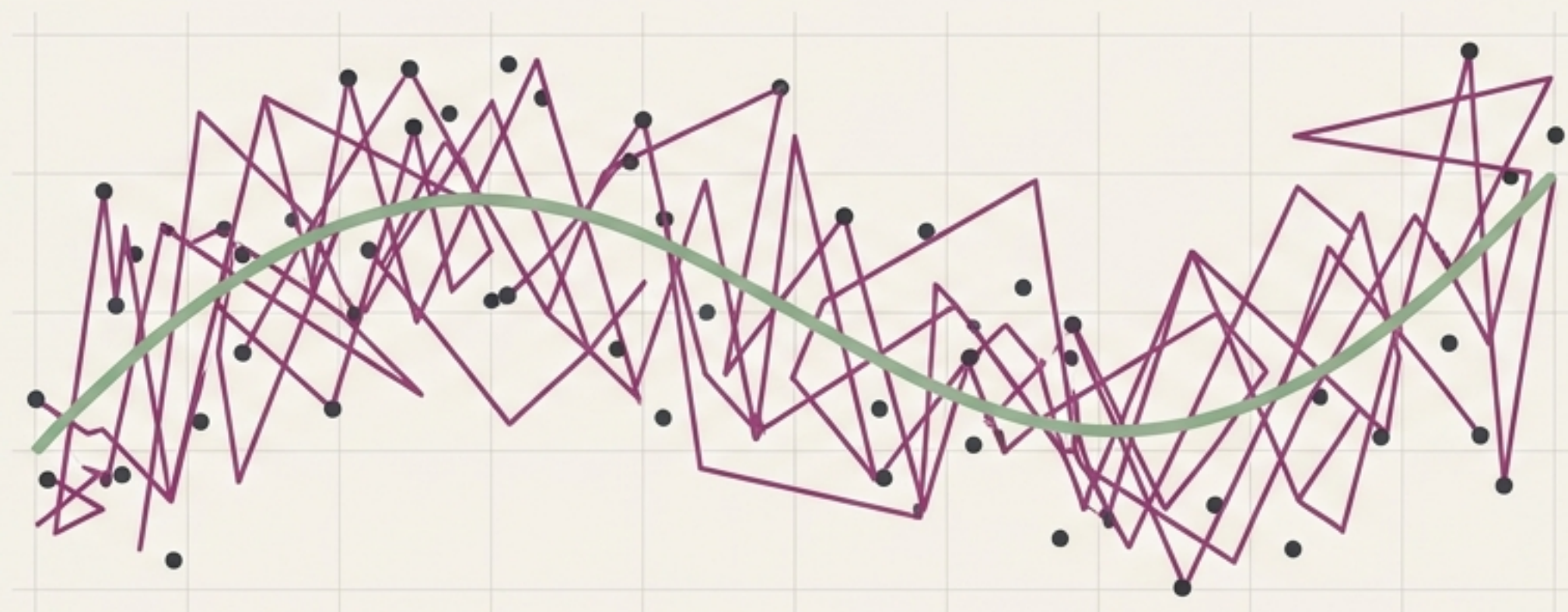


# The Resolution Lens: Learning Beyond the Simplicity Principle



How modern computer science reveals that human cognition might generalize best by memorizing everything

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A synthesis of the Excess Capacity Learning framework by Dubova & Sloman

# The Simplicity Consensus

Learning requires compression. We discard noisy details to find generalizable patterns.

“Psychological organization will always be as “good” [regular, simple] as prevailing conditions allow.” (Koffka, 1935)

“Preservation of invariances... and variances... are mutually incompatible tasks best handled by separate systems.” (Sherry & Schacter, 1987)

“Good decisions in a partly uncertain world require ignoring part of the available information.” (Gigerenzer, 2008)

# The **Excess Capacity** Reality

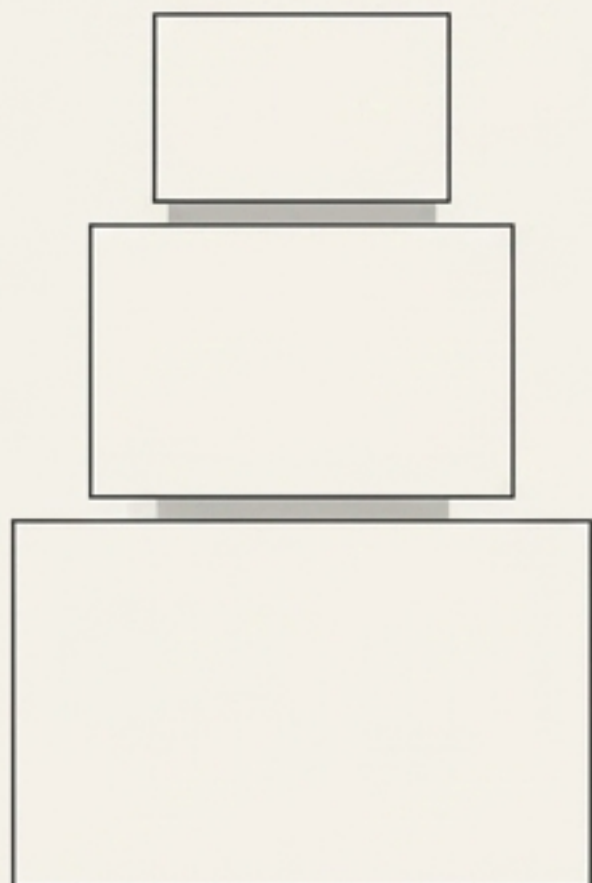
Learning thrives on expansion. Systems can generalize perfectly by over-allocating resources to memorize all details.

- Robust decisions can be attained using all situational information.

- Extracting structure and memorizing arbitrary traces are not at odds.

