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Aesthetic Topology as Pre-Symbolic Readout

Persistent homology, gaze, and the Book VII aesthetic-functional picture

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1. INTRODUCTION: ART TOPOLOGY AS A GUARDED READOUT SURFACE

The Panta Rhei research-note series is built for a particular kind of encounter. A recent external result appears in a neighbouring discipline; the result is not part of the Panta Rhei framework and should not be absorbed into it rhetorically; nevertheless, the result exposes a measurement surface that resembles one of the framework's own open readout problems. The task is to let the external paper speak in its own vocabulary first, then ask what kind of bridge, calibration surface, or falsification surface it might provide.

Dmitruk et al.'s paper is such an encounter. Its object is abstract visual art, not black-hole polarimetry, flavour physics, or cosmological structure. Its method is persistent homology, not category theory. Its human data are gaze, EEG connectivity, and subjective aesthetic questionnaires. Yet the paper's central question is almost unnervingly close to a Book VII question: can the structure of a visual motif be measured in a way that connects to how the motif is perceived before the viewer has translated it into an explicit object label, iconographic reading, or symbolic statement?

For public readers, the terms need a quick map. Book VII is the Panta Rhei monograph layer that treats metaphysics, perception, aesthetics, language, and reflective structure. Category τ names the program's proposed categorical kernel. Reg_E is the empirical registration surface, where observations, measurements, and external data live. Reg_D is the diagrammatic registration surface, where structural maps, symbolic diagrams, and mathematical descriptors live. Registry identifiers such as VII.D44 and VII.T19 are route labels for definitions, propositions, and theorems; they are not empirical certifications.

Book VII approaches aesthetics through motifs, pre-symbolic resonance, and an aesthetic functional. A motif is a structured pattern that can be recognized across changes of viewpoint, medium, or realization. Pre-symbolic resonance names the felt recognition that such a pattern "works" before it is named. The aesthetic functional $\mathcal{A}$ is a defect measure for the failure of a motif to transport under admissible transformations [12]. In that language, a visual artwork is not first a proposition. It is a motif-field presented to an embodied perceiver.

The external paper gives us an empirical instrument for one slice of that problem. It converts images into grayscale cubical complexes, computes persistent homology across intensity filtrations, derives feature maps for cycle density, maximum persistence, and cycle perimeter, then overlays those feature maps with fixation heat maps. This is not a measurement of beauty itself. It is a measurement of image-filtration topology. The distinction is what makes the bridge useful.

> **SCOPE DISCIPLINE**
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> This note is a calibrated bridge note. It does not claim that Dmitruk et al. prove Category τ, that persistent homology is Book VII topology, that the paper validates Beauty as Invariance, or that the authors have found a universal law of art. It claims only that the paper provides a promising empirical readout surface for Book VII's aesthetic-functional picture.

What this note contributes. The note has five purposes. First, it reconstructs the Dmitruk et al. paper in its own terms. Second, it separates image-filtration topology from categorical aesthetics so that the word "topology" does not become a category error. Third, it introduces a descriptor ledger so the reader can see exactly where topology, gaze, rating, and EEG enter the chain. Fourth, it maps the paper to the relevant Book VII concepts: VII.D44, VII.D46, VII.D47, VII.T19, VII.P11, and VII.R21. Fifth, it turns the bridge into a future research program with explicit weakening and falsification conditions.

Why this is a Book VII note. The natural first temptation is to file this case study under computational biology, image analysis, or cognitive neuroscience. Those are the paper's native disciplines. The Panta Rhei reason to engage it, however, lies elsewhere. Book VII is where the framework asks how experience, meaning, language, aesthetics, and metaphysics appear after the life and consciousness layers have already prepared the carrier. The case study sits at that threshold. It does not ask whether a visual cortex can detect edges. It asks whether mesoscale image structure can be tied to looking, rating, and neural organization in an aesthetic setting. That makes it a Book VII case study with Book VI support, not a Book VI note with aesthetic decoration.

The line this note will not cross. There is an obvious rhetorical trap. Because the external paper uses the word "topology" and because Book VII also uses topological and categorical language, one could write a too-easy sentence saying that computational topology has now found Book VII aesthetic topology in art. That sentence would be wrong. The bridge has to pass through a typed measurement chain:

$$\begin{aligned} &\text{image} \longrightarrow \text{filtration descriptor} \longrightarrow \text{feature map} \\ &\longrightarrow \text{viewer trace} \longrightarrow \text{Book VII interpretation} \end{aligned}.$$

Every arrow in that chain is lossy. The value of the note is not to hide those losses but to make them inspectable.

