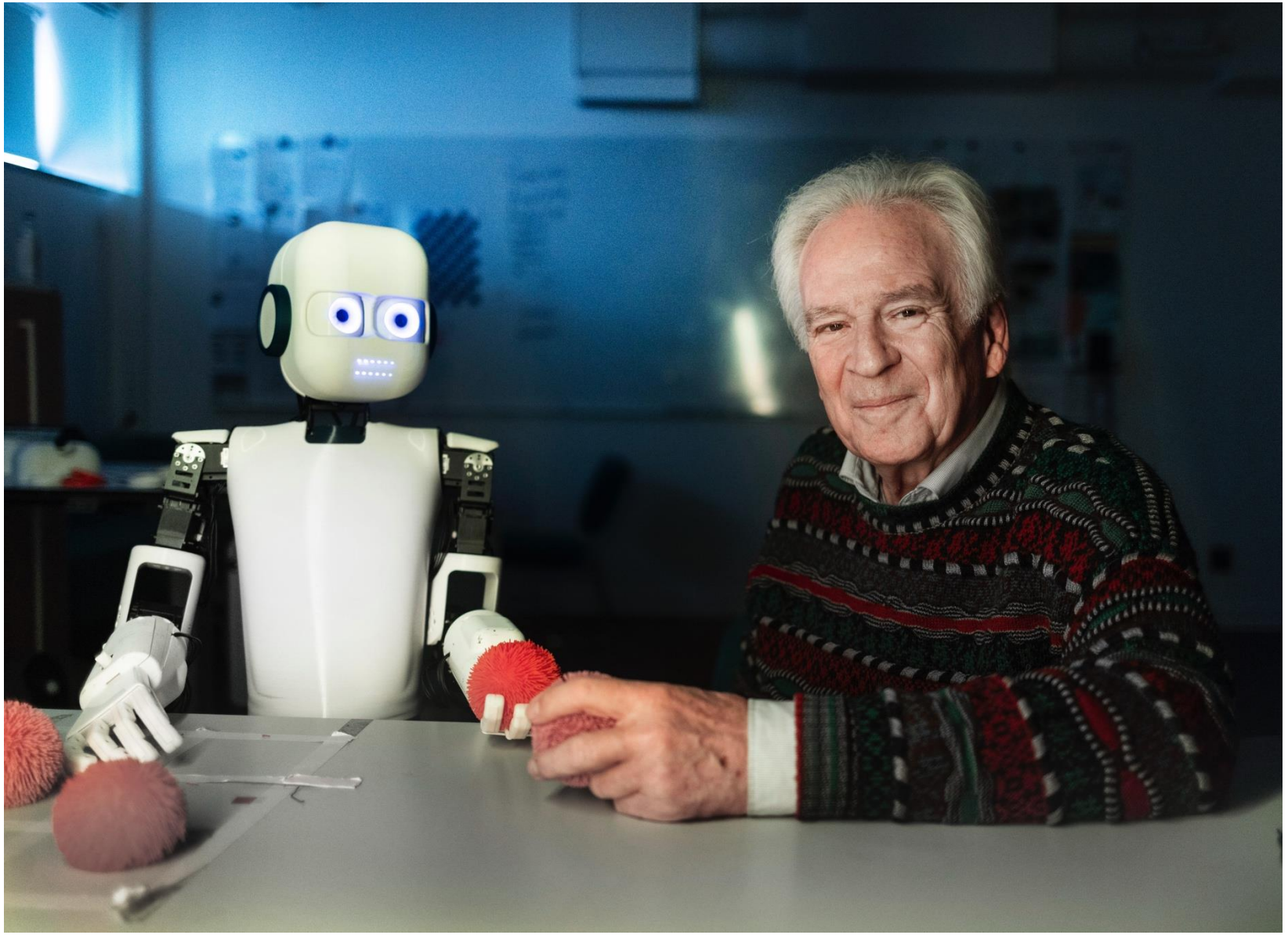
Peter Gärdenfors

How can robots generalize actions?

