Open Problems

Version: 1.1
Date: 2026-06-06
Status: Living document — problems are added but never closed without researcher approval.

> This document provides a formal registry of unresolved questions in the Structure Recognition Research Program. Problems are distinguished from hypotheses: a hypothesis proposes a candidate answer; an open problem names a question that has no settled answer yet.

How to Use This Document

- Add a problem when a question is identified that resists quick resolution
- Never mark a problem as "solved" in isolation — flag it as "candidate resolution proposed" and wait for researcher evaluation
- Problems are numbered for cross-reference but the numbers are not priority orderings

---

Open Problem Registry

OP-01: The Attention Selection Problem

Statement: Not all patterns receive investigative attention. A prior selection process exists. But the criteria governing this selection are unknown.

Origin: H3 (Attention Filter Hypothesis)

What we observe: The checkerboard K-map pattern attracted attention and investigation. Many other patterns (same visual complexity) did not.

What we don't know:

- Is attention selection based on visual salience?
- Is it based on some implicit estimate of explanatory payoff?
- Does familiarity (geometric forms, symmetry) influence which patterns are selected?
- Is the selection partly unconscious and partly deliberate?

Candidate research approach: Comparative case study: patterns that received investigation vs. patterns that did not. Identify what they share and what differs.

Status: Open. No systematic evidence yet.

OP-02: The Significance Boundary Problem

Statement: Some recognized structures pass a significance filter and become research questions. Others do not, even when equally recognized. The boundary conditions for this filter are unknown.

Origin: H4 (Significance Filter Hypothesis)

Candidate criteria (unvalidated):

- Compression: does the structure compress large information into a short rule?
- Prediction: does the structure enable prediction of unobserved cases?
- Generalizability: does the structure appear applicable across multiple domains?
- Explanation pull: does the structure feel like it **demands** a causal explanation?

What we don't know:

- Are these criteria necessary? Sufficient? Neither?
- Does the significance filter operate differently across domains?
- Can the filter be trained or improved?

Status: Open. Candidate criteria proposed but not validated.

OP-03: The Explanation Anticipation Mechanism

Statement: Before finding a structural explanation, humans appear to anticipate that one exists. The mechanism underlying this anticipation is unknown.

Origin: H5 (Explanation Anticipation Hypothesis)

What we observe: In Paper 1, the checkerboard was labeled "non-random" before the XOR connection was made. In Paper 2, the recurring forms were considered "explicable" before Hamming Weight was identified.

What we don't know:

- Is the anticipation a genuine predictive sense or a post-hoc rationalization?
- What triggers it? Pattern regularity? Geometric simplicity? Frequency of occurrence?
- Is it tied to prior experience with similar structures (analogical reasoning)?
- Does this mechanism differ across individuals?

Status: Open. Observational evidence only; no mechanistic explanation.

OP-04: The Representation Design Problem

Statement: H2 claims that representation transformation can reveal structure. But which transformations are **good** transformations? The design principles for structure-revealing representations are unknown.

Origin: H2 (Representation Transformation Hypothesis)

What we observe:

- K-map (Gray code arrangement) makes checkerboard patterns visible
- Standard binary ordering does not make the same patterns visible
- The K-map was not designed to reveal checkerboard patterns — it was designed for grouping

What we don't know:

- Is there a principled method for finding structure-revealing representations?
- Is the match between representation and structure discoverable in advance?
- Or is the good representation found only after the structure is known?

Status: Open. The K-map case suggests representations can be discovered serendipitously.

OP-05: The Invariance Significance Problem

Statement: In Paper 3, invariance under variable rearrangement was deemed research-worthy while the changes themselves were treated as secondary. Why is invariance more significant than change?

Origin: H4, H6

What we observe: The observation "some structural properties survive all 24 variable arrangements" generated research questions. The observation "patterns change under rearrangement" did not, although it holds only for functions that are not totally symmetric (the 4-variable XOR/XNOR checkerboard and the Exactly-k ring/corner/point patterns do not change at all).

What we don't know:

- Is invariance intrinsically more significant than change? Or is this context-dependent?
- Does the presence of change (the 24 arrangements give different pictures for most functions, but one picture for totally symmetric functions) make the invariant properties **more** salient (contrast effect)?
- Is invariance a general criterion for significance, or specific to structural research?

Status: Open. Cross-paper pattern (see HANDOVER.md, "How Papers 1–3 Connect to SRT" — condensed; original CaseStudyConnections.md v1.0 deleted 2026-06-21, git 7c8ef5f^) suggests invariance as a candidate significance criterion.

OP-06: The AI Structure Discovery Problem

Statement: H1 claims humans have a comparative advantage in structure discovery. But it is unclear whether AI **cannot** discover structures or simply **has not yet**.

Origin: H1, H7

What we observe: In the research program, structure discovery (noticing patterns, generating questions) was done by the human researcher. AI contributed connections, frameworks, organization.

