NEURAL INFORMATION PROCESSING SYSTEMS

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To Learn or Not to Learn, That is the Question

A Feature-Task Dual Learning Model of Perceptual Learning

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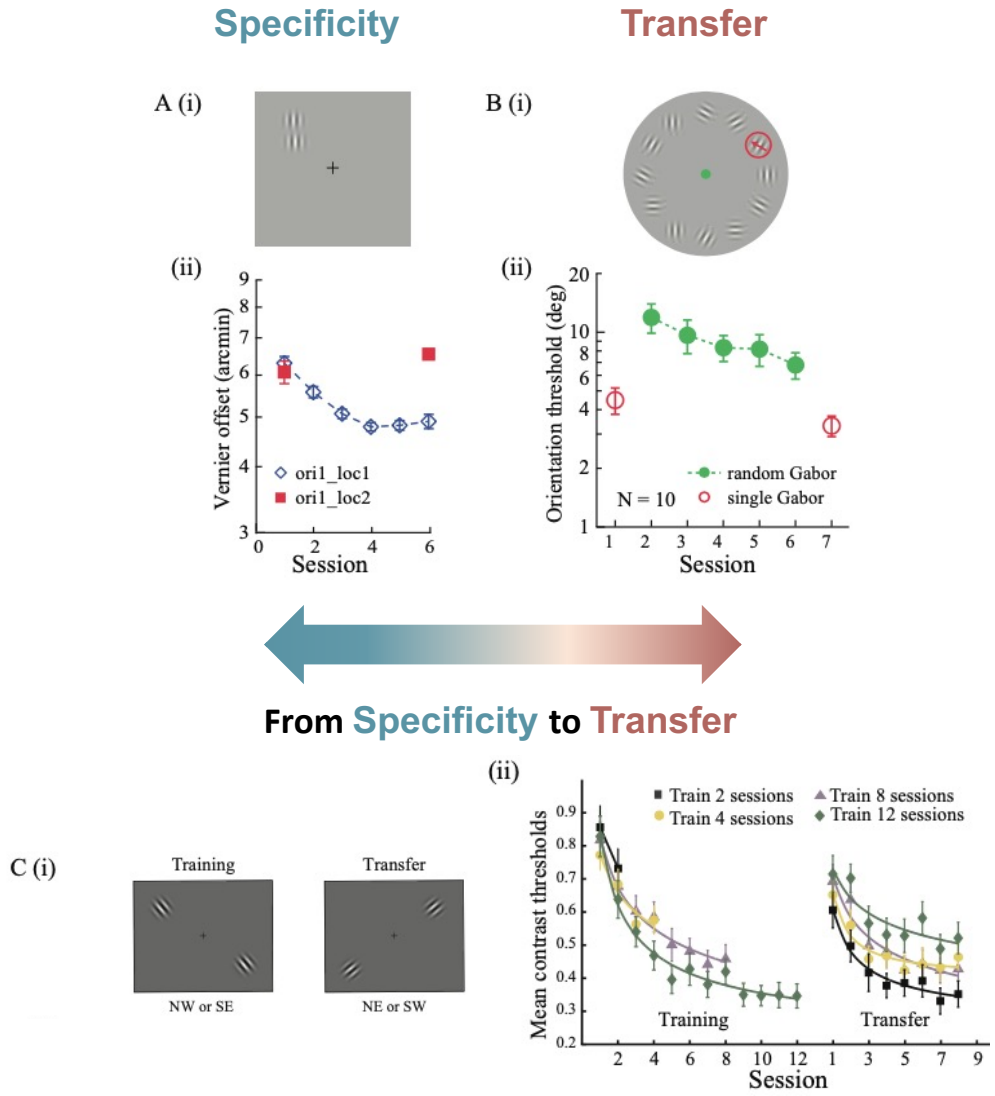
Perceptual Learning and the Framework

Perceptual Learning
- Improving sensory interpretation through learning.

