
Learn
sketch
A/a
Focus on

The presentation for the committee of Doctoral School

Constructivist Cognitive Architecture

Jianyong XUE

Université de Lyon, LIRIS CNRS UMR5205
Université Claude Bernard Lyon 1

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Outline

- Introduction
- Research objectives
- Related work
- Research process
- Contributions
- Application scenario
- Study and training process
- Perspective
- Timeline

Introduction

- During the initial phase of cognitive development, infants exhibit amazing abilities to generate novel behaviors with unfamiliar situations and explore actively to learn the best with lacking extrinsic rewards from the environment.

- In the area of learning from interactions, it's becoming more and more accepted as viable alternative paradigm in designing a self-motivated and self-adaptive agent which like babies that can behave in a intelligent"" and flexible manner under dynamic conditions

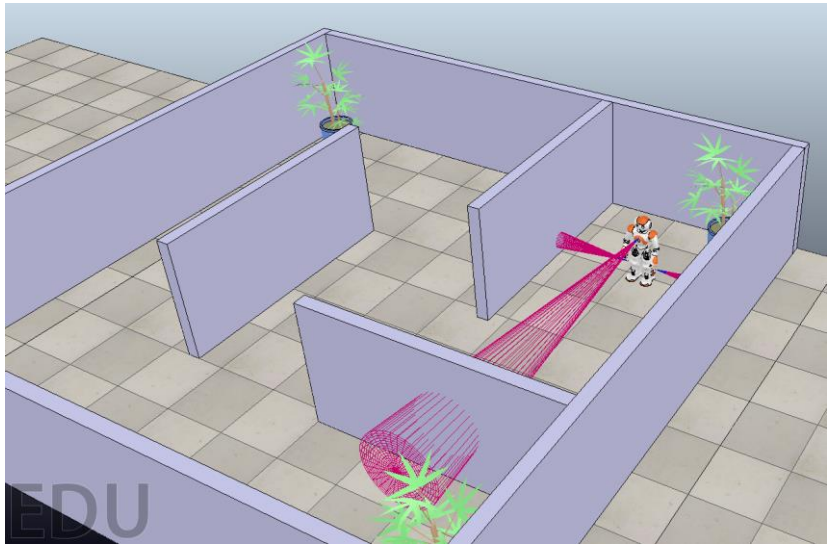
- Constructivism as a knowledge acquisition theory proposing that learning happens as a result of a internal mental representations and external perceptions from interactions.

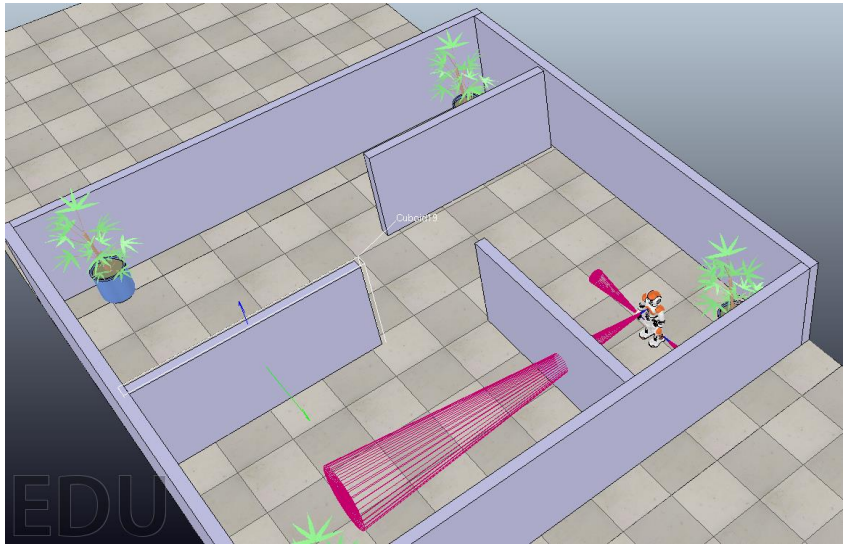
Problem definition

Imagining the following scenario:

An agent is placed in an **unfamiliar** environment, with only **innate actions** that could let it move around and interact with objects to start the journey of “feeling the world”.