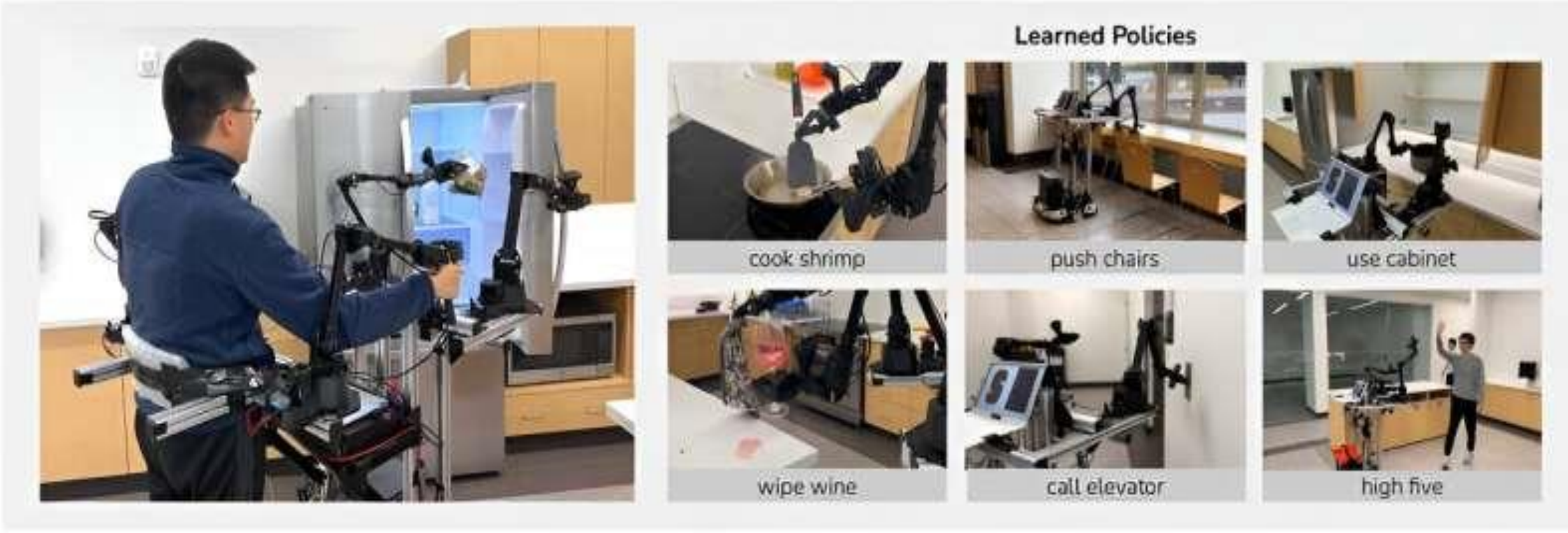
Epi

The friendly Robot

(built by Christian Balkenius och Birger Johansson)



