Research & Design
www.jrede.org

Research Article

Designing continuity without closure: a morphological framework for incomplete geometric configurations

Hiroko Nakajima*[a], Haruka Matsukura[b], Maki Sakamoto[c]

Department of Informatics, Graduate School of Informatics and Engineering, The University of Electro-Communications, Tokyo, Japan

Article Info

Article History:

Received:
27 May 2026

Accepted:
20 July 2026

Keywords:

Relational continuity;
Visual design;
Incomplete form;
Geometric configuration;
Formal analysis;
Perceptual organization

Abstract

Visual continuity is conventionally associated with closure, repeated units, or intact outlines, yet many visual-design contexts require coherence under cropping, interruption, displacement, and omission, where existing perceptual and shape-analytic accounts provide no work-level descriptive vocabulary. This paper addresses that gap with three objectives: to define a set of visible formal operations by which incomplete geometric configurations remain coherent, to organize these operations into recurrent modes of continuity, and to formulate testable perceptual hypotheses. Through qualitative formal analysis of selected documented work states from Hiroko Nakajima's CONTINUUM series—Hilbert curve (2021), Incomplete continuum (2021), and Construction Drawing 01–03 (2021)—the study identifies six operations: repetition, connection, spatial filling, interruption, boundary displacement, and partial omission, each grounded jointly in observable features of the works and in prior accounts from Gestalt psychology, perceptual completion research, shape analysis, and design cognition. These operations are organized into three modes of relational continuity—path-based, connective, and field continuity. The principal finding is that incompletion need not weaken order when relational cues remain operative; under specific conditions it can make relational structure more legible. Three falsifiable hypotheses (H1–H3) are formulated to bridge this qualitative, work-level description toward future quantitative perceptual and applied-design evaluation.

1. Introduction

Visual continuity is often associated with repeated units, closed figures, or the stable extension of a pattern. However, many visual configurations remain coherent even when they are interrupted, displaced, cropped, or partially omitted. This problem is especially relevant to design fields such as textile design, surface design, exhibition layout, architectural facades, diagrams, and screen-based interfaces, where continuity often has to be sustained across gaps, edges, modules, and open fields.

This paper asks how incomplete geometric configurations can maintain visual coherence without complete closure. To address this question, it analyzes selected documented work states from Hiroko Nakajima's CONTINUUM series, presented in HIRAKU PROJECT VOL.12 at the Pola Museum of Art: Hilbert curve (2021), Incomplete continuum (2021), and Construction Drawing 01–03 (2021) [1]. Although these works belong to contemporary artistic practice, they are treated here as structured visual cases for design research. The aim is not to interpret the works symbolically, but to derive a descriptive vocabulary for how continuity is organized through visible formal operations.

*Corresponding author: nakajima.h@mac.com
[a]orcid.org/0009-0001-8043-8373; [b]orcid.org/0000-0002-6390-0861; [c]orcid.org/0000-0001-6241-8670
DOI: http://dx.doi.org/10.17515/rede2026-030ae0527rs
Research & Design Vol. 3 Iss. 2 (2026) 79-94

Prior research offers four useful but partial perspectives on this problem. Gestalt psychology and its contemporary syntheses show that visual order is not reducible to literal completeness; principles such as good continuation, closure, grouping, and figure–ground organization explain how coherence emerges through relations among elements [2,3]. Research on contour interpolation and amodal completion further specifies conditions under which separated fragments may be perceived as continuous [4,5,6]. Design cognition shows that visual representation can generate and test relations rather than simply record a fixed image [7,8]. Finally, shape analysis and studies of decorative order describe operations such as recurrence, subdivision, and adjacency through which visual structures are produced and read [9,10].

These bodies of research are extensive, but they do not by themselves provide a work-level vocabulary for describing how an incomplete configuration remains coherent as a whole. Perceptual studies model how viewers process fragmented stimuli, but they do not fully describe the configuration of incompletion at the scale of a work. Shape analysis specifies operations on rule-governed forms, but it is less concerned with how withholding closure can remain visually readable. Art-historical accounts of grids, modular reduction, and open structures illuminate the cultural stakes of incompletion [11–14], but they do not directly yield a transferable design instrument. What remains underdeveloped is a vocabulary for comparing visible operations of continuity across incomplete visual cases. The novelty of the present study lies precisely here. Prior work treats completion either as a local perceptual process (contour interpolation, amodal completion) or as a rule for generating complete forms (shape grammars, plane divisions), while art-historical scholarship interprets incompletion thematically. None of these offers a comparative, work-level operational vocabulary that simultaneously (a) names the visible operations by which an incomplete configuration remains coherent and (b) links each operation both to an observable feature and to an independent perceptual or shape-theoretic rationale. The contribution of this paper is to define such a vocabulary—six operations organized into three relational modes—and to render it falsifiable through Hypotheses H1–H3. To our knowledge, continuity has not previously been formalized as a relational state describable at the level of visible operations independently of closure.

This gap matters for design research. In visual design, textile and surface design, architectural facades, exhibition layouts, diagrams, interfaces, and spatial compositions, continuity is often required even when forms are cropped, modularly displaced, interrupted by edges, or distributed across fields. A designer may need to sustain coherence without closing a contour or repeating a module uniformly. The present paper therefore reframes the analysis of the CONTINUUM series as a design-relevant inquiry into relational continuity: a condition in which direction, interval, connection, boundary implication, and field distribution remain active despite incompletion.

The study has three objectives. First, it defines six descriptive operations—repetition, connection, spatial filling, interruption, boundary displacement, and partial omission—each grounded jointly in visible features of the selected works and in prior theory. Second, it compares the selected works in order to identify three recurrent modes of relational continuity: path-based, connective, and field. Third, it clarifies how these modes may function as a design vocabulary for analyzing and developing open-ended visual structures, and it formulates testable perceptual hypotheses that future research may pursue.

The epistemic position of the paper should be stated clearly. The present study does not empirically test viewer responses. Instead, it proposes a design-research framework that can be operationalized in later perceptual evaluation experiments and in applied design contexts. Accordingly, the paper does not claim a universal law of perception. It proposes a transparent and contestable vocabulary that can be revised through further case analysis, controlled perceptual studies along the lines of Hypotheses H1–H3 introduced in Section 4.5, and applied use in visual design, kansei informatics [15,16], exhibition layout, architectural surfaces, and screen-based interfaces. A specific methodological risk must be acknowledged at the outset: because the analyzed works were produced by the first author, the analysis is a form of self-analysis. Accordingly, we treat this study as a provisional, single-investigator case analysis rather than a generalizable result. To contain the attendant interpretive bias, all claims are restricted to externally inspectable visual features and were cross-examined by the co-authors (Section 3.1), and the framework is offered as a contestable, hypothesis-generating instrument whose generality remains to be established through external cases and inter-rater coding (Sections 3.5 and 4.5).