2. DMITRUK ET AL. IN THEIR OWN TERMS

Dmitruk et al. begin from a familiar problem in empirical aesthetics: researchers have long tried to connect measurable image properties to human experience, but the relation between what is in the image and what is felt by the viewer remains difficult to establish [9]. Their proposal is that shape and visual structure should not be reduced to local pixel statistics or global summary measures alone. Between pixels and whole image statistics lies a mesoscale of loops, components, boundaries, holes, and frame interactions. Persistent homology is introduced as a way to measure that mesoscale.

The load-bearing external source is the PLOS Computational Biology article with DOI `https://doi.org/10.1371/journal.pcbi.1014156`. The paper also publishes an OSF data route and a public GitHub code route for the image-analysis tooling [10, 8]. This release-candidate note does not reproduce that pipeline; it records reproduction as a future test surface.

2.1 The image sets

The study uses two principal image sets. The art condition consists of twelve works by the Polish artist Lidia Kot, drawn from a solo exhibition dedicated to black. The images were displayed as large prints and also shown as digital stimuli in the laboratory. The pseudo-art condition consists of twelve images selected from 4,500 outputs generated by randomly perturbed BigGAN networks [3]. The pseudo-art images were chosen by pixel-difference matching to the original artworks, processed for display, upscaled using a super-resolution workflow [20], printed with matching technology and paper, and placed inside a generated curatorial frame with generated titles [9].

This design is both bold and fragile. It is bold because the pseudo-art images were not merely random noise; they were made plausible enough that participants did not reject them as inauthentic. It is fragile because the comparison does not isolate "artist intent" as a single experimental variable. It contrasts one human exhibition package with a particular generative pipeline, a matching procedure, upscaling, generated titles, curatorial text, proofreading, print matching, and exhibition framing. The pseudo-art condition is therefore not "absence of human mediation." It is a constructed counter-condition designed to be plausible enough for the study's art-viewing task.

The comparison is nevertheless unusually useful for a research note because it is neither a purely naturalistic art-historical comparison nor a purely synthetic psychophysics stimulus set. It lies in between. The pseudo-art images are constructed to be plausible exhibition objects, but they are not claimed to carry a coherent human artistic process. The artwork set carries a coherent artist/exhibition origin, but it is still narrow enough to be measured. That intermediate status is what makes the paper a useful calibration case: it is messy enough to be ecologically interesting and controlled enough to expose operational descriptors.

2.2 The human readouts

Participants viewed either the art exhibition or the pseudo-art exhibition, with measurements collected in gallery and laboratory settings. The two groups were matched and separated; participants did not view both exhibitions as a counterbalanced within-subject comparison. The paper reports eye-tracking metrics, EEG connectivity measures, and modified AEQ-S ratings. The AEQ-S instrument is a shortened adaptation of the Aesthetic Experience Questionnaire family [28]: in the gallery it refers to the whole exhibition experience, while in the laboratory it refers to individual images. The laboratory setting produced clearer aesthetic-rating and fixation differences in favour of the art images. The gallery setting was more ambiguous: pseudo-art images attracted longer viewing times, while the gallery questionnaires did not show the same strong subjective separation.

For this note, that ambiguity is not an embarrassment. It is a clue. Book VII does not treat perception as passive retinal reception. Perception is an embodied readout process in which the observer, the sensory context, the viewing conditions, and the motif-field jointly determine what can be glued into experience [12]. A lab/gallery split is therefore not merely noise. It is a boundary condition compatible with the thought that an aesthetic descriptor only becomes perceptual through a situated readout.

This matters for the tone of the note. The laboratory findings cannot be turned into a simple statement that the art images were "better perceived" or that the pseudo-art images were "worse perceived." The gallery findings already block that simplification. What can be said is more interesting: the same image-topological descriptors may participate differently in different covers of the viewing situation. Laboratory fixation, gallery movement, changing illumination, printed material

Table 1. Descriptor ledger for the release-candidate reading of the primary paper. Each row marks a type change; none of the empirical objects in the table is identical with the Book VII aesthetic functional.

