A Visual Question Answering Study In Intuitive Physics

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Overview

- ✳Intuitive Physics
- ✳VQA
- ✳Motivation
- ✳Related Work
- ✳Dataset
- ✳Design

What is Intuitive Physics?

The knowledge underlying the human ability to understand the physical environment and interact with objects and substances that undergo dynamic state changes, making at least approximate predictions about how observed events will unfold.

*Intuitive Physics: Current Research and Controversies

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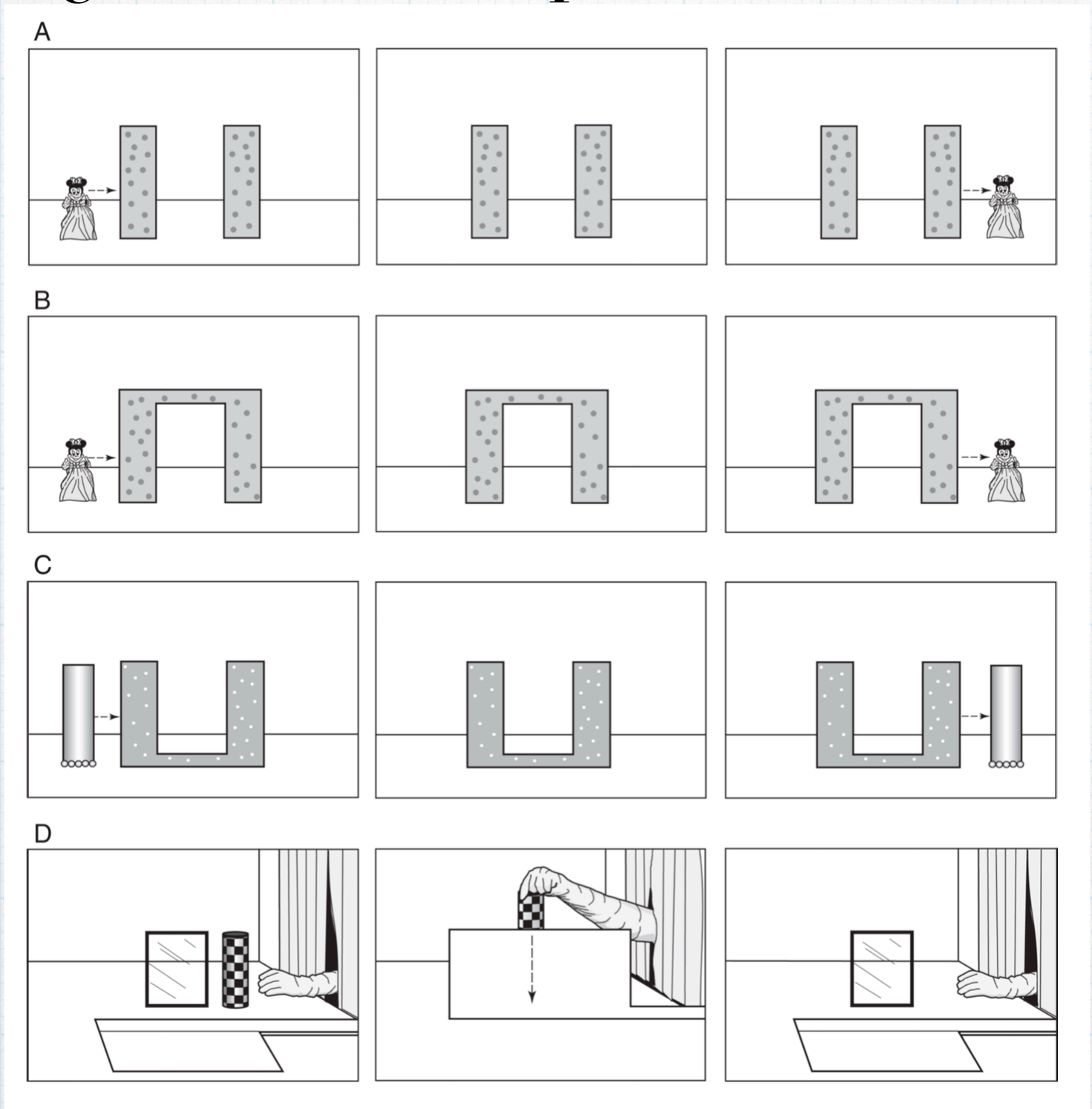
*Intuitive Physics: Current Research and Controversies

Cognitive Science and Machine Learning

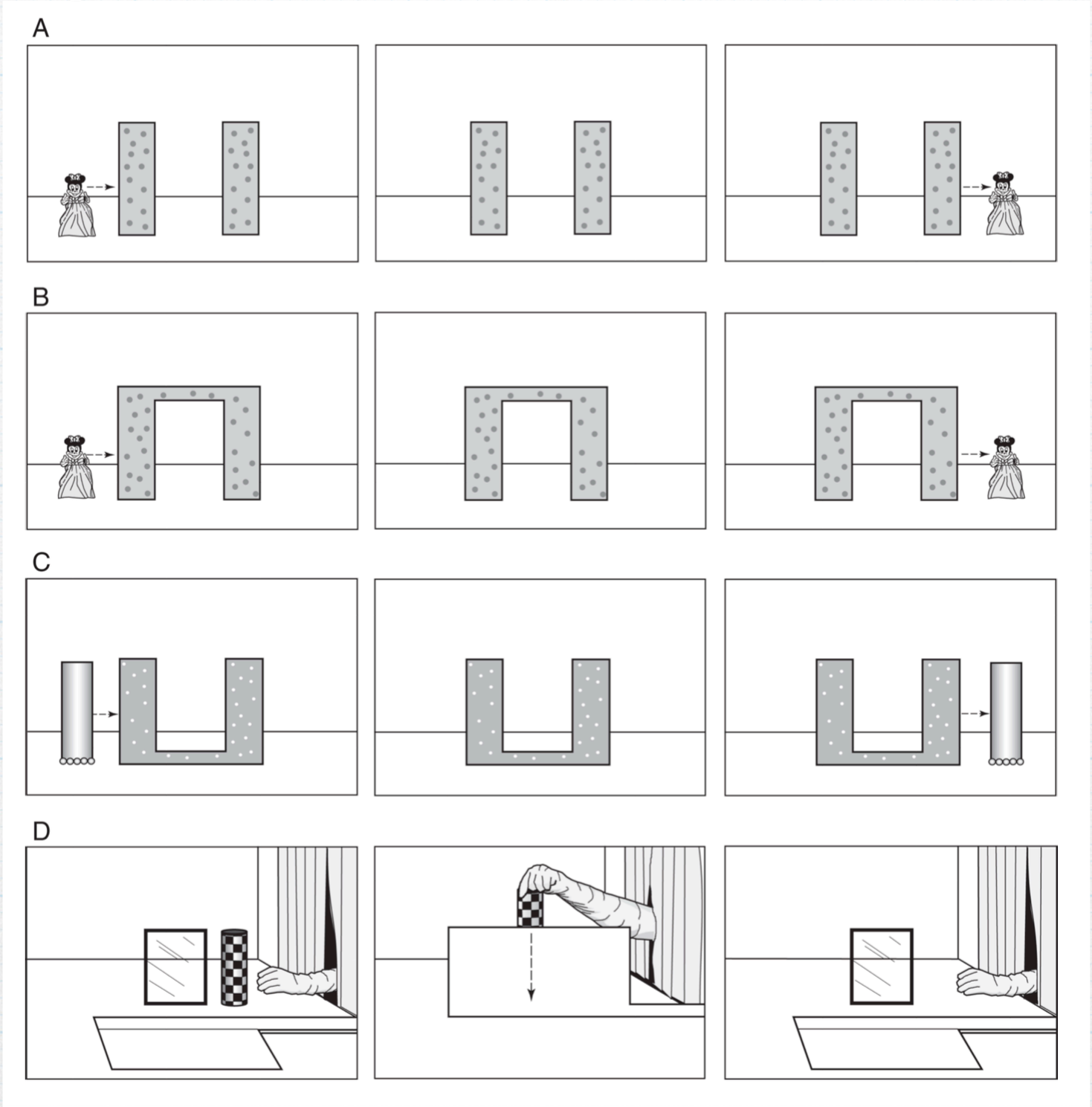
Cognitive Development of Infants



Continuity violation detection of infants for different setups

*Innate Ideas Revisited For a Principle of Persistence in Infants' Physical Reasoning