Unlike other interactive scenarios that this interactive process without any **prior** knowledge, nor the final goal for the agent to achieve.





A challenge

How can we design an alternative learning paradigm that satisfies the conditions mentioned above. The agent could successfully interact with its environment and learn to avoid unfavorable interactions using regularities that it has learned.

The agent with structured behaviors it has learned from interactions obtains capabilities of self-motivated and self-adaptive that can behave in a “intelligent” and flexible manner under dynamic conditions.

Research objectives

- **Knowledge construction through interactions** between the agent and the environment. A self-motivated agent could discover and explore regularities in its stream of experiences and to construct knowledge about phenomena, which hypothetical presence in the environment explains these regularities.

- **Higher-level sequence learning with constructivist paradigm**. The agent could increasingly learn elaborated behaviors and gradually organized them in a hierarchy that reflects how the agent exploits the higher-level regularities afforded by the environment.

- **Context adaptation and generate proper behaviors**. The agent could understand current interactive situation, learn behavioral patterns for affectively generating proper behaviors or even more optimal structured behaviors for enacting.

Research goal

The short-term goal is to create new cognitive architectures which could let the agent construct their own knowledge of their environment through experience, rather than exploiting pre-coded knowledge.

The Long-term goal is that the agent could comprehend the context and have capabilities to generate proper behaviors for flexible interactions to obtain positive experiences.

Related work

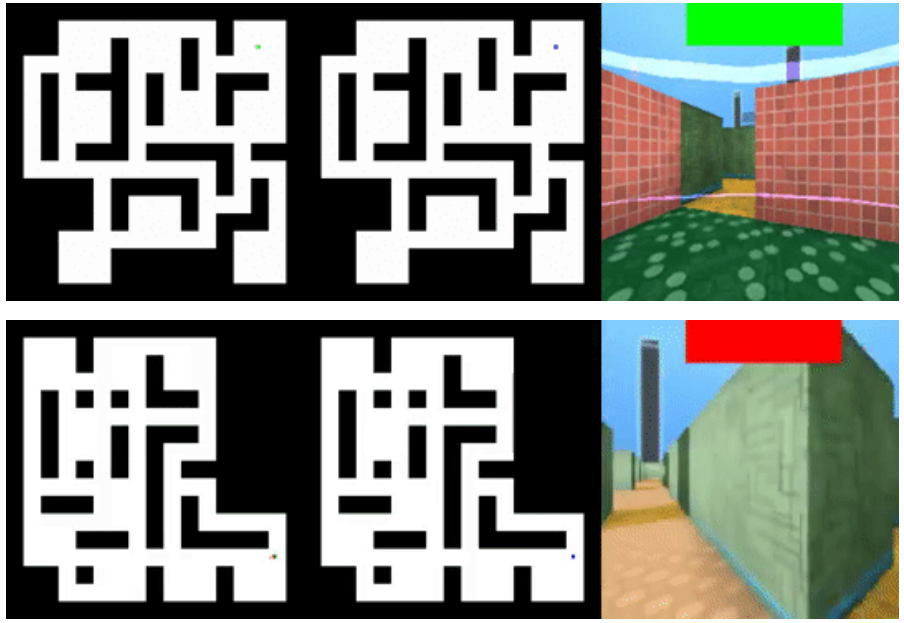


Fig. 1. Reward visualization. The results from Google and ETH's model about "Episodic curiosity through reachability".(See the link: https://ai.googleblog.com/2018/10/curiosity-and-procrastination-in.html)