Aloha: The kitchen robot

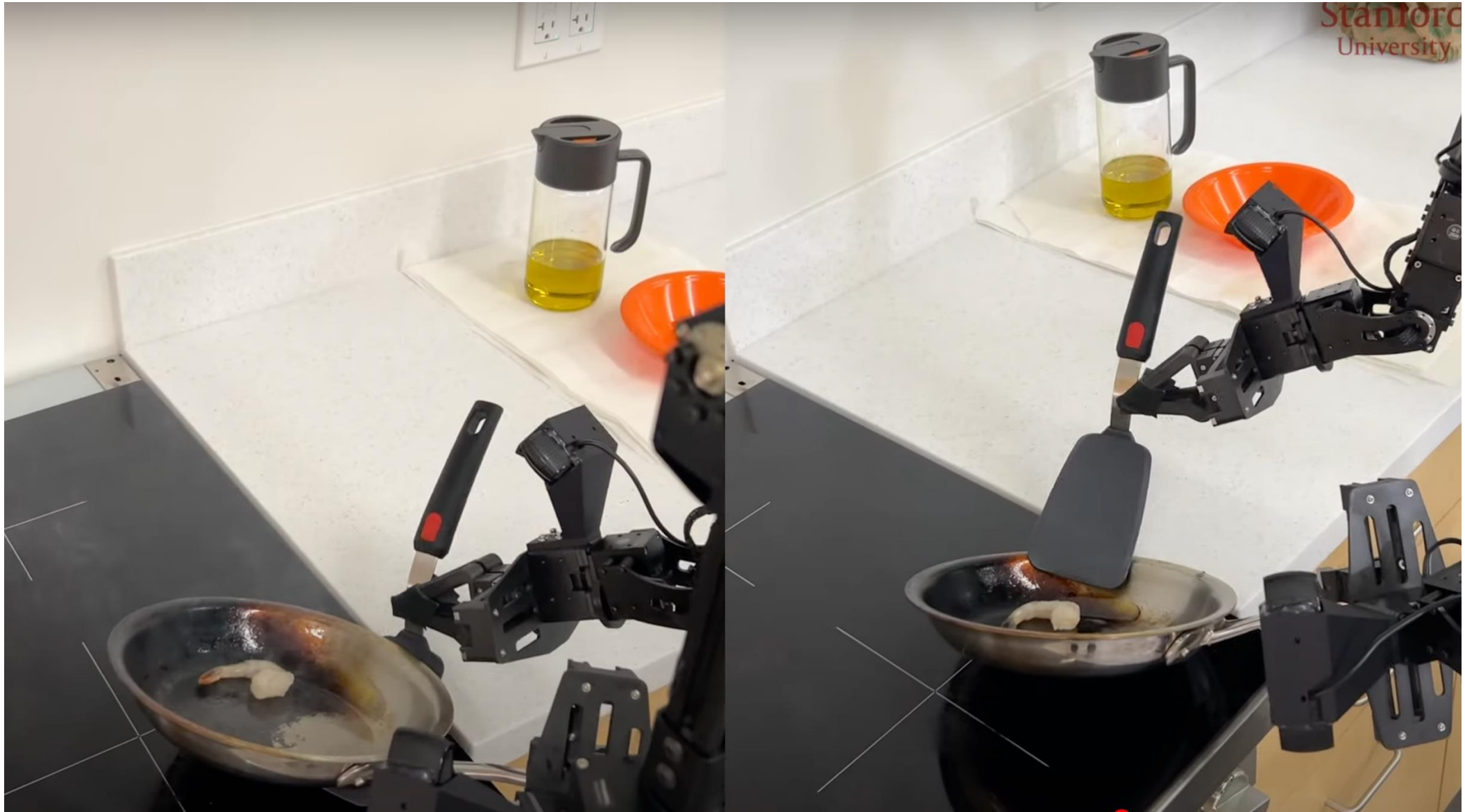


The robot is trained by repeated demonstrations and is supposed to generalize


Cook Shrimp
(autonomous)
3x speed
Stanford
University


Stanford
University

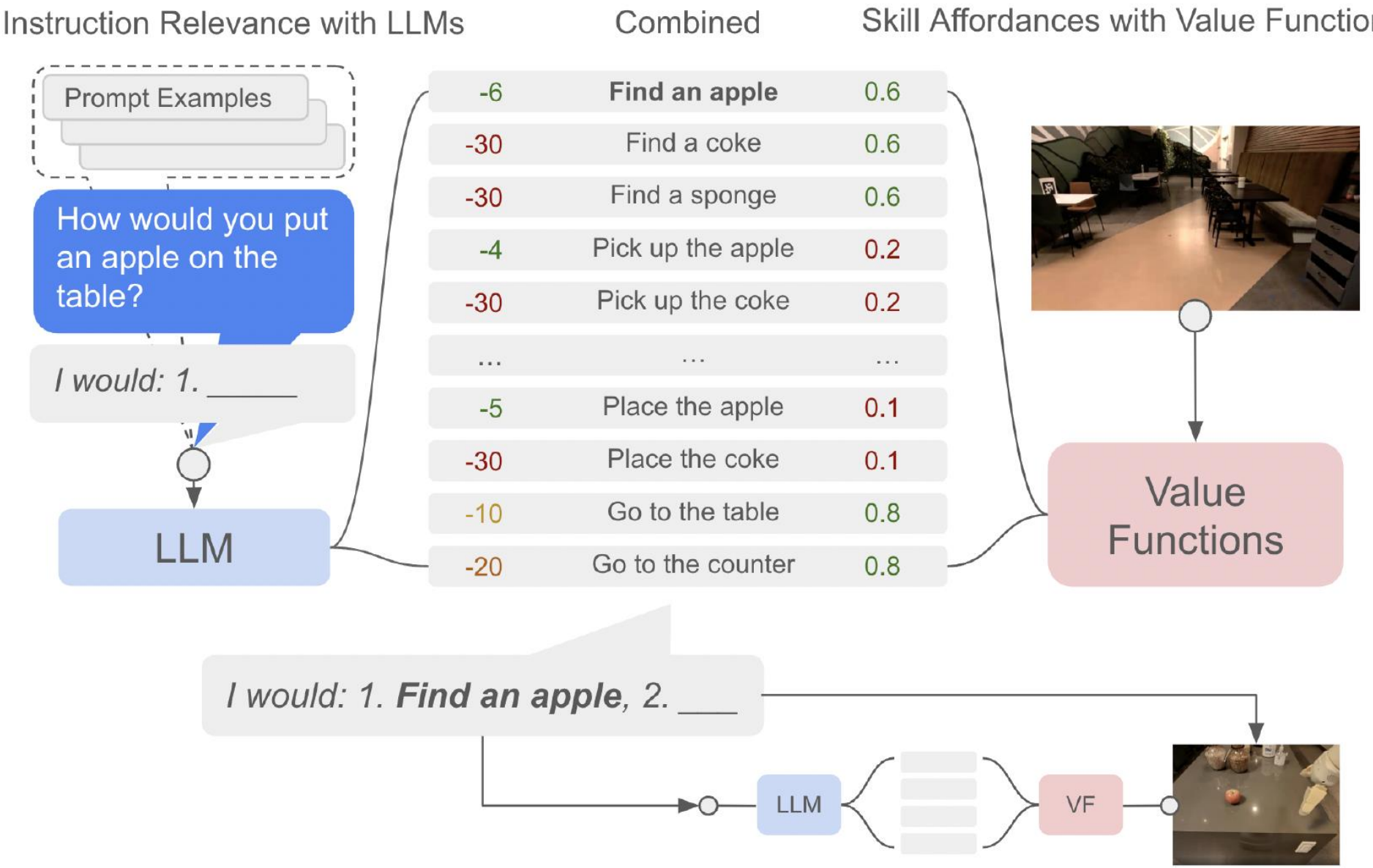
A child would not make this kind of mistake



PALM Say-Can

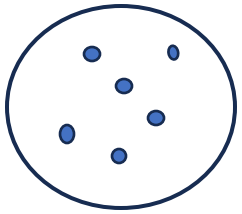
SayCan uses an LLM to generate a plan

SayCan has a limited repertoire of basic actions

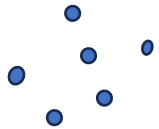


Small ”islands” of action space are pretrained

Pick up apple



Pick up coke



Pick up bucket

?

