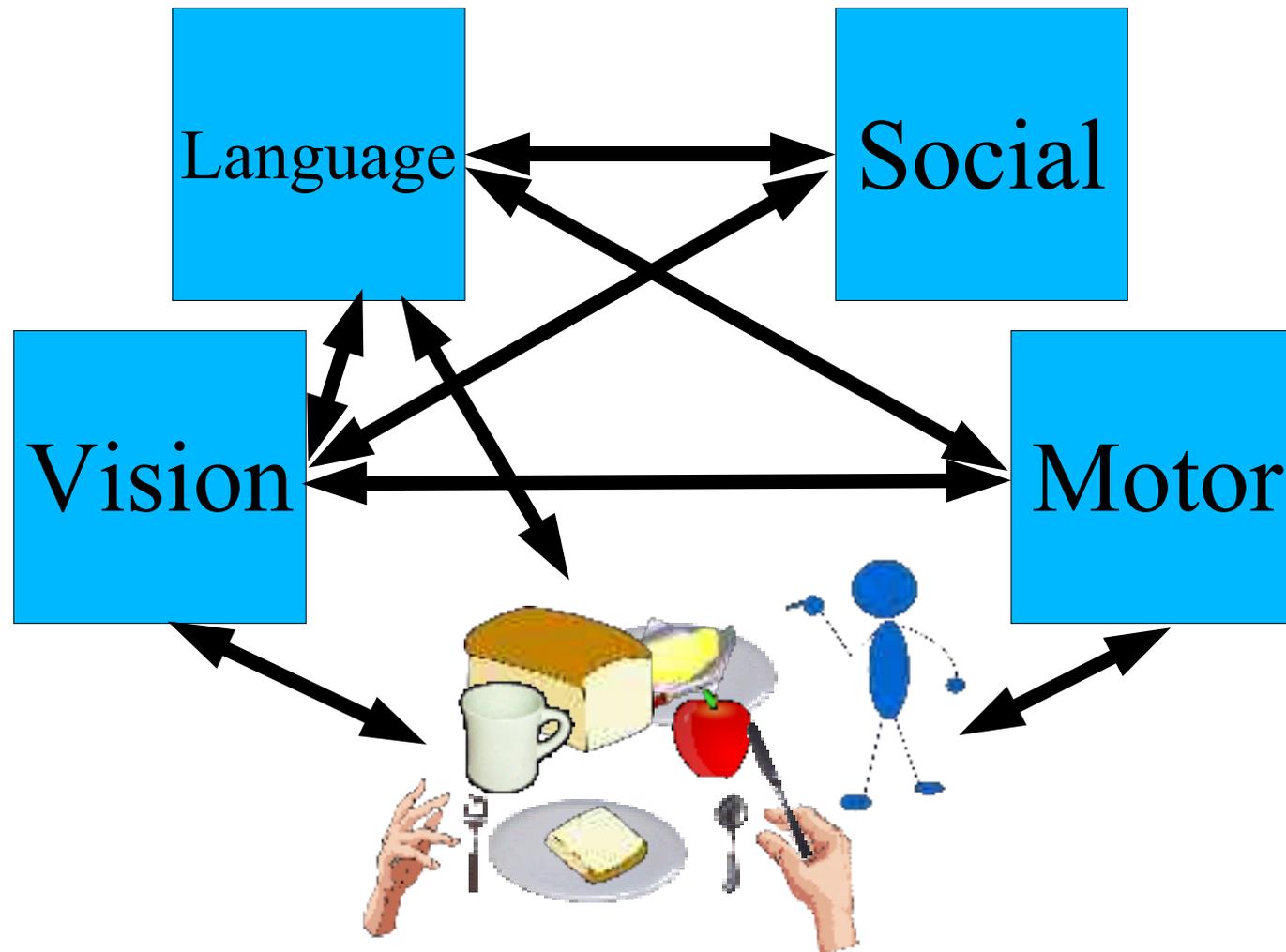


Integration by Coincidence

Status and Speculation

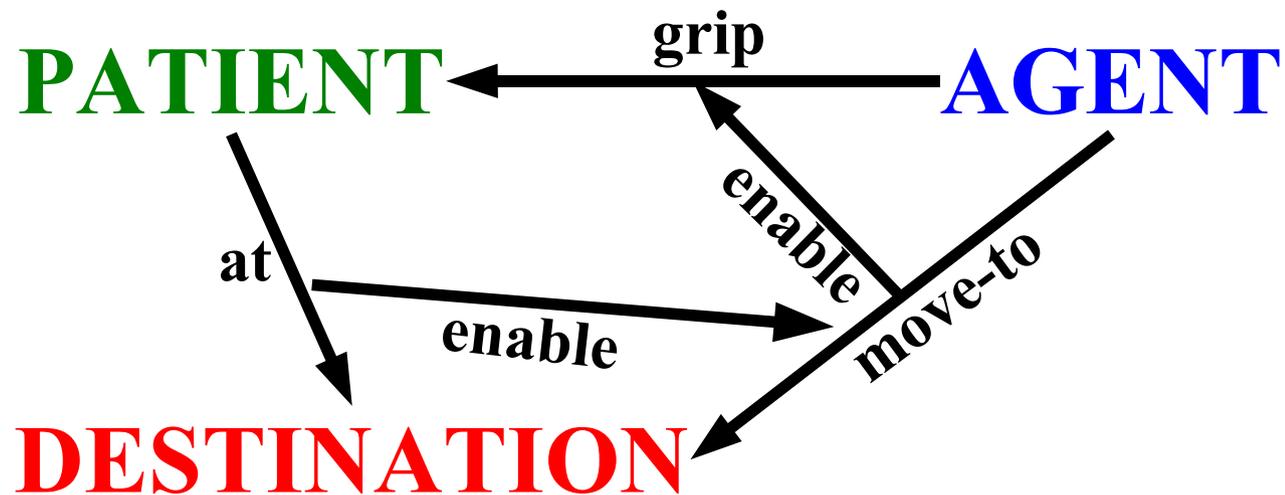
Jacob Beal
BICA Workshop
January, 2006

Consider a mind built of specialists...



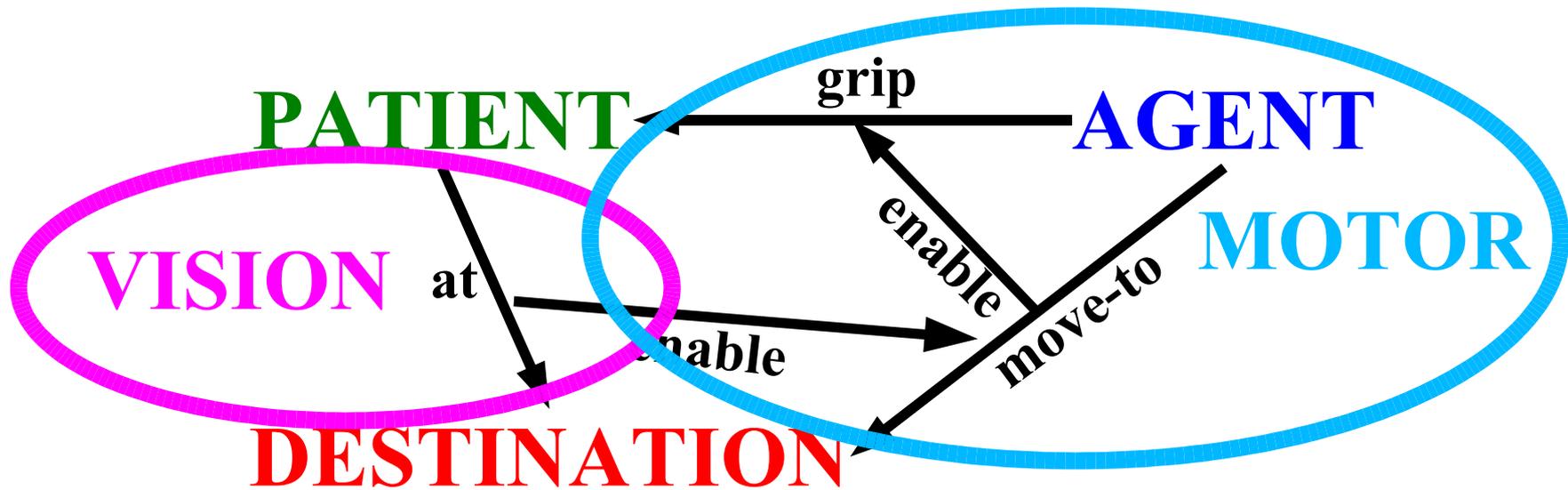
Coincidence allows the parts to learn to cooperate

What's hard about cooperation?



Consider a script for grabbing an item...

We need knowledge that crosses the boundaries between modules



How does it fit into the modules?

Did I make a bad design decision?

AI abuses abstraction barriers

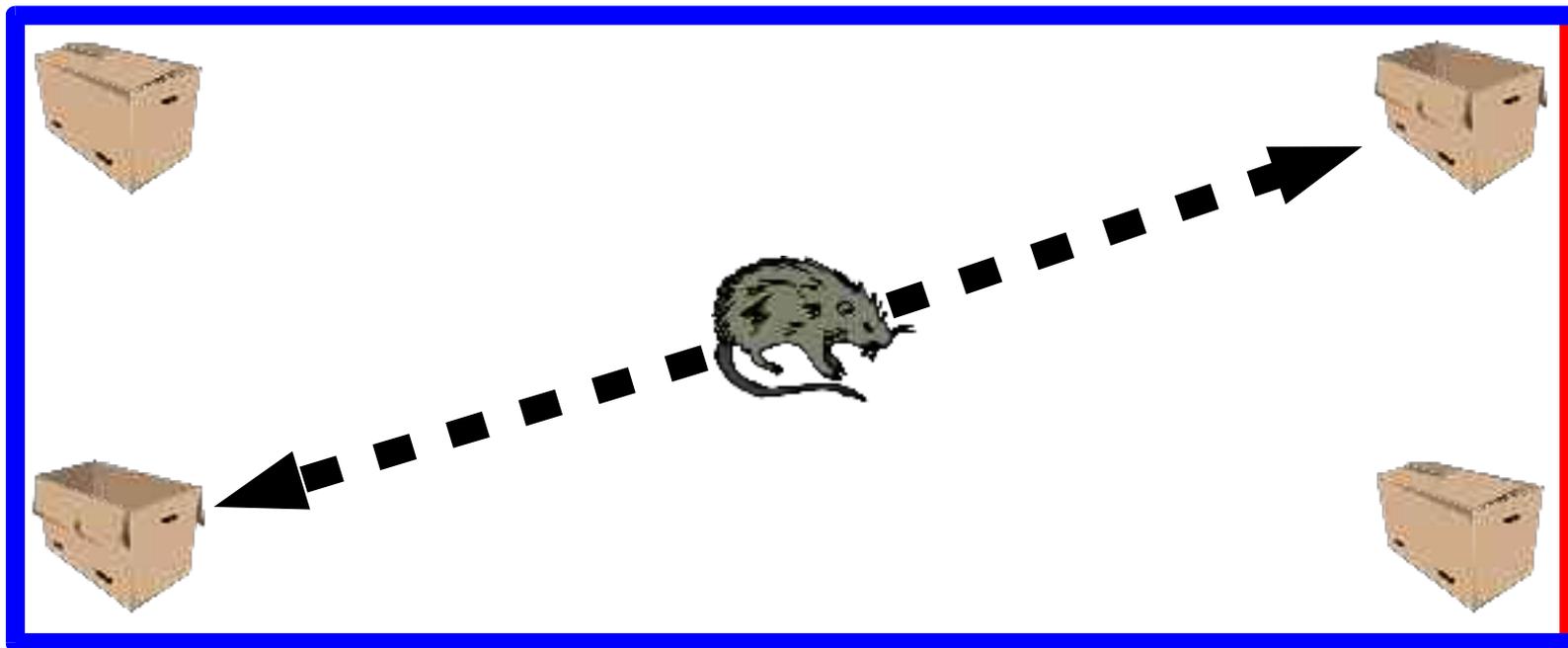
No “right” set of modules can avoid the problem

- Horns of the Dilemma
 - Modules need complex information sharing
 - Complex interfaces degrade modularity
- How can a simple interface between modules support complex interactions?