2. Conceptual and Design Background

2.1. Continuity beyond Repeat and Complete Closure

Continuity is often treated as the persistence of a stable form or the extension of a repeated unit. Such models describe patterns, tilings, and closed figures—exemplified in their most systematic form by Escher's regular division of the plane [17]— but they are insufficient for configurations whose coherence depends on a path, an open edge, an implied continuation, or a displaced boundary. We therefore approach continuity as an effect of relation rather than as the survival of an intact whole.

This position draws on a broader understanding of perceptual organization. Classic Gestalt theory holds that visual order emerges through relations among elements rather than through isolated local features [2]. Arnheim's account of visual perception treats form as a dynamic structure of tensions, directions, balances, and field relations [18]. Chen's topological approach further argues that global properties such as connectedness may be processed before more local metric features [19], suggesting that a configuration can remain legible through global relational properties even when local details are displaced or incomplete. Subsequent syntheses restate this relational account of perceptual organization on contemporary empirical and theoretical grounds [20,21].

In this paper, relational continuity refers to a work-level condition in which a configuration remains visually coherent even when it is open, interrupted, displaced, or incomplete. A line may remain directionally active across a gap; an open boundary may continue to organize a field; and repeated intervals may sustain coherence without enclosure. Relational continuity presupposes perceptual grouping, but it operates at a different analytic level. Whereas grouping principles explain how local elements may be bound into perceptual units, relational continuity describes how an entire configuration remains coherent when closure, extension, or enclosure is withheld.

2.2. Incomplete Form and Visual Coherence

Incomplete form is not defined here as accidental damage or unfinished execution. It refers to a visually organized condition in which part of a configuration is open, interrupted, shifted, or selectively omitted while the overall structure remains readable. This distinction is crucial because not all incompletion produces coherence. Some interruptions dissolve organization; others intensify it by making direction, interval, or boundary implication more visible.

Perceptual research supports this distinction. Kanizsa showed that contours and surfaces can be perceived even where they are not fully given in the stimulus [4]. Kellman and Shipley formalized visual interpolation by identifying geometric conditions, including tangent continuity, that support perceptual completion between separated fragments [5]. Gerbino's later discussion of amodal completion emphasizes that perception actively organizes incomplete information rather than restoring a missing object [6]. Ecological analyses of natural images further show that good continuation and proximity are statistically reliable cues for grouping separated contour fragments, grounding these principles in the regularities of the visual environment [22].

These accounts do not imply that a viewer simply fills in a lost complete form. Rather, they suggest that relational cues distributed across a visual field can activate coherence under incomplete conditions. For design analysis, this is the key point: incompletion becomes analytically significant not because something is missing, but because the remaining relations continue to organize perception.

2.3. Artistic Practice as Material for Design Research

The present study treats artistic practice as a source of formal inquiry. This does not reduce artworks to design products or functional artifacts. Rather, artworks organized through geometry, repetition, path structure, and rule-based construction provide highly structured material for analyzing visible relations. Frayling's distinction between research into, for, and through art and design, and Borgdorff's account of artistic research, support the view that artistic practice can generate knowledge when its methods, materials, and criteria are made explicit [17,20].

Design research has also emphasized that visual representation operates as a mode of thinking. Goldschmidt describes sketching as a dialectical process in which visual marks generate new relations [7]; Goel shows that sketches support transformations of thought because they remain open, ambiguous, and reconfigurable [8]. Stiny's work on shape and visual calculation encourages analysis at the level of operation: repetition, subdivision, adjacency, extension, and reconfiguration [9]. Cross's articulation of designerly ways of knowing further supports the use of work-level operational descriptions as legitimate, if non-scientific, design knowledge [25]. Related formal approaches describe how rule-based transformation generates stylistic variation in pattern and ornament [26], and how plane-pattern (symmetry) analysis classifies the repetition structures of decorative fields [27].

The conceptual and minimalist art of the post-war period offers important precedents for this analytical posture. Krauss's account of the grid as a structure that is at once modular and open [11], LeWitt's use of rule-governed yet incomplete geometric series [12], Meyer's history of minimalist reduction [13], Fer's reading of the line as an infinite, non-closing trajectory [28], and Foster's discussion of the openness of contemporary practice [14] all show that incompletion has functioned as a deliberate compositional resource rather than as the absence of order. These precedents motivate the morphological move undertaken here: treating incompletion as a positive structural condition that can be described in operational terms.

From this perspective, the CONTINUUM series is not used as a private illustration of authorial intention. It is treated as a limited set of visible cases through which operations of incompletion and continuity can be described. The methodological value of the selected works lies in their capacity to make design-relevant relations visible: paths, intervals, boundaries, gaps, junctions, and fields.

3. Material and Method

3.1. Selected Cases, Selection Criteria, and Authorship

The material for this study consists of selected documented work states from the CONTINUUM series as presented in HIRAKU PROJECT VOL.12 at the Pola Museum of Art [1] (Fig. 1). The selected cases are Hilbert curve (2021), Incomplete continuum (2021) considered through both overall and detail views, and Construction Drawing 01–03 (2021). The works share a geometric basis while presenting different forms of incompletion, interruption, displacement, and open-ended organization. Three selection criteria were applied. First, the work had to exhibit a clearly identifiable geometric organization rather than a purely gestural composition. Second, it had to include controlled incompletion, such as interruption, partial omission, boundary displacement, or open-ended extension. Third, it had to support comparison across recurring formal operations. These criteria mean that the selected cases are analytically focused rather than statistically representative. They were chosen because they make the proposed operations visible, not because they represent the full field of incomplete art or design.

Authorship and division of labor warrant explicit statement. The first author is the artist who produced the works; she also conducted the close formal description. The co-authors did not participate in the artistic production but contributed to the refinement of the framework, methodological positioning, and critical review of the analysis. Their review helped consolidate the present six operations and three modes as a design-research framework rather than as a statement of authorial intention. This division of labor mitigates, although it does not eliminate, the self-interpretive bias inherent in the analysis of one's own artistic production.