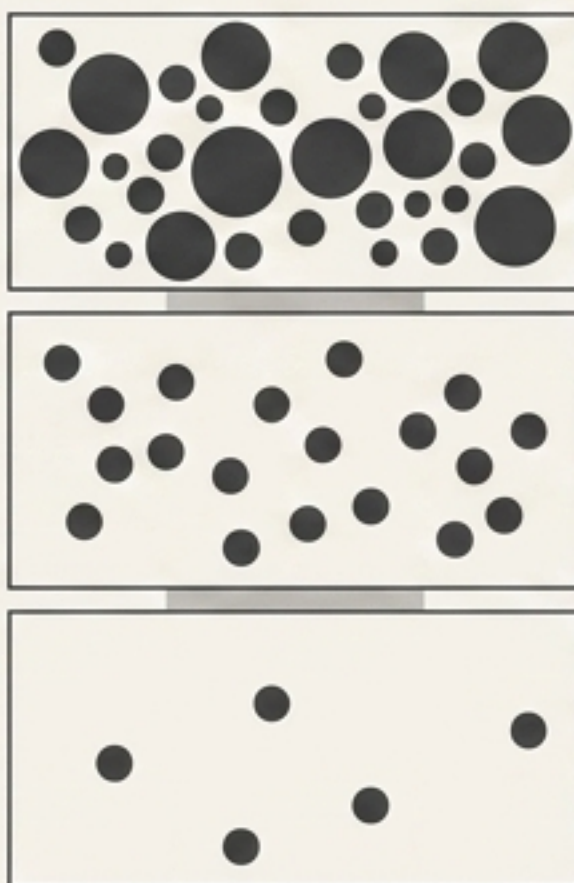
- A single system can handle both generalizable patterns and unique details.

## Expressivity (The Artist's Toolkit)



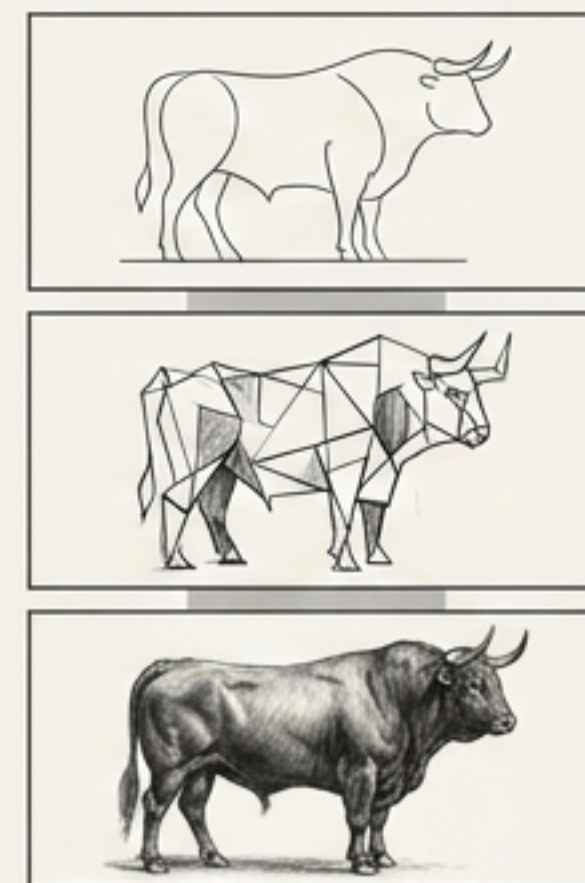
The absolute amount of representational resources a cognitive system entertains.

## Experiences (The Subject)



The underlying events, contexts, and outcomes the system attempts to learn.

## Capacity (The Output)



The dynamic ratio of resources available after accounting for past events.

**Capacity = Expressivity relative to Experiences.**

Capacity is dynamic. A system with fixed expressivity can shift from Excess to Constrained simply by accumulating more experiences.

# Capacity Regimes: Constrained, Sufficient, and Excess

Constrained Capacity  
(Degree 1)



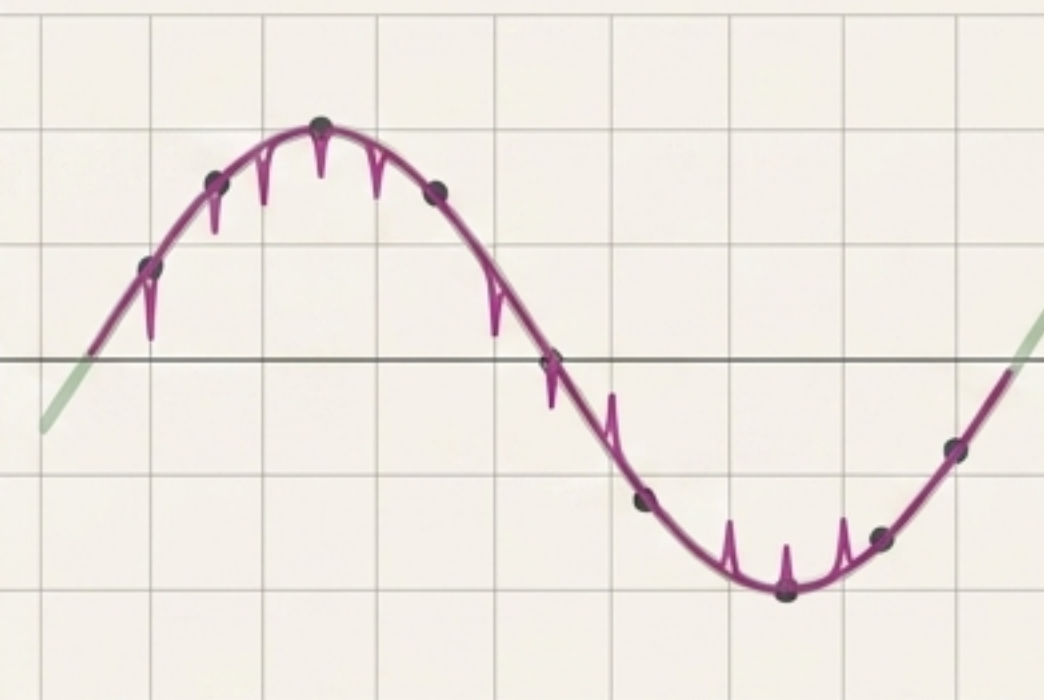
Cannot express enough patterns to account for data. Compresses experience. Memorization is impossible.