Can human minds give us inspiration?

Human integration develops slowly

- Spelke's rectangular room

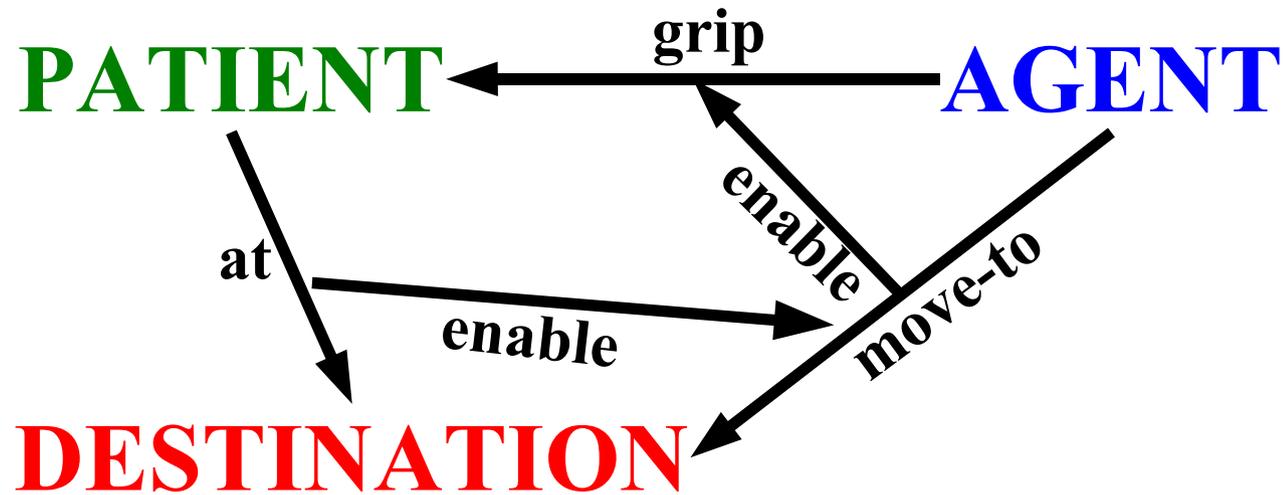


Engineering Guidelines

- **Acquire integration from experience**
- **Language is the means of integration**

How can language solve our module problems?

Projecting “grab”

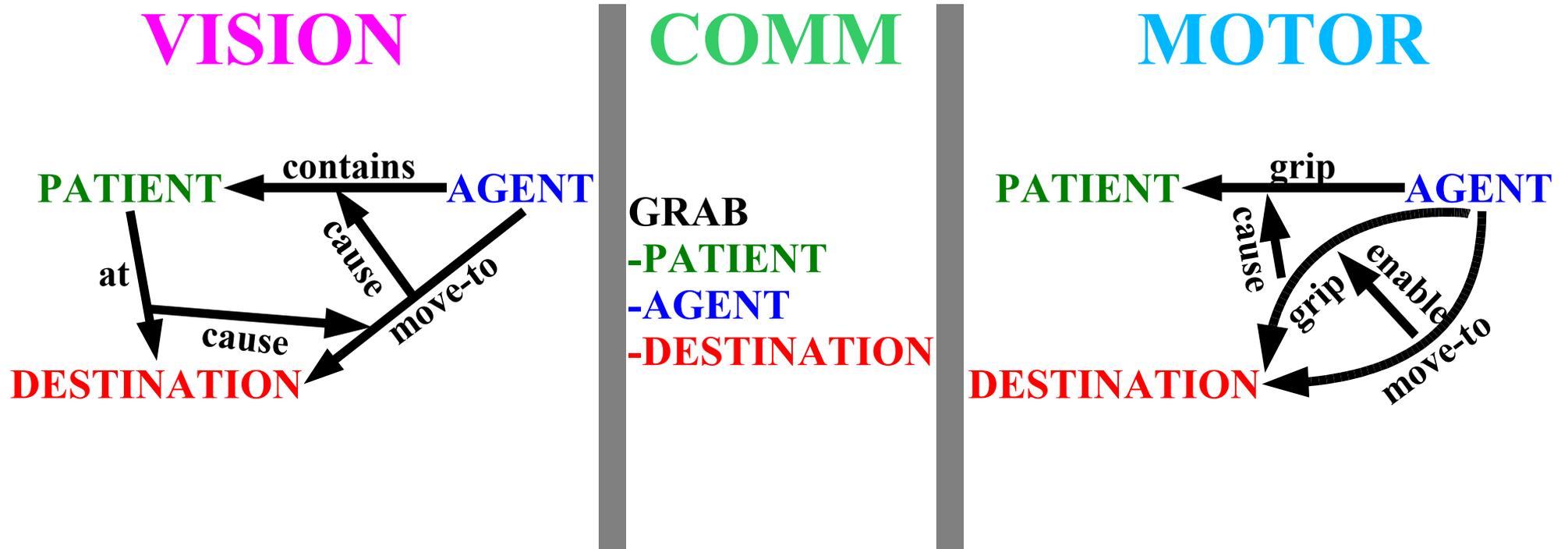


Projecting “grab”



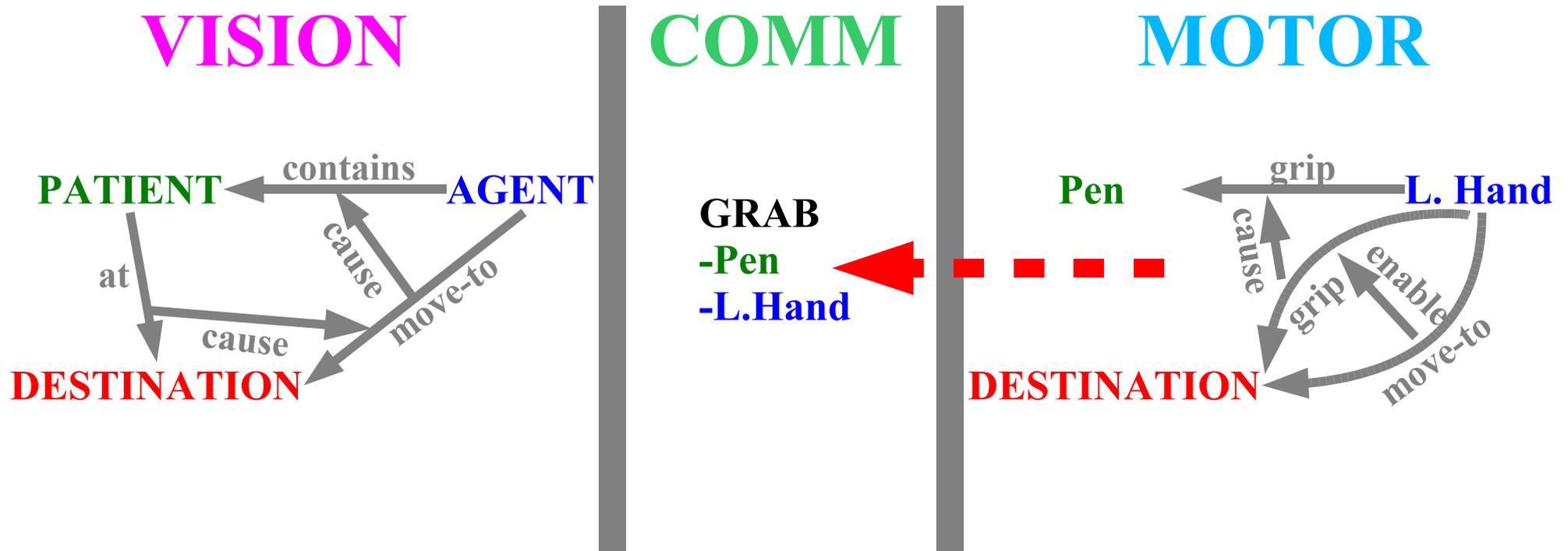
We can project a script into the modules it spans

Coordination by Communication



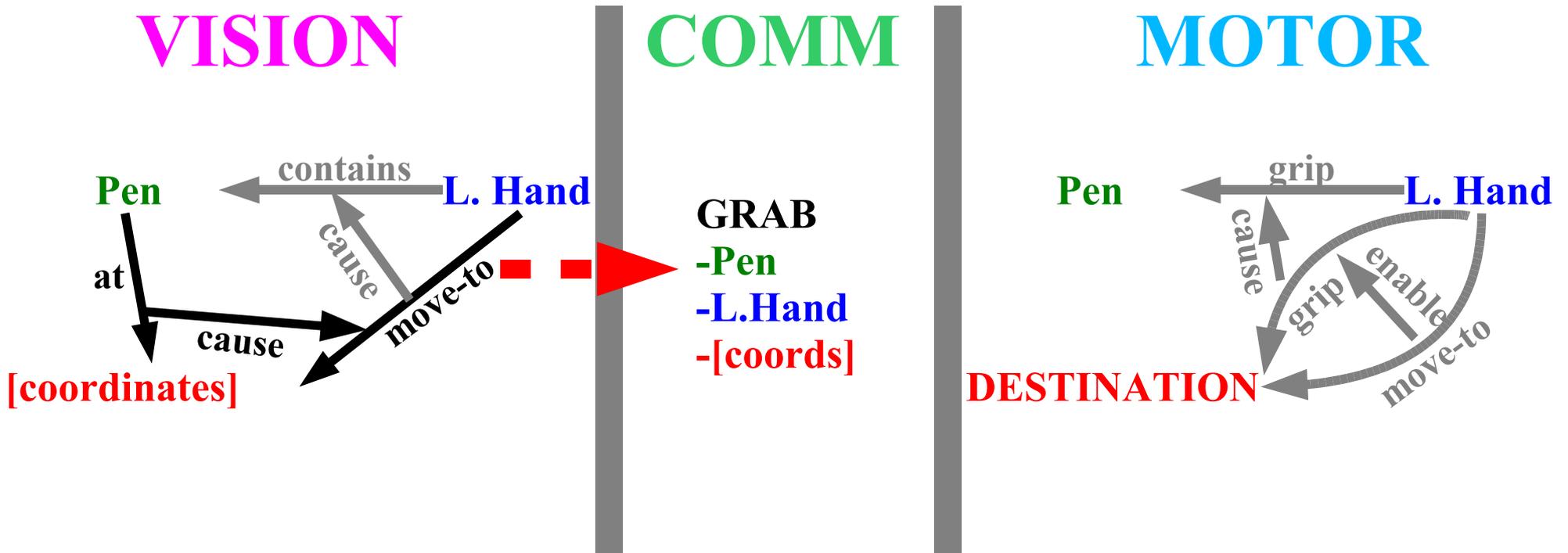
Given shared protocol for expressing the slots, the projections can emulate the cross-module script.