Challenges

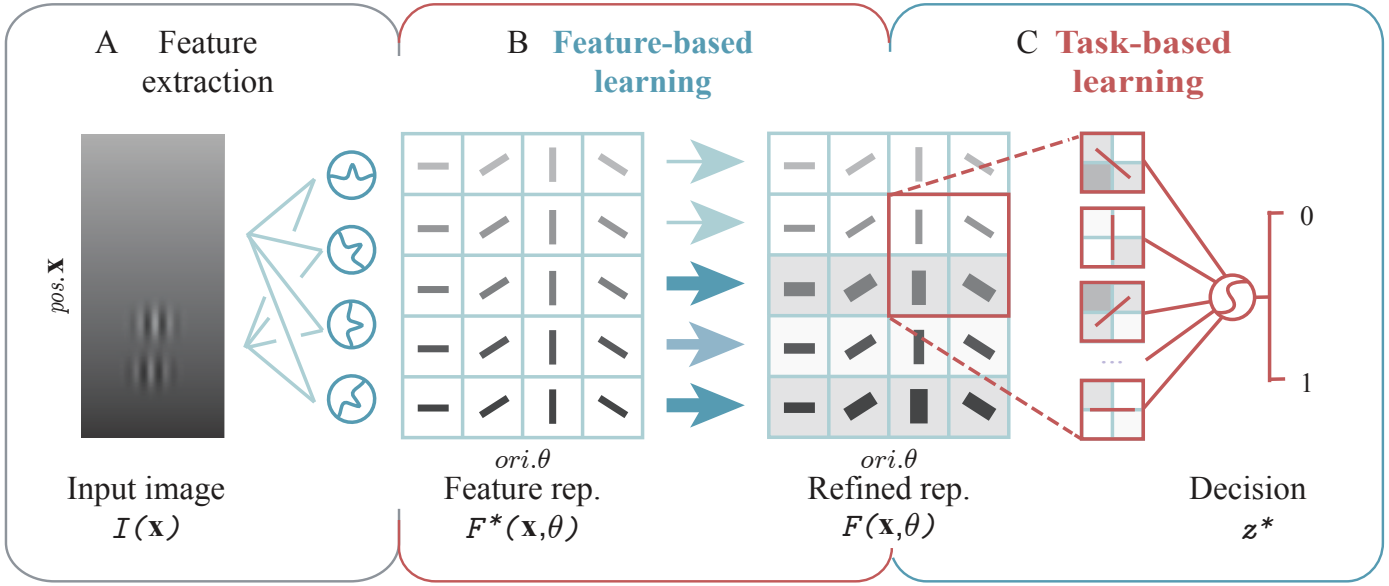
Specificity vs. Transfer
- **Specificity**: Limited to trained stimuli.
- **Transfer**: Generalizes to new stimuli.

Objective:
- Reconcile specificity and transfer through a dual-learning framework.
- **Task-based Learning**: Fast, supports transfer.
- **Feature-based Learning**: Slow, enhances specificity.



The Feature-Task Dual-Learning Framework

The dual-learning model reconciles specificity and transfer in perceptual learning through three stages:



Feature Extraction:

- Transforms input images into basic feature representations.

Feature-based Learning:

