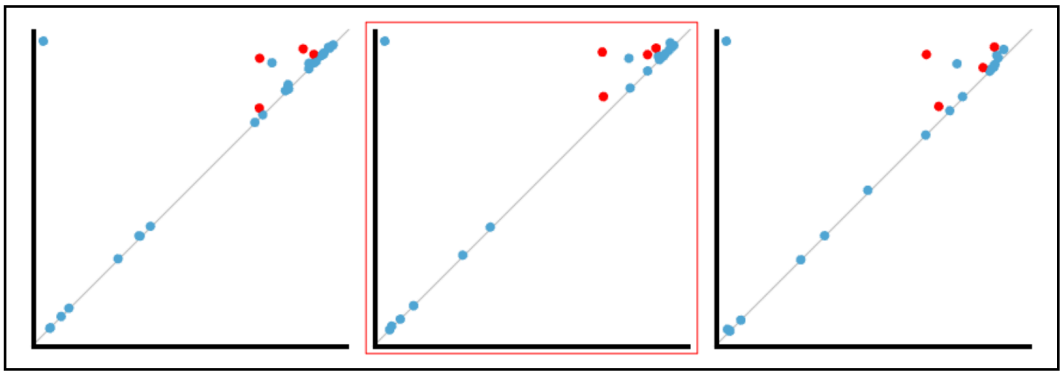
Answer the question based on the 3 visualizations below.

57 seconds remaining

3 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail Maximum Detail

Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

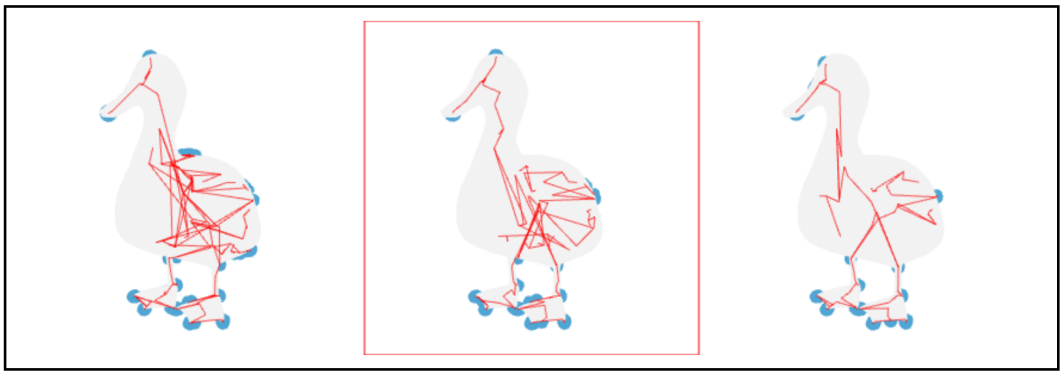
Answer the question based on the 3 visualizations below.

58 seconds remaining

4 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

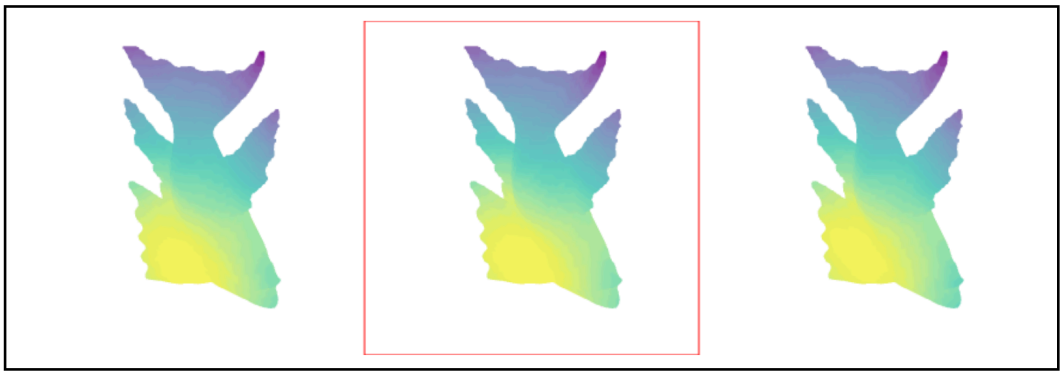
Answer the question based on the 3 visualizations below.

58 seconds remaining

5 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

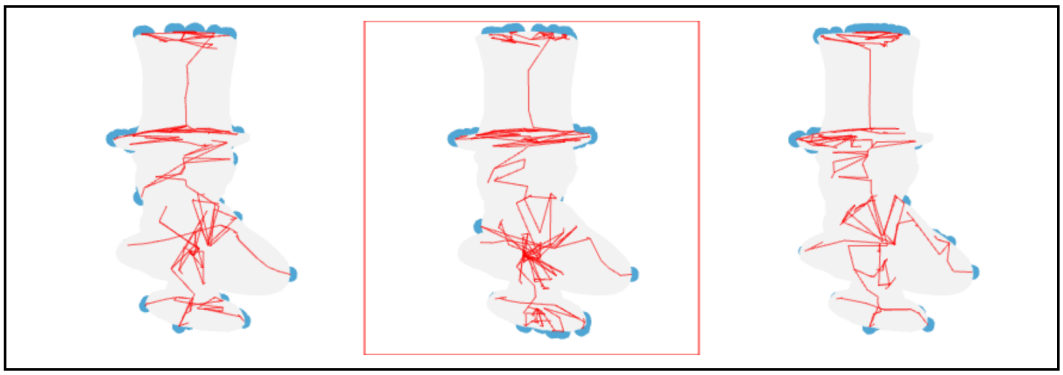
Answer the question based on the 3 visualizations below.

58 seconds remaining

6 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

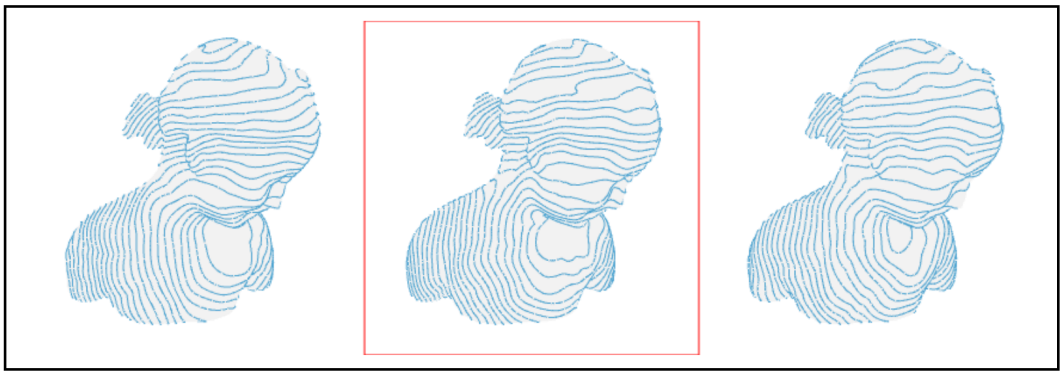
Answer the question based on the 3 visualizations below.