Sufficient Capacity  
(Degree 20)



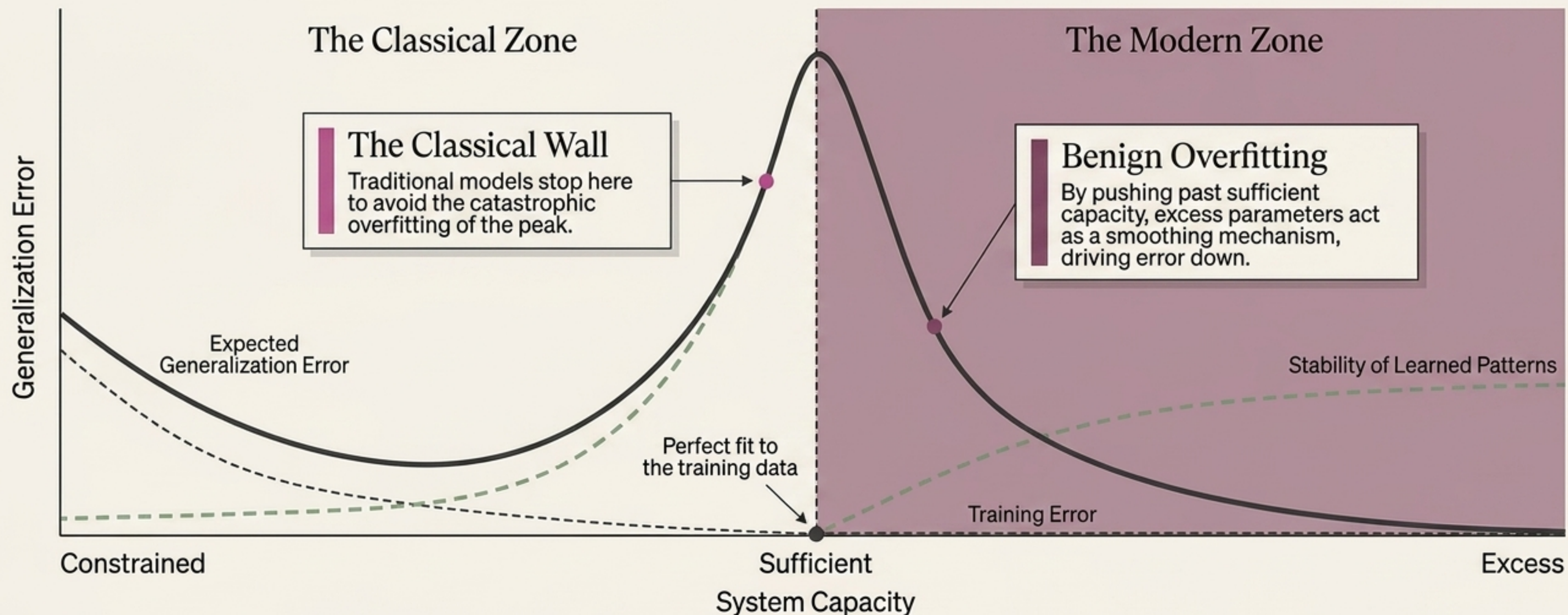
Exactly expressive enough to memorize. High variance. Predictions in novel situations are catastrophic.

Excess Capacity  
(Degree 1000)



More than enough resources. Memorizes everything perfectly AND interpolates smoothly between them.

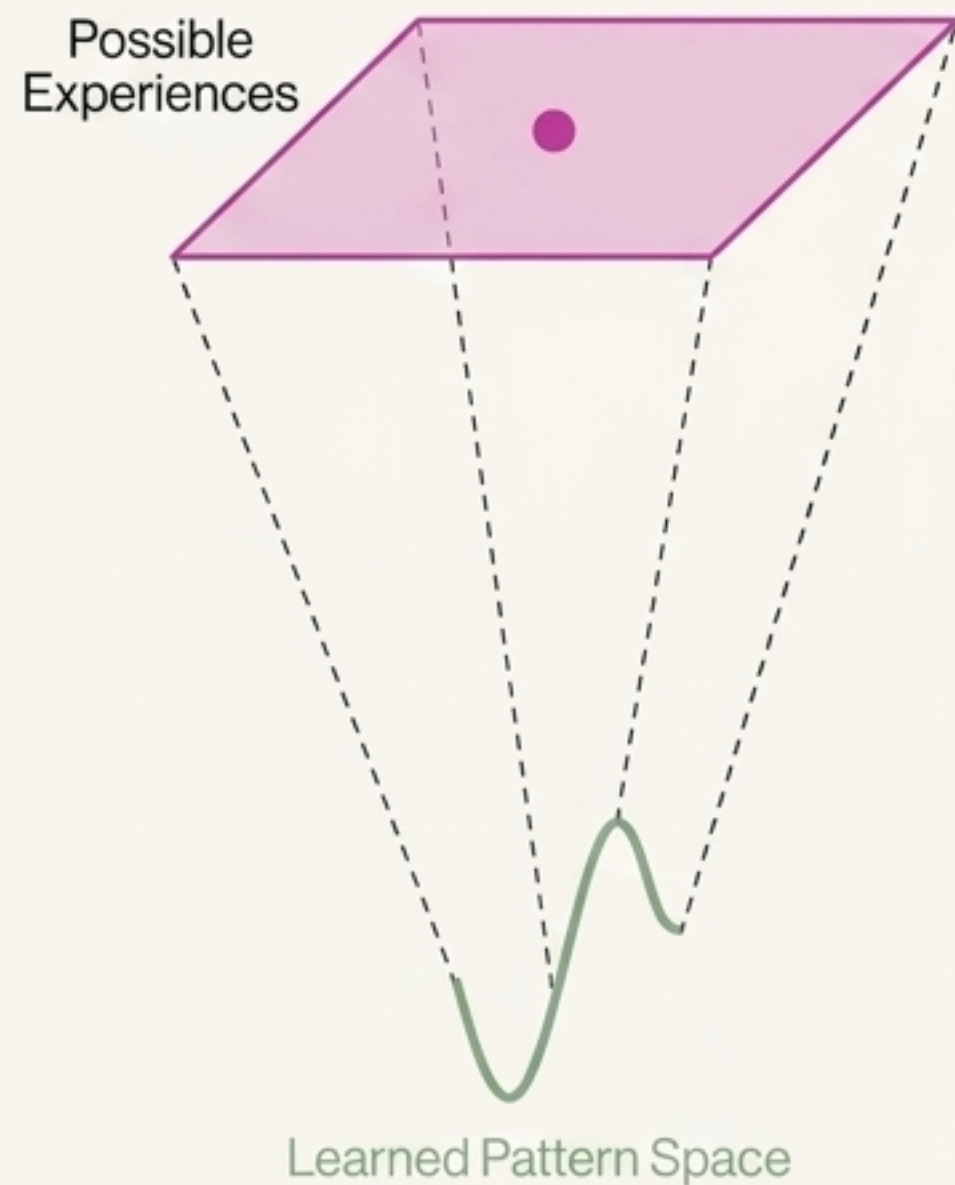
# The Double Descent Phenomenon



## Insight

Insight: The best generalizing model is not always the simplest one. Sometimes, adding massive excess capacity stabilizes the system.