Cognitive Development of Infants



After 2.5 months

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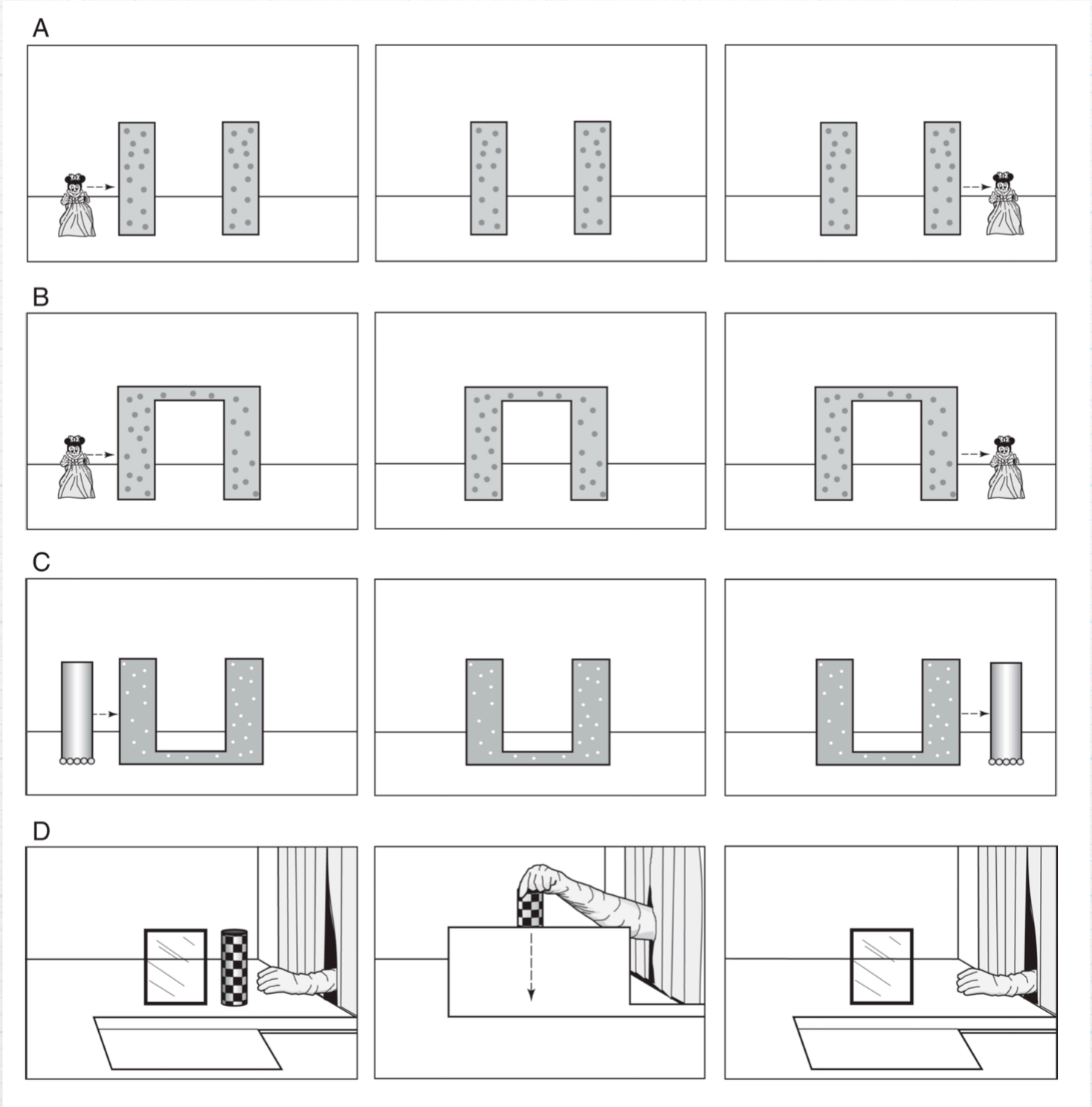

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After 3 months

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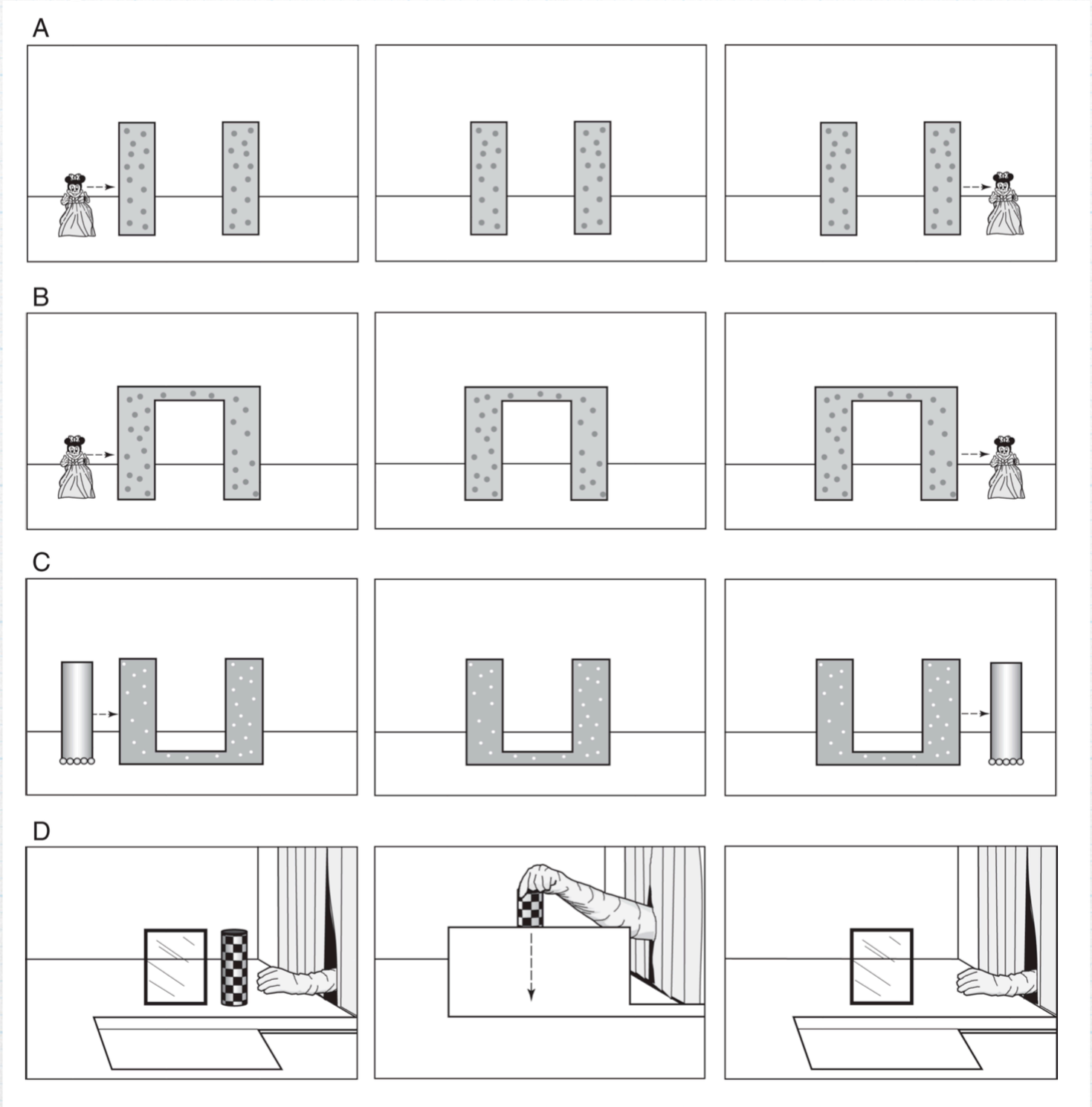