Layer	Object	Guardrail
Image source	RGB artwork or pseudo-art print/digital copy	The image is a stimulus under exhibition or lab conditions, not the artwork's full historical or intentional life.
Intensity projection	Weighted grayscale image, with limited RGB-channel checks	Color topology, material surface, scale, illumination, and curatorial frame are only partially represented.
Filtrations	BW and WB cubical filtrations over image intensity	These are image-filtration topologies, not categorical topology in the Book VII sense.
Homology summaries	H_0/H_1 barcodes, persistence diagrams, landscapes, Betti curves, Alexander duality residuals	Persistence records threshold-stable components and loops; it does not name motifs or explain response by itself.
Feature maps	Cycle-density, maximum-persistence, and perimeter maps derived from H_1 representatives	Localized maps depend on representative choices, windowing, smoothing, and image preprocessing.
Gaze comparison	Fixation-weighted ECDF, mean squared error, and mean error against feature maps	The published topology/gaze overlay is laboratory-only and should be checked against saliency baselines.
Human reports	Modified AEQ-S ratings in gallery and lab contexts	Gallery ratings refer to exhibitions; lab ratings refer to individual images; the two contexts are not interchangeable.
Neurophysiology	EEG connectivity condition measures	EEG readouts are downstream condition markers, not evidence that topology causes neural response.
Book VII bridge	Candidate operational triple $(\mathcal{M}_{\text{img}}, G_{\text{adm,img}}, D_{\text{PH}})$	A typed proxy bridge; not a proof of Category τ and not the aesthetic functional $\mathcal{A}$ itself.

surface, calibration quality, and viewer expectation all become part of the perceptual context. EEG connectivity should be read in the same disciplined way: it is a downstream condition marker, estimated with known connectivity pitfalls and noise sensitivities, not a proof that topology causes a neural state [27, 2].

2.3 The topological instrument

The computational core converts RGB images to weighted grayscale, using the standard luminance projection $Y = 0.299R + 0.587G + 0.114B$, and treats the result as a cubical complex. Persistent homology is then computed over intensity filtrations [18, 19]. In one direction, a black-to-white filtration BW includes darker regions before lighter ones; in the reverse direction, a white-to-black filtration WB includes lighter regions before darker ones. The output includes persistence barcodes, persistence diagrams, persistence landscapes, Betti curves, and image-local feature maps derived from H_1 cycle representatives. That representative layer is useful but not neutral: cycle selection, localization windows, smoothing, and image preprocessing can change the local map while leaving the global barcode summary less affected.

The paper reports that art images contain many more cycles than the pseudo-art set: roughly an order-of-magnitude difference in mean cycle counts in both dimension 0 and dimension 1. The group persistence landscapes differ significantly, and the Betti curves have markedly different shapes. These are the strongest results in the paper because they do not depend on a subtle interpretation of subjective experience. They say that the two image sets have substantially different image-filtration topology.

The grayscale projection is also a central limitation. It suppresses chromatic relations, pigment/material effects, and some color-boundary interactions. Color-aware topology is therefore not a decorative extension; it is a required future test if the bridge is to address painting as painting rather than image intensity alone [7].

2.4 The paper's result package

For the Panta Rhei bridge, the paper's findings can be sorted into four classes. The first class is image-internal: the art and pseudo-art sets differ strongly in persistent landscapes, Betti curves, and cycle counts. The second class is frame-sensitive: the paired filtrations expose residuals associated with finite image boundaries. The third class is viewer-trace: fixation maps overlap with topological feature maps in ways that differ between art and pseudo-art. The fourth class is downstream experience: subjective ratings and EEG connectivity differ in the laboratory, while the gallery results are more context-dependent.

That ordering is important. The image-internal results are the most stable descriptor base. The viewer-trace results are the most interesting bridge. The subjective and EEG results are suggestive but must remain downstream. A research note that reverses the order–starting from subjective experience and then claiming that topology explains it–would be too strong. The safer reading starts with descriptors and asks what kinds of perception they can help organize.

2.5 The frame residual

The most rhetorically charged part of the paper concerns Alexander duality. The authors compare paired Betti curves from opposite filtrations and define a normalized difference between the integrated Betti-curve areas. They call this a measure of "violation" of Alexander duality. They then report that artworks differ from pseudo-art in this residual and that a broader set of eminent abstract painters appears to cluster near a particular value.

This note uses more cautious language. The relevant object is a normalized paired-filtration Betti-curve area residual, which we abbreviate as ADV. It is not a failure of the theorem of Alexander duality; it is a measure of how cycles interact with the finite image frame, the chosen filtration direction, and the boundary handling of the image. That makes it relevant to visual composition, but only if the boundary status is kept explicit. The residual must not be converted into a golden-ratio claim or a bridge to the Panta Rhei constant ι_τ.