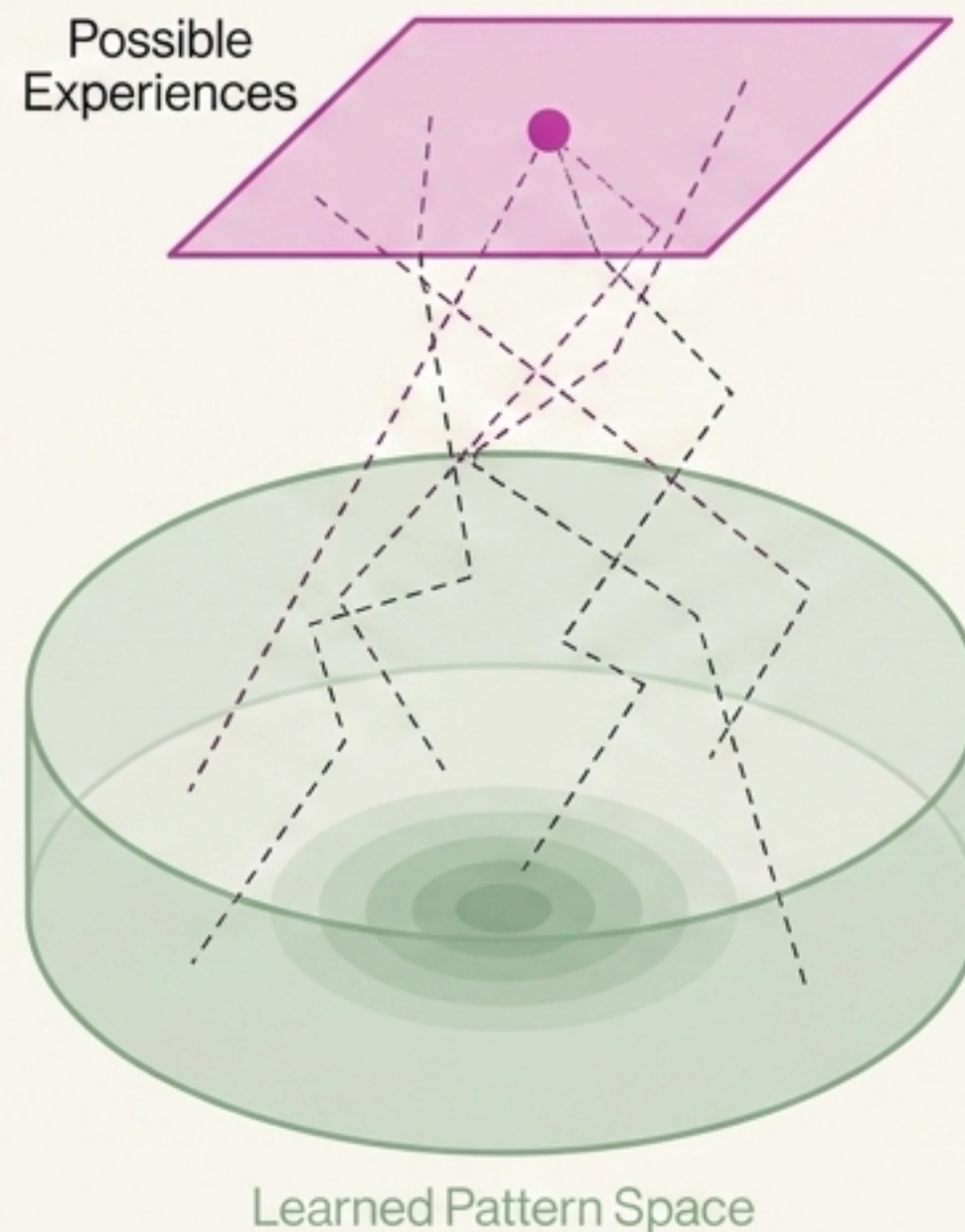
# Constrained Capacity



## Restriction Biases

The system generalizes by being incapable of imagining complex solutions. It is restricted by its architecture to simple lines.

# Excess Capacity



## Soft Inductive Biases

The system can imagine infinite complex solutions that perfectly fit the data. It generalizes via an emergent preference (favoring the flattest solution) without discarding data.