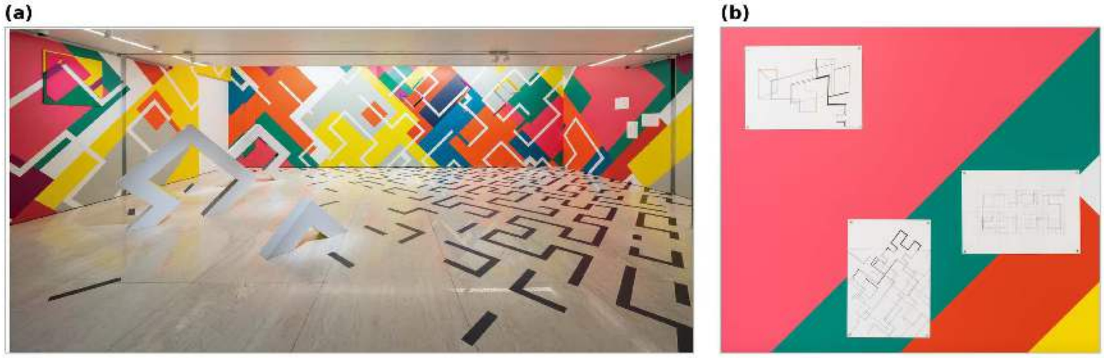

Fig. 1. Installation documentation of the CONTINUUM series at HIRAKU PROJECT VOL.12, Pola Museum of Art: (a) overall gallery view showing the spatial extension of Incomplete continuum; (b) installation view of Construction Drawing 01–03 in dialogue with the wall-based configuration. Artwork by Hiroko Nakajima. Photo: Ken Kato.

To further constrain such bias, all descriptive claims are restricted to visible and contestable features of the documented images: line or directional trace, interval, boundary, repeated unit, junction, and field relation. Authorial intention is not used as evidence unless it is supported by visible configuration. For this reason, the proposed framework should be read as a provisional, externally inspectable description of selected visual configurations, not as proof of the artist's intention or as a general theory derived from a representative sample.

3.2. Units of Analysis

The units of analysis are formal relations rather than symbolic motifs. Six units served as anchors for close description: (1) line or directional trace—any visible element that establishes movement, extension, or orientation; (2) boundary—a visible or implied edge that defines a limit, transition, or field condition; (3) interval—the spacing or gap between elements; (4) repeated unit—a segment, turn, module, or directional pattern that recurs; (5) junction or connection point—a site where elements meet, align, overlap, or imply continuation; and (6) field relation—the larger organization through which local elements participate in an overall configuration.

These units were selected because incomplete geometric configurations sustain coherence through relations among direction, spacing, boundary implication, and distributed field organization rather than through completed outline. A broken line can remain coherent when its direction continues across a gap; an open boundary can remain active when adjacent elements imply its extension; a field can remain organized when intervals are sufficiently regulated.

3.3. Derivation of the Descriptive Operations

Six descriptive operations were derived through a two-source procedure that crosses close observation of the selected works with prior theory. From each work state, we noted which of the six analytical units (Section 3.2) supported the legibility of continuity and which were withheld, displaced, or interrupted. We then examined which prior theoretical accounts—Gestalt grouping principles [2,3], amodal and contour-completion theory [4,5,6], Arnheim's visual field [18], Chen's topological perception [19], Stiny's shape analysis [9], Gombrich's morphology of decorative order [10], Meyer's history of minimalist reduction [13], and the conceptual and minimalist precedents that treat incompletion as a structural resource [11,12,28]—offered explanatory traction for the observed effect. The six operations consolidate this dual reading: each operation is named at a level abstract enough to describe a visible feature in the selected works, and each is supported by a prior theoretical account of why the feature can carry coherence. The operations are operational, not foundational: they are intended to be transferable insofar as future analysis confirms their usefulness in other cases and in design practice.

This procedure is abductive. The operations were neither deduced from a prior axiomatic framework nor inferred inductively from a representative sample; they were constructed to provide the best available joint description of the selected works and the relevant theory. This character has consequences for evaluation: the framework can be challenged by (i) incomplete geometric configurations that the six operations cannot describe, (ii) cases where two analysts produce divergent operation assignments, or (iii) perceptual experiments along the lines of H1–H3 in which the predicted modes do not produce differential coherence judgments. Such results would constrain the perceptual relevance of the proposed modes without invalidating the operations as descriptive units. We return to these conditions in Section 4.5.

This dual grounding is the primary methodological move of the paper. It does not eliminate the abductive character of the framework, but it constrains the operations to those that are jointly motivated: visible in the selected works and explicable by an existing account of why visibility produces coherence.

3.4. Analytical Procedure

The analysis proceeded in three stages. First, each documented work state was read independently as a fixed visual field. Notes were taken only on visible formal relations: directional turns, gaps, edge conditions, repeated modules, junctions, intervals, and field distribution. Second, the six descriptive operations (Table 1) were applied to each work state using the same questions: Is the operation visibly present? Does it function locally or across the field? Does it contribute centrally or secondarily to the legibility of continuity? Third, cross-case comparison identified recurrent modes of relational continuity.

Table 1. The six descriptive operations, their derivation from analytical units of the selected cases, and the prior theoretical accounts that support them

Operation	Definition	Visible features in the selected cases	Theoretical grounding	Function in continuity analysis
Repetition	Recurrence of similar forms, segments, directions, or spatial units	Repeated turns; recurring intervals; repeated directional patterns	Gestalt similarity and proximity [2,3]; Stiny's shape analysis [9]; Gombrich on regularity [10]	Sustains continuity through recurrence and anticipatable structure
Connection	Visible or implied linking across parts	Alignment; adjacency; overlap; implied extension; implied closure; directional flow	Good continuation [2]; tangent continuity and contour interpolation [5]; topological connectedness [19]	Supports continuity across breaks or separations
Spatial filling	Distribution of form across a compositional field	Distributed intervals; activated surface; repeated spatial occupation	Arnheim's visual field [18]; Krauss on the grid as open structure [11]	Extends continuity beyond a closed figure toward field organization
Interruption	Break, gap, omission, or discontinuity treated as a structural element	Gaps; broken paths; interrupted segments; discontinuous edges	Kanizsa's amodal contours [4]; Kellman and Shipley on interpolation [5]; Gerbino [6]	Reveals where continuity is challenged and how it is maintained
Boundary displacement	Shifted, open, deferred, or redistributed edge condition	Open edges; shifted limits; displaced borders; implied boundaries	Arnheim on boundary as dynamic relation [18]; Fer on the non-closing line [28]	Sustains continuity without full closure or stable enclosure
Partial omission	Selective absence within an organized structure	Missing segments; withheld elements; incomplete but legible structures	LeWitt's rule-governed incomplete geometry [12]; Meyer on minimalist reduction [13]; amodal completion [4,6]	Distinguishes structured incompletion from disorder or accidental loss, and can sustain or intensify field coherence rather than dissolving it

Three modes emerged: path-based continuity, organized by directional persistence and repeated turning; connective continuity, sustained by implied linkage across separation; and field continuity, distributed across an activated surface rather than concentrated in a closed figure. We treat these modes as provisional outputs of the analysis rather than as exhaustive types. In practical terms, the framework applies the six operations in Table 1 to each selected work state; the resulting operation profile then allows comparison across cases and yields the three modes used in Section 4.