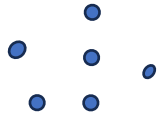
Pick up pen

?

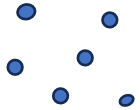
Pick up blanket

?

Put down apple



Put down coke



Put down bucket

?

Put down pen

?

Put down blanket

?

Push apple

?

Push coke

?

Push bucket

?

Push pen

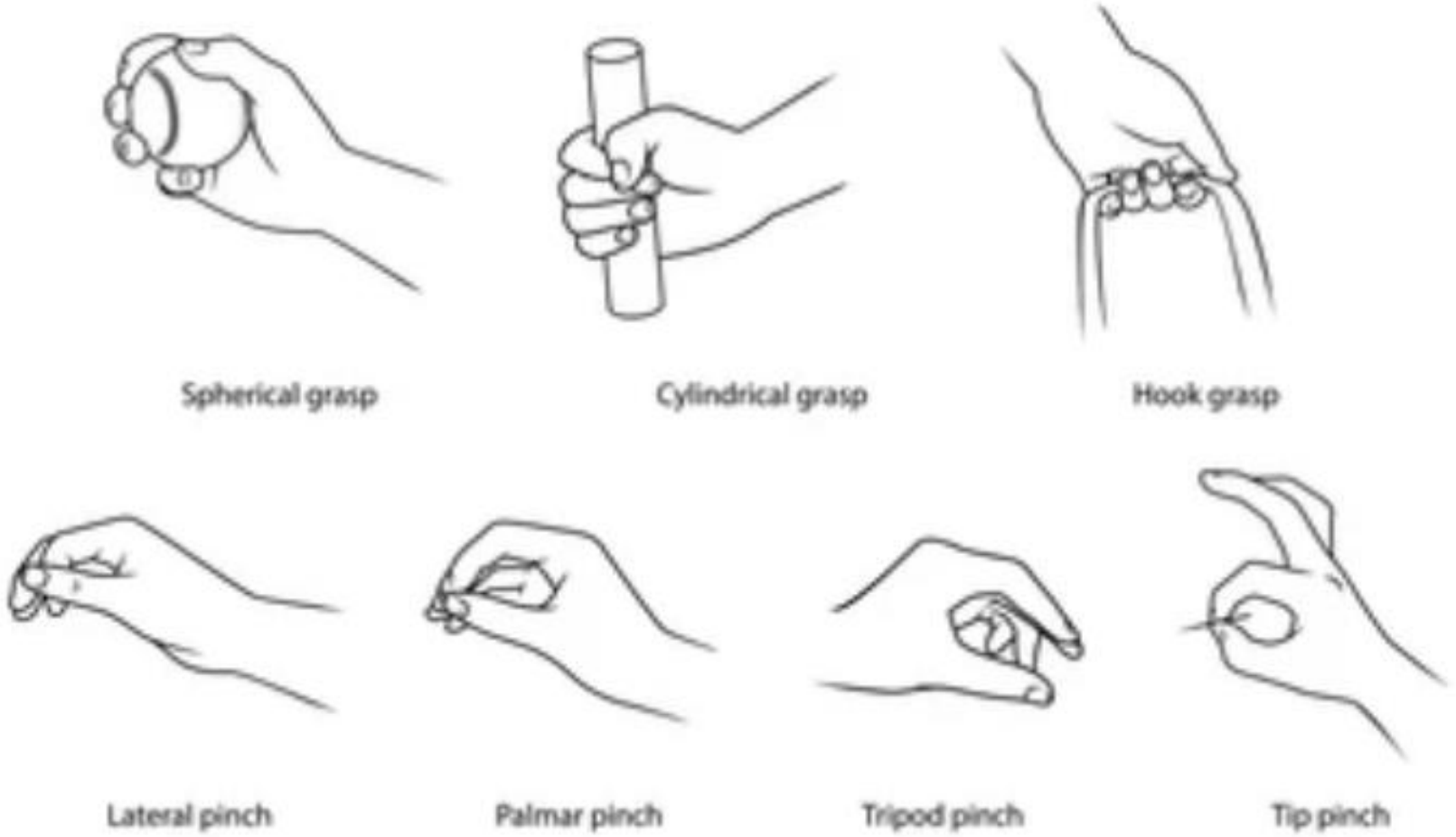
?

Push blanket

?

What is the *structure* of the action space?