# The Resolution Lens

## Diagnostic Scorecard: Identifying Excess Capacity

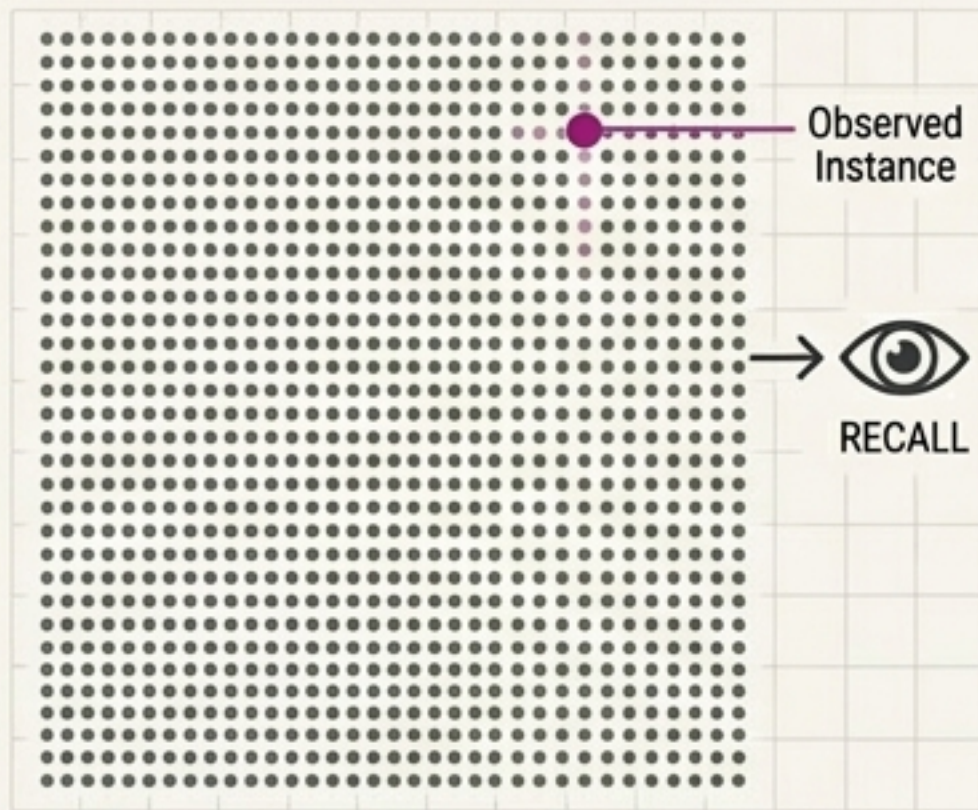
		C	S	E
Representational Signatures		Constrained	Sufficient	Excess
A	Retains individual experiences perfectly.		✓	✓
B	Constructs unnecessarily complex, detailed representations.		✓	✓
C	Learned patterns act as smooth summaries.	✓		✓
Temporal Signatures				
D	Acquiring more experiences can actually hurt generalization.			✓
Contextual Signatures				
E	High sensitivity to noisy environments.		✓	✓

**Takeaway:** No single property proves Excess Capacity. It is the **co-occurrence of high-fidelity memorization, complex representations, AND smooth generalization** that acts as the fingerprint.