Coordination by Communication



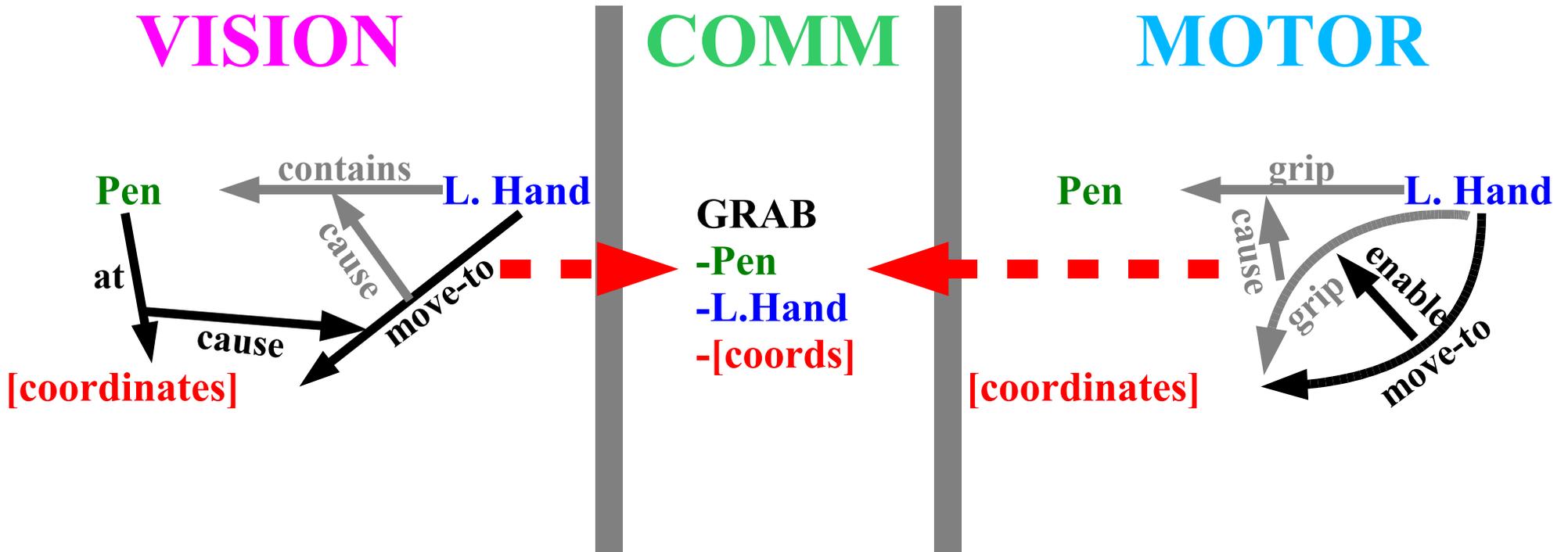
For example, motor wants to pick up a pen...

Coordination by Communication



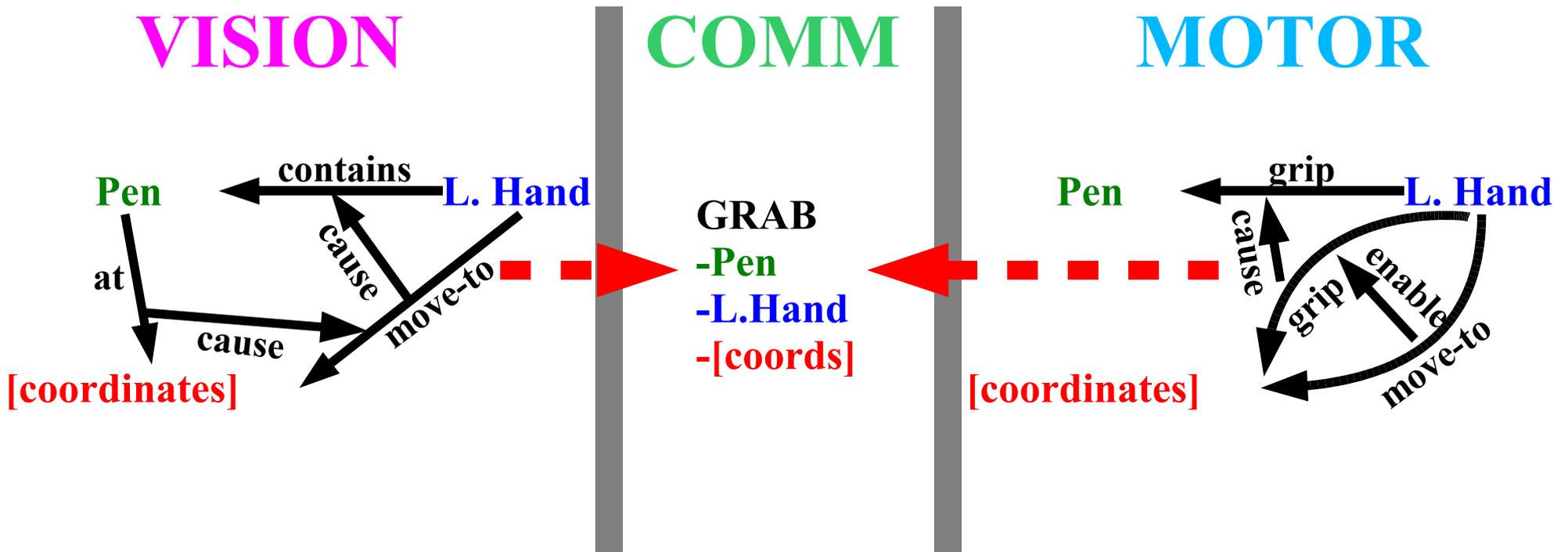
...vision contributes the location...

Coordination by Communication



...motor goes to the location, the two sides agree...

Coordination by Communication



...and the rest of the script can play out.

So how can we get communicating scripts?