58 seconds remaining

7 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

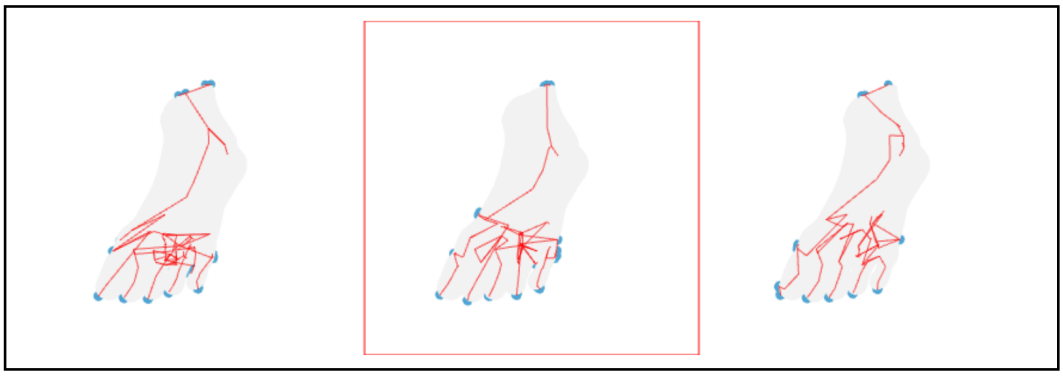
Answer the question based on the 3 visualizations below.

58 seconds remaining

8 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

Answer the question based on the 3 visualizations below.

57 seconds remaining

9 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**

Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

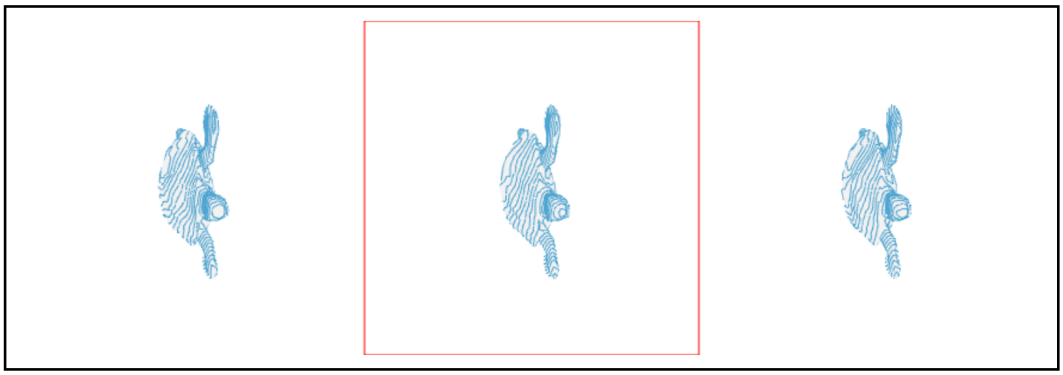
Answer the question based on the 3 visualizations below.

56 seconds remaining

10 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

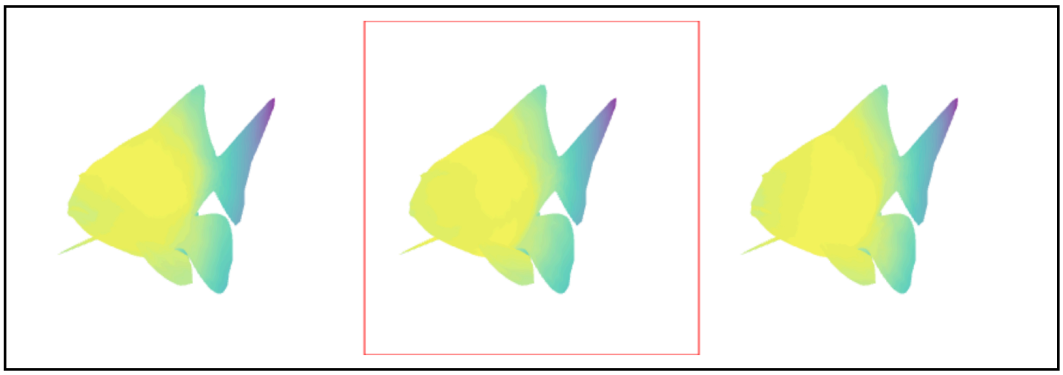
Answer the question based on the 3 visualizations below.

57 seconds remaining

11 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**



Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

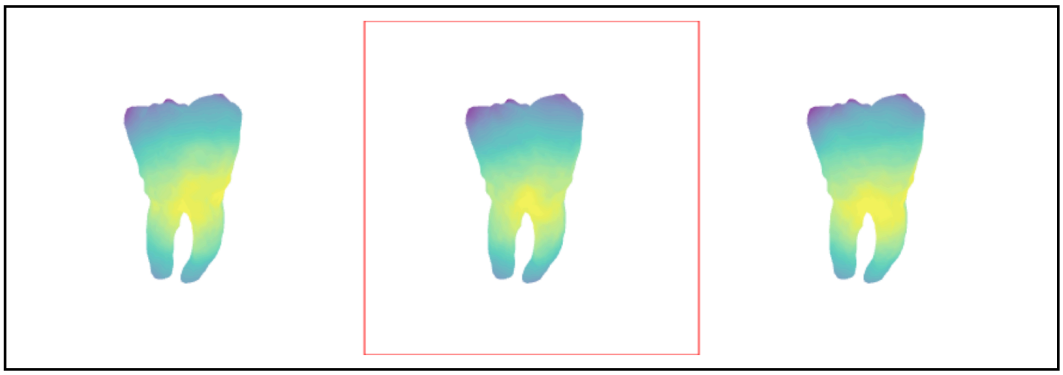
Answer the question based on the 3 visualizations below.

57 seconds remaining

12 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

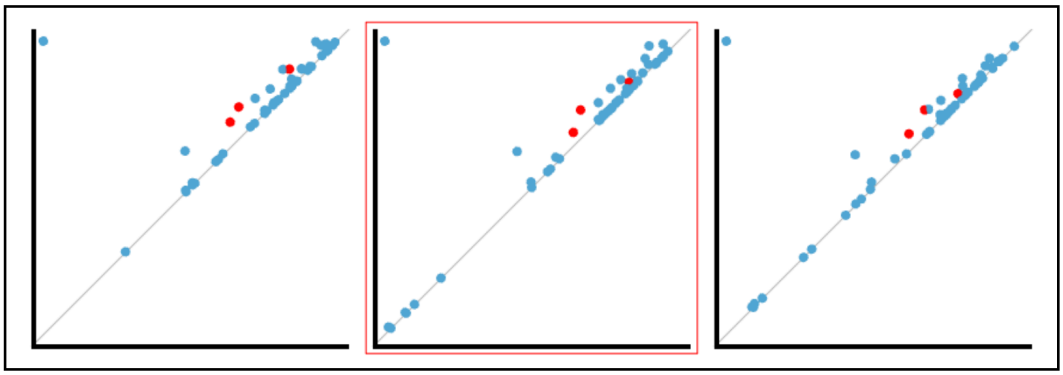
Answer the question based on the 3 visualizations below.