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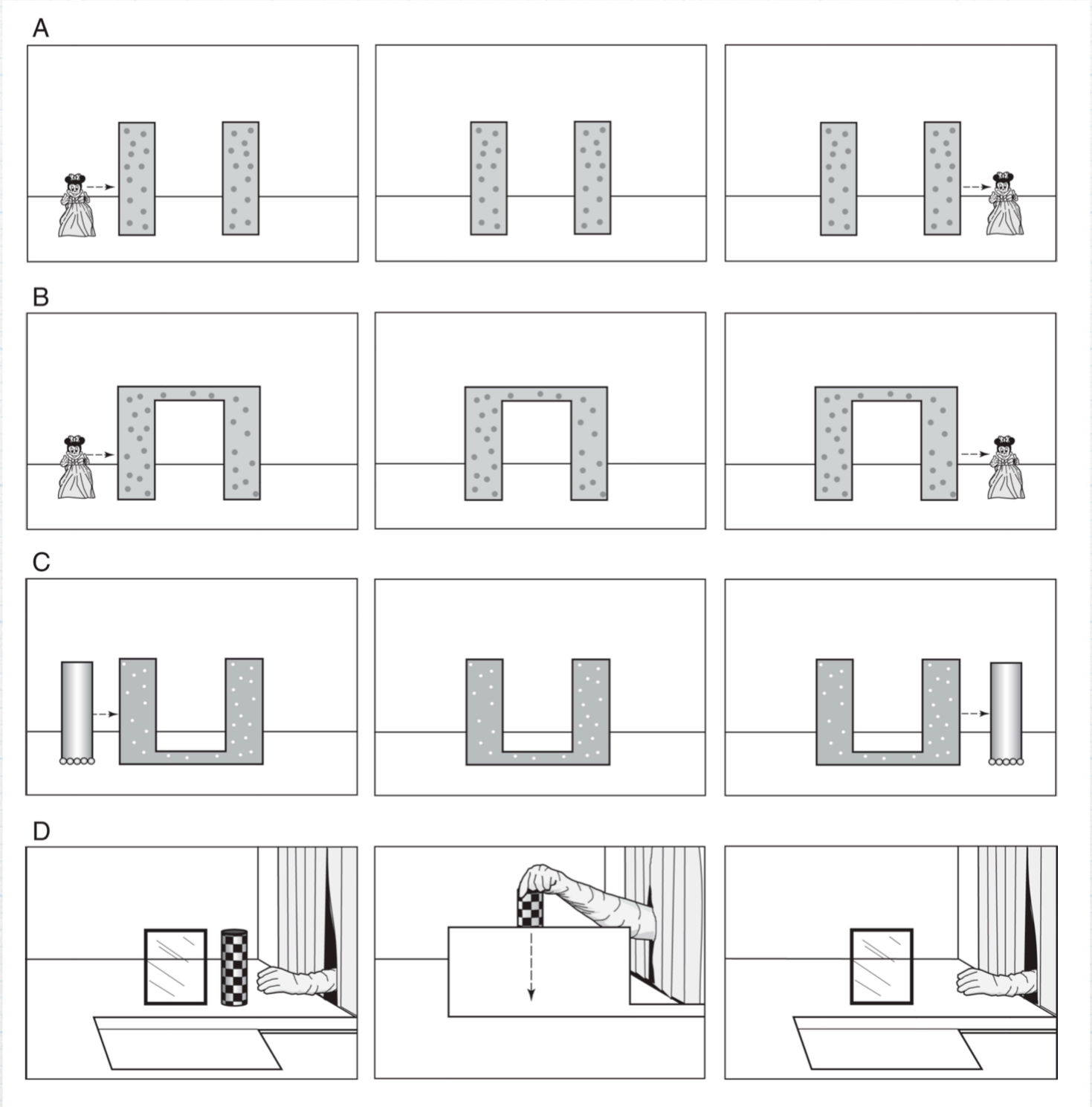

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After 7.5 months

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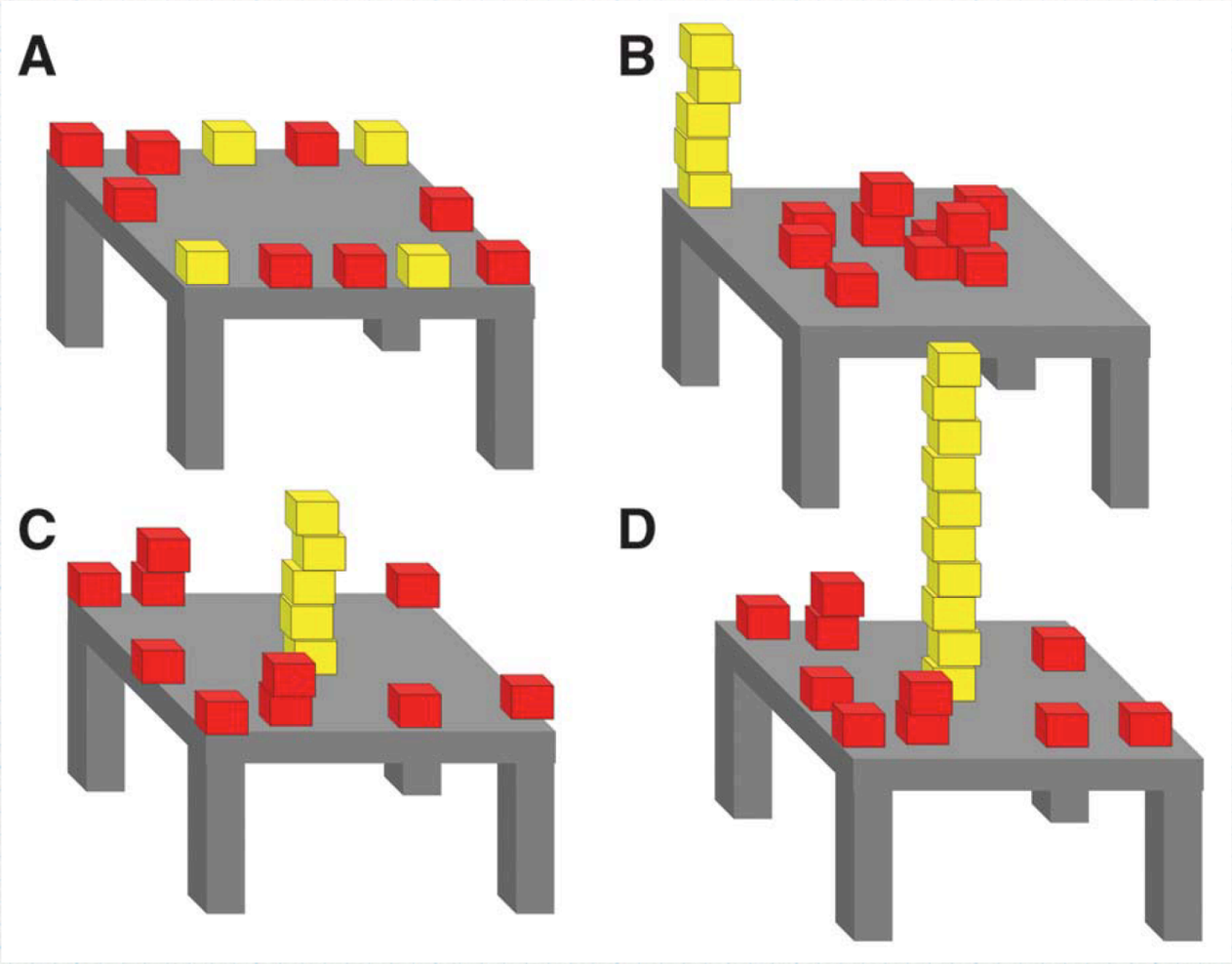
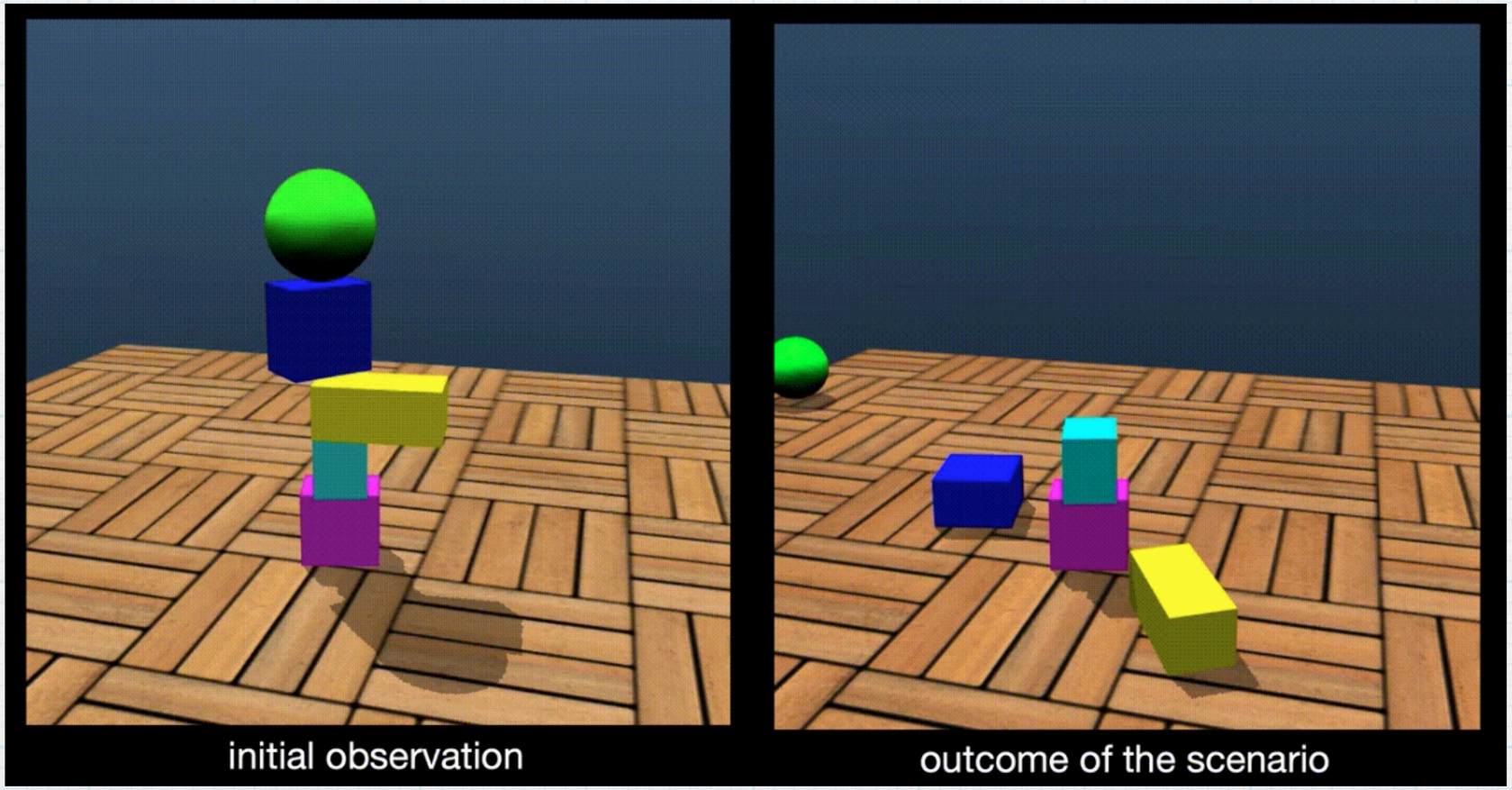
An Example