3. WHAT PERSISTENT HOMOLOGY MEASURES

Persistent homology is a method for tracking topological features across a filtration [30, 11, 14, 5, 23]. In an image setting, the filtration parameter is not metaphysical depth. It is an operational threshold, such as pixel intensity. Components and cycles appear, persist, and disappear as the threshold changes. Their persistence becomes a measure of robustness within that chosen filtration. Stability theorems and persistence landscapes make such descriptors usable for comparison and statistics, but they do not remove the need to specify the filtration, metric, and preprocessing choices [6, 4].

The bridge depends on not collapsing these layers. A persistent cycle in a grayscale filtration is not a motif in the Book VII sense. A motif is a pattern that can be recognized and transported across perspectives. A persistent cycle may be part of the empirical descriptor by which a motif becomes visible to an instrument, but the descriptor is not the motif. Likewise, a fixation heat map is not experience. It is a trace of looking behaviour, which may constrain a model of experience but does not replace one.

This distinction also clarifies the phrase "hidden topology." What is hidden is not an occult metaphysical essence in the artwork. What is hidden is mesoscale image structure that standard local or global image statistics may not expose. Persistent homology is valuable because it occupies the middle scale between pixels and whole-image summaries. It describes the organization of shape across thresholds, not merely the distribution of intensity values.

Table 2. What the primary paper establishes, suggests, and leaves open.

Level	Strong reading	Guardrail
Image topology	The two image sets differ sharply in persistent-homology descriptors.	This is a contrast between selected sets, not art as such.
Gaze topology	Laboratory fixated regions can be compared with topological feature maps.	The gaze-topology analysis is correlational, lab-only, and sensitive to saliency and fixation-map assumptions.
Subjective rating	Topological features relate to AEQ-S scores in laboratory data.	Ratings are pooled, context-sensitive, and not a direct beauty measure.
EEG connectivity	Art and pseudo-art viewing differ in beta/gamma connectivity patterns.	EEG effects are not shown to be mediated by topology.
Frame residual	Boundary-sensitive residuals distinguish art from pseudo-art and broader image sets.	The residual is not literal theorem violation or a universal law.

Table 3. Layer discipline for the aesthetic-topology bridge.

Layer	External paper object	Panta Rhei reading
Pixel field	Grayscale image after preprocessing	Empirical input, not motif itself
Filtration topology	Persistent cycles, landscapes, Betti curves	Candidate descriptor family for visual structure
Feature map	Cycle density, maximum persistence, perimeter	Local readout proxy for motif salience
Viewer trace	Fixation heat map, EEG, AEQ-S	Empirical-register trace of perception
Book VII object	Motif, resonance, aesthetic functional	Diagrammatic-register structure requiring typed translation

3.1 Instrument, descriptor, motif

Three terms should be kept separate throughout the note. An *instrument* is the operational procedure: grayscale conversion, cubical-complex construction, filtration, persistent-homology computation, and feature-map construction. A *descriptor* is an output of that instrument: persistence, cycle density, perimeter, a Betti-curve area, or a residual. A *motif* is the Book VII object: a structured pattern that can be recognized and transported across perspectives.

The bridge does not identify these three. It proposes that certain descriptors may be useful empirical shadows of motif properties. That is exactly the same discipline used in other Panta Rhei research notes. A word embedding is not meaning; it is a downstream public-language instrument. A polarimetric map is not a horizon theorem; it is an observational readout. Here, a persistence landscape is not beauty; it is a descriptor of image structure.

3.2 Why mesoscale matters

The paper's own discussion emphasizes a mesoscale analogy. Pixels are local components. Whole-image statistics are macroscopic summaries. Persistent homology captures structures between those scales: loops, components, boundaries, and their stability across thresholds. This is exactly the scale at which visual composition usually lives. A composition is not reducible to the mean luminance of a canvas, nor is it only a catalogue of individual pixels. It is an arrangement of relations in a bounded field.

Book VII's motif language has the same middle-scale flavour. A motif is neither a raw sensory atom nor a fully symbolic proposition. It is a recognizable pattern capable of surviving controlled transformation. The external paper does not prove that persistent cycles are motifs, but it gives us a way to measure candidate visual structures at the right scale of organization.

TOPOLOGY NAME COLLISION

The word "topology" appears on both sides of the bridge, but with different types. The paper studies persistent homology of cubical complexes derived from images. Book VII studies categorical perception, motif transport, and aesthetic invariance. The research note is viable only if those two senses remain distinct.