SayCan cannot generalize to other forms of ”picking up”

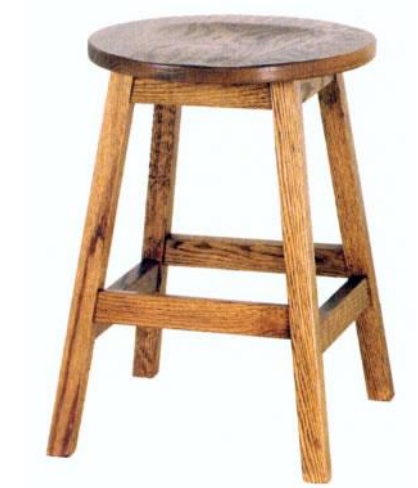


Humans perceive the *affordances* of different objects and adjust their action to them

Articulated objects (Abhinav Valada) tell the robot *where* to interact but not *how* (Roberto Calandra’s examples)

Affordances

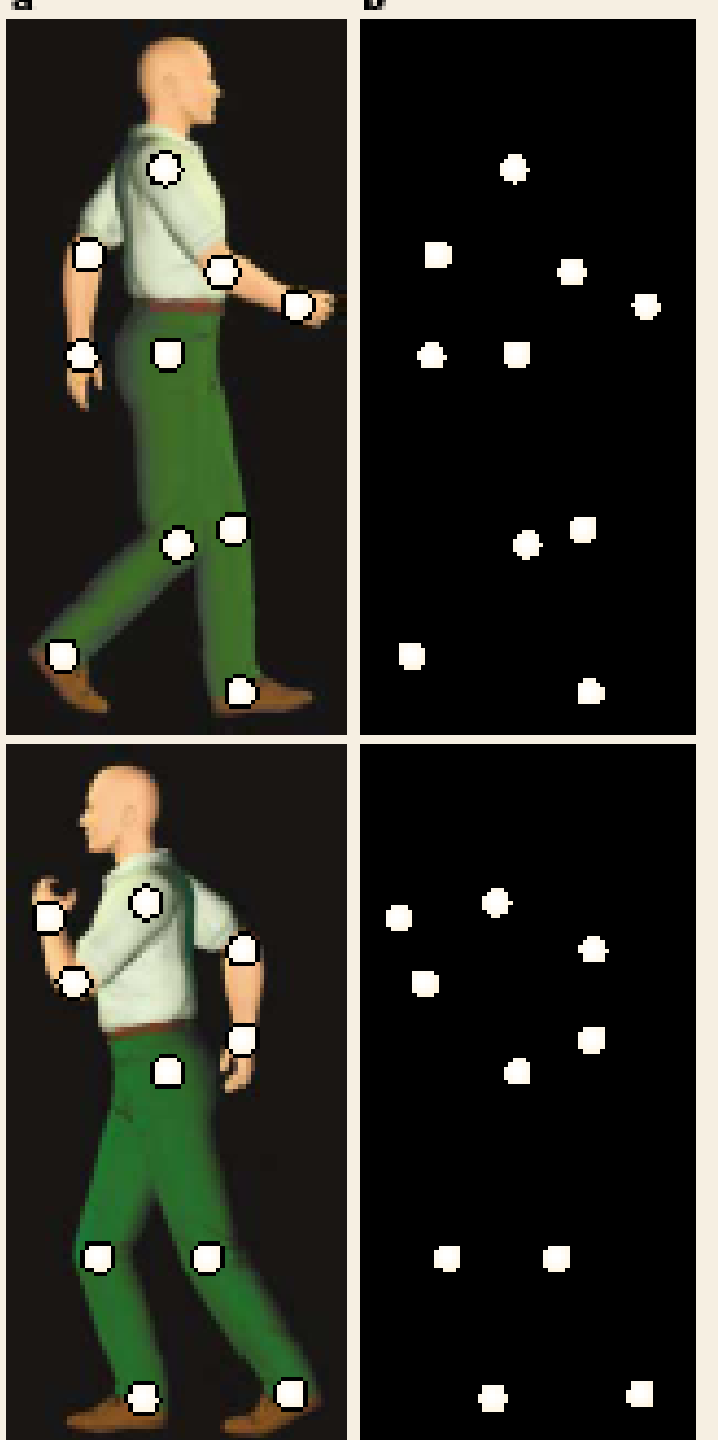
What you can do with an object in a given siituation



- What is the difference between a stool, a chair and a sofa?
- **The function of an object consists of the set of *actions* that can be performed with the object**