57 seconds remaining

13 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

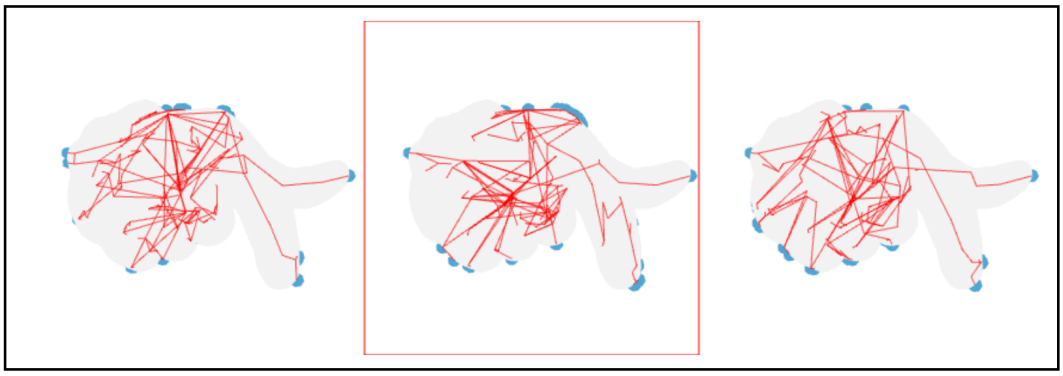
Answer the question based on the 3 visualizations below.

58 seconds remaining

14 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

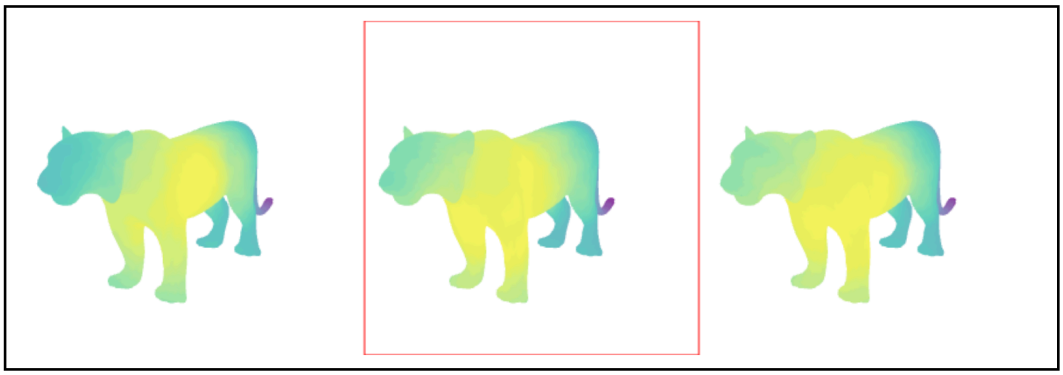
Answer the question based on the 3 visualizations below.

57 seconds remaining

15 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

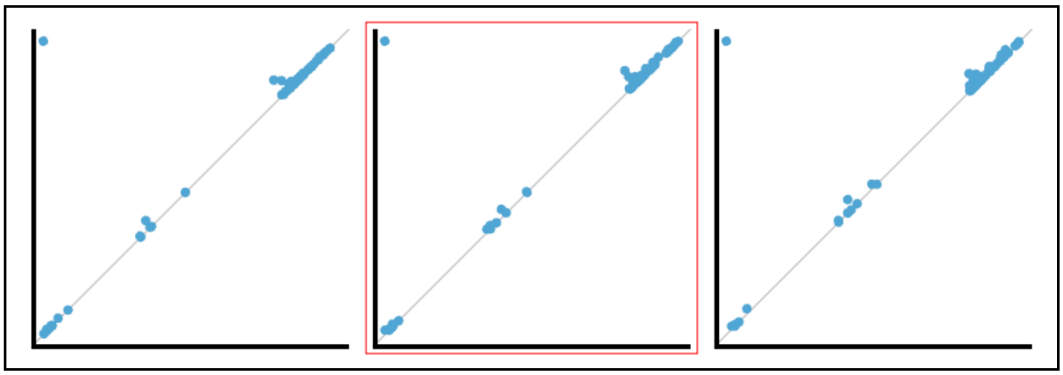
Answer the question based on the 3 visualizations below.

57 seconds remaining

16 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

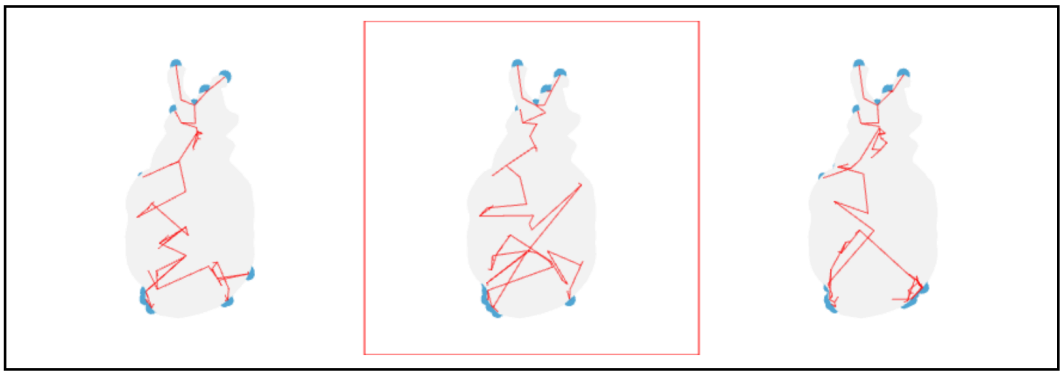
Answer the question based on the 3 visualizations below.

58 seconds remaining

17 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

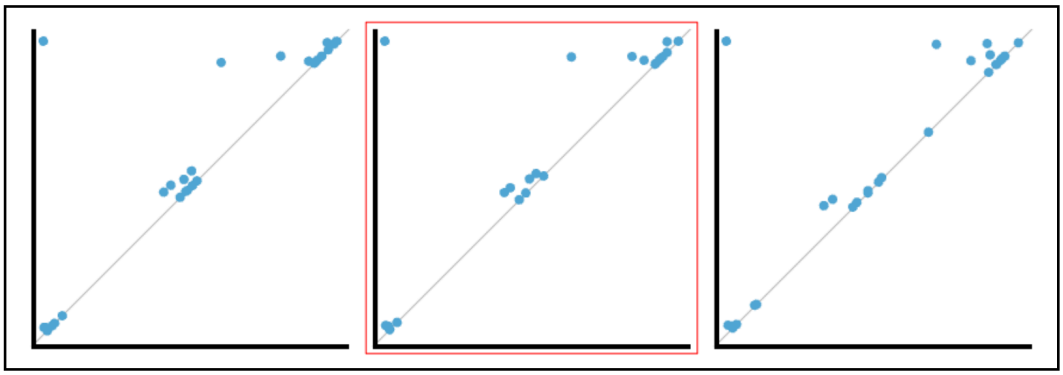
Answer the question based on the 3 visualizations below.

58 seconds remaining

18 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

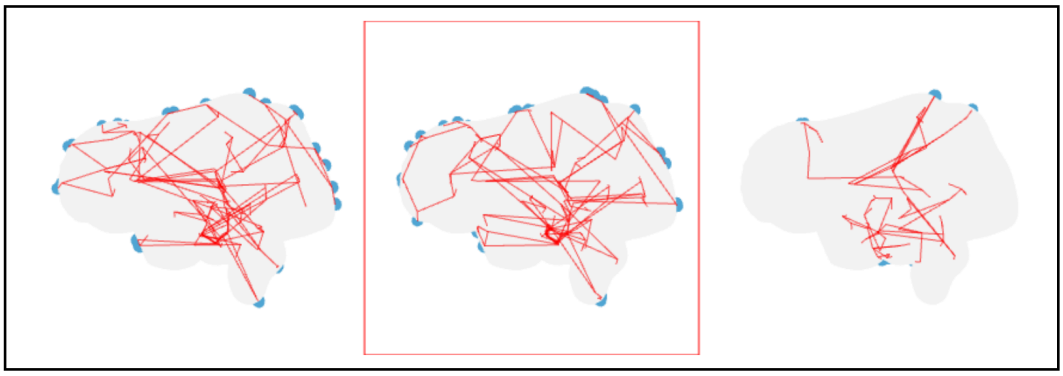
Answer the question based on the 3 visualizations below.