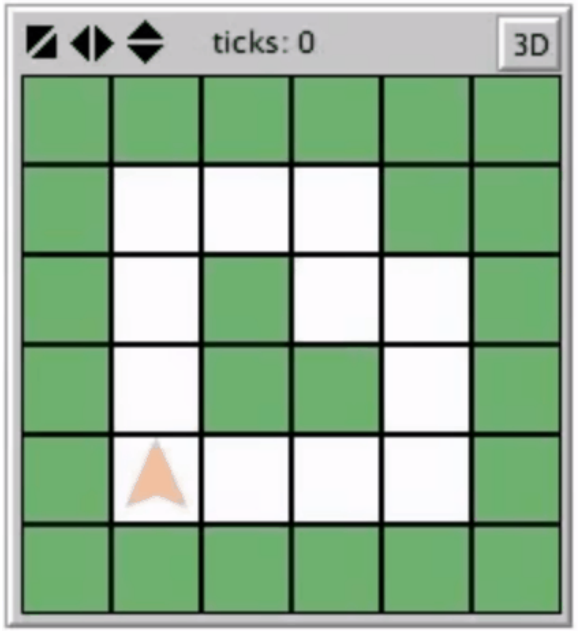
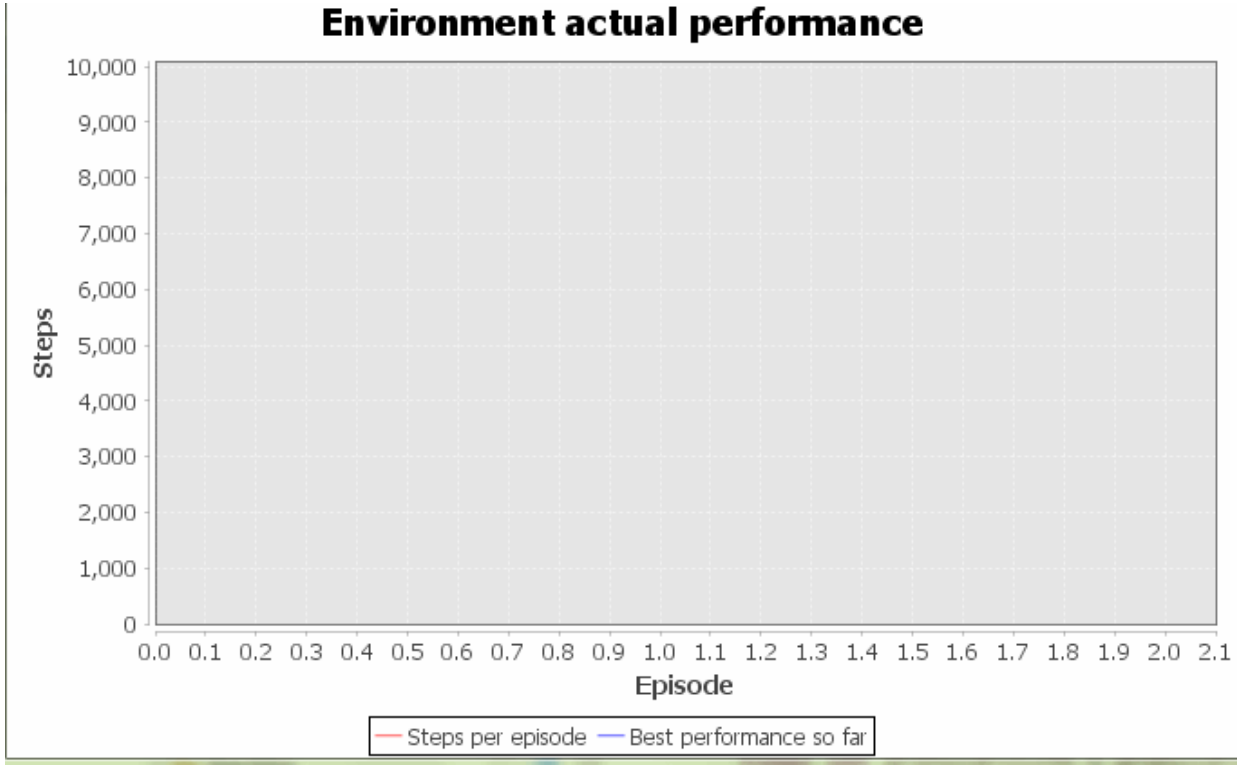