# The Resolution Lens

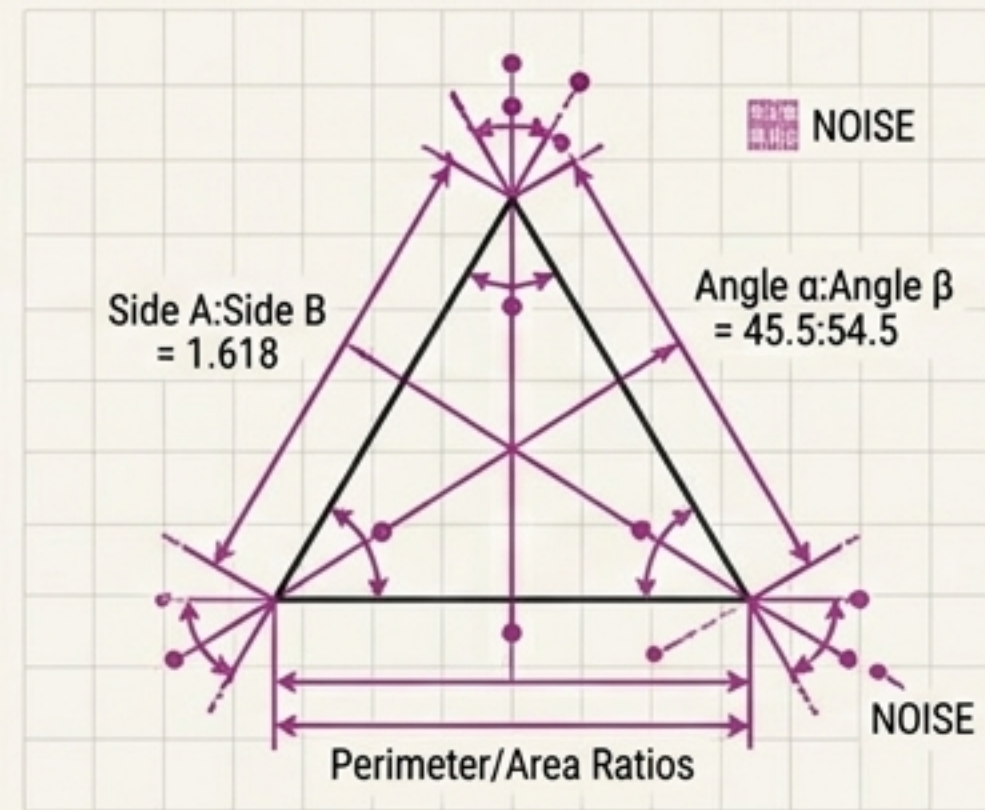
## Signature 1: Massive Memorization

**Brady et al. (2008)** - Humans shown 2,500 objects correctly identify the exact observed instance with 80%+ accuracy.



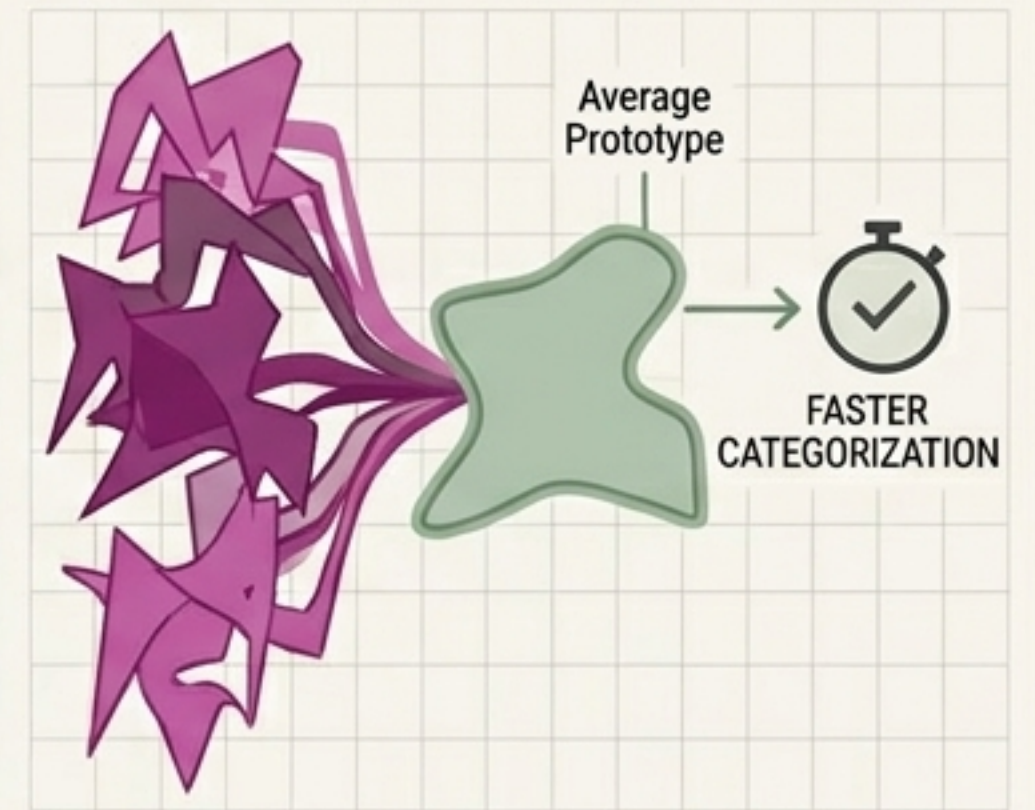
## Signature 2: Irrelevant Complexity

**Lupyan (2013)** - When identifying a triangle, humans track unnecessary details like side-length ratios, indicating they do not compress out the noise.



## Signature 3: Prototypical Summaries

**Posner & Keele (1968)** - Despite storing all this complex noise, humans categorize an unseen 'average' prototype faster than any specific instance they actually studied.



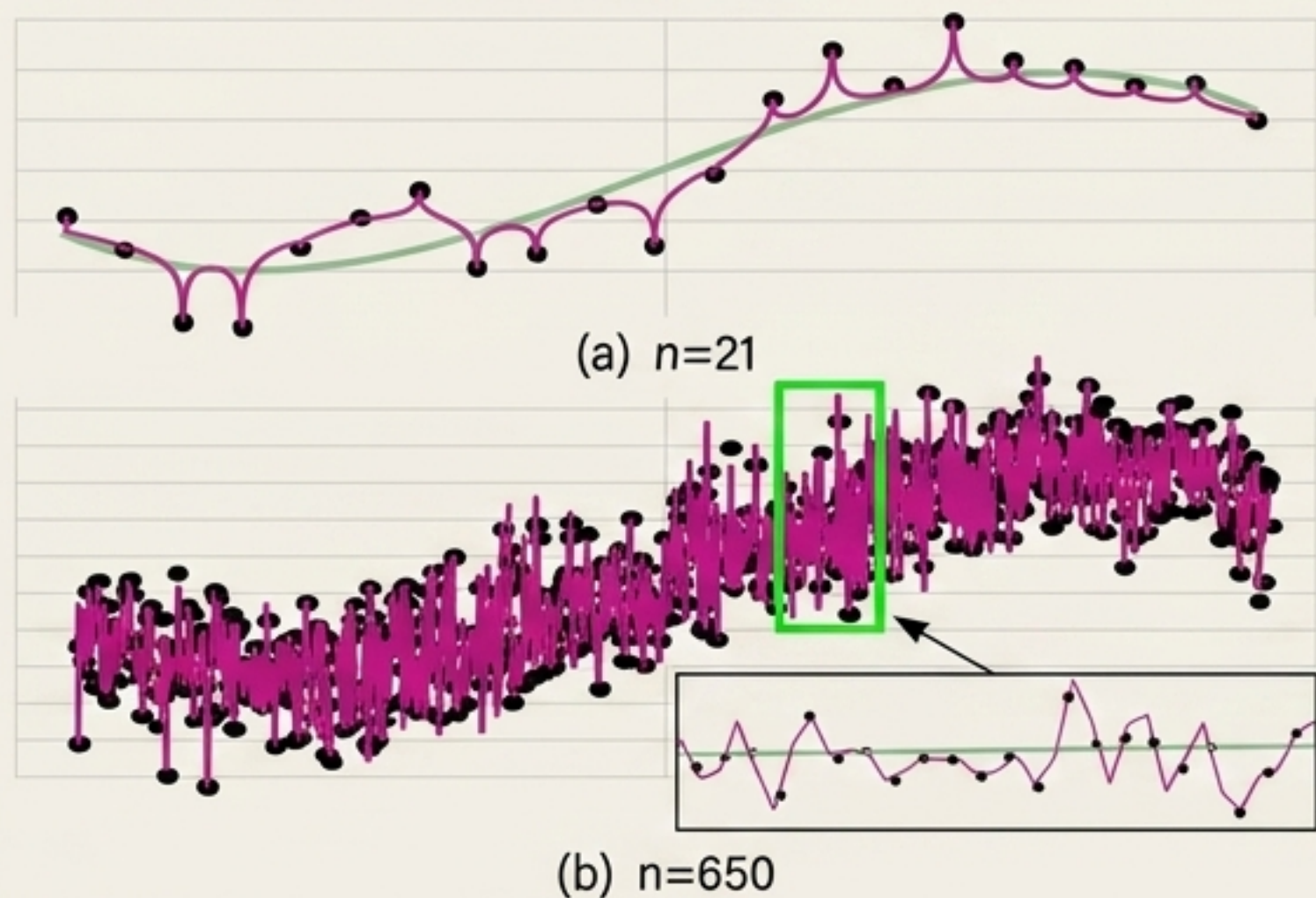
The human brain mimics an **overparameterized neural network**: it stores everything, models unnecessary complexity, but **interpolates smoothly**.

# The Resolution Lens

## *The Experience Paradox*

**Concept Text:** As a system acquires more experiences, its excess capacity shrinks, reducing resources needed to smooth out predictions.