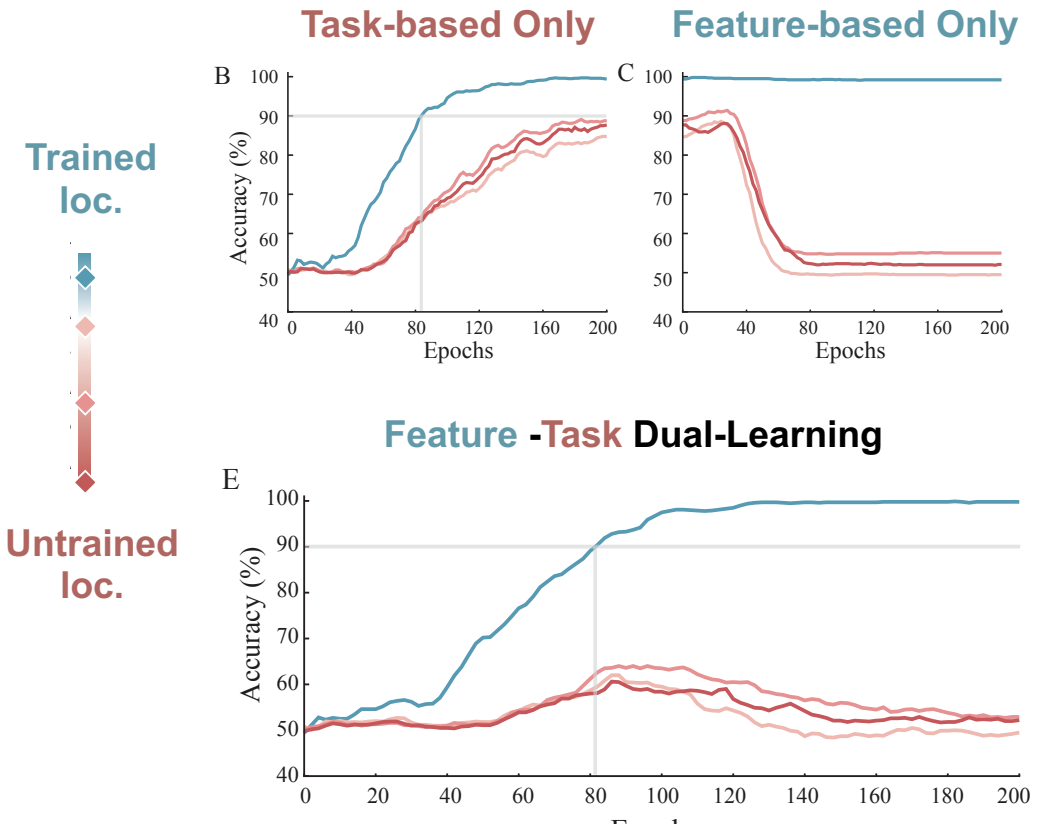
- **Specificity** → Refines features to capture statistical changes.
- **Slower** → Improves precision with repeated exposure.

Task-based Learning:

- **Transfer** → Generalizes well across different stimuli.
- **Faster** → Adapts quickly to new tasks by using existing features.

Interplay Between Feature and Task Learning

Specificity vs. Transfer



Task-based Learning Only:
Increases accuracy at both trained and untrained locations, supporting transfer via max pooling.

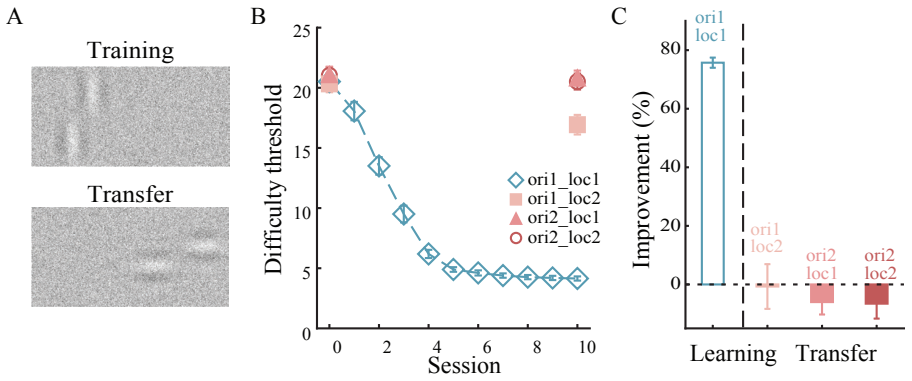
Feature-based Learning Only:
High accuracy at trained location; accuracy drops at untrained locations, supporting specificity via refined representations.