What we don't know:

- Is the human advantage due to inherent constraints of AI systems?
- Or is it an artifact of how AI systems are currently prompted and used?
- Does AI have an "analogue of intuition" that could support structure discovery?
- Would a differently designed AI system discover structures differently?

Status: Open. H7 reformulates the question but does not answer it.

OP-07: The Concept-as-Lens Problem

Statement: New concepts appear to enable the discovery of structures not previously visible. The mechanism by which a concept "opens" new perception is unknown.

Origin: ConceptEvolution.md (Concept-as-Lens Hypothesis; original deleted 2026-06-21, git 87c8f59^ — continued as H8–H10 in Hypotheses.md)

What we observe: After the concept of "structural invariance" was available, researchers could ask questions that were not formulable before the concept existed.

What we don't know:

- Does the concept create new categories of perception, or merely new vocabulary?
- Are all concepts equally generative, or do some function better as lenses?
- Can concept-as-lens be operationalized for deliberate discovery?

Status: Open. See H8–H10 in Hypotheses.md and Levels 6–8 in CoreQuestions.md for further analysis (original ConceptEvolution.md deleted 2026-06-21, git 87c8f59^).

OP-08: The Research Question Origin Problem

Statement: Research questions arise from interactions between observations, concepts, and significance evaluations. The precise mechanism is not understood.

Origin: H6, CoreQuestions.md Q4

What we observe: Research questions in this program emerged from:

- Noticing an unusual pattern (Papers 1–3)
- Finding that standard concepts did not explain it
- Anticipating that an explanation exists

What we don't know:

- Is this sequence generalizable to other research programs?
- What role does prior knowledge play vs. surprise?
- Is research question generation a skill that can be improved?

Status: Open. This problem is central to the program's meta-theoretical goal.

OP-09: The Definition 3.3 Necessity Conditions Problem

Statement: Definition 3.3 (Explanatory Significance, SRT v0.3) is formulated with four conditions as jointly necessary and sufficient. But whether this conjunction of four conditions actually captures explanatory significance — or whether a weaker or alternative set could substitute — is an open question with direct implications for the theory's empirical testability.

Origin: SRT v0.3, Section 11 (Q8); H4 (Significance Filter); H6 (Explanatory Significance)

What we observe: In the three case studies (Papers 1–3), all four conditions appear to have been satisfied in each instance that generated sustained research:

- **Condition 1** (Non-randomness perception): patterns were experienced as non-random before structural analysis.
- **Condition 2** (Explanation-implication): an underlying rule was anticipated before it was found.
- **Condition 3** (Productive research expectation): researchers expected investigation to be fruitful.
- **Condition 4** (Research-threshold crossing): sustained investigation was initiated.

What we don't know:

- Are all four conditions **individually necessary**? Could a structure have explanatory significance while failing to satisfy one condition?
- Is Condition 4 (research-threshold crossing) a logical consequence of Conditions 1–3 together, or an independent requirement?
- Do the conditions apply conjunctively, disjunctively, or in weighted combination?
- Is the definition **too strong** — does it exclude genuinely research-worthy structures by requiring all four conditions simultaneously?
- Is the definition **too weak** — can all four conditions be satisfied by a structure that does not, in practice, generate productive research?
- Could there be a deeper necessary condition that the four-condition formulation is tracking only approximately?

Relation to OP-02: OP-02 (Significance Boundary Problem) addresses the **empirical** boundary of the significance filter — what determines whether a structure passes the filter in practice. OP-09 is more specific and formal: it addresses the **logical structure of Definition 3.3 itself** — whether the definition correctly captures necessary and sufficient conditions for explanatory significance, independently of how the filter is applied.

Candidate research approach: Identify or construct cases in which exactly one of the four conditions is absent. Ask whether explanatory significance (and sustained investigation) still occurred. If a structure generates research while failing Condition 3 (productive research expectation is low), for example, this would constitute evidence that Condition 3 is not individually necessary.

Status: Open. Raised in SRT v0.3, Section 11. No empirical test yet designed.

Problems Marked as "Candidate Resolution Proposed"

None yet.

Problems That Were Closed (With Reason)

None yet. No problem should be marked closed without researcher approval.

Notes on Problem Addition

When adding a new problem:

```
### OP-[next number]: [Short Name]

**Statement:** [Clear, precise statement of what is unknown]

**Origin:** [Which hypothesis, observation, or document raised this]

**What we observe:** [Empirical grounding]

**What we don't know:** [Specific unknowns, as a list]

**Candidate research approach:** [Optional — how one might investigate this]

**Status:** Open / Candidate resolution proposed / [other]
```

Created: 2026-06-06
Cross-reference: Hypotheses.md, CoreQuestions.md, HANDOVER.md
Scope: Structure Recognition Research Program — Problems are program-level, not paper-level