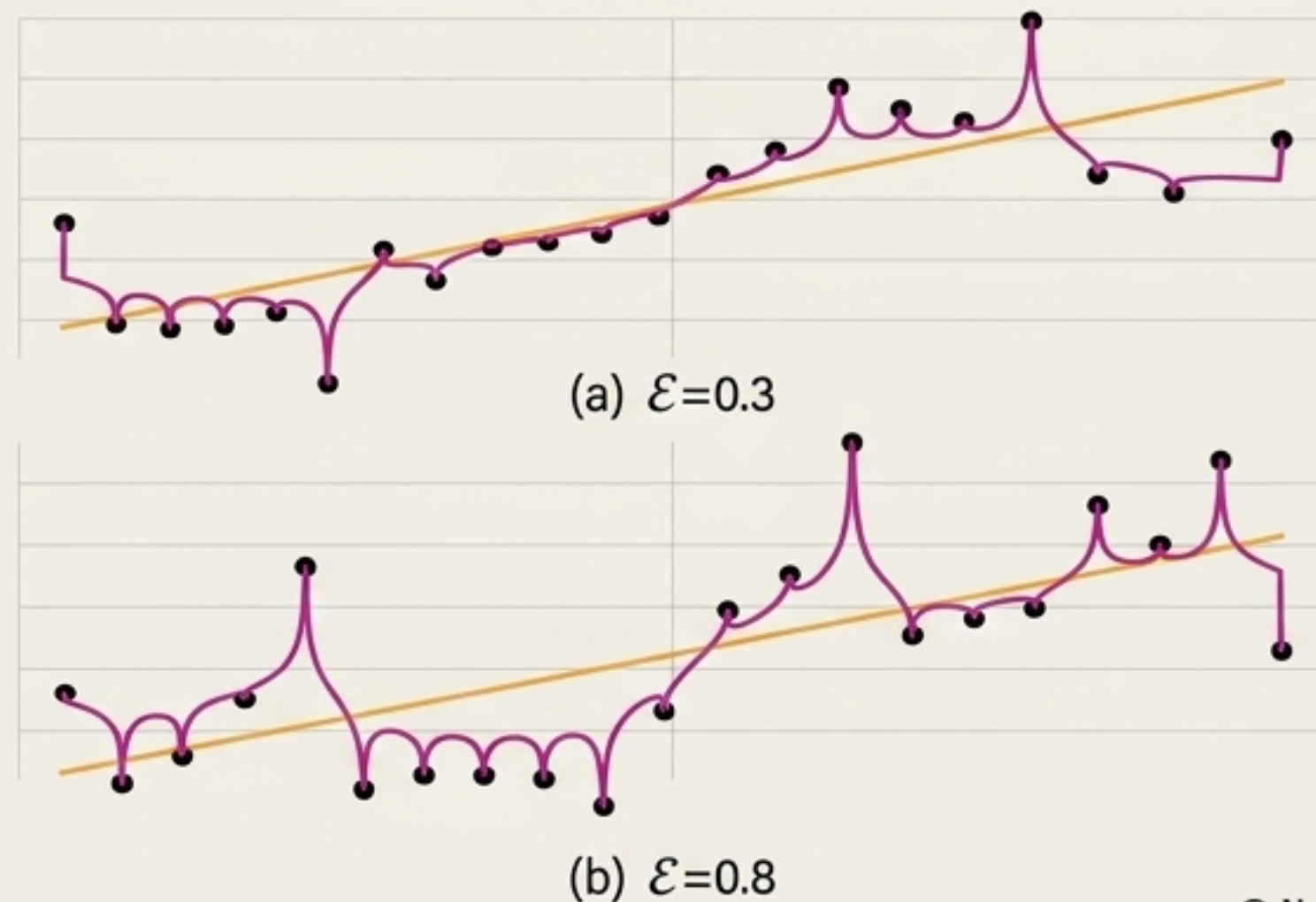
**Human Evidence Text:** Extensive training in visual texture discrimination can decrease human performance. As humans see more examples, they become worse at distinguishing old from new (false recognition of lures).



## *The Noise Sensitivity Trap*

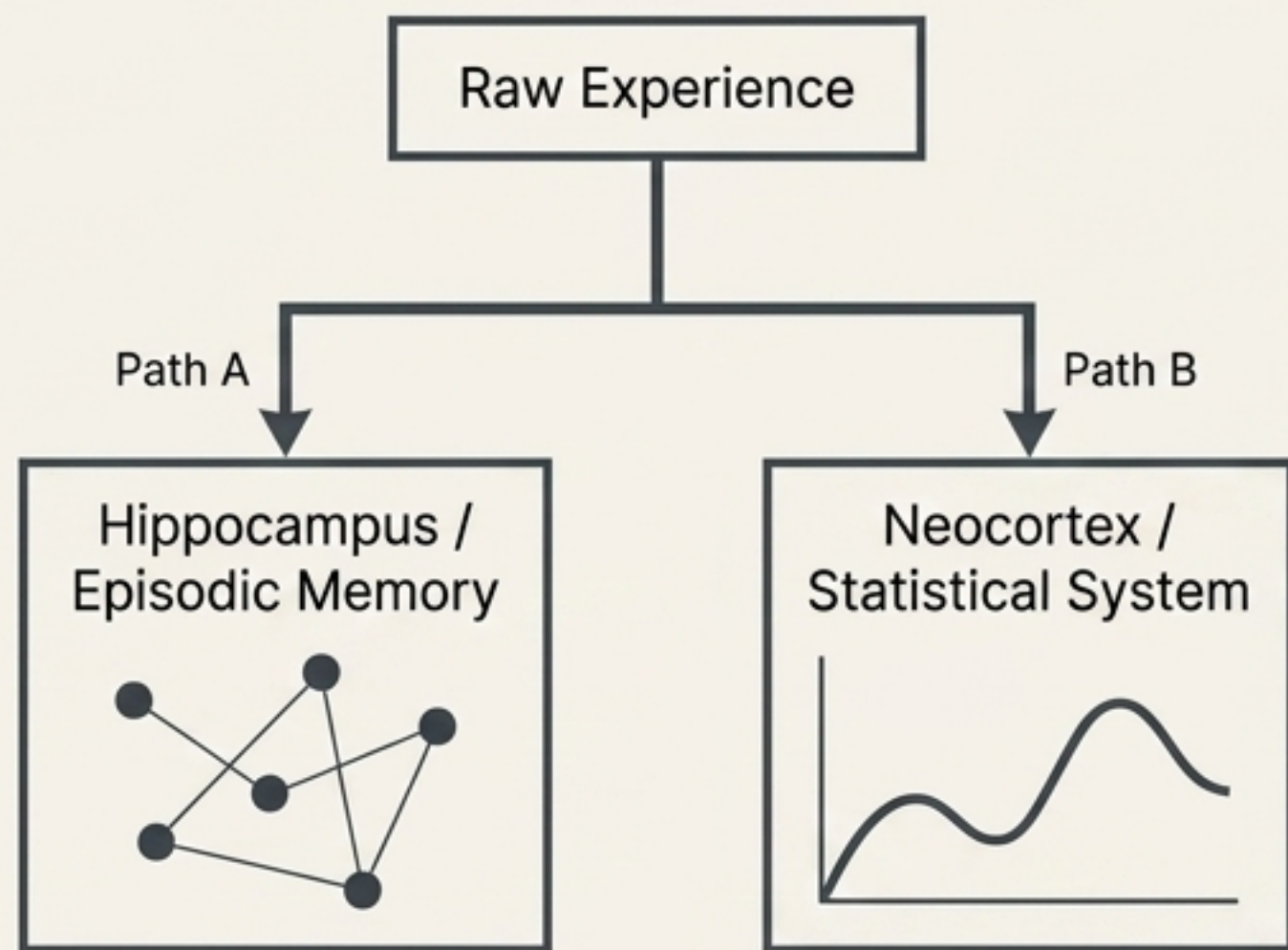
**Concept Text:** Excess capacity models incorporate all deviations, making them highly sensitive to environmental noise.