Feature -Task Dual Learning:
Initially supports transfer because of fast Task-based learning.
Specificity strengthens over time due to slow Feature-based learning.

Dual-learning framework balances adaptability and precision—**Fast Task-based learning** enables transfer, while **Slow Feature-based learning** reinforces specificity.

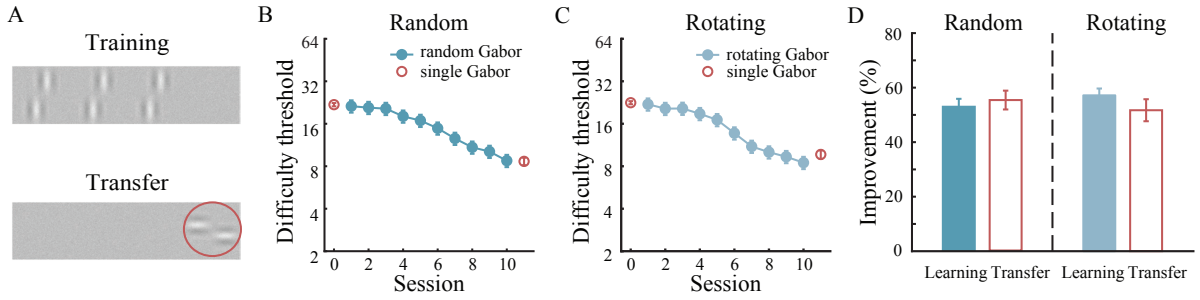
Reproducing Classical Findings

Experiment 1: Specificity



- **Setup**: Training focused on a single location and orientation.
- **Result**: High accuracy at the trained location, low accuracy at untrained locations, indicating that learning is location-specific.

Experiment 2: Transfer

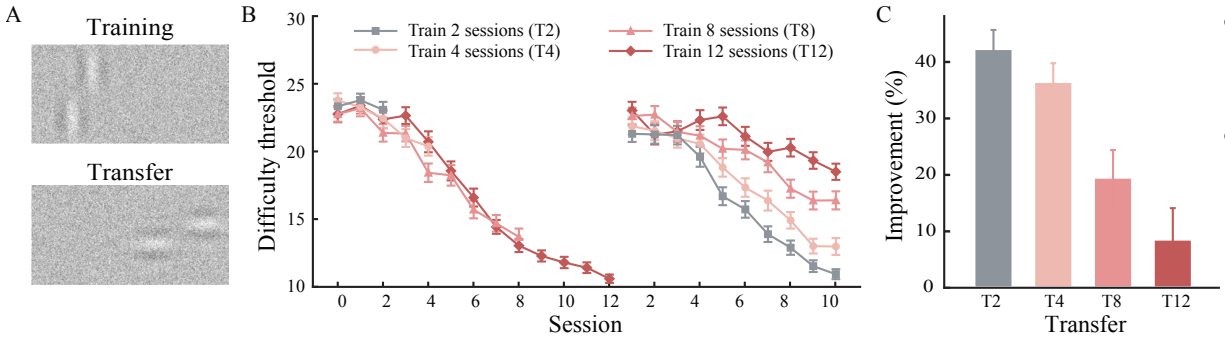


- **Setup**: Training included varied orientations and locations.
- **Result**: Improved performance at both trained and untrained locations, showing that varied training enables generalization to new areas.

The model successfully reproduces **classical perceptual learning effects**, demonstrating both **specificity** and **transfer**.