4. AESTHETIC FUNCTIONAL AND PRE-SYMBOLIC RESONANCE

Book VII defines pre-symbolic resonance as the felt recognition that a motif works before the pattern is named or conceptually parsed. Formally, a motif is resonant when it is transportable under admissible transformations. The aesthetic functional $\mathcal{A}$ measures the worst-case failure of such transport over subregions and admissible maps [12].

That vocabulary gives a precise place for Dmitruk et al.'s result. The paper does not measure $\mathcal{A}$. It measures image descriptors that could become components of a future empirical estimator for motif transport. Persistence tracks robustness

Table 4. Persistent-homology caveats that matter for the bridge.

Issue	Why it matters	RC discipline
Filtration choice	Grayscale thresholding privileges intensity order.	Treat BW/WB as one descriptor family, not the artwork's full topology.
Color loss	Luminance projection can erase chromatic boundaries and harmonies.	Require color-aware extensions before any painting-wide claim.
Representative choice	Local feature maps depend on selected cycle representatives.	Use maps as probes, not as canonical motif locations.
Frame dependence	Boundary-touching cycles can dominate residuals.	Read ADV as frame interaction, not theorem failure.
Gaze weighting	Fixations are sparse, smoothed, and context-dependent.	Compare against saliency, central-bias, and scanpath baselines.
Stimulus inference	Images are finite stimuli, not artworks as lived cultural objects.	Keep artist, exhibition, title, and material context in view.

across filtration thresholds. Cycle density tracks how crowded the local topological field is. Cycle perimeter tracks the spatial extent of cycles. The Alexander duality residual tracks how strongly cycles interact with the frame. None of these is beauty, but each is a plausible observable for some aspect of visual motif structure.

The connection to Book VII is therefore analogical in method but structural in question. The external paper asks whether there are measurable image structures that distinguish artwork from pseudo-art and relate to looking behaviour. Book VII asks how motifs become resonant before symbolic articulation. The shared problem is not "what is art?" but "how can visual structure be available to pre-symbolic perception?"

4.1 Register typing

Panta Rhei's register discipline helps avoid inflation. The paper's pixel filtrations, gaze data, EEG connectivity, and subjective ratings belong to the empirical register Reg_E. Book VII's motif transport, aesthetic functional, and Beauty as Invariance theorem belong to the diagrammatic/metaphysical register Reg_D. A bridge from Reg_E to Reg_D is possible, but it is a bridge, not an identity.

This distinction is not bureaucratic. It changes what counts as support. A significant persistence-landscape difference can support the claim that image sets differ in measured topology. It cannot by itself support the claim that Beauty as Invariance has been validated. Conversely, the Book VII aesthetic functional can specify what kind of structure a future empirical descriptor should seek, but it cannot license post hoc celebration of any descriptor that happens to separate two image sets.

4.2 A typed operational bridge

The safest Book VII bridge is typed as an operational proxy rather than an identity. Let $\mathcal{M}_{\mathrm{img}}$ denote an image-level motif carrier: not the artwork itself, but the structured visual field presented by a particular image under a particular cover. Let $G_{\mathrm{adm,img}}$ denote the admissible transformations that belong to the image experiment: contrast changes, scaling, cropping, padding, filtration direction, color projection, viewing distance, and contextual cover. Let D_{PH} denote a family of persistent-homology descriptor distances and residuals over that carrier.

Then the empirical bridge can be stated as a candidate:

$$(\mathcal{M}_{\mathrm{img}}, G_{\mathrm{adm,img}}, D_{\mathrm{PH}}) \rightsquigarrow \text{one observable family for pre-symbolic visual readout.}$$

This is deliberately weaker than saying $D_{\mathrm{PH}} = \mathcal{A}$. The aesthetic functional belongs to the Book VII diagrammatic level. D_{PH} is a measurement family that may constrain, falsify, or calibrate candidate empirical interfaces to that level. The bridge becomes stronger only if future studies show that D_{PH} remains informative under preregistered transformations, stimulus sets, color-aware topology, independent reproduction, and competing saliency controls.

4.3 Beauty as invariance, carefully typed

Book VII's Beauty as Invariance theorem VII.T19 identifies beauty, in the categorical sense, with the vanishing of the aesthetic functional under the relevant admissible transformations [12]. This is a structural identification, not a psychometric claim. A viewer may prefer high-tension, asymmetric, disturbing, or unstable motifs. Such preference does not refute the theorem because the theorem fixes a structural use of "beauty," not every use of "liking."