58 seconds remaining

19 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

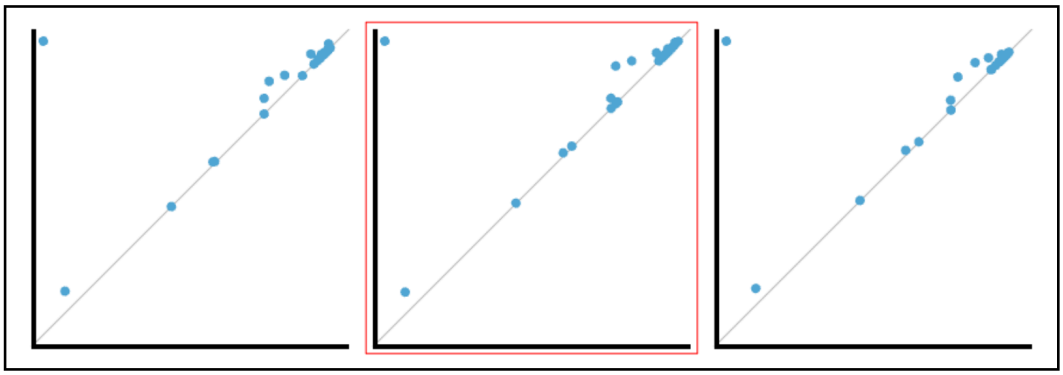
Answer the question based on the 3 visualizations below.

57 seconds remaining

20 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

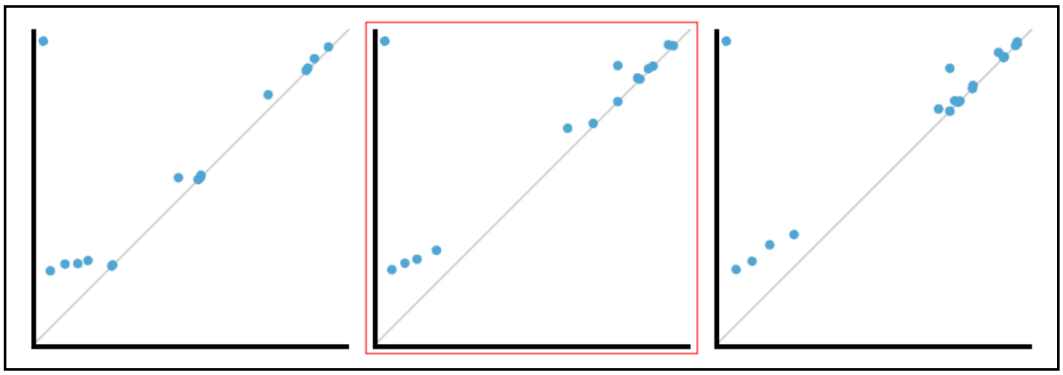
Answer the question based on the 3 visualizations below.

57 seconds remaining

21 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

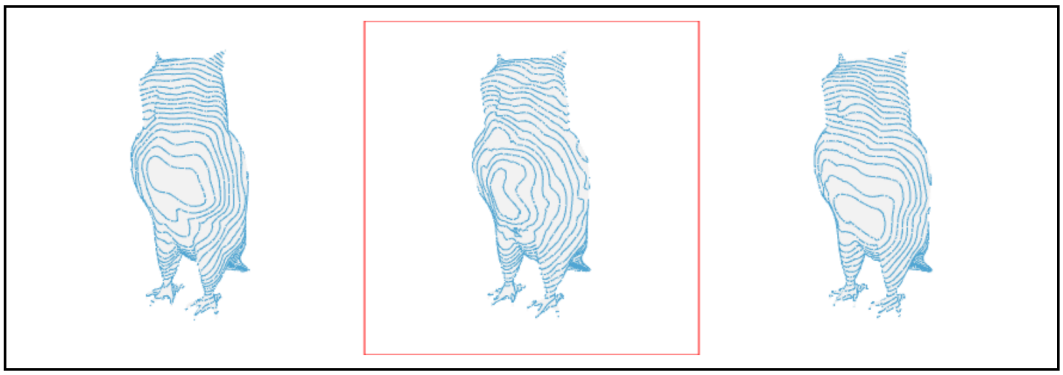
Answer the question based on the 3 visualizations below.

58 seconds remaining

22 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left Unsure Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

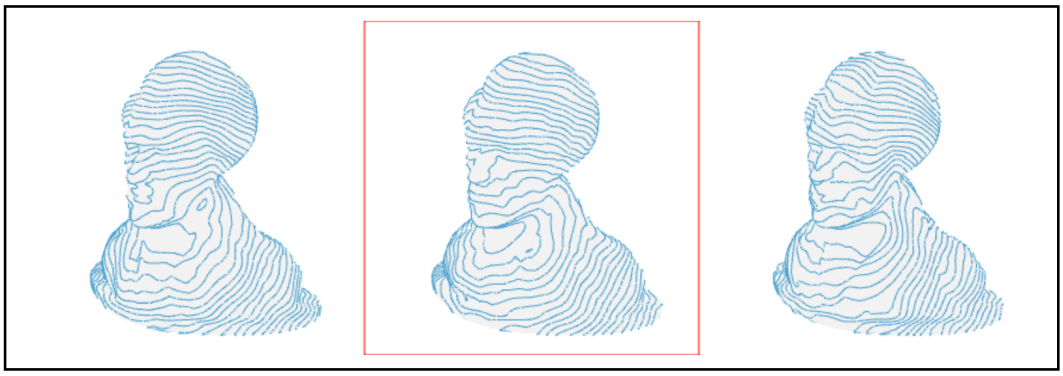
Answer the question based on the 3 visualizations below.

59 seconds remaining

23 of 24

Which is more similar to the baseline – left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Experiment Questions

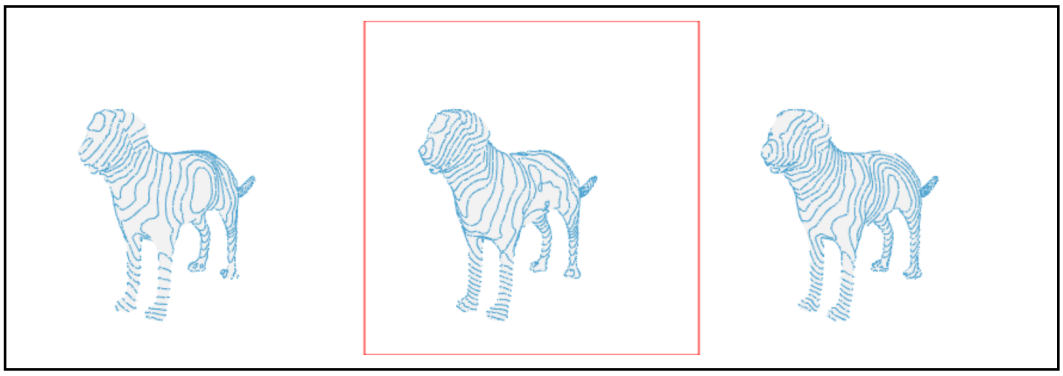
Answer the question based on the 3 visualizations below.