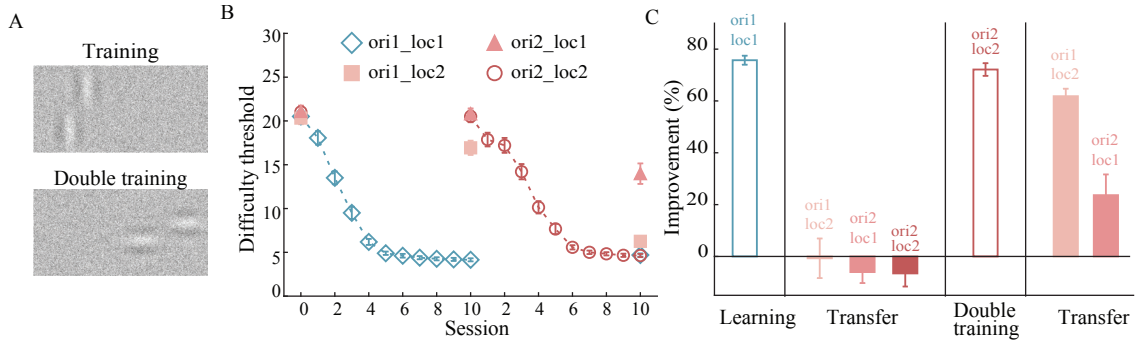
Reproducing Advanced Findings

Experiment 3: Transition from **Transfer** to **Specificity**



- **Setup:** Varied number of training sessions then training a new orientation and location.
- **Result:** More training shifts performance from transfer to specificity, aligning with classical perceptual learning patterns.

Experiment 4: **Double Training** Paradigm



- **Setup:** Introduced a second training with a different orientation and location.
- **Result:** Double training reduces specificity, enhancing transfer by adjusting feature representations.

The model replicates complex interactions between **specificity** and **transfer**, consistent with advanced experimental paradigms.

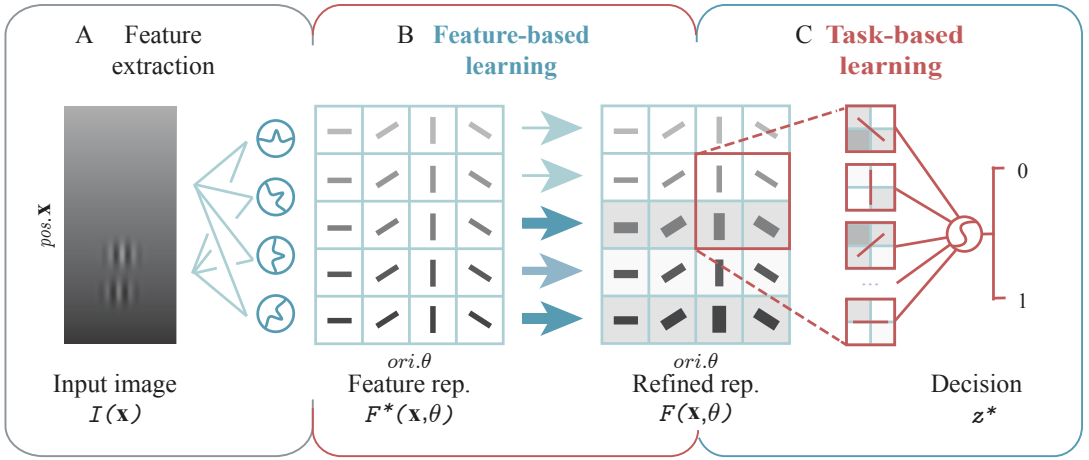
To Learn or Not to Learn, That is the Question

Core Challenge:

- **Balancing task performance with the cost of learning**
  – a fundamental issue for all learning agents, including the brain.

Dual Learning Strategies:

- **Feature-based Learning:**
  Slow, resource-intensive, refines representations to capture meaningful environmental changes.
- **Task-based Learning:**
  Fast, efficient, and reuses existing representations for low-cost adaptation.



Model Insights:

Quick Task-based & Slow Feature-based Strategy

- **Default State:** Task-based learning favors transfer by optimizing existing representations.
- **Specificity through Repetition:** Repeated stimuli encourage specificity via feature-based learning.

Thank You!

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