Dmitruk et al.'s paper is relevant here because it measures multi-scale structural features that could participate in aesthetic tension. It is not relevant because it would show that viewers prefer all invariant motifs. In fact, the paper's lab/gallery split and feature-specific findings argue against any simple universal preference rule. A topological feature can attract attention in one image context and not in another. That is exactly why Book VII needs a motif-space and an admissible-transformation group rather than a single scalar "beauty score."

Table 5. Candidate bridge from paper descriptors to Book VII concepts.

Descriptor	Safe interpretation	Unsafe interpretation
Maximum persistence	Robust feature across filtration thresholds	Beauty or meaning itself
Cycle density	Local crowding of topological features	Direct measure of complexity preference in all viewers
Cycle perimeter	Spatial extent of a persistent cycle	Composition quality without context
Alexander duality residual	Boundary/frame-sensitive proxy	Failure of Alexander duality as a theorem
Fixation overlap	Trace of what viewers sampled	Direct access to aesthetic experience

Table 6. Registry bridge for the release-candidate note.

ID	Concept	Role in this note
VII.D44	Perception Functor	Gaze and lab/gallery differences are treated as empirical traces of embodied sensory-context readout.
VII.D46	Pre-Symbolic Resonance	Topological salience is interpreted as candidate pre-symbolic motif availability before object-label naming.
VII.D47	Aesthetic Functional	Persistent descriptors are possible empirical proxies for motif-transport defects, not the functional itself.
VII.T19	Beauty as Invariance	Provides the structural horizon; the paper does not validate it.
VII.P11	Fractal Beauty	Provides a scale-invariance precedent; persistent homology is a broader descriptor family, not a fractal-dimension replacement slogan.
VII.R21	Visual Composition	Boundary residuals, flow, gaze, and frame interaction become composition-relevant only with curatorial and material discipline.

4.4 Fractal aesthetics as a nearby precedent

Book VII already contains a nearby precedent: fractal aesthetics. Fractals are visually compelling because they present scale-invariant motif structure. The external literature around fractal dimension and aesthetic preference has long made the empirical side of that question visible [26, 25]. But fractal dimension is only one way to quantify multi-scale structure. Persistent homology widens the instrument set. It tracks not only scaling regularity but also components, cycles, lifetimes, and boundary interactions.

That is why the paper is interesting even if every strong interpretive claim is weakened. It suggests that Book VII's aesthetics should not be operationalized through one favourite number. The aesthetic functional is a structural object; different empirical descriptors may approximate different aspects of its defect landscape. Fractal dimension may describe one invariant family. Persistent cycles may describe another. Boundary residuals may describe a third. A mature empirical aesthetics of Book VII would need a typed family of descriptors, not a single magic scalar.

5. GAZE MAPS AND THE PERCEPTION FUNCTOR

The closest Book VII match to the gaze component is the Perception Functor VII.D44. Perception maps sensory contexts to experiential contents. It is not a passive copying operation; it is a structure-preserving readout that depends on the observer's body, attention, and context [12]. Eye tracking is therefore a valuable proxy because it records part of the embodied sampling process by which the image is made available to perception.

Dmitruk et al. overlay laboratory fixation heat maps with topological feature maps and ask whether viewers look at regions with different topological properties from regions they ignore. The answer is context-sensitive. For art images, viewers showed no simple preference for regions of maximum persistence or perimeter and showed a preference for lower cycle density. For pseudo-art images, viewers favoured regions with higher persistence and larger spatial extent. This is stronger than a universal "people look at persistent cycles" claim would have been, because it shows that local salience depends on the global image field.

Book VII frames perception as more than local feature extraction. A local section has to glue into a larger experiential field. The paper's context-dependence is therefore a natural bridge: a topological descriptor is not perceptually meaningful by itself; it becomes meaningful relative to the whole image and the viewer's sampling path. The next empirical step is not to declare that topology forecasts gaze, but to test whether topological feature maps add explanatory value beyond saliency, contrast, central-bias, and scanpath baselines [16, 29, 15].

5.1 Laboratory and gallery as different covers

The lab/gallery split is especially important. In the laboratory, the art images produced stronger subjective and fixation differences. In the gallery, pseudo-art attracted longer viewing times and the subjective ratings did not separate the exhibitions in the same way. The authors intentionally avoid a simple direct comparison between gallery and laboratory settings because the presentation, movement, illumination, and response units differ. Whether or not their suggested explanations survive replication, the structural point is valuable: the same image is not the same perceptual object under every cover.