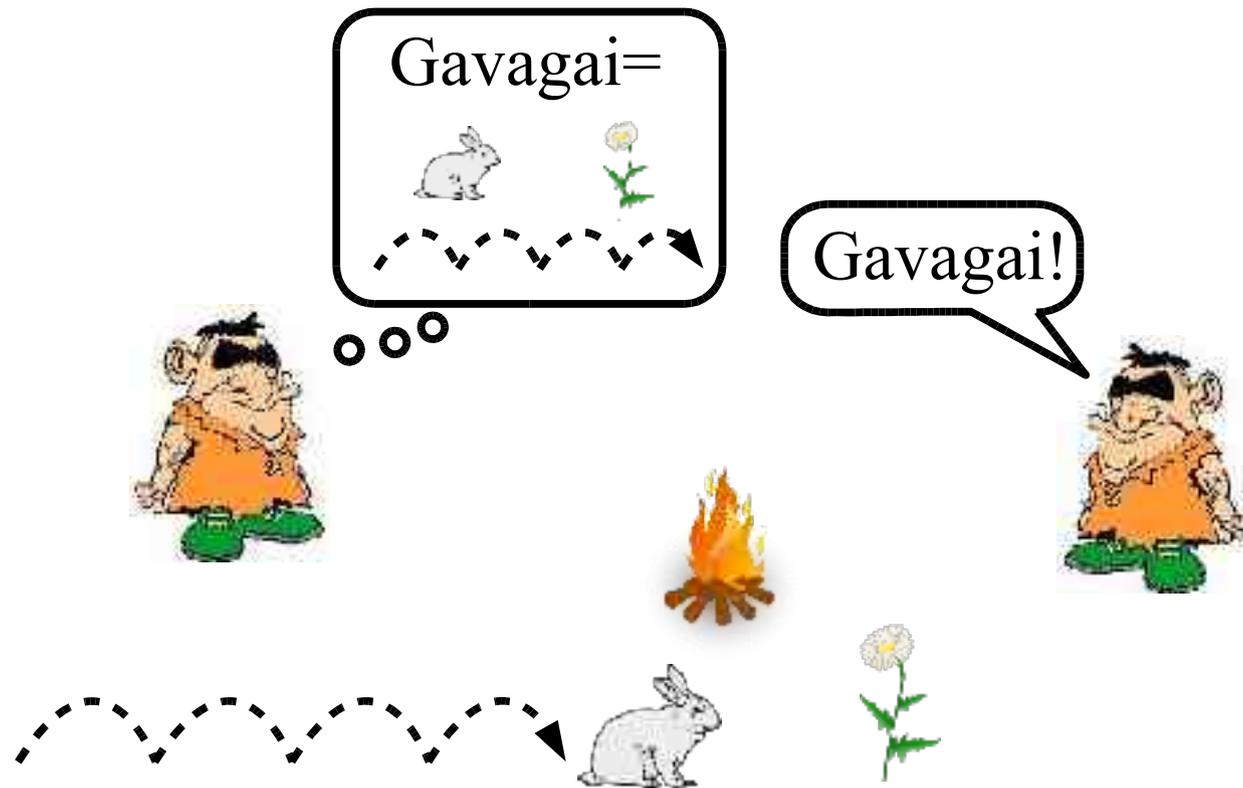
Language can arise from coincidence

- Kirby's language evolution



Language can arise from coincidence

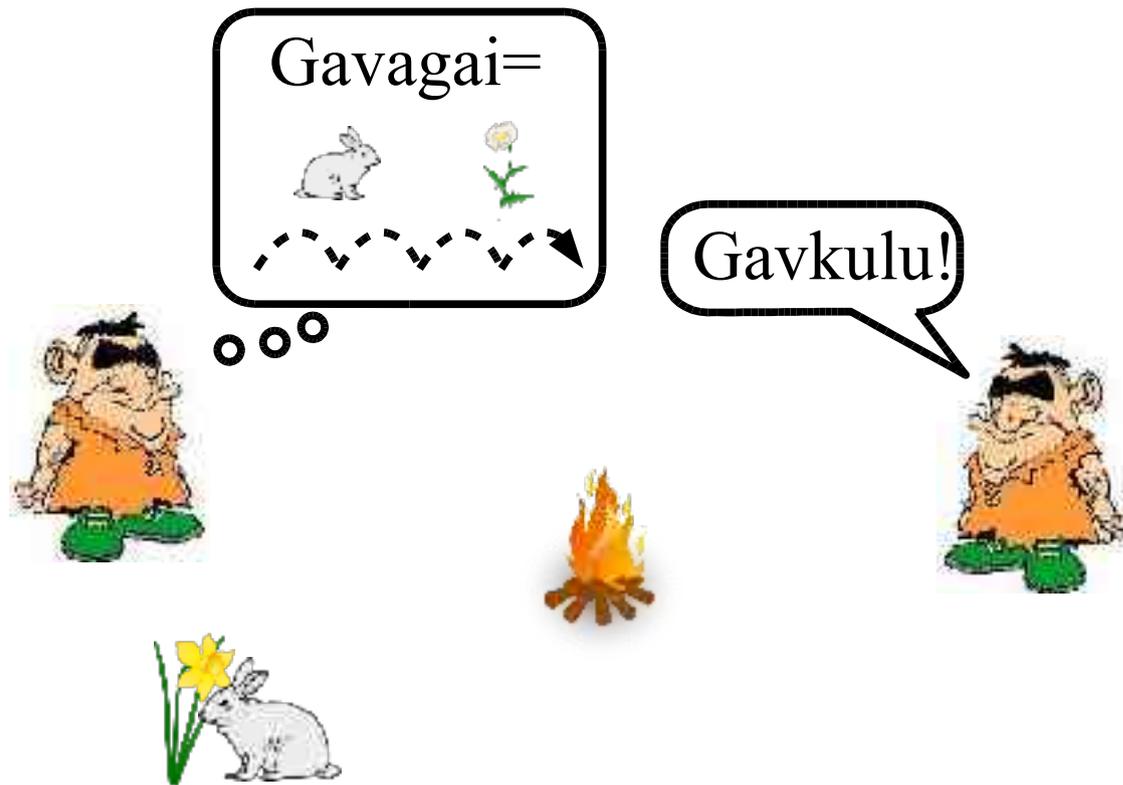
- Kirby's language evolution



Shared experience suggests word meanings

Language can arise from coincidence

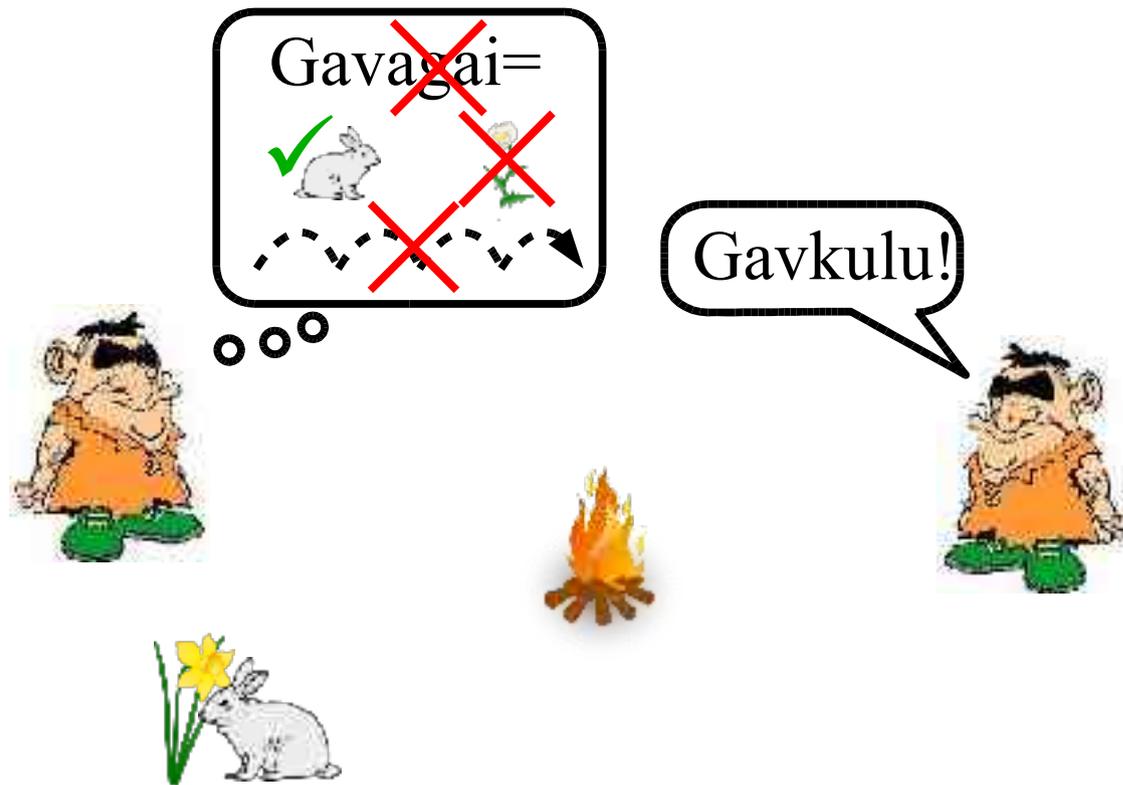
- Kirby's language evolution



In a sparse world, coincidence implies connection.

Language can arise from coincidence

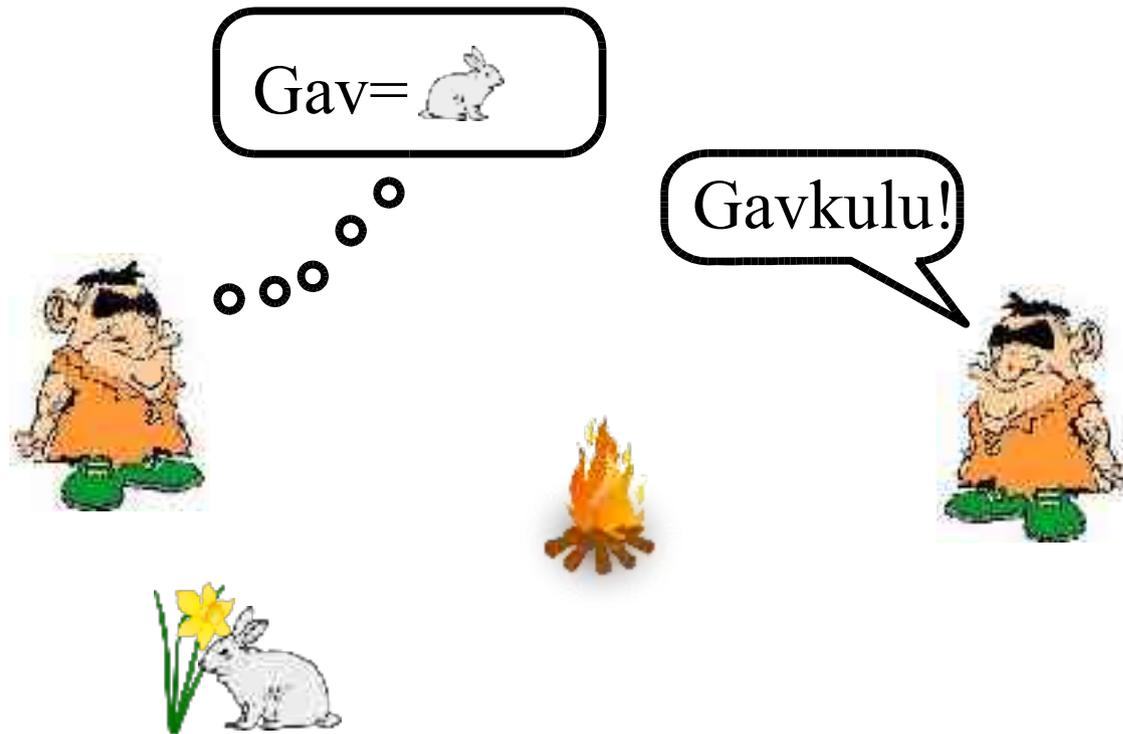
- Kirby's language evolution



In a sparse world, coincidence implies connection.

Language can arise from coincidence

- Kirby's language evolution



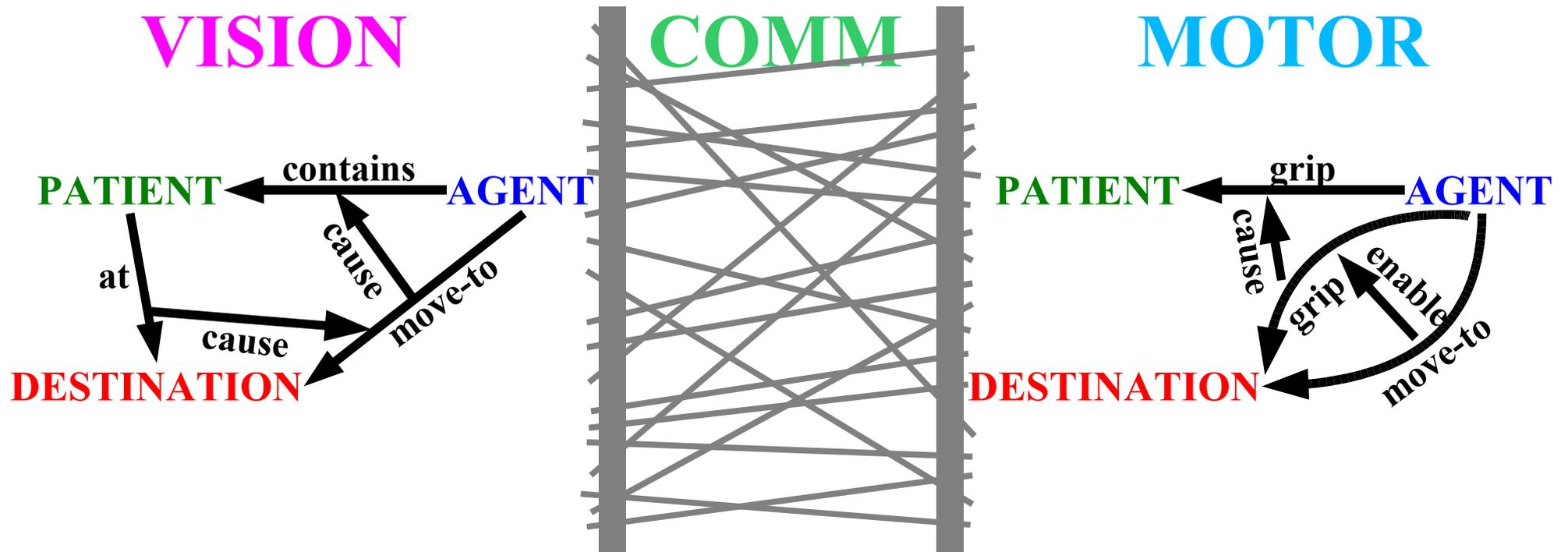
In a sparse world, coincidence implies connection.