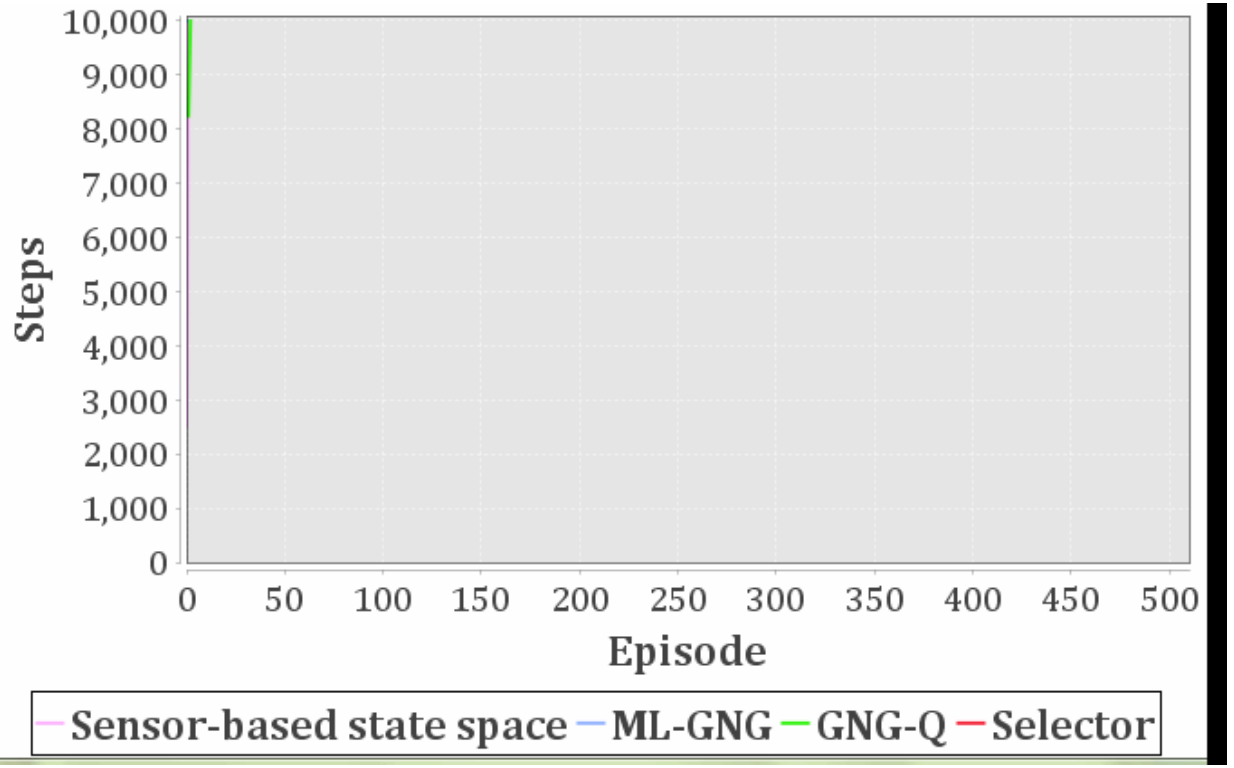