In Book VII language, a gallery visit and a laboratory session are different sensory contexts. They provide different local sections of the experience presheaf. A robust aesthetic account should not erase that difference. It should ask which motif properties survive changes of lighting, distance, movement, material surface, and attention.

5.2 AEQ-S, EEG, and downstream readout limits

The subjective and EEG layers should remain downstream. The modified AEQ-S instrument gives a useful report vector across emotional, cultural, perceptual, cognitive-understanding, and flow-like dimensions, but it is not a direct beauty meter. It is also not identical across gallery and laboratory: one context asks after the exhibition experience, the other after individual images. Future work should model stimuli and participants explicitly as random factors rather than treating image-level observations as independent replicas of a universal aesthetic effect [17, 1].

The EEG connectivity layer is even more delicate. Weighted phase-lag connectivity is designed to reduce some volume-conduction problems, yet connectivity measures still require care in interpretation, sample-size stability, and frequency-band inference [27, 21, 2]. For this note, EEG differences are treated as condition markers that may help triangulate aesthetic response. They are not treated as warrant for saying persistent homology drives neural organization.

5.3 Attention, salience, and non-equivalence

It is tempting to treat fixation as endorsement: if the eye dwells on a region, perhaps the viewer finds it beautiful. The paper itself does not license that simplification. Attention can indicate attraction, confusion, search, effort, surprise, or failure to integrate. In the gallery, pseudo-art attracted longer viewing times without producing the same clean subjective rating separation. That is not a contradiction; it is a warning that salience and aesthetic resonance are not equivalent.

Book VII makes room for that distinction. Pre-symbolic resonance is not the same as raw attention. A high-tension motif may capture attention because it resists integration. A low-tension motif may produce recognition without long search. A sublime or disturbing motif may overwhelm the available motif-space. The gaze data are therefore best treated as sampling traces: they tell us where and how the viewer looked, not what the final aesthetic experience was.

6. BOUNDARY, FRAME, AND ALEXANDER-DUALITY RESIDUALS

Visual composition is spatial aesthetics at the frame. Book VII's Visual Composition Principles VII.R21 treat balance, flow, color harmony, and framing as structural optimizations in a two-dimensional field [12]. Art-historical and curatorial theory already warns that the frame, field, gallery, label, and exhibition apparatus help constitute how a work is read, not merely where it is placed [24, 22, 13]. The paper's Alexander duality residual is relevant because it operationalizes a boundary effect: cycles that interact with the image frame fail to pair cleanly under opposite filtrations.

This is not a theorem-violation claim. In the mathematical background, Alexander duality is a theorem about complementary dimensions under appropriate conditions. The paper's residual arises because finite images, filtrations, and boundary touching features do not satisfy the ideal pairing conditions everywhere. The residual is therefore best read as a frame-interaction metric.

That cautious interpretation is actually more interesting for Book VII than a dramatic theorem-violation interpretation. It suggests that composition may be measurable not only by what lies inside the image but by how internal features meet the edge. A painting is not just a field of marks. It is a field of marks bounded by a frame, and the frame participates in how visual flow is organized.

6.1 Boundary as aesthetic object

In ordinary discussion, a frame can sound external to the artwork: a rectangle around the real content. Composition theory says otherwise. The frame is part of the visual field because it determines where balance, flow, entry, exit, and edge tension occur. A cycle touching the boundary is not merely a technical failure to remain interior. It may indicate that visual structure is being organized through the edge.

This is the safe Book VII relevance of the Alexander duality residual. It is not a hidden appearance of the lemniscate, not a secret proof of Category τ, and not a numerical signature of genius. It is a possible descriptor of frame-participation. Future work could test this directly by cropping, padding, translating, extending, or reframing images while measuring how residuals, saliency maps, and fixation paths change.

GOLDEN-RULE GUARDRAIL

Dmitruk et al. speculate that eminent abstract artists may cluster around a particular Alexander-duality residual value. This note treats that as a hypothesis, not as a law. It is not a golden-ratio claim, not an ι_τ claim, and not a Book VII consequence unless future work derives a typed bridge before looking at the data.