Engineering Guidelines

- Acquire integration from experience
- Language is the means of integration
- **Shared experience suggests word meanings**
- **Coincidence implies connection.**

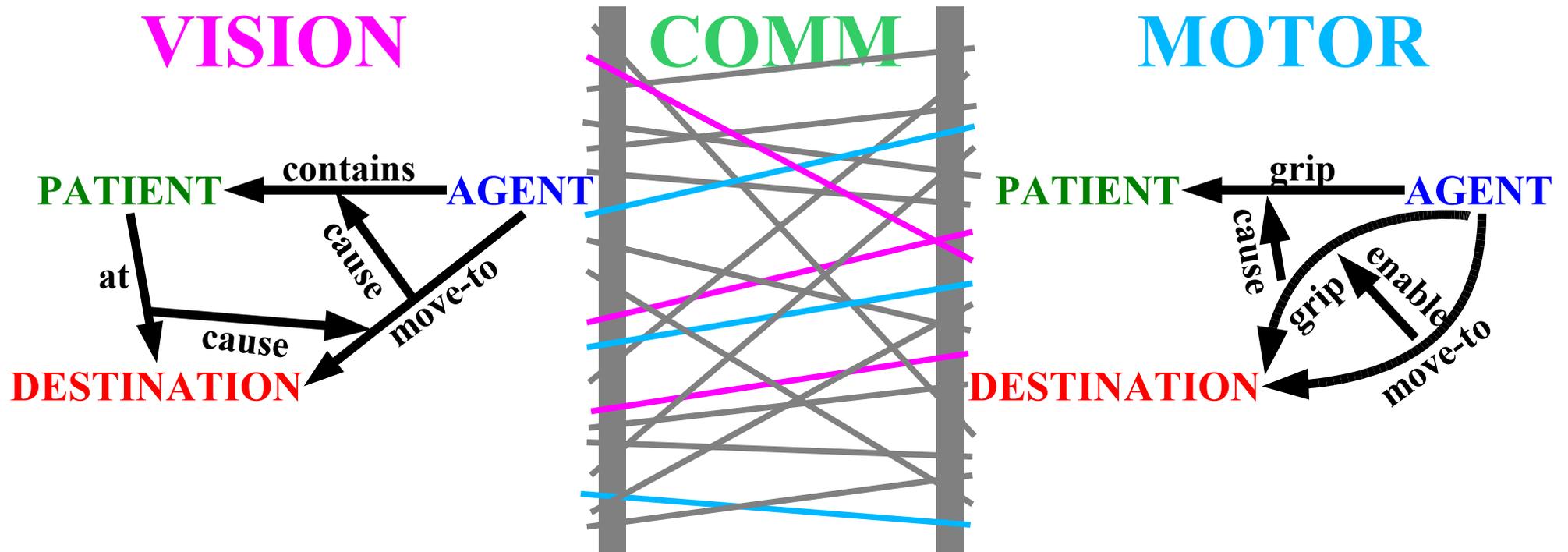
How can we build a robust, non-stop learner?

Communication Bootstrapping



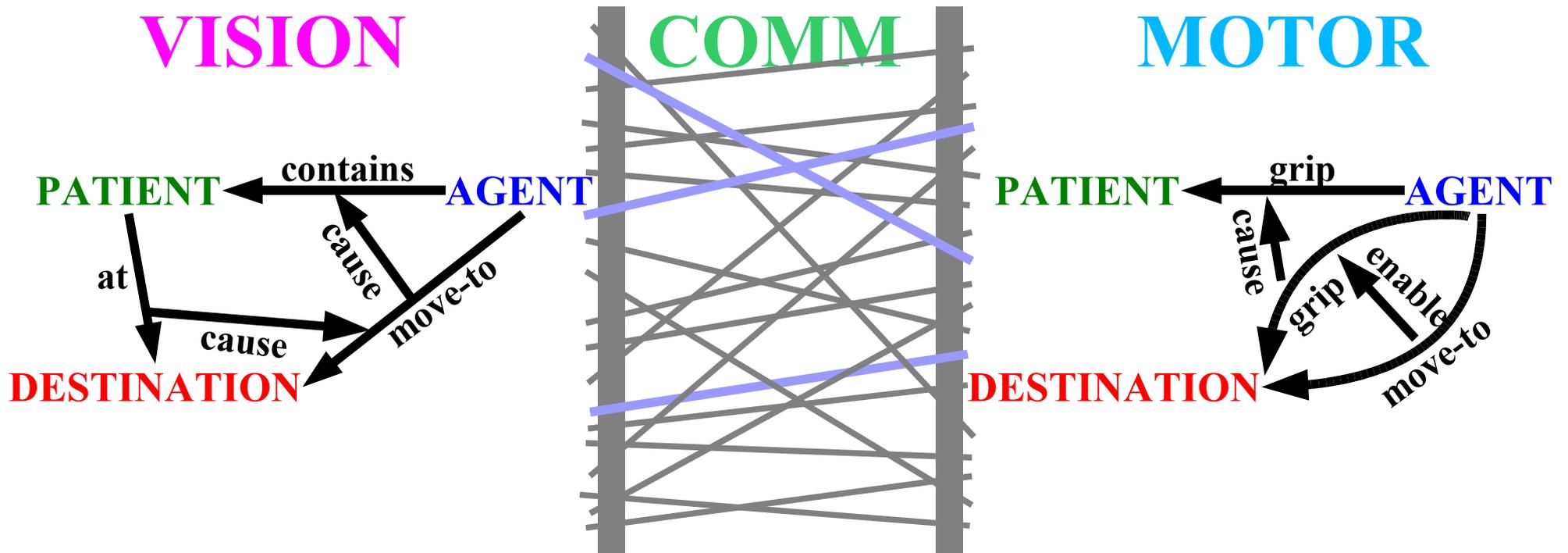
On a large, randomly permuted bundle of wires...

Communication Bootstrapping



...each side chooses a random sparse subset...