If the table in this scene is bumped so that one block falls off the table onto the floor, is it more likely to be a red or a yellow block?

*Pure Reasoning in 12-Month-Old Infants as Probabilistic Inference

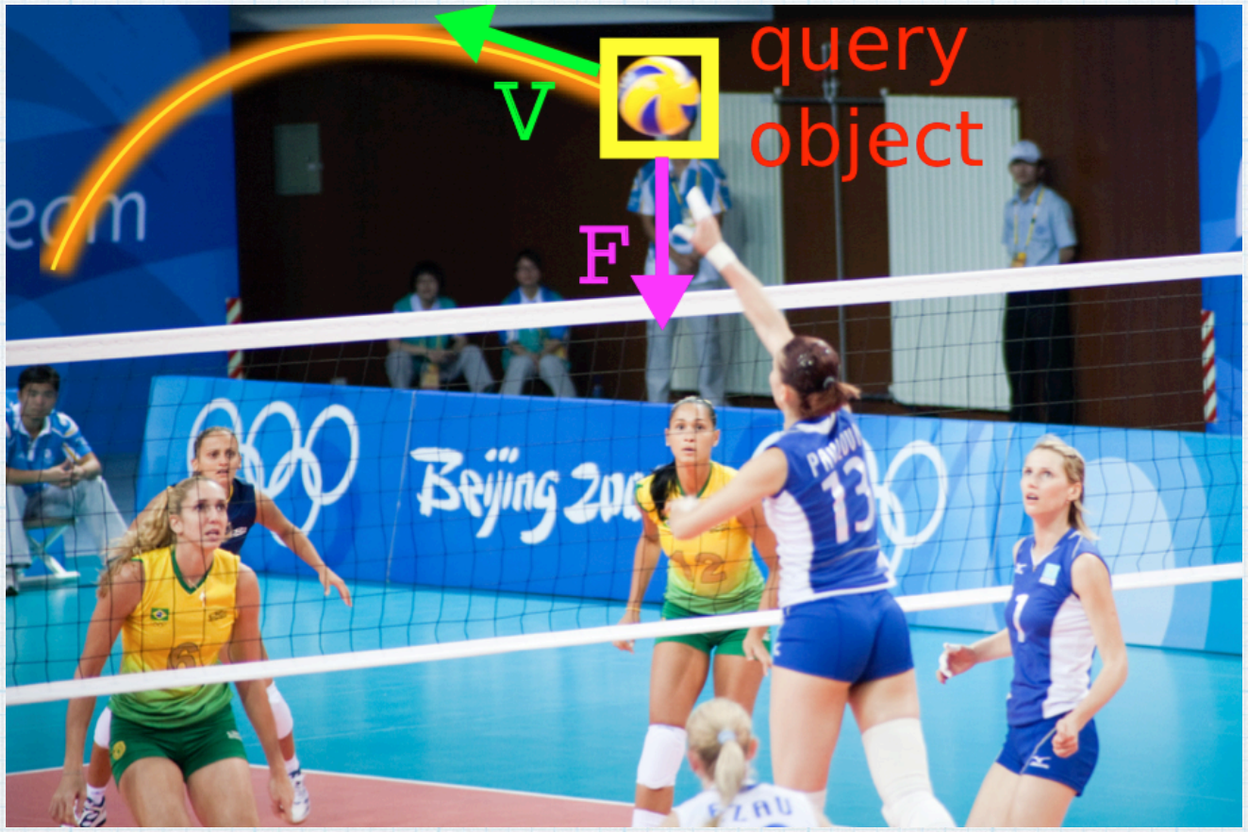
Another Example



Is the scene titled as initial observation is stable or not?

*ShapeStacks: Learning Vision-Based Physical Intuition for Generalised Object Stacking

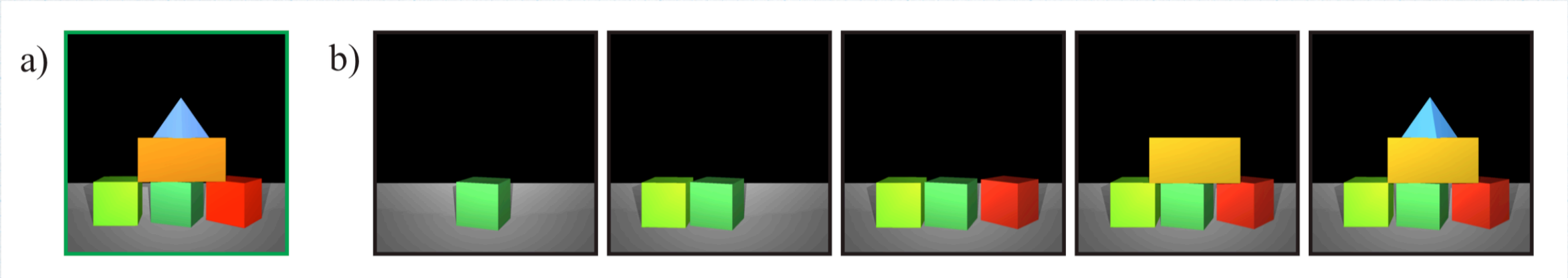
Another Example



Can you estimate the motion path of a specific object under seen in a single image under different forces?