7. CALIBRATION AND FALSIFICATION SURFACES

The value of the paper for Panta Rhei lies less in what it settles than in what it makes testable. It turns several Book VII phrases into future measurement questions:

1. Can visual motifs be described by descriptor families that remain stable under admissible transformations?
2. Do viewers fixate motif regions identified by such descriptors more strongly than regions identified by conventional image statistics alone?
3. Do lab and gallery contexts change which descriptors are perceptually available?
4. Can topological descriptors be manipulated causally while keeping lower level statistics approximately fixed?
5. Does color-aware topology materially change the relation between image structure and aesthetic response?

These questions are not merely empirical add-ons. They specify how a Category τ-facing aesthetic theory could be disciplined. If topological descriptors do not generalize beyond one artist, one pseudo-art pipeline, and grayscale images, then they should remain local descriptors rather than candidates for the aesthetic functional. If they forecast gaze no better than edge density, contrast, or other conventional image statistics, the Book VII bridge weakens. If the Alexander duality residual disappears under boundary controls, the visual-composition interpretation must be revised.

The next research step is therefore not to declare victory. It is to build a small, reproducible bridge protocol: choose descriptors, define their relation to motif transport, preregister what would count as support or failure, and then test against images designed to separate topology from conventional image statistics.

7.1 A release-candidate mini-program

For the Panta Rhei research program, this case study suggests a compact three-stage mini-program.

Stage 1: reproduction and typing. Reproduce the released image-analysis pipeline and document exactly which choices affect the descriptors: grayscale conversion, filtration direction, cycle thresholding, window size, border handling, and feature-map construction. The output should be a typed descriptor ledger, not an aesthetic conclusion.

Stage 2: controlled perturbation. Construct image variants that change one descriptor family while holding others as stable as possible. Examples include boundary padding/cropping, contrast-preserving cycle perturbation, color-channel manipulations, and synthetic motifs with known persistence structure. This is where the bridge becomes causal rather than merely comparative.

Stage 3: preregistered readout. Before collecting viewer data, specify which descriptors are expected to forecast fixation, which are expected to forecast subjective ratings, and which are expected to interact with lab/gallery context. The result can then weaken or strengthen the Book VII bridge without post hoc reinterpretation.

8. HONEST NON-CLAIMS AND NEXT RESEARCH STEPS

This note closes by making the non-claims explicit.

First, this is not a proof of Category τ. The external paper is an empirical and computational study in image topology and human perception. It does not establish the Panta Rhei framework.

Second, persistent homology is not the aesthetic functional. Persistent homology is an instrument. The aesthetic functional $\mathcal{A}$ is a Book VII structural object. The bridge is that persistent descriptors may become empirical proxies for some components of motif transport.

Third, gaze is not experience. Fixation maps constrain theories of perception, but they do not exhaust aesthetic experience. They are traces of looking, not the totality of pre-symbolic resonance.

Fourth, art versus pseudo-art is not intent versus non-intent. The paper's design is powerful but confounded. A human exhibition and a generated pseudo-exhibition differ in many ways. Any claim about artist intent must remain secondary.

Fifth, the frame residual is not a numerological bridge. The reported residual near a particular value is intriguing, but it is not a golden-ratio result and not a bridge to ι_τ. It is a hypothesis about composition and boundary interaction.

What remains after these guardrails is still exciting. Dmitruk et al. give us a computationally explicit way to ask whether visual motifs have measurable multi-scale structure and whether human looking is sensitive to that structure. For Book VII, that is the right kind of external neighbor: not a proof, not a trophy, but a carefully bounded readout surface.

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Table 7. Future tests that would strengthen or weaken the bridge.

Test surface	Strengthening result	Weakening result
Color-aware topology	Channel-coupled descriptors improve gaze/rating accounting	Grayscale-only effects fail under color controls
Controlled synthesis	Manipulated persistence changes fixation under matched saliency and image-statistic controls	Effects vanish when edge density/contrast are matched
Within-subject design	Same viewers show stable descriptor sensitivity across sets	Between-group effects dominate and do not replicate
Boundary controls	Frame residual tracks composition-specific gaze patterns	Residual tracks preprocessing or crop artifacts only
Saliency baseline	Persistent-homology maps add value beyond saliency, central-bias, and edge/contrast models	Conventional saliency explains the gaze-topology association
Independent reproduction	OSF/code pipeline reproduces reported descriptors and statistics	Key descriptor/rating/gaze links fail under independent rerun
Curatorial controls	Title, wall text, exhibition order, and print condition are modeled separately	Framing variables absorb the apparent topology/art contrast
Preregistered Category τ map	Motif descriptors retain value before model adjustment	Bridge appears only after post hoc descriptor selection

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