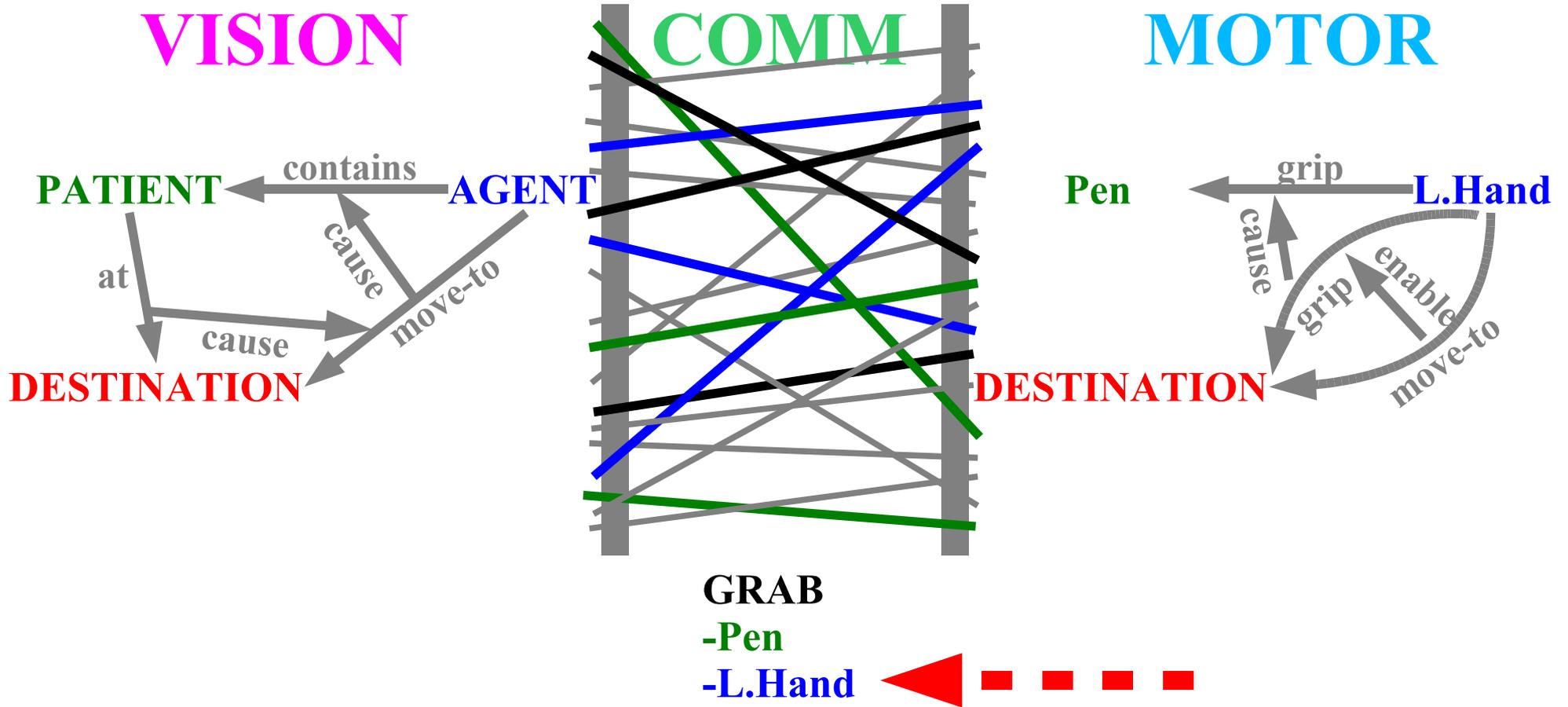
Communication Bootstrapping



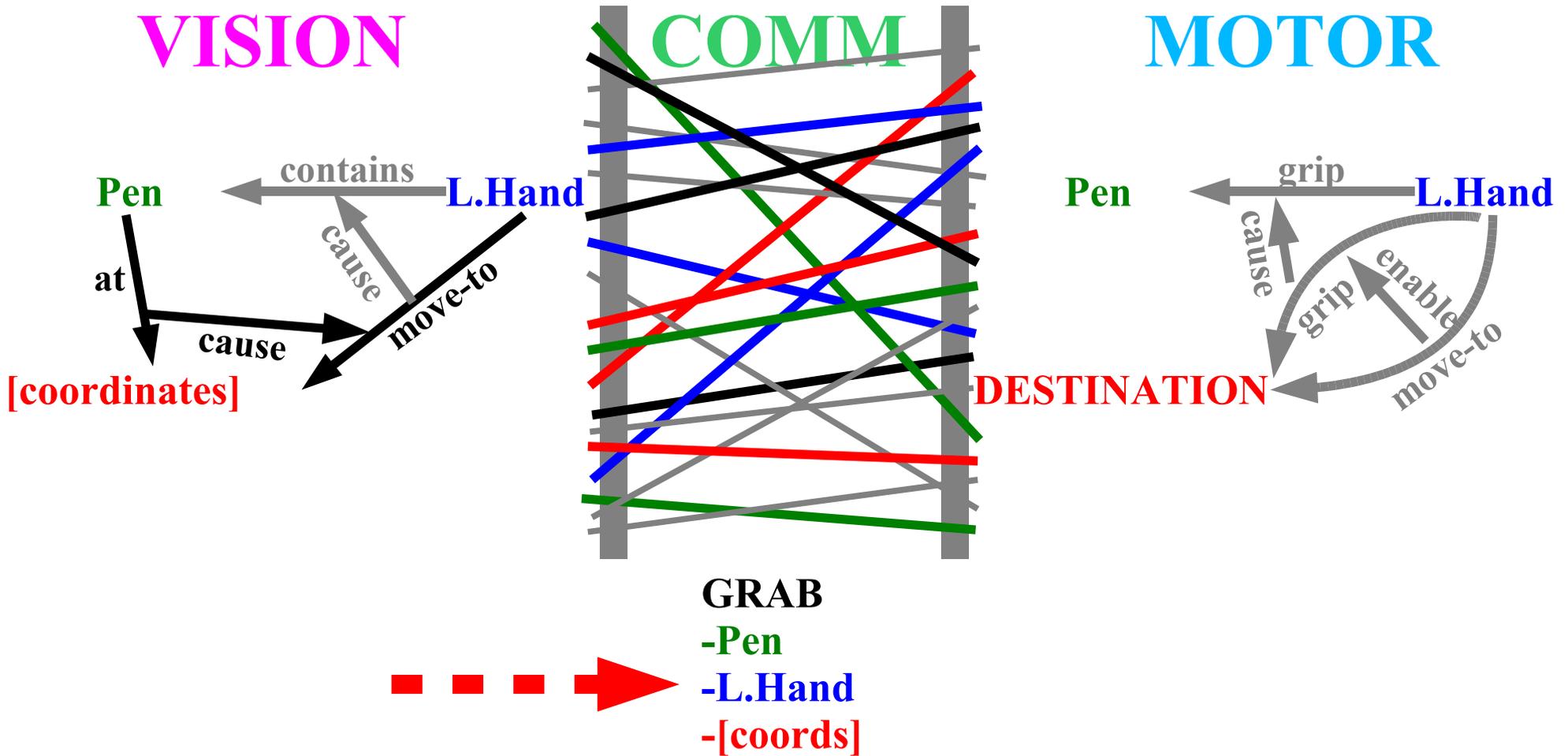
...and coincidence makes agreement easy.

Look, a symbol! Roles are learned similarly...

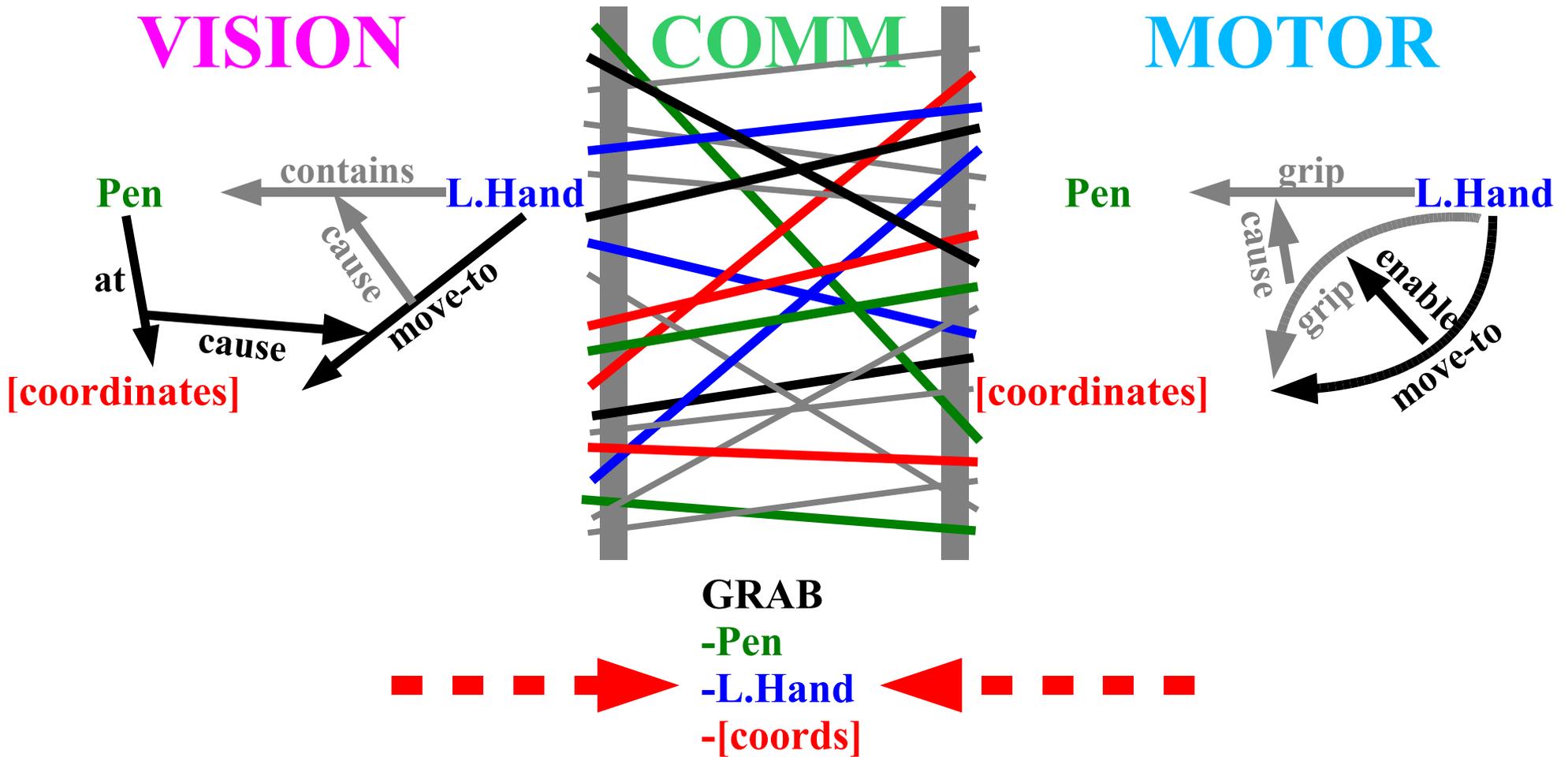
Communication Bootstrapping



Communication Bootstrapping



Communication Bootstrapping



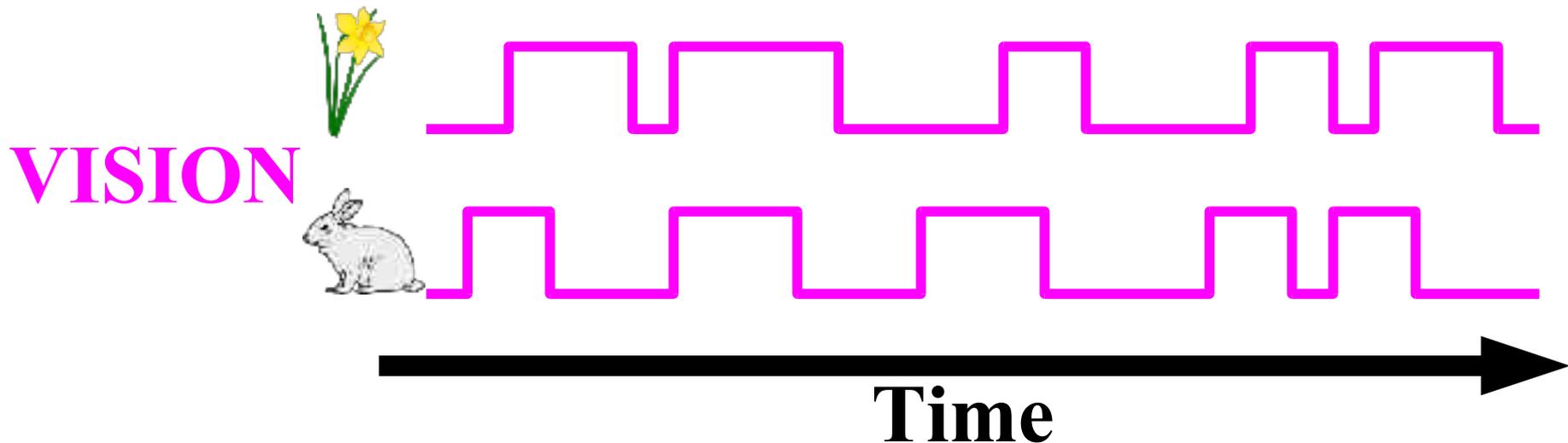
When does this work, and when does it fail?

Open Question: Creating Good Learning Conditions

- Experimentally, when does Bootstrapping fail?
 - Non-sparseness
 - Stutter
 - Burn-in