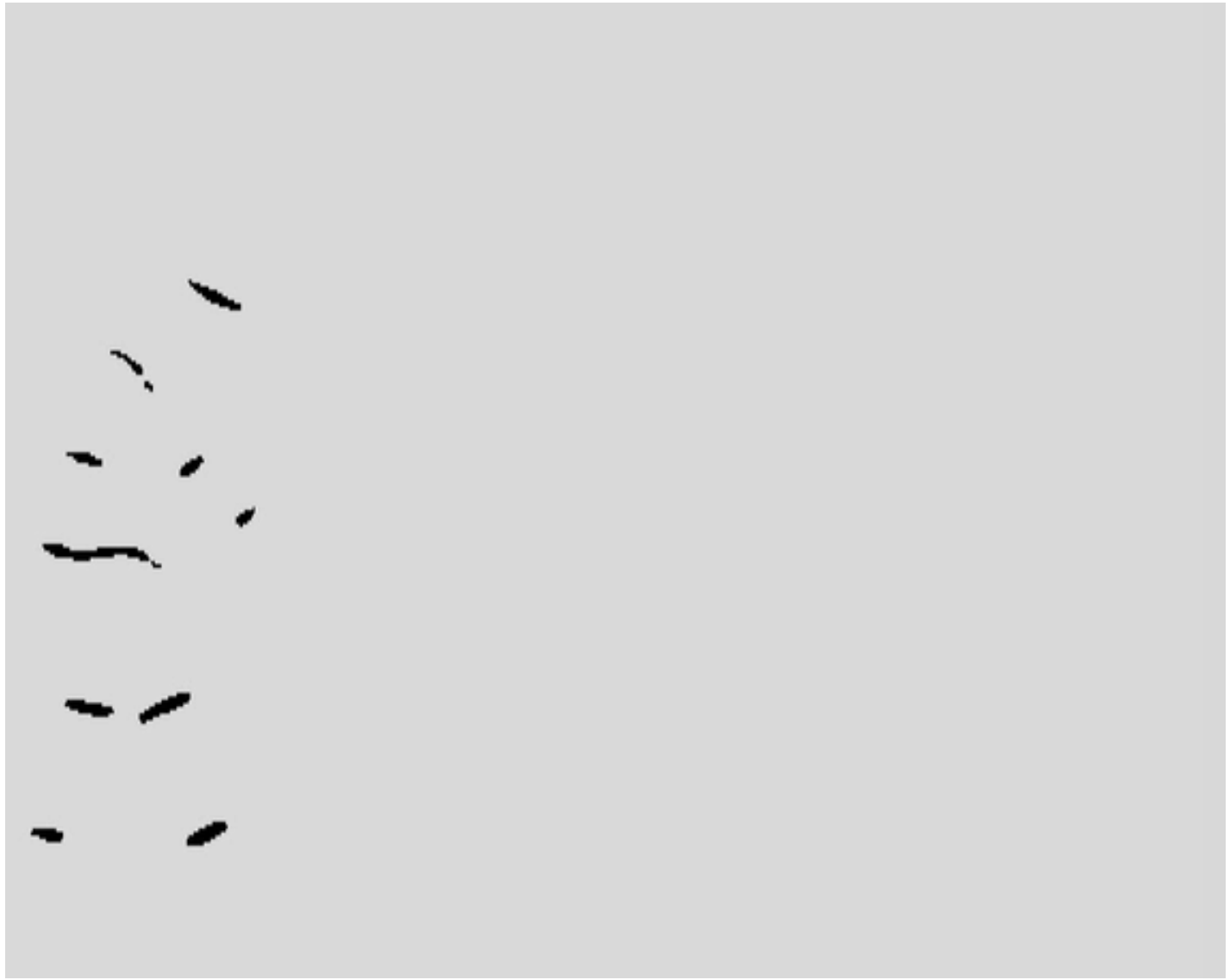
Actions

- How do human recognize and categorize actions?