58 seconds remaining

24 of 24

Which is more similar to the baseline - left or right?

Left-Option **Baseline** **Right-Option**



Minimum Detail — Maximum Detail

Left | Unsure | Right

Remember that you can move the camera to see a different angle and zoom in or out if looking at a 3D model. You can also change the level of detail if the slider is available.

Post-Quiz Questionaire

Which visualization type was the easiest to answer the baseline similarity question?

- ○ Reeb Graph
- ○ Persistence Diagram
- ○ Isocontour
- ○ Color Map
- ○ N/A

Which visualization type was the hardest to answer the baseline similarity question?

- ○ Reeb Graph
- ○ Persistence Diagram
- ○ Isocontour
- ○ Color Map
- ○ N/A

If possible, please provide a brief explanation of the rationale you used when selecting a Reeb Graph visualization.

If possible, please provide a brief explanation of the rationale you used when selecting a Persistance diagram visualization.

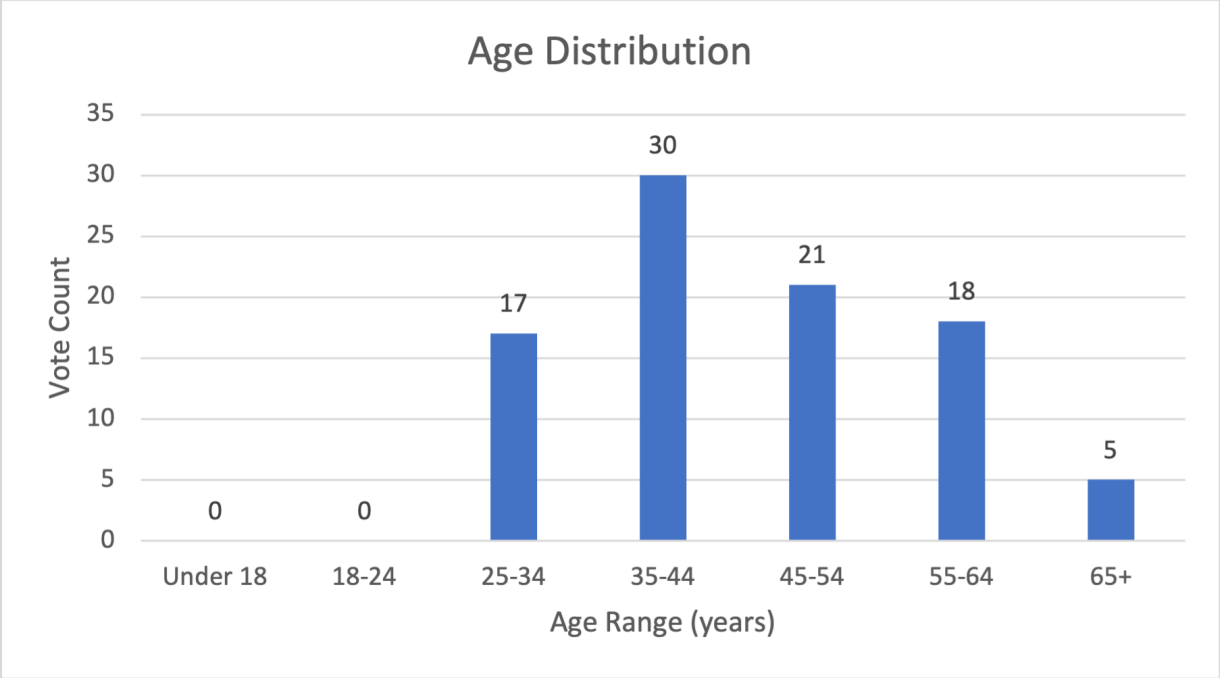
If possible, please provide a brief explanation of the rationale you used when selecting an Isocontour visualization.

If possible, please provide a brief explanation of the rationale you used when selecting a Color Map visualization.