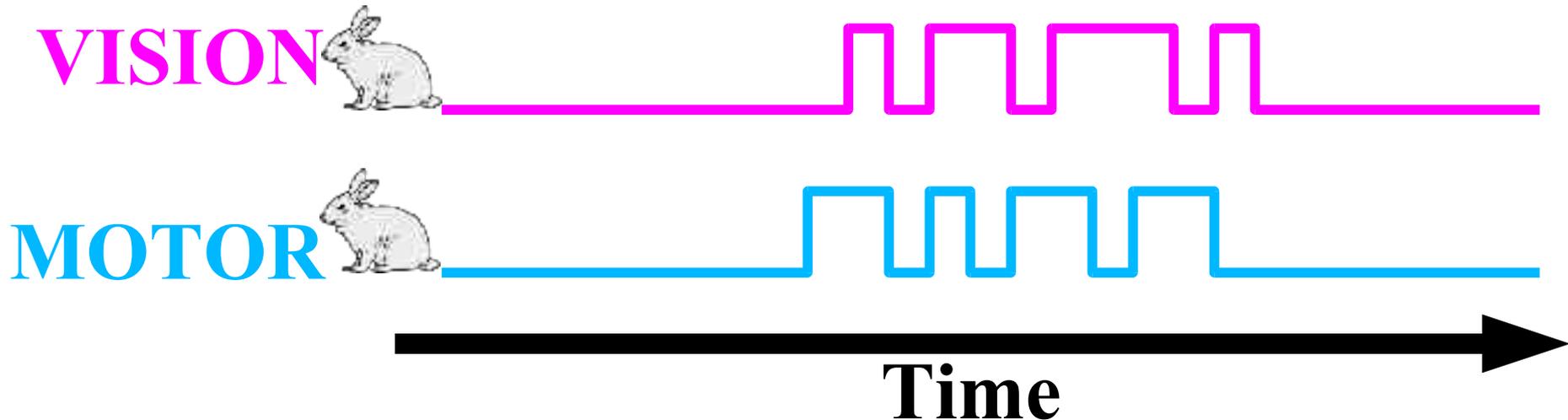
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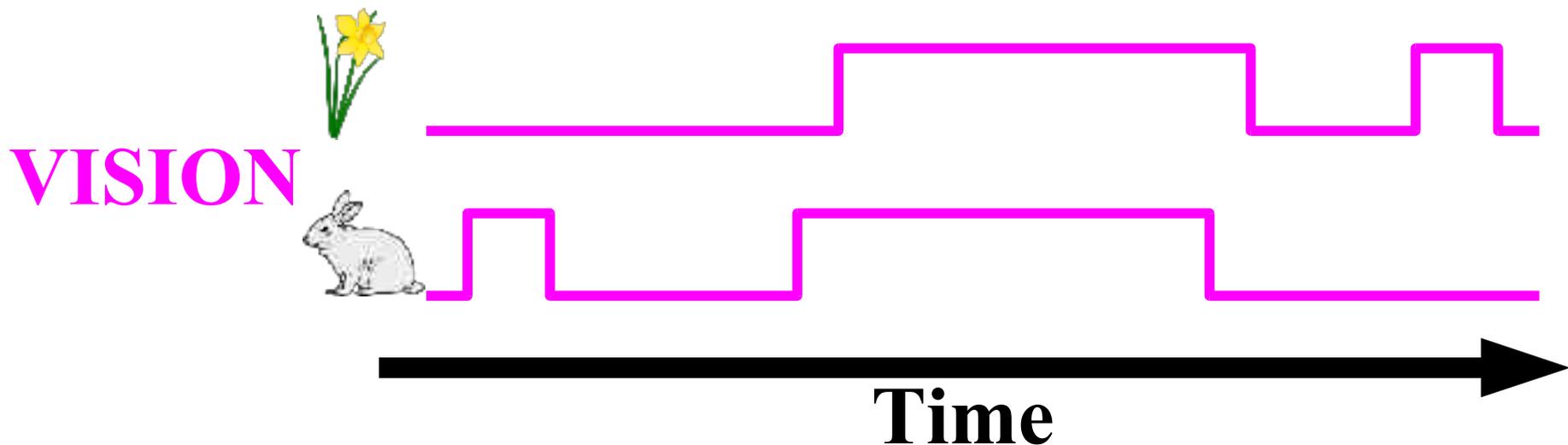
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Open Question: Creating Good Learning Conditions

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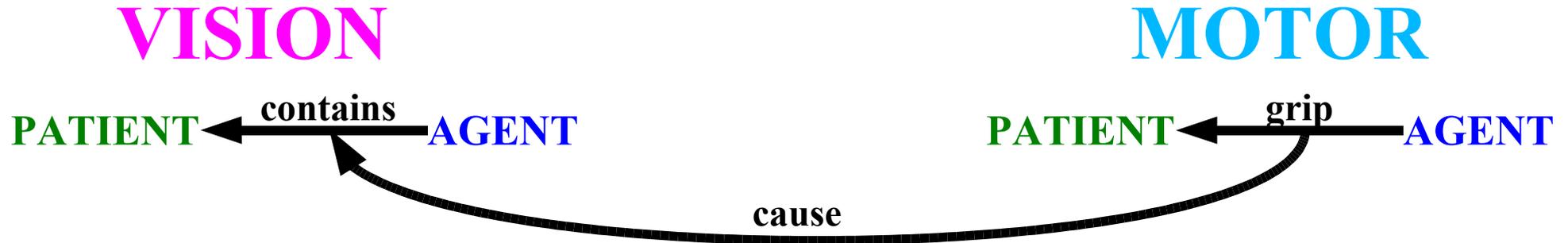


Open Question: Creating Good Learning Conditions

- Experimentally, when does Bootstrapping fail?
 - Non-sparseness *Coen, Granger*
 - Stutter *Abstraction*
 - Burn-in *Temporal schemas*

Proposed Answer: Temporal Schemas

- How can we learn relations that aren't 1-to-1?
 - Basis of ~10 types, positive & negative for each
 - Equality relations are a special case



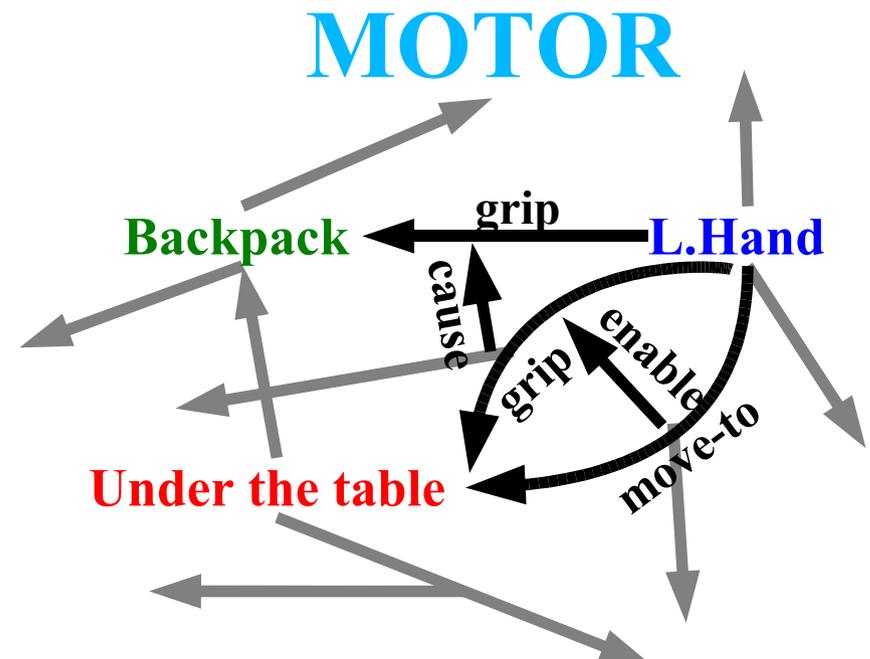
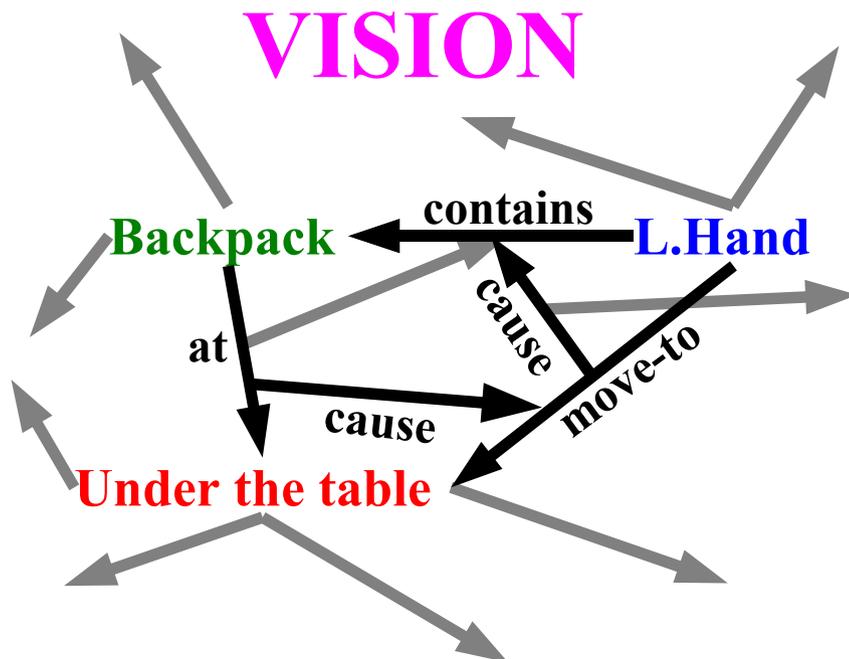
Positive: CAUSE → **meets** → EFFECT

Positive: CAUSE → **meets** → VIA → **meets** → EFFECT

Negative: EFFECT → **before** → CAUSE

Open Question: Where do the projections come from?

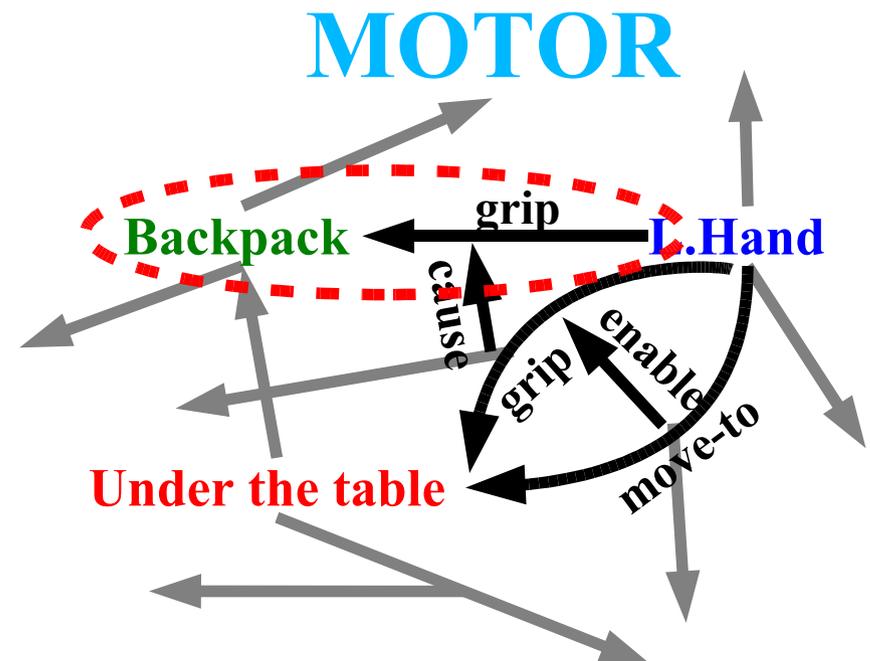
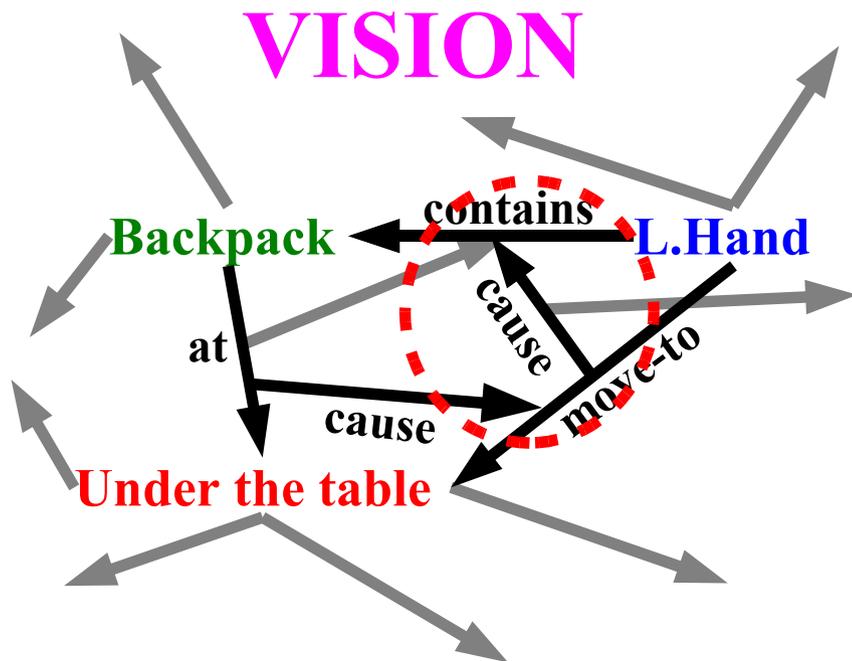
You can't learn something until you almost already know it. -Bill Martin



Open Question: Where do the projections come from?