Supplementary diagrams and analytical annotations are used where verbal description alone could not make directional flow, missing segments, implied connections, or boundary displacement sufficiently visible. In each figure, the artwork and the analytical overlay are kept distinguishable: the artwork is reproduced as photographed, and analytical annotations are added in a contrasting register clearly labeled in the caption. The legend of every figure is calibrated to the operations of Table 1: each annotation is tagged with the corresponding operation name (Repetition, Connection, Spatial filling, Interruption, Boundary displacement, or Partial omission), so that the reader can inspect the same operation–annotation mapping across the selected cases. Two clarifications govern the relation between the figures and Table 2. First, the same graphic primitive (e.g., a dotted ellipse, a dashed line, or a coloured arrow) may carry different operation labels in different figures, because heterogeneous configurations require locally appropriate marks; the textual operation label, not the graphic primitive itself, determines the operation–annotation mapping. Second, each figure foregrounds the operations that the corresponding text section identifies as central to the mode under discussion, while Table 2 reports the full operation profile for each work state; operations listed in Table 2 but not separately marked in a given figure are addressed in the body text rather than in the overlay. The annotations therefore function as visual evidence that allows the reader to verify the relation between the descriptive claim and the documented configuration. To make this mapping fully explicit in a single place, Table 3 provides a consolidated annotation key that lists, for every figure, the operation denoted by each graphic primitive; a reader who encounters the same primitive used for different operations across figures (for example, a dotted ellipse) can resolve the intended operation at a glance.

Table 2. Mapping of selected works to dominant modes of relational continuity

Selected work state	Repetition	Connection	Spatial filling	Interruption	Boundary displacement	Partial omission	Dominant mode
Hilbert curve (2021)	●	●	○	–	–	–	Path-based continuity
Incomplete continuum (2021, overall view)	●	○	–	●	●	–	Path-based continuity
Construction Drawing 01 (2021)	○	●	–	●	–	–	Connective continuity
Construction Drawing 02 (2021)	○	●	○	–	–	–	Connective continuity
Construction Drawing 03 (2021)	○	●	●	–	–	–	Field continuity
Incomplete continuum (2021, detail view)	○	●	●	–	●	●	Field continuity

Each of the six operations is rated for every work state on a three-level scale: ● primary (explicitly annotated in the corresponding figure and central to the work's dominant mode), ○ secondary (visibly present and supporting coherence but not mode-defining), and – not salient. To read the matrix, one proceeds row by row: for the Hilbert curve (2021), for instance, Repetition and Connection are marked as primary (●), Spatial filling as secondary (○), and Interruption, Boundary displacement, and Partial omission as not salient (–); this co-occurrence of primary repetition and connection with only supporting spatial filling is precisely what the framework reads as the dominant mode of path-based continuity, and the same procedure applied across rows lets the reader see how differing operation profiles give rise to the connective, field, and path-based modes listed in the final column.

Table 3. Annotation key: the operation denoted by each graphic primitive in every figure

Figure	Graphic primitive	Operation (Table 1)
Fig. 2 (Hilbert curve)	Blue arrows	Connection
Fig. 2 (Hilbert curve)	Dotted ellipses	Repetition
Fig. 3 (Incomplete continuum, overall)	Black dashed lines	Boundary displacement
Fig. 3 (Incomplete continuum, overall)	Red dotted lines	Boundary displacement
Fig. 3 (Incomplete continuum, overall)	Red double-headed arrows	Interruption
Fig. 4 (Construction Drawing 01)	Black dots (segment endpoints)	Interruption
Fig. 4 (Construction Drawing 01)	Dotted lines	Interruption
Fig. 4 (Construction Drawing 01)	Dashed arrows	Connection

Fig. 5 (Construction Drawing 02)	Dotted ellipses	Connection
Fig. 5 (Construction Drawing 02)	Double-headed arrows	Connection
Fig. 6 (Construction Drawing 03)	Blue grid	Spatial filling
Fig. 6 (Construction Drawing 03)	White nodes	Connection
Fig. 7 (Incomplete continuum, detail)	Dotted ellipses	Partial omission
Fig. 7 (Incomplete continuum, detail)	Orange line	Boundary displacement
Fig. 7 (Incomplete continuum, detail)	Blue dashed line	Connection

Because heterogeneous configurations require locally appropriate marks, the same primitive may denote different operations in different figures; the operation column gives the intended Table 1 operation in each case.

3.5. Scope and Limitations

The method has four limitations. First, the selected case set is small and specific to the CONTINUUM series. Because all cases derive from a single artist and a single series, the generality of the framework beyond these works is explicitly untested; the six operations and three modes are therefore advanced as transferable hypotheses rather than as validated categories, to be confirmed or revised against an external corpus. Second, the study is qualitative and does not include viewer-response data. Third, the study does not include a formal inter-rater reliability test or computational proxies: the co-authors served as internal critical readers, but the operation assignments were not produced by independent coders, so quantifying replicability with independent coders (e.g., Cohen's or Fleiss' κ) and developing computational proxies for the six operations remain tasks for future work; to improve replicability within the present descriptive scope, the revised Table 2 reports the full operation-by-case matrix so that the coding scheme is explicit and externally re-applicable. This design choice is deliberate rather than incidental: at the present stage the framework is intended as a hypothesis-generating, exploratory instrument whose primary purpose is to make the six operations describable, inspectable, and communicable, rather than as a confirmatory measurement protocol. We therefore prioritized specifying the analytic scheme itself—its operations, criteria, and case-by-case application—as the precondition that any subsequent independent multi-coder validation would require, and we treat such validation as the natural next step rather than as an omission. Fourth, the framework prioritizes structural readability and does not address all symbolic, historical, or institutional dimensions of the works. These limitations define the scope of the study rather than invalidating it. The framework should be read as a first-stage morphological tool—a set of jointly grounded operations and three proposed modes of relational continuity—not as a final empirical model of perception.