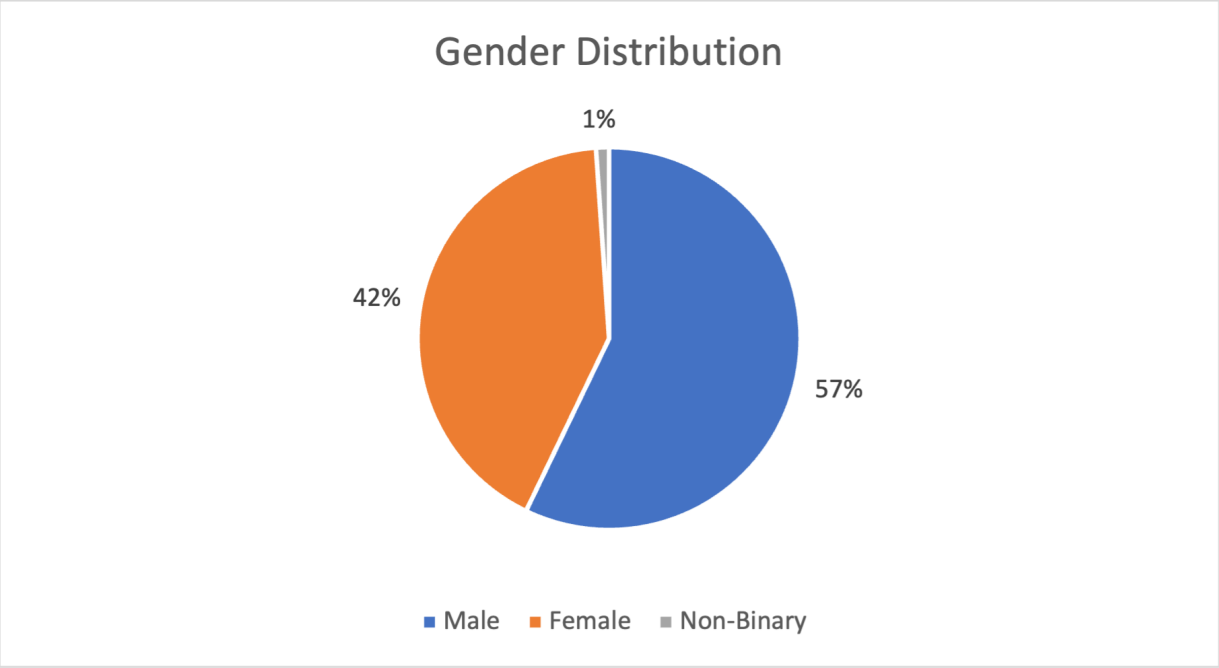
Finish

Final Survey Results

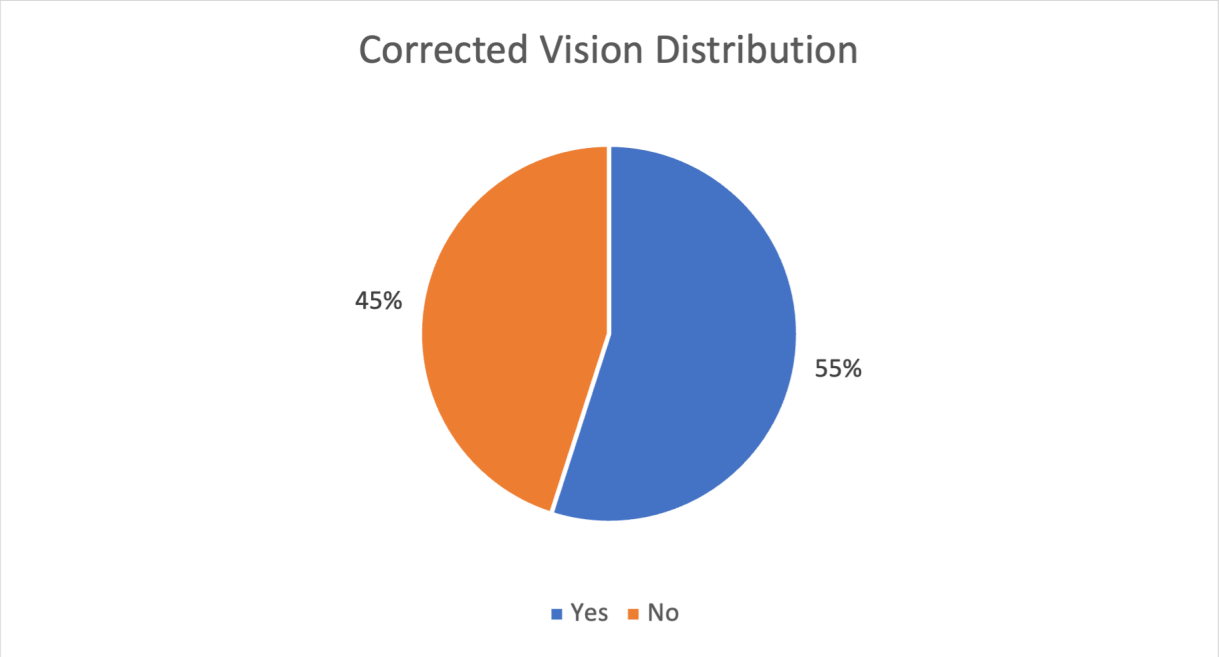
Age Distribution



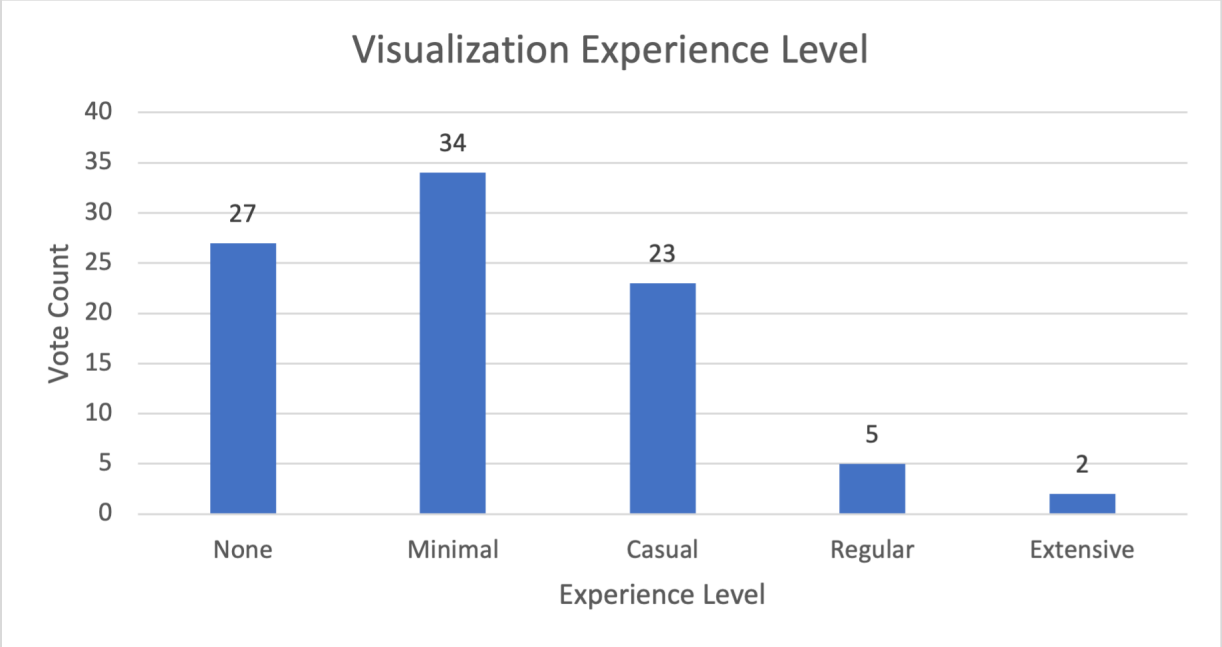
Gender Distribution



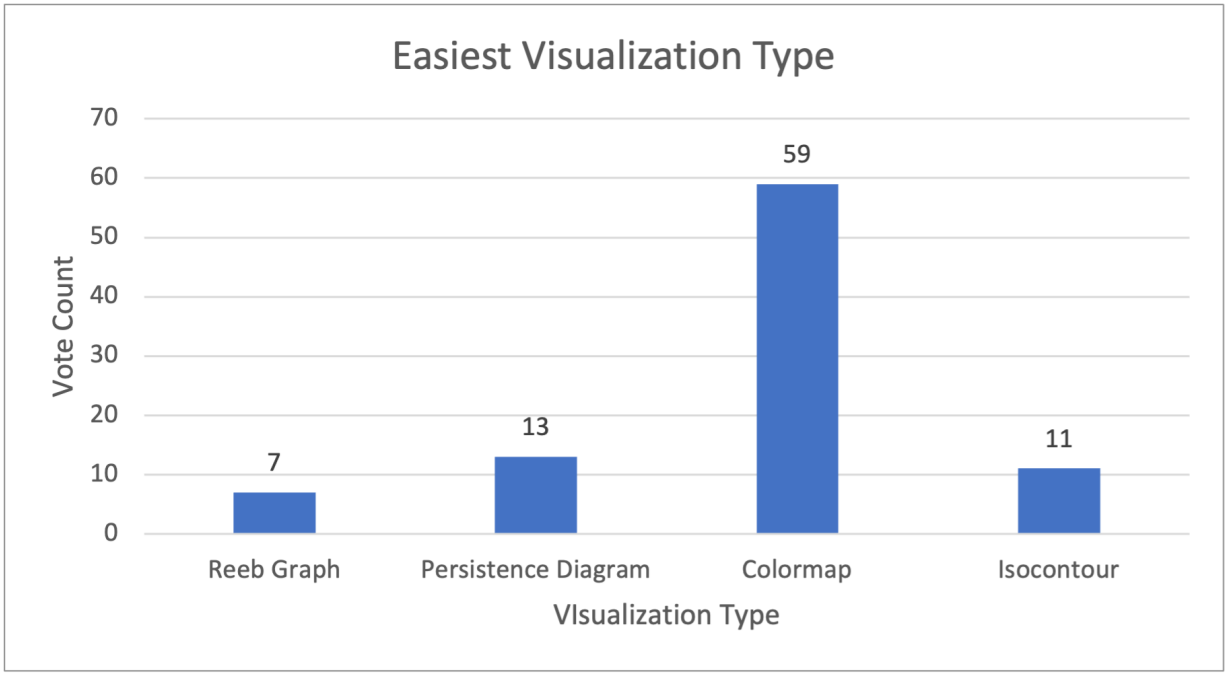
Vision Distribution



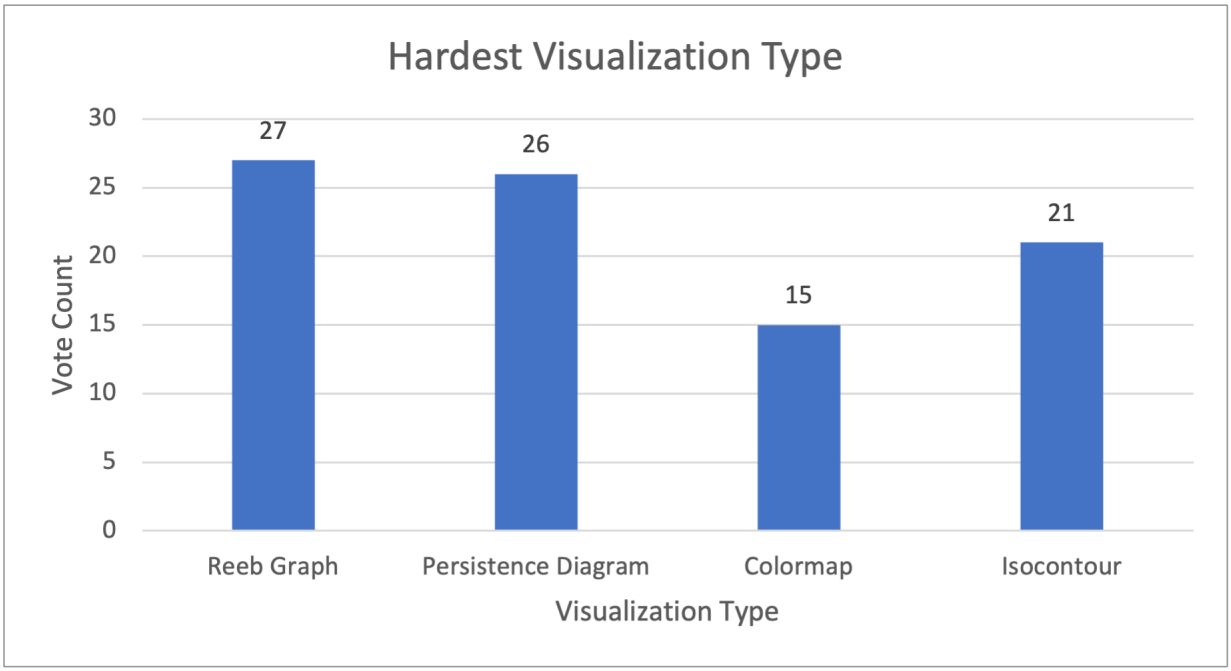
Visualization Experience Level



Easiest Visualization Type



Hardest Visualization Type



Reeb Graph Explanations

- I tried to follow the outside edge
- Just trying to identify which was most closest to the center one. It was quite difficult in some cases.

- It won by process of elimination. They were all kind of hard to decipher. This stuck out as slightly easier.
- I thought the Reeb Graph was most difficult because of the unusual spikes and connections, and it was hard to compare the two graphs for me, even when rotating and changing the detail levels.
- I just tried to compare points on the graph.
- I just looked at the images from different sides, and if I couldn't tell I would go down to basic detail and see which ones had the most similar basic structure.
- I basically tried to connect the dots to see if the path was similar.
- The models that looked most alike with less detail
- I went by the amount of color in certain areas of the picture.
- Honestly just seemed hard to read and interpret it.
- This was a tough one for me, I just tried to zoom in/out and adjust detail to look for differences in rings.
- I tried to see if there were various patterns in the graph that were similar and chose the one that had the most.
- They were not too bad to figure out. What was the most similar that's all
- I just tried to follow the lines and see if there is a pattern
- tried to match and lines closely
- went with what lined up the best and was closest
- I tried to see which lines were most similar to the main image.
- I compared the blue points, and looked for points that were very different.
- I scrolled through the details levels and tried to compare the visualizations with the dots closest together.
- matching the circles
- I just compared what the baseline was to each option and went with my gut as to which matched best.
- Just tried paying attention to certain areas, seeing what areas would change and how much, among the images
- I just look at the general shape and try to find which one had the most similarity in points on the drawing
- I found it hard to tell because you could see through the model which made a bit confusing.
- I just tried to compare features visually, rotate, and progress to see which was most similar
- I'm not really sure what I did. I just tried to look for similar sections by rotating it.

- Similar to the isocontour in approach. I'd usually take it somewhere about halfway on the scale and it would usually be apparent between that and the full scale as to which one was more similar.
- Just moved the line settings to see a less crowded graph and moved it back and forth to see the changes.
- I zoomed in if needed and looked for similarities first and the overall shape also the one that had the most changes I don't think I chose usually
- Primarily through placement.
- I tried to look for similarities in the patterns of the lines.
- I try to look for similarities and common points.
- I just tried to figure out different points and identify similarities.
- which was the reeb graph? the hardest one was the one with radiating red lines - it just didn't form an image
- I tried to find the least amount of differences and choose the best option.