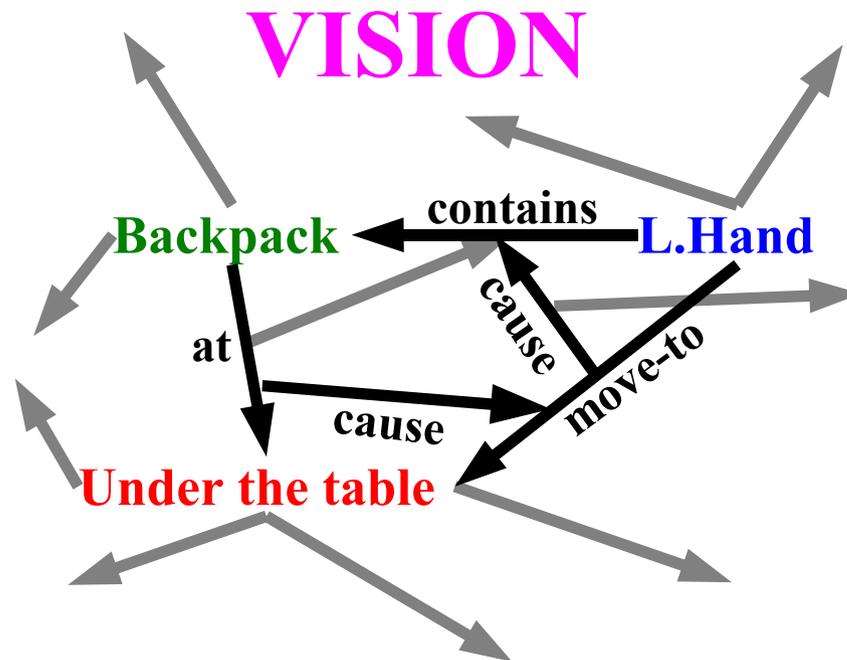
You can't learn something until you almost already know it. -Bill Martin

- Build around something not predicted



Proposed Answer: Kuhn Lifecycle

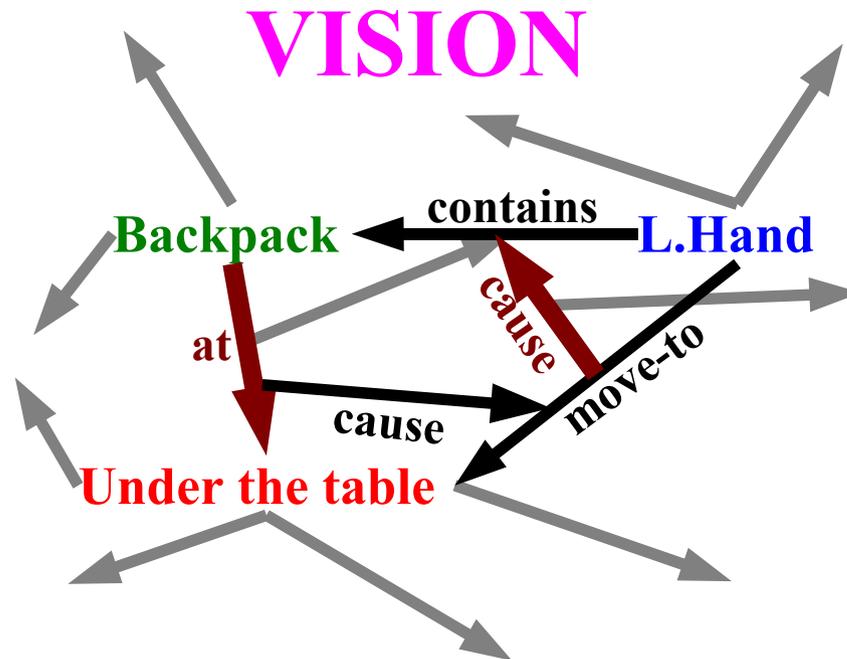
- Creation
- Formation
- Validation
- Acceptance
- Refutation



What do you do with negative evidence?

Proposed Answer: Kuhn Lifecycle

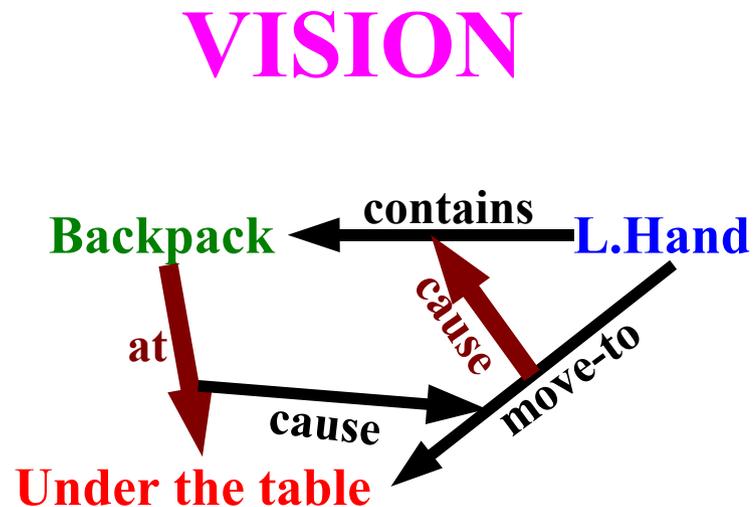
- **Creation** – guess *core*
- Formation
- Validation
- Acceptance
- Refutation



What do you do with negative evidence?

Proposed Answer: Kuhn Lifecycle

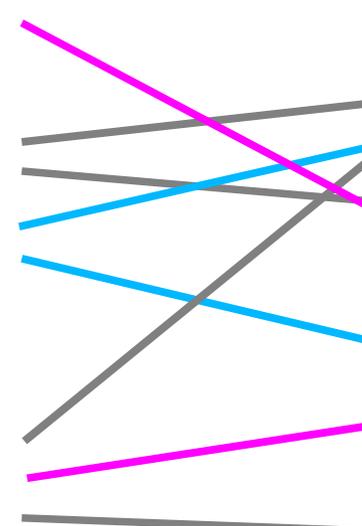
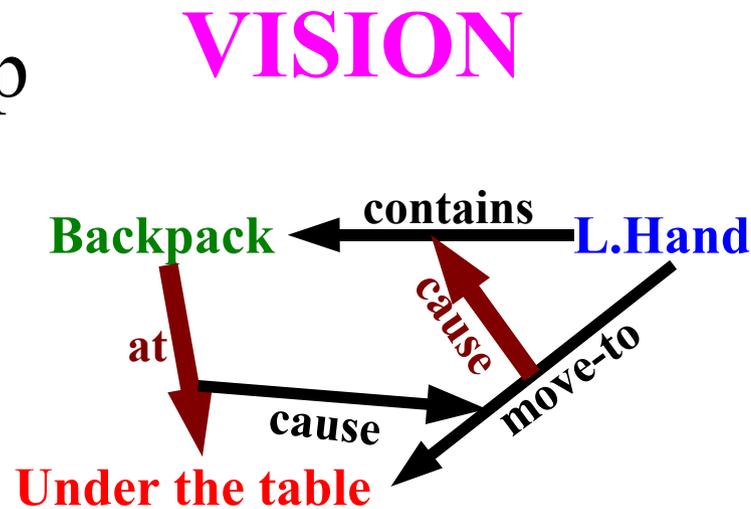
- Creation – guess *core*
- **Formation** - prune
- Validation
- Acceptance
- Refutation



What do you do with negative evidence?

Proposed Answer: Kuhn Lifecycle

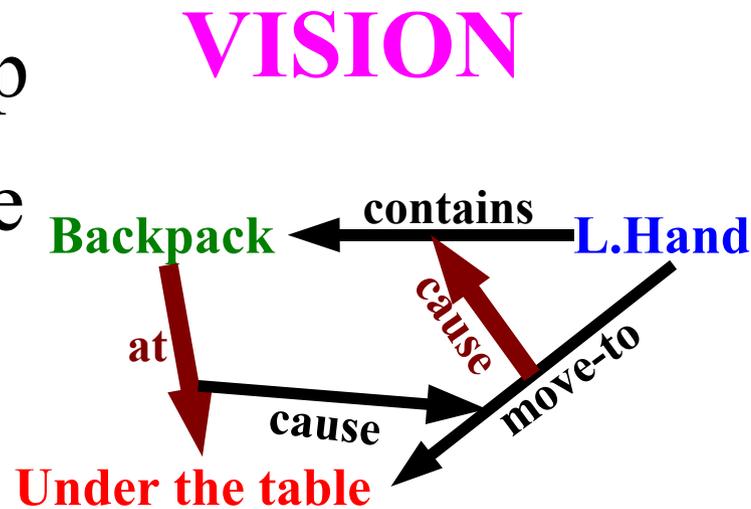
- Creation – guess *core*
- Formation - prune
- **Validation** - bootstrap
- Acceptance
- Refutation



What do you do with negative evidence?

Proposed Answer: Kuhn Lifecycle

- Creation – guess *core*
- Formation - prune
- Validation - bootstrap
- **Acceptance** - imagine
- Refutation

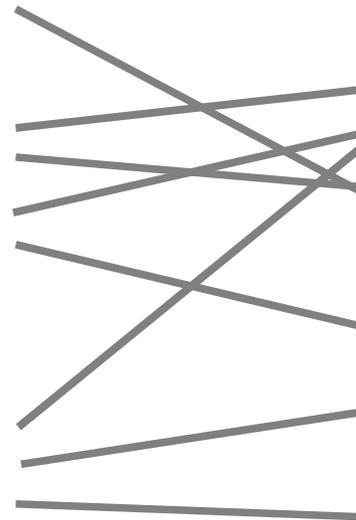


What do you do with negative evidence?

Proposed Answer: Kuhn Lifecycle

- Creation – guess *core*
- Formation - prune
- Validation - bootstrap
- Acceptance - imagine
- **Refutation** - delete

VISION



What do you do with negative evidence?

Does it all work?

Ask me again in a couple months...