Fig. 2. Demonstration of developmental learning. This result comes from the IDEAL MOOC of Olivier Georgeon, the link is: http://liris.cnrs.fr/ideal/mooc/, the video from: https://www.youtube.com/watch?v=LVZ0cPpmSu8

Related work





Constructivist Approach to State Space Adaptation in Reinforcement Learning

Constructivist learning paradigm

Constructivist learning paradigm

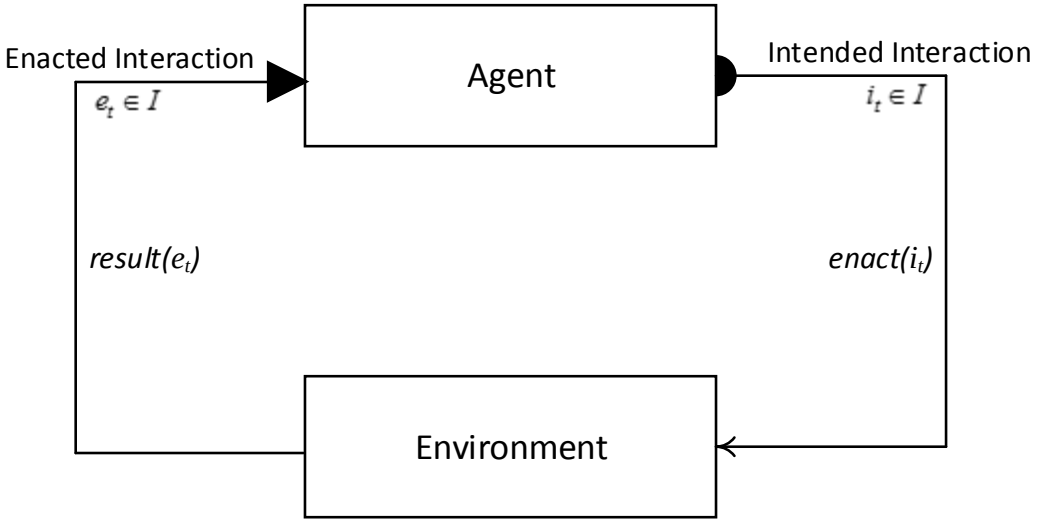


Fig 1. Constructivist paradigm for the agent to interact with the environment

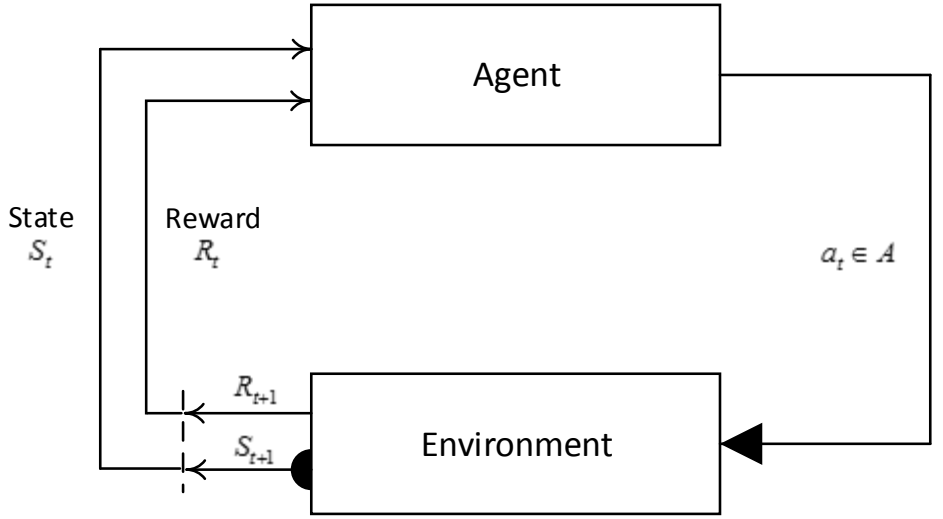


Fig 2. The agent-environment interaction in reinforcement learning

Constructivist learning paradigm

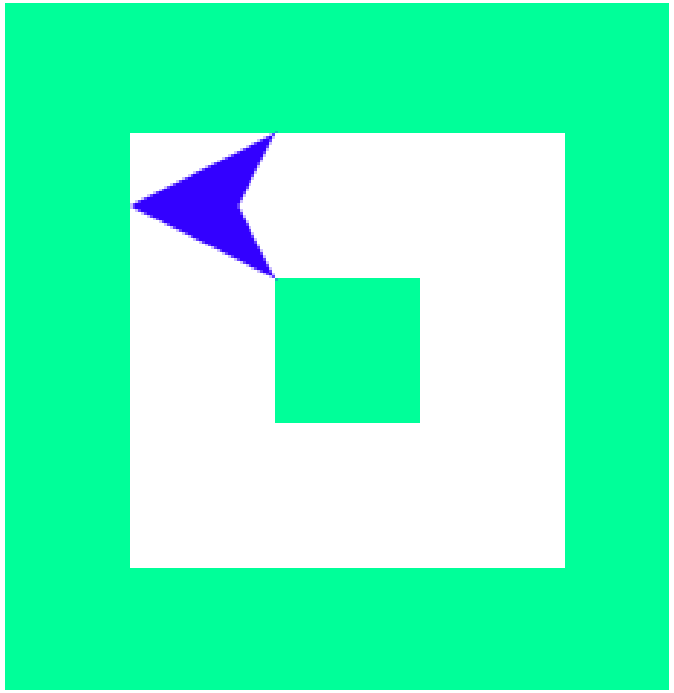


Fig 4. Learning process with constructivist paradigm in Small loop problem.