Gunnar Johansson’s patch-light technique for analysing motion perception

Humans are excellent at recognizing actions



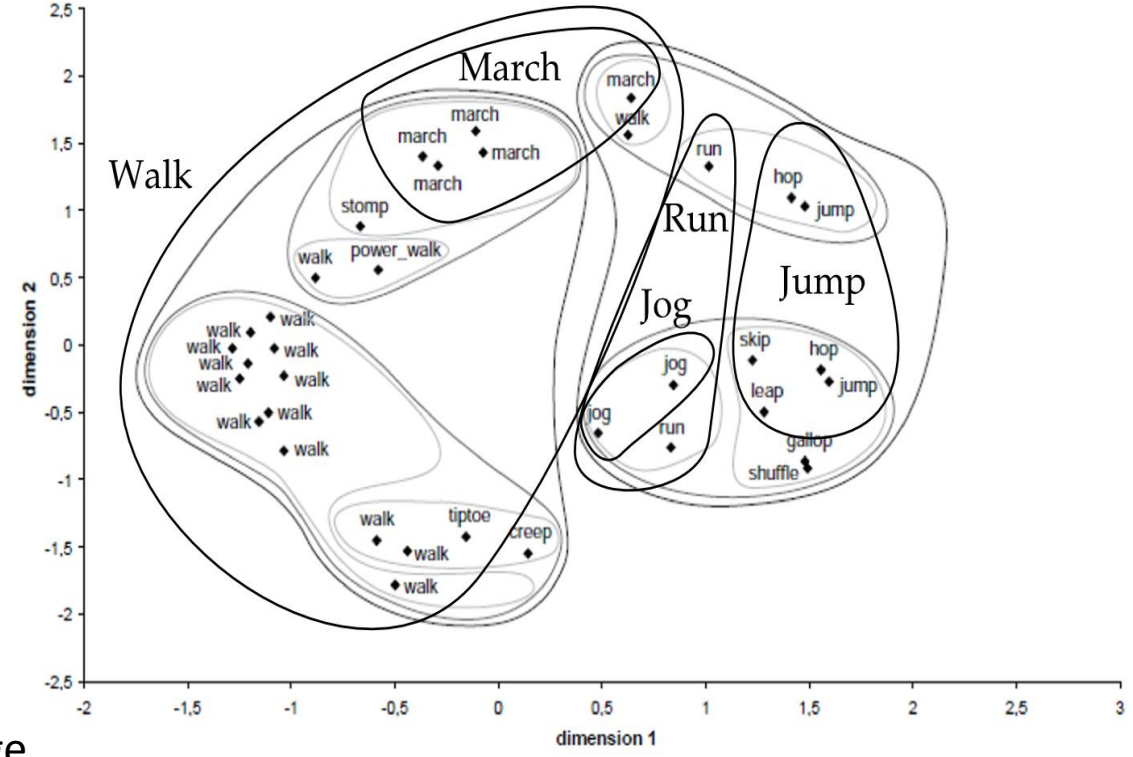
From the Ph.D. work of Paul Hemeren

Kinematic specification of dynamics (Runesson)

The kinematics of a movement contains sufficient information to identify the underlying *dynamic force patterns*

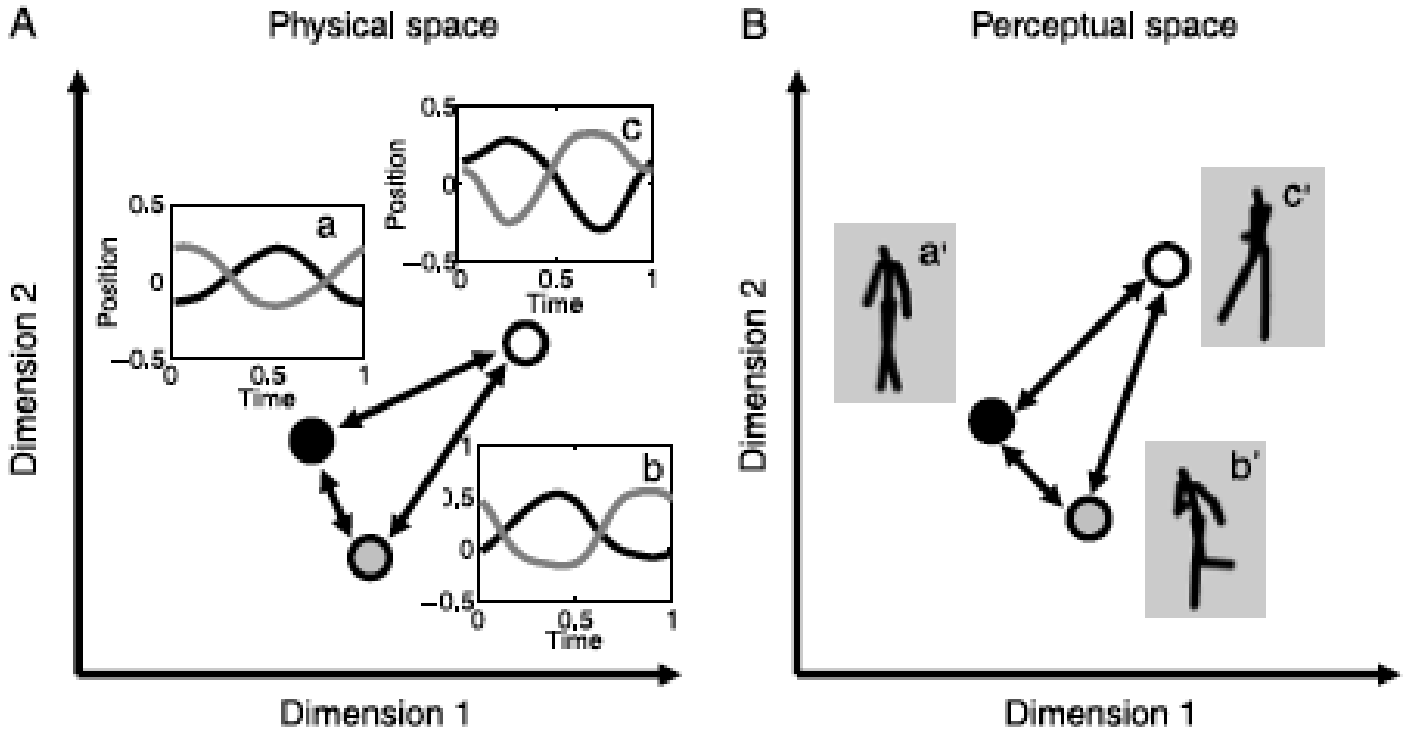
Representational thesis for actions

- **We recognize and categorize an action by the *pattern of forces* that generates it**
- Actions are more or less *similar* and show prototype effects
- An *action concept* is a convex region in the space of force patterns
- Gärdenfors: *Conceptual Spaces*: *The Geometry of Thought*, MIT Press 2000.