4. Results and Discussion

4.1. Mutual Interaction of the Six Operations

The first result concerns the mutual interaction of the six operations rather than their isolated presence. Across the selected cases, continuity is organized by combinations of operations: interruption can make connection more visible by forcing the viewer to read across a gap; boundary displacement can transform expectations of a closed figure into open field relations while maintaining structural legibility; and partial omission can clarify the rule of a configuration by exposing which relations remain active when elements are withheld. The design value of the framework lies in this interaction: it does not prescribe a style but describes how coherence can be sustained when closure is not available or not desired.

4.2. Path-Based Continuity

Path-based continuity is most clearly visible in Hilbert curve (2021) and in the overall view of Incomplete continuum (2021). In Hilbert curve (Fig. 2), continuity is organized by repeated turning and directional persistence. The repeated unit is not a tile that extends in all directions; it is part of a traversing path that carries expectation through the composition. The work therefore differs from modular repeat patterning of the kind systematically catalogued in Escher's plane divisions [17]. Its coherence depends on the viewer's ability to follow directional structure across the field. The path nevertheless distributes itself across the compositional surface through repeated traversal, so that the operation of spatial filling appears as a secondary consequence of path logic rather than as an independent decorative coverage; this is why Table 2 marks Spatial filling as a secondary operation for this work.

In the overall view of Incomplete continuum (Fig. 3), repetition operates less through identical modules than through the recurrence of directional tendencies and interval regulation. Even where the form is interrupted or incompletely bounded, the visual field remains organized because the path-like logic persists. This mode is design-relevant because it shows how continuity can be carried by directional relation rather than by enclosure.

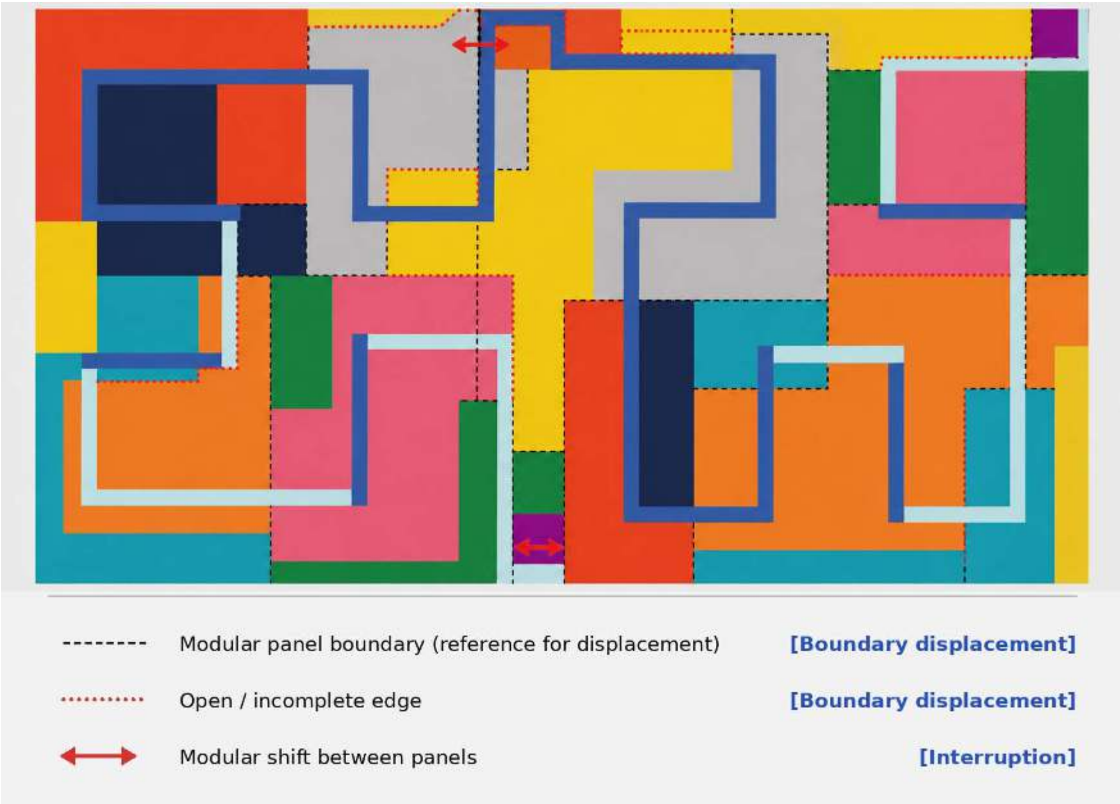

Fig. 3. Incomplete continuum (2021, overall installation view). Path-based continuity sustained under modular displacement. Black dashed lines indicate reference panel boundaries used to locate boundary displacement, and red dotted lines indicate open or incomplete edges (Boundary displacement in Table 1); red double-headed arrows mark modular shifts that introduce structured discontinuity between panels (Interruption). The legend follows Table 1 nomenclature so that the reader can verify the operation–annotation mapping. Artwork by Hiroko Nakajima; analytical overlays added by the authors.

4.3. Connective Continuity

Connective continuity appears most strongly in Construction Drawing 01 and Construction Drawing 02. In Construction Drawing 01 (Fig. 4), separated segments remain visually linked through alignment and directional implication. The break is visible, but it does not dissolve coherence; rather, it becomes the condition through which connection is perceived. This corresponds to the perceptual logic of good continuation and tangent continuity described in visual-perception research [2,5].

In Construction Drawing 02 (Fig. 5), continuity is sustained through adjacency and compositional dependency rather than through direct joining. Elements remain distinct, but their placement directs perception from one part to another. Their placement also distributes the composition across the surface, so that spatial filling operates here as a secondary support to connection. In design terms, this mode is important for layouts, diagrams, spatial sequences, and surface compositions in which separated elements must remain legibly related.