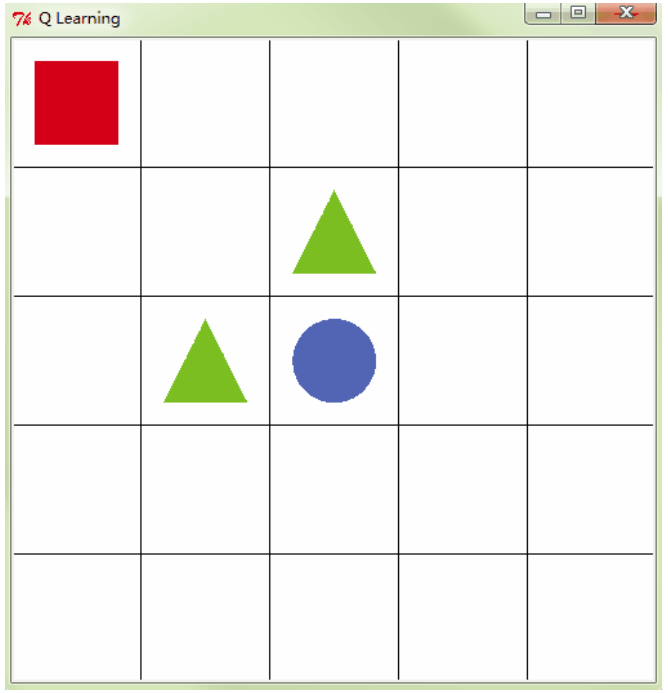


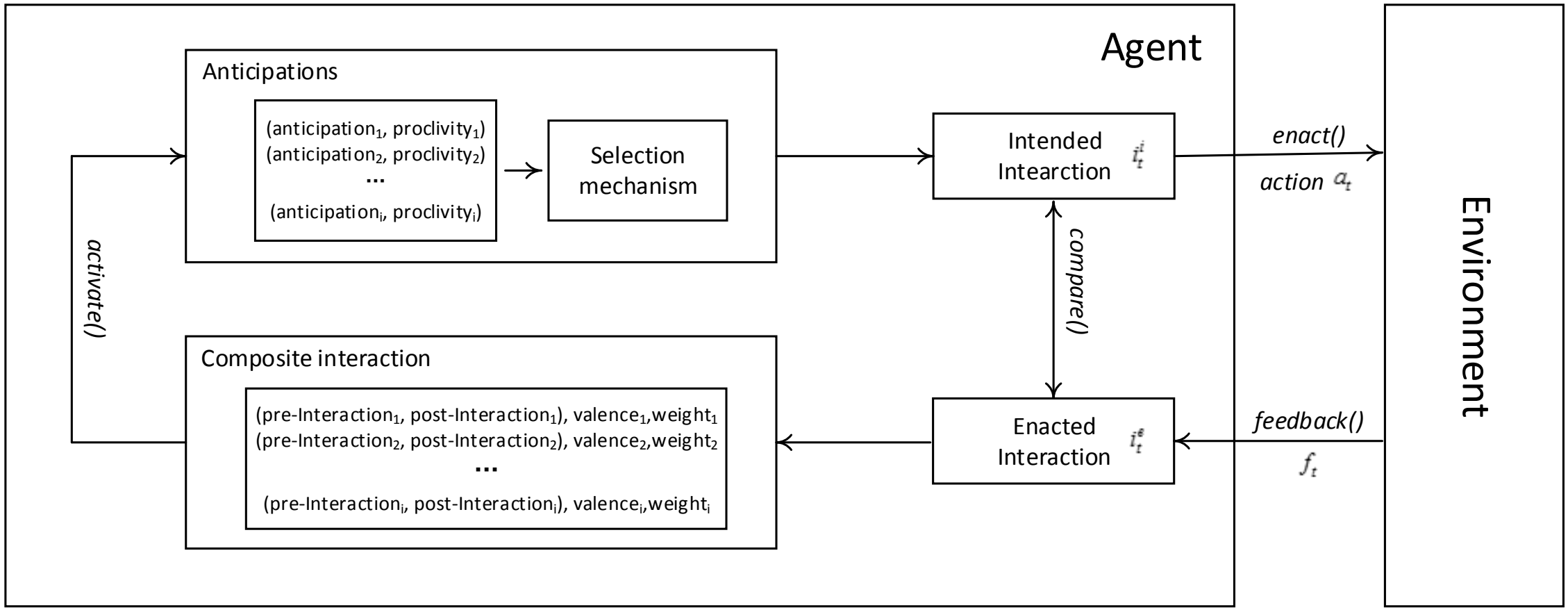
Fig 3. Q-learning with ε-exploration in grid environment.