- I looked for similar patterns in the lines.
- I just tried to zoom in as much as possible and match up the lines, but it was pretty hard, couldn't really tell when both left/right were so different.
- With all of the graphs that it was possible, I tried to take down the detail a bit to just see where the base points matched up the best.
- I just tried to do my best based on line distribution
- I tried to minimize the detail to about the halfway point and then it was easier for me to figure out which one looked more similar.

Persistence Diagrams Explanations

- I just tired to match up both outside and inside
- Again, just trying to look at which seemed to imitate it the closest. It was nice to rotate when possible.
- I used the sliders to try and evaluate the closest
- I didn't really have a rationale for this one - just went with what looked most visually similar.
- I looked for visual cues and similarity.
- I chose based on the details and how the basic structure was shown.
- I looked at the similarities in the placement of the dots
- I looked at areas of the graph to see if the points were similar to the target
- The models with similarly placed dots and where those dots were. Sometimes adjusting detail helped.

- I went by the amount of color in certain areas of the picture.
- Same with above, was difficult to comprehend the slight changes.
- No idea, shrunk the detail and went with what looked similar to the center image.
- I tried to look for similarities in distribution of data points on the graph.
- I feel like I didn't entirely understand what I was looking for. It was hard for me to see differences in how the dots were arranged around the line.
- I tried to gauge how it was related to the line in the diagram to see which one was similar.
- I'm not completely sure which was the Persistance diagram.
- Position of the dots and how many were in the same area
- The dots or line was a bit challenging.
- I tried to use the dots as a guide
- I focused on the main line to see which dots were in similar positions.
- I mostly just compared the points that were off the line and tried to choose the most similar ones.
- I scrolled through the various detail levels and tried to find the image closest to the baseline, in regard to the location of the data.
- i try to match the dots
- Paid attention to the amount of dots and the areas they would change around
- I looked at the diagonal and tried to see which one had the most similar pattern
- I just looked at the dots and picked the most similar
- I liked this one the best because it felt more familiar and there was less information to absorb. A simple line graph is a bit easier to understand.
- I tried to find clusters of similar looking dots.
- Basically the plot point regularity. For me this at least seemed the easiest.
- just trying to make sure they come close to matching
- I'm not sure other than to say I looked at the similarities first but these I weighed the differences more. These were really the most similar to each other in my opinion and hardest to judge.
- I just tried to visually overlay the baseline over left and right options, look for key points in common and estimate which was most similar.
- I looked at the points within the plane and went with the closest.
- Trying to line up the dots makes it the easiest.
- I checked for the positions of the dots away from the line.
- I paid attention to the diagonal line and looked at how the dots related to it.
- matched up the dots