*Newtonian Image Understanding: Unfolding the Dynamics of Objects in Static Images

Another Example

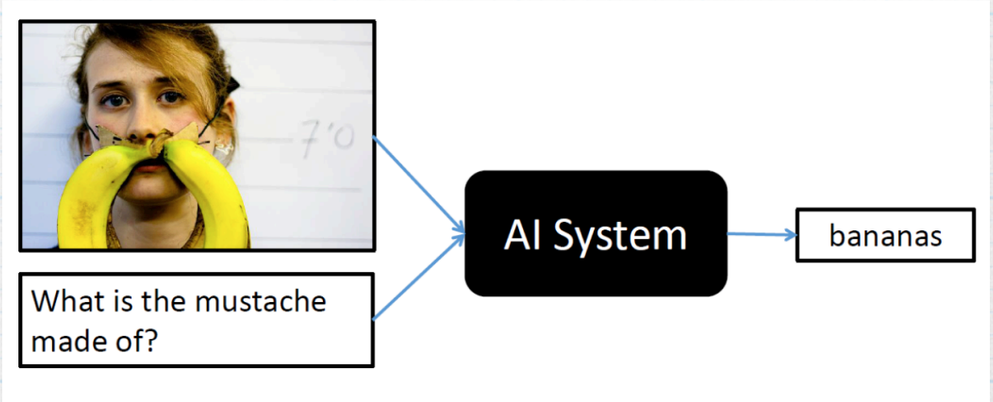


Given an initial observation can you predict how it is constructed?

*Reasoning About Physical Interactions With Object-Oriented Prediction and Planning

Visual Question Answering

- Given a visual (video or image) and a question in a textual format, model tries to give an answer by understanding the content of the image.



Visual Question Answering

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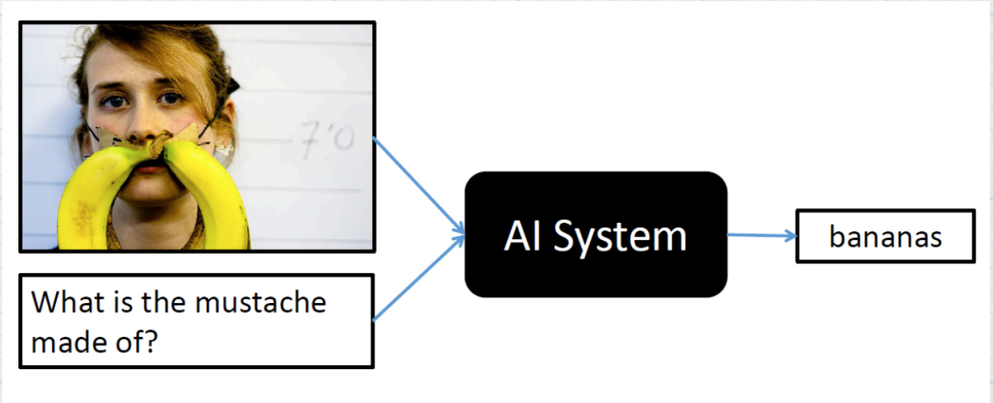

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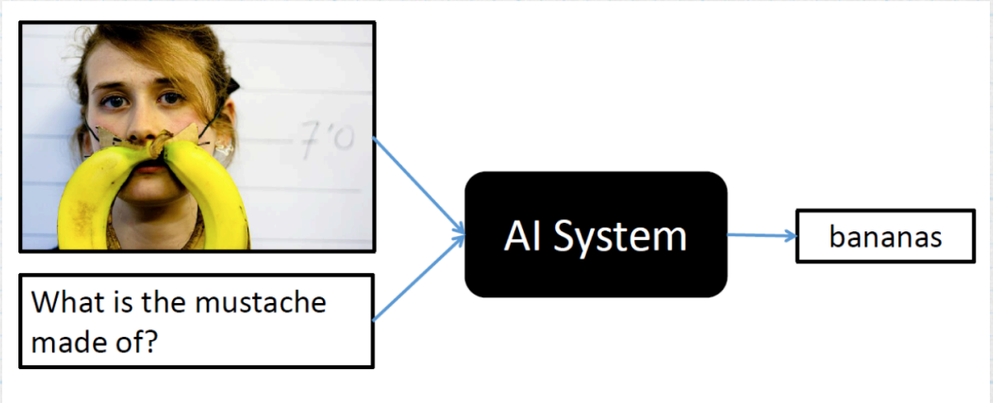
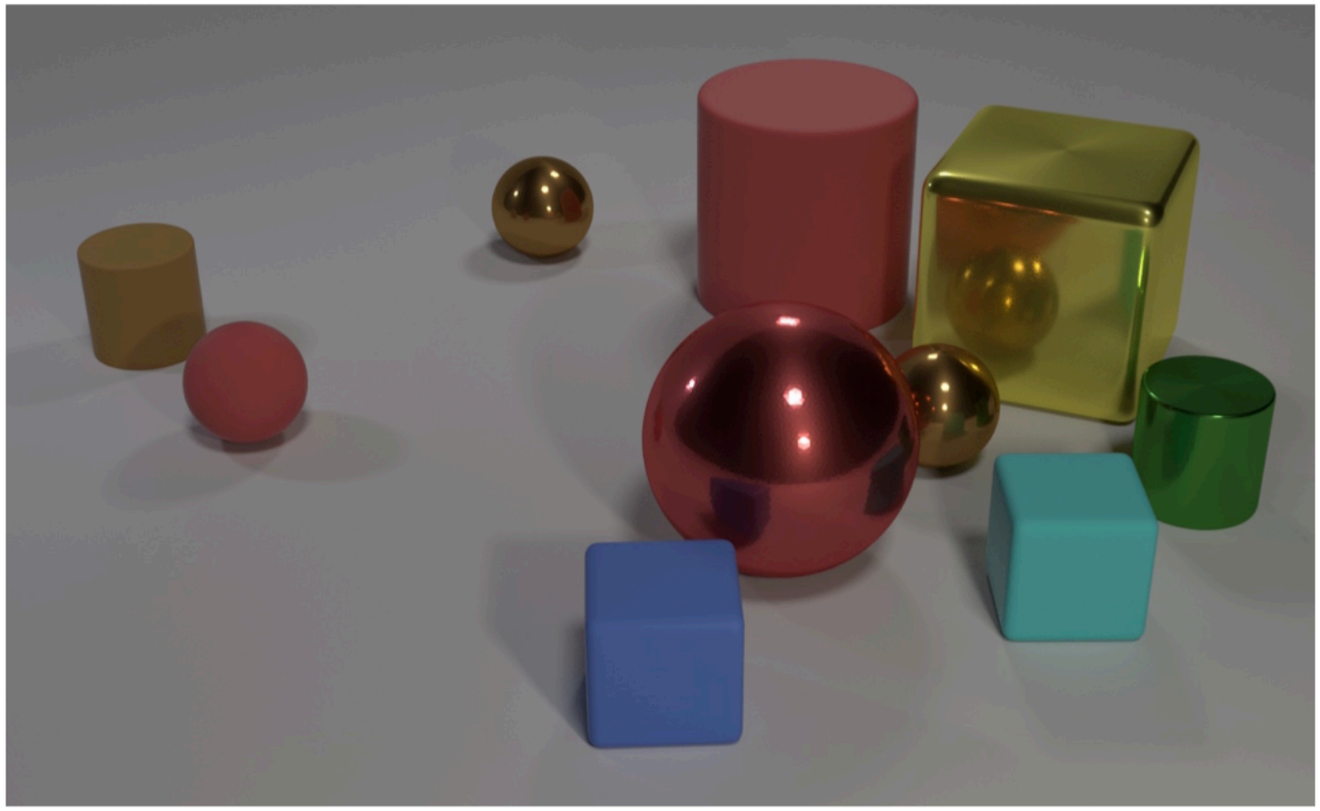
- Several datasets with different question types are introduced to evaluate the performances of current state-of-the-art.



CLEVR



Q: Are there an equal number of large things and metal spheres?
Q: What size is the cylinder that is left of the brown metal thing that is left of the big sphere? **Q:** There is a sphere with the same size as the metal cube; is it made of the same material as the small red sphere?
Q: How many objects are either small cylinders or metal things?