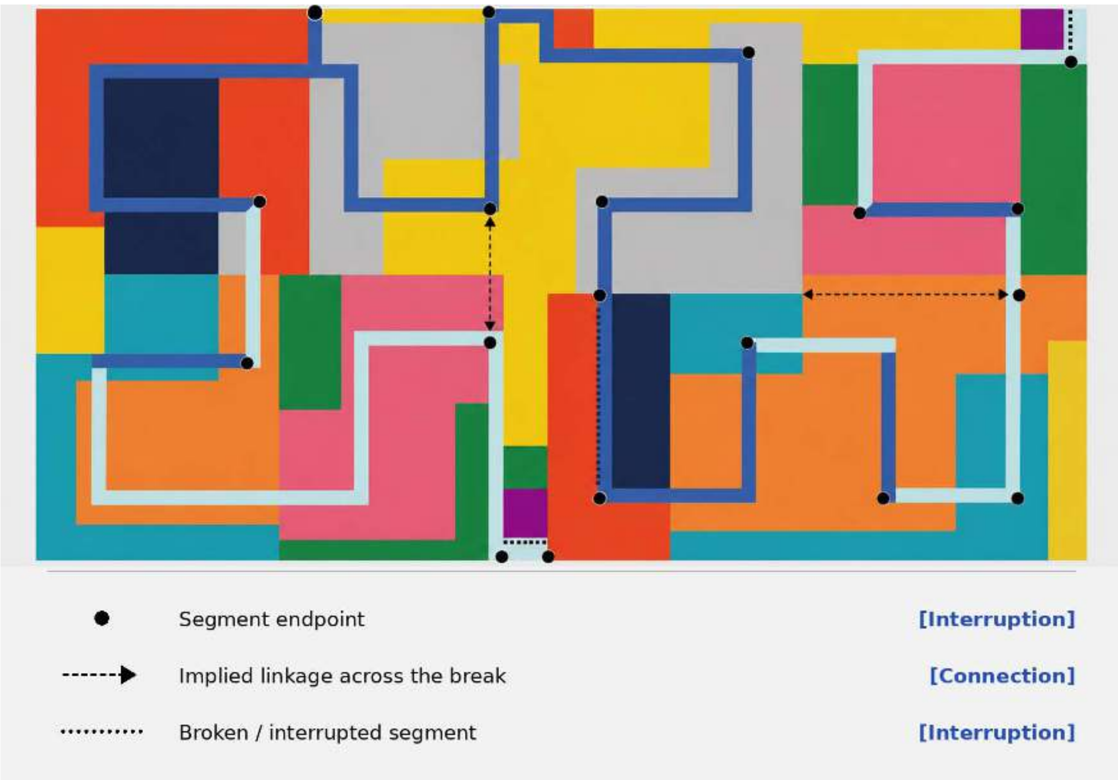

Fig. 4. Construction Drawing 01 (2021). Connective continuity across visible breaks. Black dots locate segment endpoints and dotted lines mark broken or interrupted segments (Interruption); dashed arrows mark the implied linkage identified by the analysis across the gap (Connection). The figure shows that interruption and connection co-occur as a single configurational logic. Artwork by Hiroko Nakajima; analytical overlays added by the authors.

Fig. 5. Construction Drawing 02 (2021). Connective continuity sustained without direct joining. Dotted ellipses mark adjacency relations between separated parts and double-headed

arrows mark directional alignments; both operations are identified as instances of Connection in Table 1. The figure illustrates that connection need not entail literal junction: spatial dependency is itself a connective operation. Artwork by Hiroko Nakajima; analytical overlays added by the authors.

4.4. Field Continuity

Field continuity is most clearly visible in Construction Drawing 03 (Fig. 6) and the detail view of Incomplete continuum (Fig. 7). Here, continuity is distributed across a surface through intervals, open boundaries, and repeated spatial activation. The composition does not resolve into a single closed figure. Coherence is produced instead by the regulation of relations across the field.

This mode is relevant to design situations in which a surface, layout, or spatial field must remain coherent without a central closed object. Exhibition layouts, textile surfaces, architectural panels, and screen-based interfaces often rely on this type of distributed organization. Field continuity therefore expands the concept of continuity from path-following to surface-wide relational organization.

Fig. 6. Construction Drawing 03 (2021). Field continuity organized by surface-wide distribution rather than by a closed figure. The blue grid marks the distributed field that activates the surface (Spatial filling) and the white nodes mark the junctions through which local elements participate in the configuration (Connection). The composition does not converge on a central figure; coherence is produced as a regulated field. Artwork by Hiroko Nakajima; analytical overlays added by the authors.

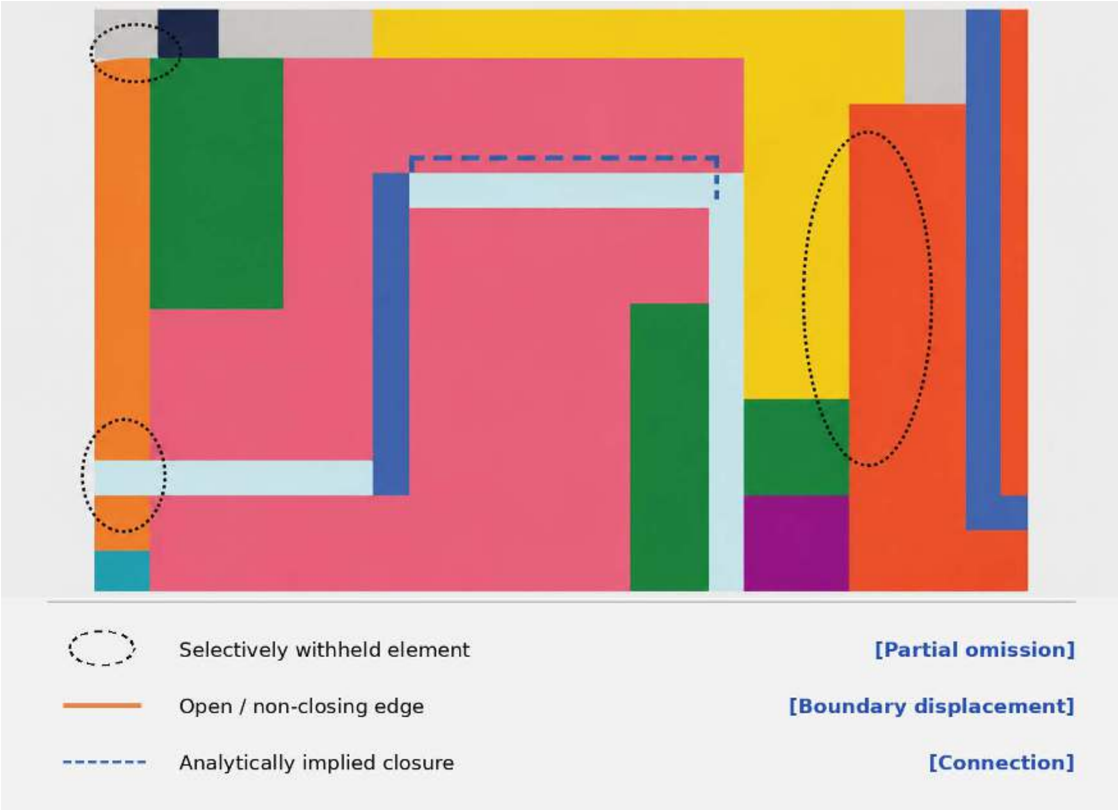

Fig. 7. Incomplete continuum (2021, detail view). Field continuity sustained through structured incompletion. Dotted ellipses mark selectively withheld elements (Partial omission); the orange line marks an open, non-closing edge (Boundary displacement); and the blue dashed line marks the analytically implied closure that organizes the open region without enclosing it (Connection). Following Table 1, implied closure is treated here as a sub-feature of Connection—an implied connecting trajectory between separated parts—rather than as a return to literal enclosure; the figure thus shows Connection operating in tension with, not in opposition to, Boundary displacement. The figure illustrates that omission and openness, rather than dissolving order, can intensify the relational structure identified by the analysis. Artwork by Hiroko Nakajima; analytical overlays added by the authors.