- I tried to see which image followed a pattern similar to the one in the middle.
- I look for the same points.
- I just tried to figure out different points and identify similarities.
- if persistance is the diagonal line, i tried to match up blue points especially
- I tried to find the least amount of differences and choose the best option.
- I looked for the most similar plot points.
- I just looked at which one had more 'outlier' dots in places not in the baseline I guess.
- I tried to look at the dots on the line and see which matched closest and then the other dots also.
- I tried to match up where the groups of points matched when the graph detail was more minimal
- That one was hardest for me but again minimizing the detail to about the halfway mark made it a little easier but I often felt like both were very close.
- It was like poking holes in paper, eventually a void is created.
- I looked for similar positioning of the outlying points

Colormap Explanations

- Looked for the colors at the edge to match.
- I looked at the colors and tried to see how they matched the closest.
- I did not notice many differences in the color map visualizations. I noticed slight differences that did not match the target image. It was a toss up.
- I thought the color maps were the easiest to compare, since I could more easily see where the hot spots were, especially when rotating.
- Comparing where areas of color change in the image
- I looked for the gradient.
- I chose based on which color images were similar
- I looked for color match in areas in certain areas
- I looked at the hottest and coldest areas to find the differences.
- I went with where the colors were on it.
- Looking at the brighter heart levels (yellow) helped in determining matches.
- I went by the amount of color in certain areas of the picture.
- Easier to see the heat map and what parts are lighter/darker.
- I looked at particularly cool or warm spots to try and spot differences.

- I simply found it easier to compare different shades. It made the differences and similarities a little less muddy to me. Hopefully, that means I got this type of visualization correct mostly.
- I used hotter (or colder) areas to try to make judgments
- I picked a few extreme points on the the map to see if the color gradients were close.
- Where the colors were and the shade and them.
- Color map allow me to just go base on the warm and cold colors which I liked. Easier, I thought to see than some of the others.
- I tried to look at the intensity of the colors the most which was hard
- made sure colors were same intensity
- matched the colors
- Looking at the color on each object and determining which one was the closest.
- I found this very difficult, I tried to look for areas where the gradient changed differently.
- Viewing similar shades, lines
- I first identified the hot spot location in each baseline, and checked the general area where this was located. I compared the other two to see which matched best.
- i looked at the end edge of the heat marking
- try to find the light part or the dark part
- I compared the lighter and darker colors on each option to the baseline and picked the one that matched closest to the baseline colors and options.
- I tried to look for areas of similar color and size of the patch of color
- Paid attention to where colors were darker, lighter
- I looked at the darkest color then the lightest color and tried to see the one that was most in common
- Zooming very close and then looked at the similarity of colors
- All I did was try to figure out what was the one that most looked like the baseline. Just looking back and forth and in this case color contours
- I looked for the small variations in gradient
- I tried to look at the brightness or lack thereof with regards to the colors as well as the color spread.
- same as above, paying attention to the colors
- I really just tried to line up the colors as best as I could, and see if there were any obviously different spots.

- Really focused hard on the color transition patterns on outlying areas and worked in on the shape. This seemed to be the hardest for me.
- I did take your hint into consideration about finding the hot spots
- This was difficult as the gradients looks virtually the same. Just looked for subtle differences.
- Color spread to color spread. With these I seem to find more like than unlikes.
- These were easier to me to judge as the I saw the changes in color but they were very similar to the baseline in both cases usually.
- I just tried to visually overlay the baseline over left and right options, look for key points in common and estimate which was most similar.
- I looked at the overall image then the colors to determine the most likely choice.
- Zooming in and looking at the heat spots in the darkest color was easiest.
- It mostly had to do with how well I could detect the changes in shading.
- I looked to see how the colors matched the baseline.
- matched the shades of color
- I looked for different color patterns and changes, but it was very hard to see differences.
- I tried to identify which image had similar colors and a similar color pattern to the one in the middle.
- I look at the tone and brightness.
- I looked for color similarities.
- color map required some zooming out; i looked for color intensity mostly
- I tried to find the least amount of differences and choose the best option.
- I mainly focused on the yellow/brightest color.
- I zoomed in as much as possible and shifted it around at the parts where the colors changed, it seemed pretty easy compared to the rest to compare.
- i examined the shades and area of the colors and turned them in all angles
- This one I rotated the most and tried to compare light/dark areas.
- Equalization of colors in each
- I looked for obvious differences in the colors and usually something stuck out more on one that the other. If not I would just guess but I feel like that one was the most intuitive to me.
- Heat maps seem to be fairly easy in a general sense but it leaves the smallest variable undetectable.
- Tried to focus on hot and cold spots. I don't think I did very good on these (or likely any of them)

- Location and spread of the yellowish hotspot.

Isocontour Explanations

- I looked at how the shapes changed
- I looked at the lines to see how close or dense they were in comparison.
- I used the sliders to try and evaluate the closest
- Comparing the most obvious lines on each three images.
- I used my intuition. I could not see many similarities.
- I looked at the similarities in lines in certain areas
- I just tried to look at the areas where the lines were most separated and compared against the target
- Matching the models to distinctive patterns, adjusting detail level helped.
- This one was hard, but it's possible to see slight changes.
- I looked for various points to see if there were similar patterns.
- Which ever one seems the most similar in lines and patterns
- It allow me to move the lines, which perhaps help me with my answers or decision making.
- I tried to see where the concentrations of lines matched up with the center image.
- I tried to look at "ends" and find areas where they were quite different.
- Observing the same sequence of shades, lines
- Using the zoom levels, I tried to find the image with the closest 3D representation of the baseline model.
- matching the ridges
- I tried to match how the lines were moving and how far apart they were
- Paid attention to the lines and how they would change, or how much contour or curving of the lines was taking place
- It just seemed harder. Maybe because there were less differences. Sometimes when there were more differences it was also hard to judge.
- All I did was try to figure out what was the one that most looked like the baseline. Just looking back and forth
- I looked for similarity in contour lines
- I tried to look at the connectivity as best I could here.
- same as above, but paying attention to the lines and contours
- I tried to match up the contour lines, and brought the detail down to get a better look in some instances.

- If it wasn't apparent initially, take it down to about halfway on the scale and usually the one more similar looked more apparent.
- just trying to make sure they come close to matching
- Just tried to eyeball it and look for overall similar contours
- Compared the basic outlines to find the best matching pair.
- I just tried to visually overlay the baseline over left and right options, look for key points in common and estimate which was most similar.
- Looking at the lines, their placement, and the spacing was how I did it.
- The contour lines gave a pretty good indicator, so I followed them. Sometimes I rotated the figures to see how the lines traveled.
- I tried to see which image had a similar contour to the one in the middle.
- To be honest, no idea, these ones were completely incomprehensible to me, the left/right always looked so wildly different.
- Matrix type map consisting of threads/lines that become confusing. Chaos theory?
- I mostly looked for similar shapes in the lines with more space around them
- Closeness (density) of the contour lines on various body parts.