Figure 1. A sample image and questions from CLEVR. Questions test aspects of visual reasoning such as attribute identification, counting, comparison, multiple attention, and logical operations.

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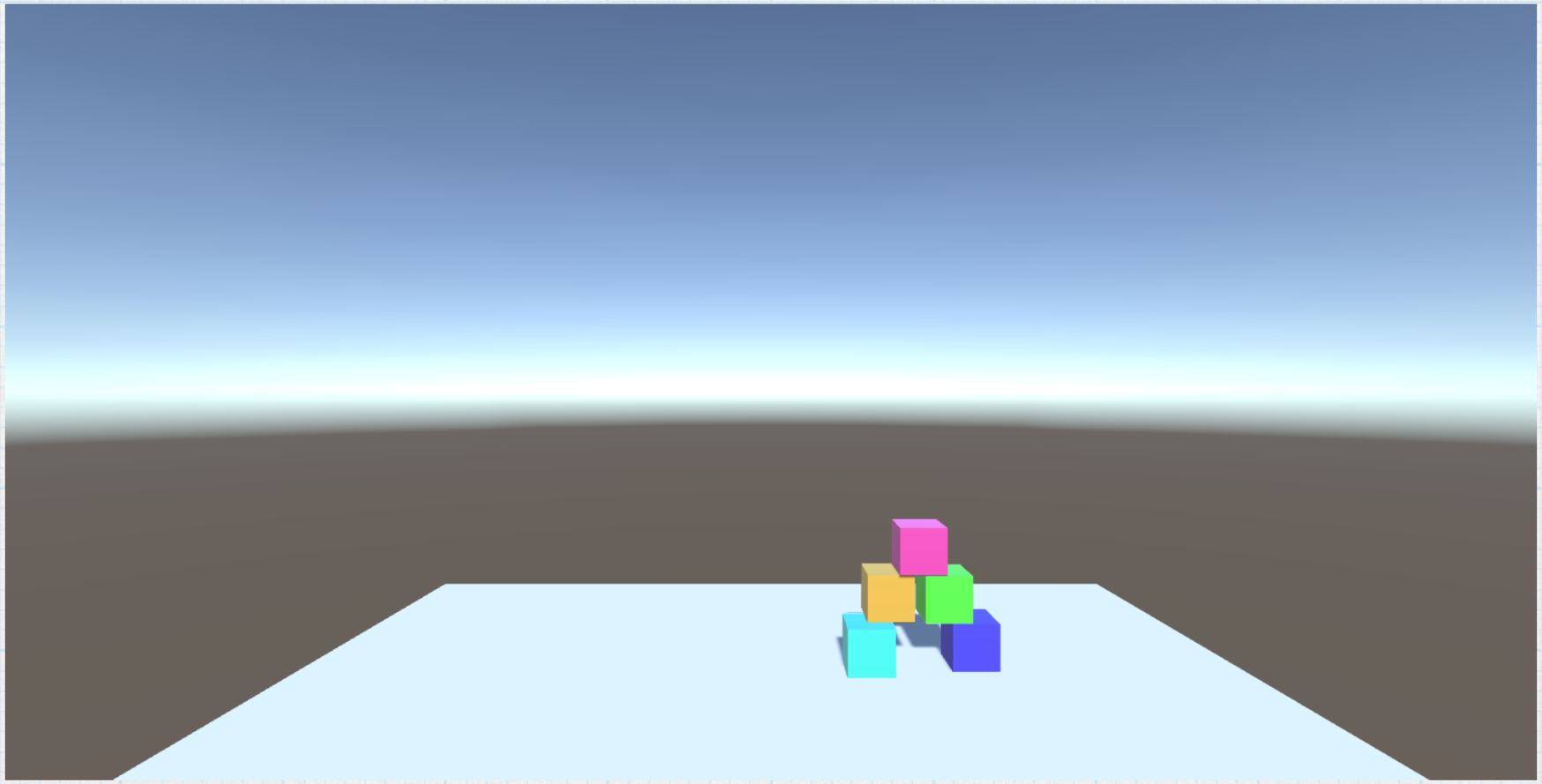
- Besides the model that is capable of simulating such intuitions, we will output a VQA dataset for further improvements.

An Example Question in Intuitive Physics



If I remove the object which just on top of blue object, does the object with orange color move?

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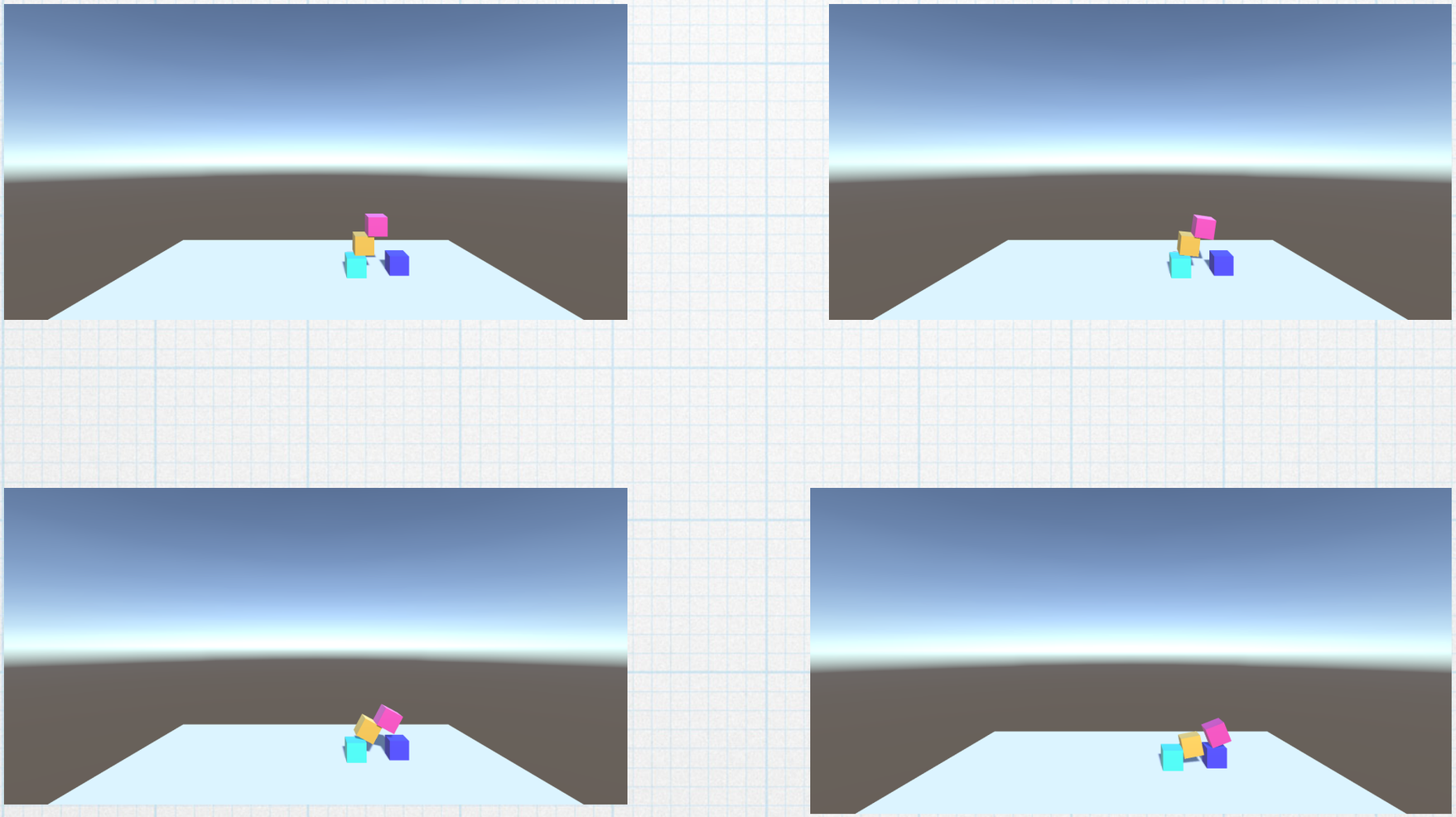
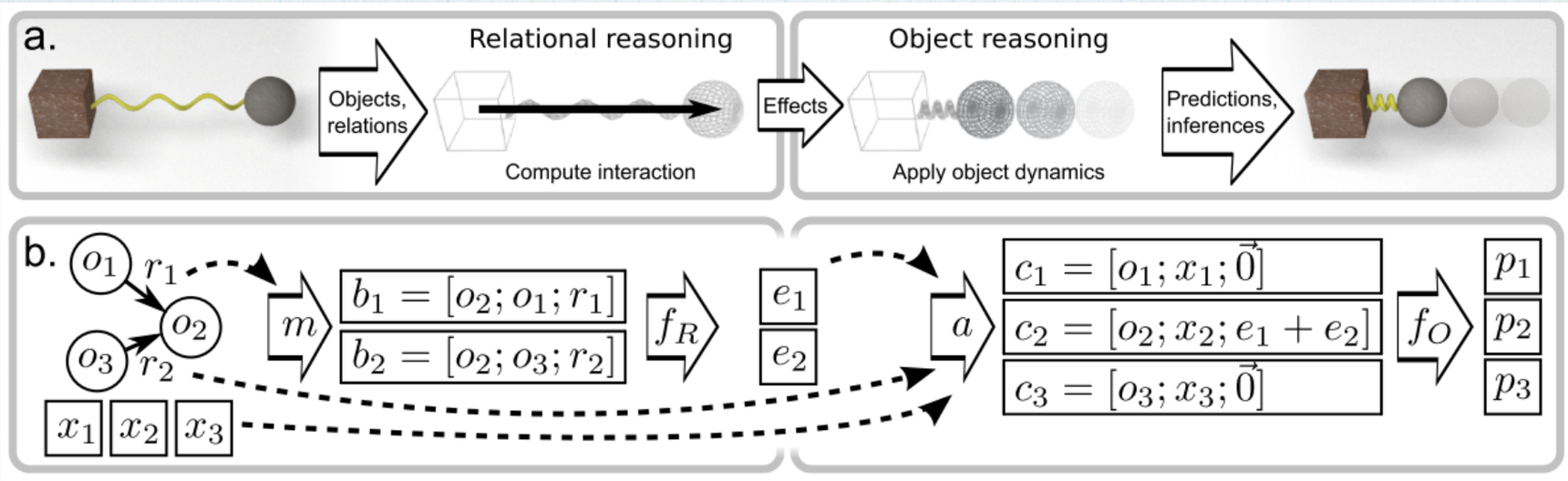