Malt et al. 2014, J. of Memory and Language

Mapping physical space to action space



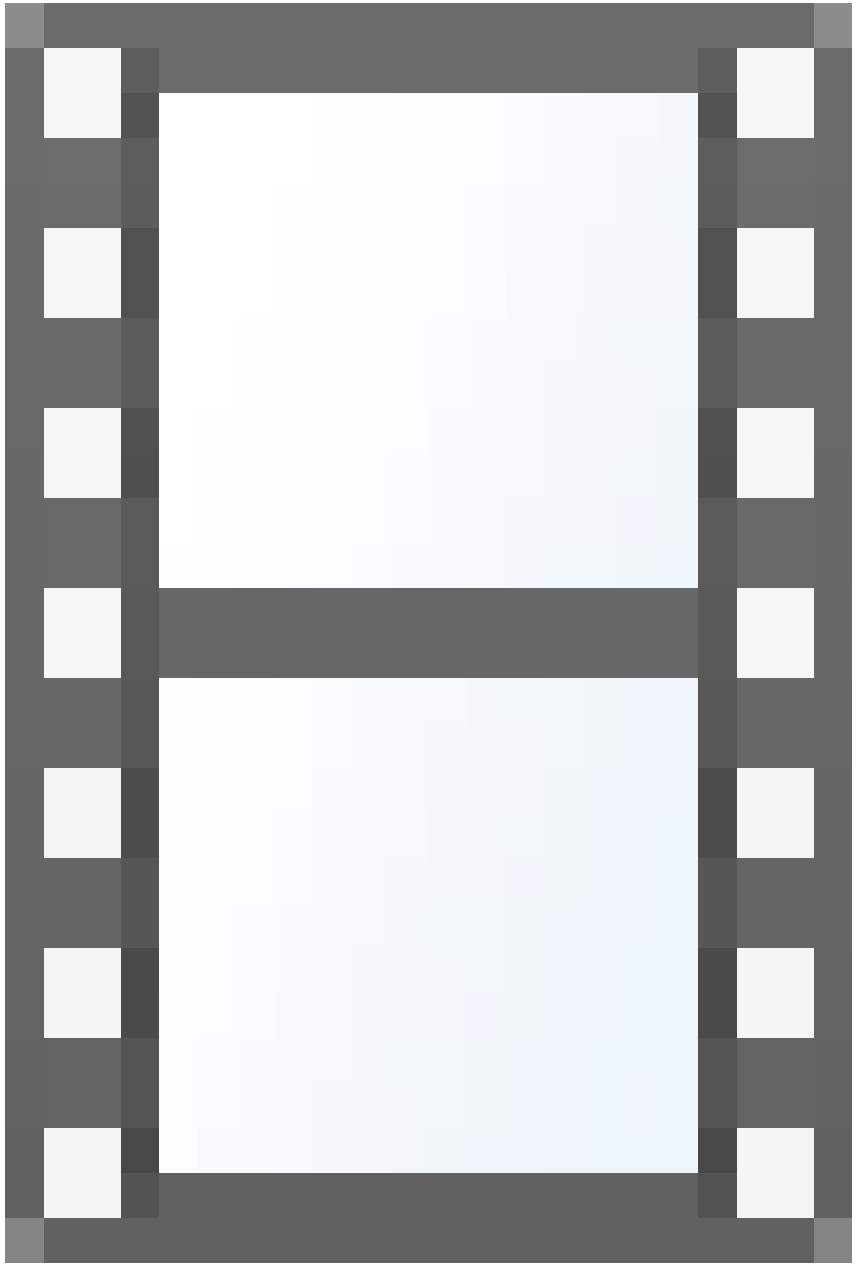
By F = m·a, taking the second derivative of positions gives force patterns

(Justus Piater only uses first derivative of location)

Giese, Thornton & Edelman (2008)

Real time action identification

From
Zahra Gharaee's
Ph.D. work



Gharaee, Gärdenfors & Johnsson "First and second order dynamics in a hierarchical SOM system for action recognition", *Applied Soft Computing* 2017

How can basic affordances be learned?

- Children learn by practicing and playing with objects, and by imitating others (Dongheui Lee)
- Exploring the affordance space of ordinary objects
- They learn basic *causal relations* in this way
- Let robots do the same!
- **Use a force based *action space* for reinforcement learning**
- Built up from force patterns + information about object properties
- 3D position, shape, mass, scale, center of mass, friction (+ deformability) (Haozhi Qi)
- Touch and proprioception is important for information about forces (Roberto Calandra)
- Mapping from geometry of object to manipulation (Sylvain Calinon)

Peter Gärdenfors

May the force be with you!