**Human Evidence Text:** In prototype-distortion categorization tasks, increasing the amount of noise directly hinders generalization, mirroring high-degree polynomial models in noisy spaces.



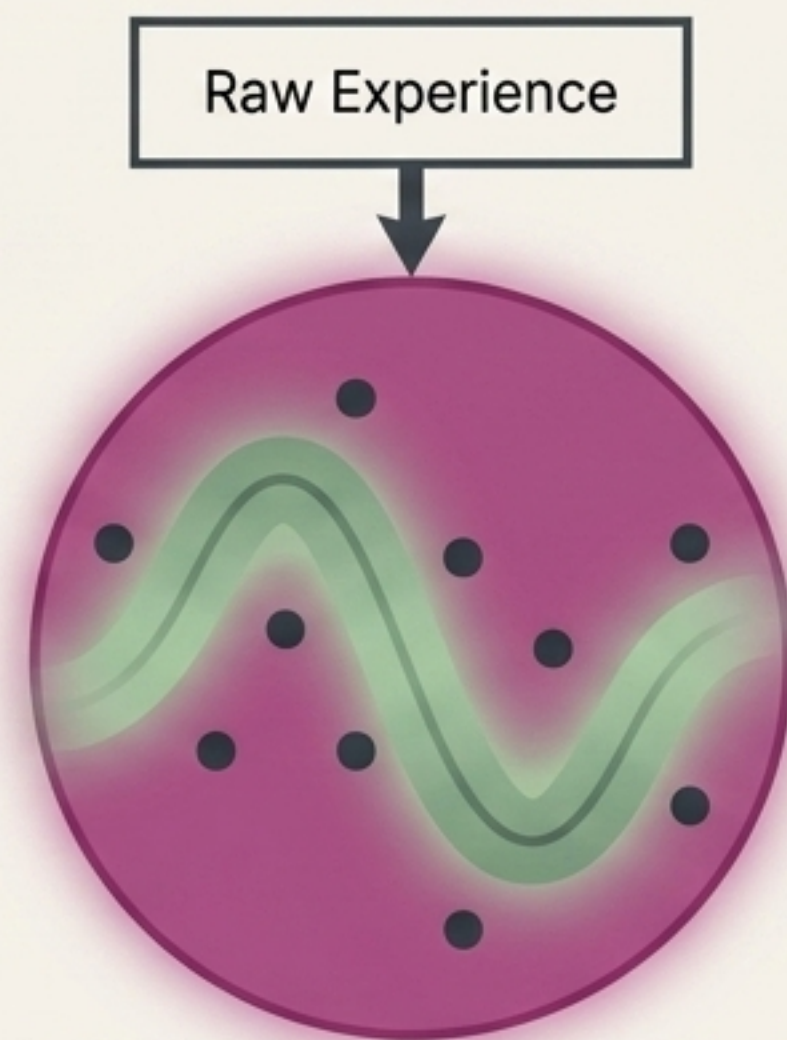
# The Resolution Lens: Architectural Comparisons

## The Old Model: Dual-System Architecture



The classical Complementary Learning Systems (CLS) theory. Assumes one system cannot computationally do both without catastrophic forgetting.

## The Unified Model: Excess Capacity Architecture



A single Excess Capacity network can rapidly acquire novel episodes AND extract statistical structure. Overparameterization buffers against catastrophic forgetting natively. One system does the work of two.

# The Resolution Lens: Mapping Human Phenomena to Capacity Regimes



## Amnesia (Constrained Capacity)

### Phenomenon:

Patients cannot recognize individual stimuli (failed episodic) but can identify the underlying category rule (intact generalization).

### Explanation:

The brain is trapped in a constrained regime—compressing to the rule, losing the detail.



## Parkinson's Disease (Sufficient Capacity)

### Phenomenon:

Patients can memorize individual training stimuli perfectly, but perform terribly at generalizing to new items.

### Explanation:

The system possesses just enough capacity to memorize, putting them precisely at the catastrophic peak of the bias-variance U-curve.



## Child U-Shaped Development (Transitioning Regimes)

### Phenomenon:

Children learn a grammar rule, suddenly over-apply it (forgetting exceptions), then recover.

### Explanation:

A temporary loss of Excess Capacity. The child encounters vocabulary faster than their representational resources grow, pushing them into a Constrained state, before expressivity catches back up.

# Redefining Ockham's Razor for the Mind.

For a century, cognitive science assumed that Simplicity meant throwing away data. We assumed the brain was an editor, red-lining the noise of reality to find the truth.

Excess Capacity Learning reveals a different kind of parsimony. The mind does not discard reality; it expands to absorb it completely.

By deploying massive, overlapping, and redundant neural resources, the brain finds the simplest path through infinite complexity.

The mind doesn't throw away data to be simple.  
It expands its capacity to find a deeper harmony.