The answer should be: YES.

Future State Prediction in Intuitive Physics (1)

✳Interaction Networks for Learning about Objects, Relations and Physics



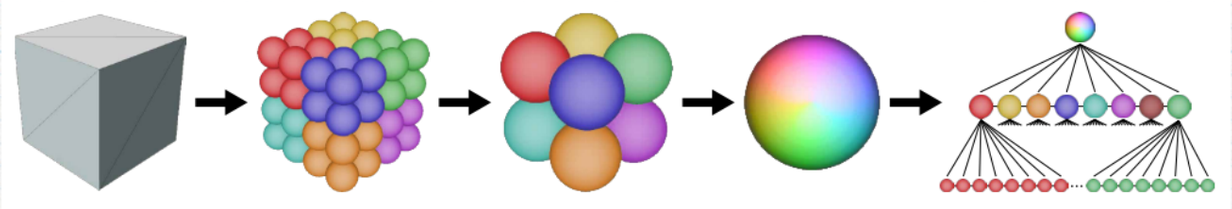
✳Take objects and their relations as an input **graph**

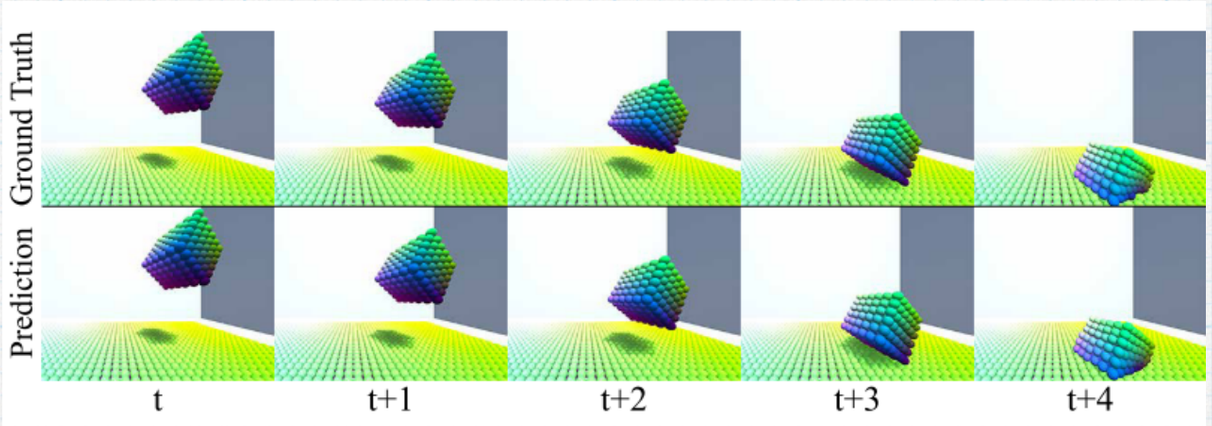
✳Compute interactions and effects via a **relational** model

✳Predict how the interactions and dynamics influence the object

Future State Prediction in Intuitive Physics (2)

✳Flexible Neural Representation for Physics Prediction





✳A hierarchical **particle-based** object representation

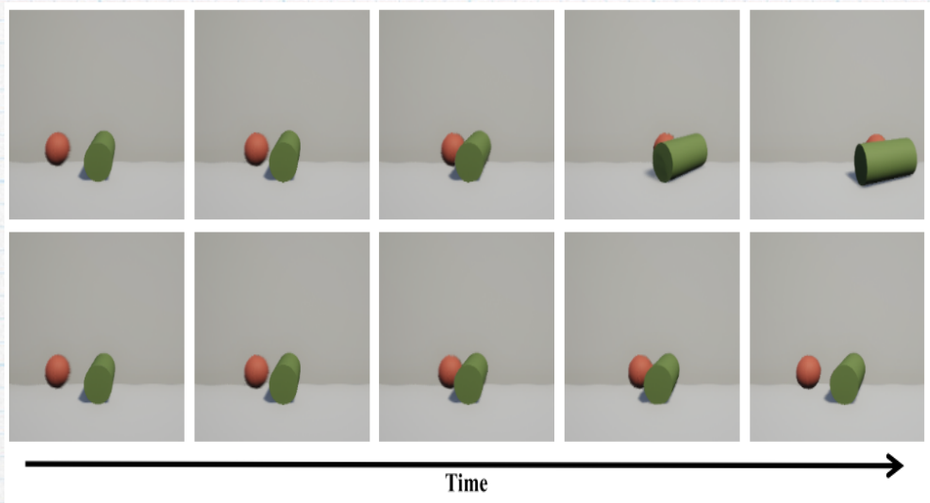
✳For rigid and deformable bodies

✳A hierarchical graph convolution to predict physical dynamics

✳The task is to predict the future physical states

Future State Prediction in Intuitive Physics (3)

✳Interpretable Intuitive Physics Model



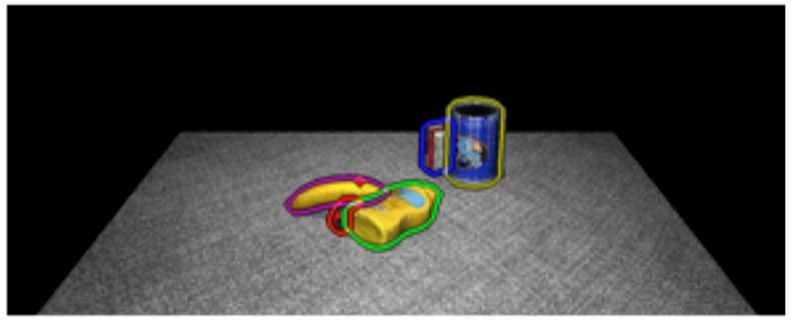
✳Built and intuitive physics model with a focus on interpretability

✳Not an end-to-end model with black-box physics representations

✳Specific vectors in the model represent specific physical parameters (mass, friction and speed)