4.5. Cross-Case Comparison, Design Implications, and Testable Hypotheses

Across the selected cases, the works do not rely on a single operation. Repetition, connection, spatial filling, interruption, boundary displacement, and partial omission interact differently in each case. Hilbert curve and the overall view of Incomplete continuum emphasize path-based continuity; Construction Drawing 01 and Construction Drawing 02 emphasize connective continuity; Construction Drawing 03 and the detail view of Incomplete continuum emphasize field continuity (Table 2).

The framework has implications beyond the CONTINUUM series, but these implications are advanced here as testable applications, not as established findings. In visual and spatial design, continuity is frequently required under conditions of cropping, modular displacement, interruption, and partial omission. We therefore propose three hypotheses that future research may test. (H1) Path-based configurations may produce more stable coherence judgments than configurations exhibiting field continuity under brief exposure, because directional structure can be processed efficiently as a coherent path, consistent with the Gestalt principle of good continuation [2]. (H2) Connective configurations may be more sensitive to angular misalignment at junctions than path-based configurations, because their coherence depends critically on tangent-like continuation [5]. (H3) Boundary displacement may preserve coherence more robustly than partial omission when interval regulation is preserved, because the field can remain organized even as edges are displaced, an effect consistent with Arnheim's account of boundary as a dynamic relation rather than a fixed limit [18]. Future studies may operationalize these hypotheses by presenting controlled stimulus variants that manipulate one parameter at a time, such as angular alignment at implied junctions, interval regularity, degree of boundary displacement, and proportion of omitted segments. Coherence judgment can be measured using a seven-point rating scale after brief and self-paced exposure, supplemented where appropriate by forced-choice comparison tasks and response-time measures. These hypotheses are stated to be falsifiable; their refutation would constrain the perceptual scope of the framework—specifically the claim that the three modes produce differential coherence judgments—rather than invalidate the six operations as descriptive units (cf. Section 3.3). Crucially, these hypotheses function as a bridge from the present qualitative, work-level description to future quantitative perceptual research: each translates a descriptive claim about a mode into a measurable, falsifiable prediction. The present claims are descriptive (morphological) rather than claims about perceptual performance; benchmarking against human coherence ratings or computational models—including relatability/contour-interpolation models [17] and contemporary data-driven vision models—would test the perceptual-performance interpretation that this paper does not assert, and is therefore a distinct and valuable next step rather than a precondition for the present descriptive contribution. Hypotheses H1–H3 are formulated precisely to enable such triangulation, allowing the operation-based descriptions to be compared subsequently against perceptual judgments and model-based predictions.

The framework can also be used pedagogically. Students or designers may analyze a composition by asking which operation sustains continuity, then modify the configuration to test whether coherence becomes stronger or weaker. In this sense the framework is not only descriptive but generative: it offers a vocabulary for designing continuity without closure.

The framework should not be treated as a universal design recipe. Its current evidential base is a small practice-based case set, and the abductive derivation of the operations (Section 3.3) entails that further cases may motivate revision. The next stage should include comparative analysis of an external corpus spanning multiple artists and designers across several domains—textile and surface patterns, architectural façades, diagrams, and screen interfaces—to test whether the six operations remain sufficient and whether the three modes recur beyond the CONTINUUM series, together with formal inter-rater coding and perceptual testing along the lines of H1–H3.

4.6. Relevance to Kansei Informatics and Design Evaluation

The relevance of the proposed framework to kansei informatics lies not in the immediate measurement of affective responses, but in the clarification of the formal variables that may later be evaluated in relation to affective impressions. Kansei engineering has generally aimed to translate users' feelings, impressions, and affective responses into concrete design parameters [15,29]. In this sense, kansei-oriented design research requires not only appropriate evaluation words or rating scales, but also an explicit description of what formal features of a visual stimulus are being varied.

The six operations proposed in this study—repetition, connection, spatial filling, interruption, boundary displacement, and partial omission—can function as intermediate descriptors between visual configuration and kansei evaluation. For example, boundary displacement and partial omission may be manipulated as structural variables, while impression pairs such as open–closed, continuous–fragmented, stable–unstable, ordered–chaotic, rhythmic–irregular, or tense–calm may be measured through semantic differential scales. The semantic differential method, originally developed as a general technique for measuring meaning, has been widely used to quantify subjective impressions and can provide a suitable basis for future evaluation studies of incomplete visual configurations [30].

This connection is important because visual stimuli are often described through broad categories such as "abstract," "geometric," "complex," or "minimal." Such categories are useful at a general level, but they do not specify which formal operation contributes to a particular impression. By contrast, the present framework makes the formal side of evaluation more explicit. It allows future studies to ask, for instance, whether boundary displacement increases the impression of openness, whether partial omission increases perceived tension, or whether regulated repetition strengthens perceived continuity.

The present paper does not claim that the six operations already correspond to specific affective responses. Rather, it proposes that these operations provide a preparatory vocabulary for constructing stimuli, selecting evaluation scales, and interpreting the relationship between incomplete geometric form and kansei evaluation. In this respect, the framework extends the present morphological analysis toward future empirical studies in kansei informatics, visual design, and perceptual evaluation. This position also resonates with broader discussions of kansei design, which extend kansei research beyond narrowly defined product engineering toward design experience and interpretation [16].

5. Conclusions

This paper proposed a design-oriented framework for analyzing relational continuity in incomplete geometric configurations. It identified six visible operations, jointly grounded in selected works from the CONTINUUM series and in prior theory of perception and shape analysis: repetition, connection, spatial filling, interruption, boundary displacement, and partial omission. Cross-case comparison then organized these operations into three modes: path-based, connective, and field continuity.

Within the analyzed cases, the principal finding is that incomplete geometric configurations can remain coherent without complete closure, homogeneous repetition, or intact outline. When directional persistence, interval regulation, implied linkage, and active boundary relations continue to organize the visual field, incompletion does not weaken order. Under specific conditions—when one or more of the six operations actively organizes the configuration—it can make relational structure more legible.