✳Accomplished via specific training strategies

Answering visual what-if questions: from actions to predicted scene descriptions

 2) "the robot spins the screw driver in anti-clowise direction" — what happens to the mustard container?	**Ground Truth** "the screw driver pushes the mustard container" **Human Baseline** "the mustard conatainer moves a little due to the impact of spinning screw driver" **Hybrid Model Prediction** "the screw driver pushes the mustard container" **Data-Driven Prediction** "the mustard container shakes a little from the impact"

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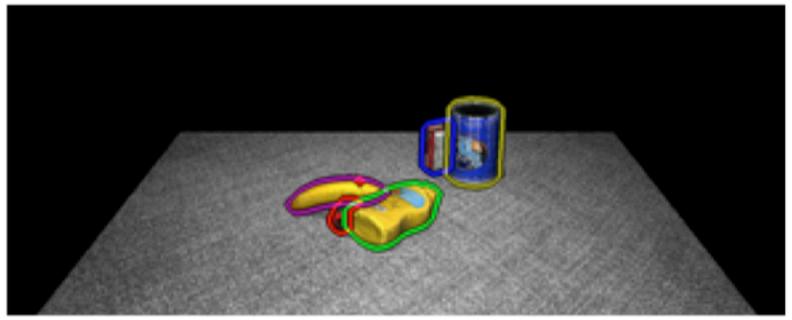 2) "the robot spins the screw driver in anti-clowise direction" — what happens to the mustard container?	**Ground Truth** "the screw driver pushes the mustard container" **Human Baseline** "the mustard conatainer moves a little due to the impact of spinning screw driver" **Hybrid Model Prediction** "the screw driver pushes the mustard container" **Data-Driven Prediction** "the mustard container shakes a little from the impact"

✳Set of actions: 1. Push an object in a specific direction. 2. Rotate an object clockwise or anti-clockwise. 3. Remove an object from the scene. 4. Drop an object on another object.

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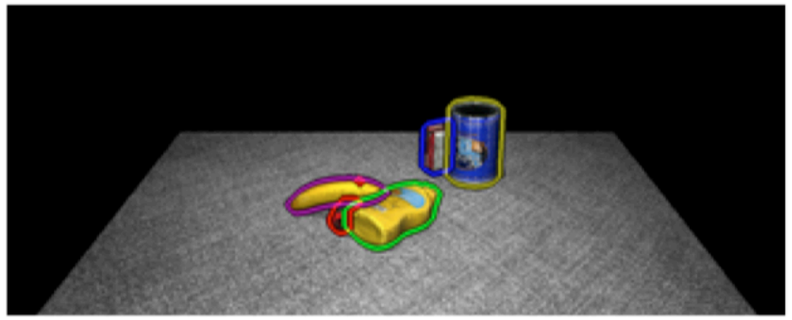 2) "the robot spins the screw driver in anti-clowise direction" — what happens to the mustard container?	**Ground Truth** "the screw driver pushes the mustard container" **Human Baseline** "the mustard conatainer moves a little due to the impact of spinning screw driver" **Hybrid Model Prediction** "the screw driver pushes the mustard container" **Data-Driven Prediction** "the mustard container shakes a little from the impact"

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- Single type questions: If I do …, what happens to …?

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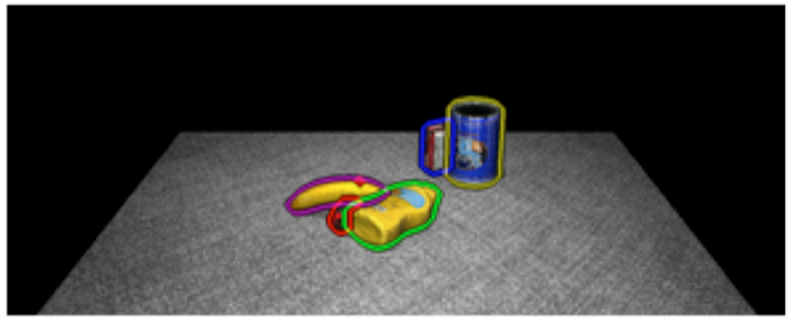 2) "the robot spins the screw driver in anti-clowise direction" — what happens to the mustard container?	**Ground Truth** "the screw driver pushes the mustard container" **Human Baseline** "the mustard conatainer moves a little due to the impact of spinning screw driver" **Hybrid Model Prediction** "the screw driver pushes the mustard container" **Data-Driven Prediction** "the mustard container shakes a little from the impact"

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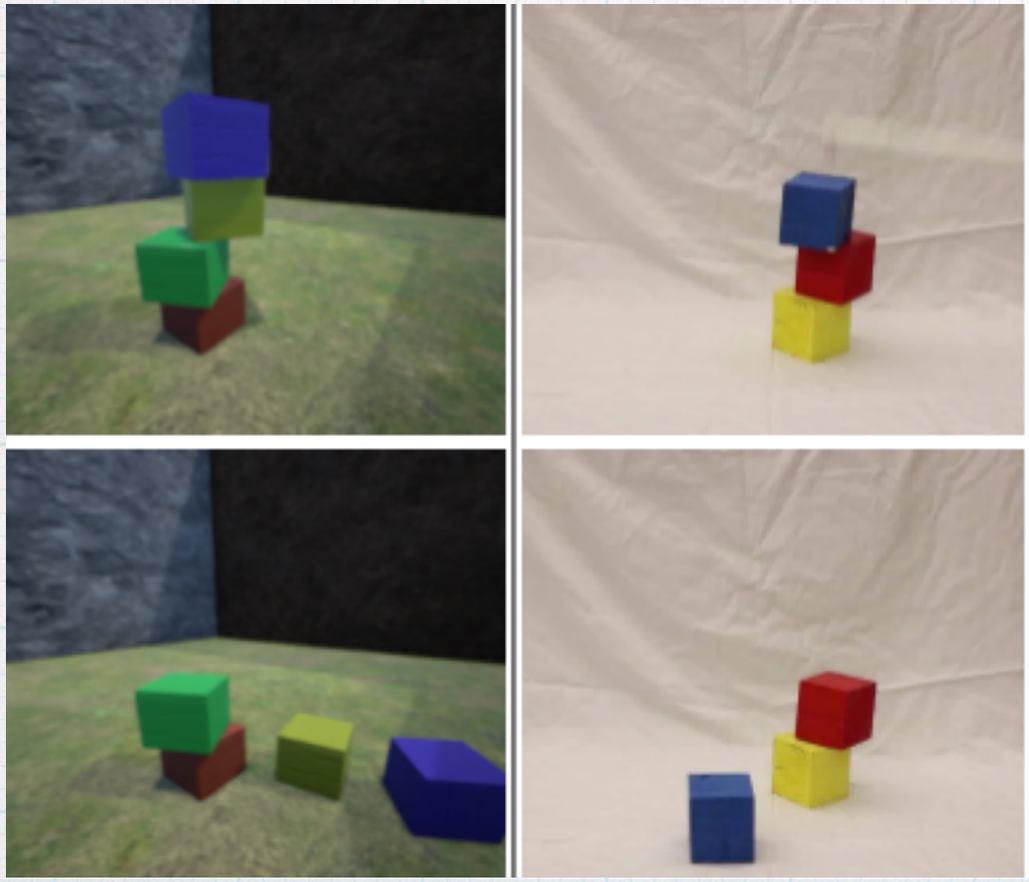
- A hybrid model using a physics engine

Dataset



	Synthetic	Real
Number of Blocks	2,3,4	2,3,4
FPS	8 frames/sec	at 60 frames/sec
Count	180,000 stable and unstable simulations	493 stable and unstable simulations

- "Learning Physical Intuition of Block Towers by Example"
- Block tower examples from synthetic (left) and real (right) datasets. The top and bottom rows show the first and the last fames, respectively
- There are other datasets that are used in the methods mentioned for different tasks. However, this one is the closest one until we generate our own VQA dataset

Design

- We will consider the future state prediction task while creating a VQA dataset in parallel

- Our scenes will have interaction objects of different shapes and physical properties

- We will only consider rigid objects (non-deformable)

- For scene generation, we will use Unity as the physics engine. For question generation, we will follow a similar path with CLEVR. For model generation, we will start by investigating the shortcomings of current architectures in detail.