The contribution is threefold. First, the paper reframes continuity as relational organization rather than as the preservation of a complete form. Second, it offers a descriptive vocabulary in which each operation is linked both to a visible feature of the selected works and to a prior theoretical account, making the framework open to critique and revision. Third, it formulates falsifiable hypotheses (H1–H3) that connect work-level description to perceptual research and applied design. These hypotheses are not offered merely as suggestions for future work but are a constitutive part of the framework's claim to be a descriptive instrument: by rendering each mode as a measurable, falsifiable prediction, H1–H3 are the cornerstone that makes the framework testable rather than interpretive, and the bridge along which the qualitative description is carried into quantitative perceptual and kansei evaluation.

This paper does not empirically demonstrate perceptual responses; it presents a descriptive framework that can be operationalized in future perceptual evaluation experiments and applied design studies. Its relevance extends beyond the analysis of contemporary artworks: the operations and modes proposed here can be treated as analytic primitives or as independent variables in visual design, kansei informatics, and future perceptual evaluation research. By clarifying the formal variables involved in incomplete geometric configurations, the proposed framework may also support future kansei evaluation studies that examine how specific operations of incompletion relate to affective impressions such as openness, continuity, rhythm, tension, and stability. The framework is limited by its small case set and qualitative method; its further development depends on external cases, inter-rater coding, perceptual experiments, and applications in pattern, exhibition, and surface design. These next steps will clarify whether the proposed operations function only as analytical descriptors or can be developed into practical variables for design evaluation.

Acknowledgement

The authors thank the Pola Museum of Art for the opportunity to present HIRAKU PROJECT VOL.12.

Funding

The exhibition and production context of HIRAKU PROJECT VOL.12 was supported by the Pola Museum of Art. The preparation of the present manuscript received no specific external funding.

Data Availability

No new empirical dataset was generated for this study. The visual documentation analyzed in the paper is included in the article; additional documentation may be available from the corresponding author upon reasonable request, subject to image-rights restrictions.

Conflict of Interest

The first author is the artist of the works analyzed in this paper. This authorship position is disclosed in Section 3.1, and the analysis is restricted to visible formal features of the documented works and reviewed by the co-authors. The authors declare no other conflicts of interest.

References

[1] Pola Museum of Art. HIRAKU PROJECT VOL.12 CONTINUUM | Kono sekai wo kosei suru mono. [Internet]. 2021 [cited 2026 Apr 22]. Available from: https://www.polamuseum.or.jp/sp/hiraku-project-12/

[2] Wertheimer M. Laws of organization in perceptual forms. In: Ellis WD, editor. A Source Book of Gestalt Psychology. London: Routledge & Kegan Paul; 1938. p. 71–88. (Originally published in 1923).

[3] Wagemans J, Elder JH, Kubovy M, Palmer SE, Peterson MA, Singh M, von der Heydt R. A century of Gestalt psychology in visual perception: I. Perceptual grouping and figure-ground organization. Psychological Bulletin. 2012;138(6):1172–1217.

[4] Kanizsa G. Organization in Vision: Essays on Gestalt Perception. New York: Praeger; 1979.

[5] Kellman PJ, Shipley TF. A theory of visual interpolation in object perception. Cognitive Psychology. 1991;23(2):141–221.

[6] Gerbino W. Amodal completion revisited. i-Perception. 2020;11(3):1–26.

[7] Goldschmidt G. The dialectics of sketching. Creativity Research Journal. 1991;4(2):123–143.

[8] Goel V. Sketches of Thought. Cambridge, MA: MIT Press; 1995.

[9] Stiny G. Shape: Talking about Seeing and Doing. Cambridge, MA: MIT Press; 2006.

[10] Gombrich EH. The Sense of Order: A Study in the Psychology of Decorative Art. Oxford: Phaidon; 1979.

[11] Krauss R. Grids. October. 1979;9:50–64.

[12] LeWitt S. Paragraphs on conceptual art. Artforum. 1967;5(10):79–83.

[13] Meyer J. Minimalism: Art and Polemics in the Sixties. New Haven: Yale University Press; 2001.

[14] Foster H. Bad New Days: Art, Criticism, Emergency. London: Verso; 2015.

[15] Nagamachi M. Kansei engineering as a powerful consumer-oriented technology for product development. Applied Ergonomics. 2002;33(3):289–294.

[16] Lévy P. Beyond kansei engineering: The emancipation of kansei design. International Journal of Design. 2013;7(2):83–94.

[17] Schattschneider D. M.C. Escher: Visions of Symmetry. New York: Harry N. Abrams; 2004.

[18] Arnheim R. Art and Visual Perception: A Psychology of the Creative Eye. New version. Berkeley: University of California Press; 1974.

[19] Chen L. The topological approach to perceptual organization. Visual Cognition. 2005;12(4):553–637.

[20] Palmer SE. Vision Science: Photons to Phenomenology. Cambridge, MA: MIT Press; 1999.

[21] Wagemans J, Feldman J, Gepshtein S, Kimchi R, Pomerantz JR, van der Helm PA, van Leeuwen C. A century of Gestalt psychology in visual perception: II. Conceptual and theoretical foundations. Psychological Bulletin. 2012;138(6):1218–1252.

[22] Elder JH, Goldberg RM. Ecological statistics of Gestalt laws for the perceptual organization of contours. Journal of Vision. 2002;2(4):324–353.

[23] Borgdorff H. The Conflict of the Faculties: Perspectives on Artistic Research and Academia. Leiden: Leiden University Press; 2012.

[24] Frayling C. Research in art and design. Royal College of Art Research Papers. 1993/1994;1(1):1–5.

[25] Cross N. Designerly Ways of Knowing. London: Springer; 2006.

[26] Knight TW. Transformations in Design: A Formal Approach to Stylistic Change and Innovation in the Visual Arts. Cambridge: Cambridge University Press; 1994.

[27] Washburn DK, Crowe DW. Symmetries of Culture: Theory and Practice of Plane Pattern Analysis. Seattle: University of Washington Press; 1988.

[28] Fer B. The Infinite Line: Re-making Art after Modernism. New Haven: Yale University Press; 2004.

[29] Schütte STW, Eklund J, Axelsson JRC, Nagamachi M. Concepts, methods and tools in Kansei Engineering. Theoretical Issues in Ergonomics Science. 2004;5(3):214–231.
[30] Osgood CE, Suci GJ, Tannenbaum PH. The Measurement of Meaning. Urbana: University of Illinois Press; 1957.