Comparison between constructivist learning and reinforcement learning

Criteria	Constructivist learning	Reinforcement learning
Theoretical framework	Constructivism	Behaviorism
Mechanism	Sequential learning	Maximize value iteration
Reward	Intrinsic (agent)	Extrinsic (environment)
Goal	Self-motivation	Predefined
Perception	internally constructed	Function of the environment
Input/output	Feedback/Experience	Observation/Action
Action cycle	Starts from the action	Starts from the environment

Research process

Research process (1):
The framework of learning process with constructivist paradigm



The definition of composite interaction

- Interaction is defined as a tuple of:

$$i_t = \langle e_t , f_t \rangle,$$

which means the agent performs an experience e_t and receives feedback f_t that composites a given interaction i_t at step t, also we call this the *agent enacts an interaction* i_t.

- The agent intends an interaction i_t^i and receives the enacted interaction i_t^e , then the agent memorizes the two-step enacted interaction sequence:

$$c_t = \langle i_{t-1}^e , i_t^e \rangle,$$

as a tuple of < contextInteraction, enactedInteraction >, made by the previous enacted interaction i_{t-1}^e of i_t^e . The interaction i_{t-1}^e is called c_t's pre-interaction, and i_t^e is called c_t's post-interaction.

Intended interaction and enacted interaction

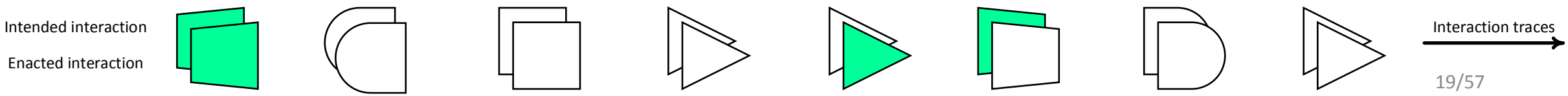
- From the perspective of constructivism:

Intended interaction as it represents the sensorimotor scheme that the agent intends to enact, and constitutes the agent's output that is sent to the environment.

The enacted interaction represents the sensorimotor scheme that the agent records as actually enacted, which constitutes the agent's input received from the environment.

If the enacted interaction equals with the intended interaction, then the attempted enaction of intended interaction is considered a *success*, otherwise *failure*.

Research process (2):
Learning of higher-level structured behaviors with constructivist paradigm



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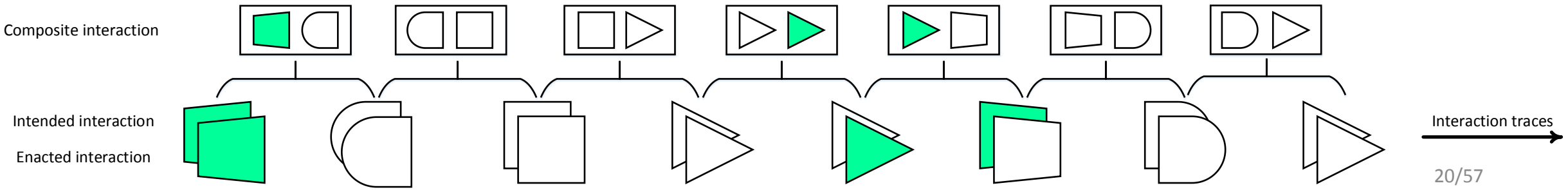

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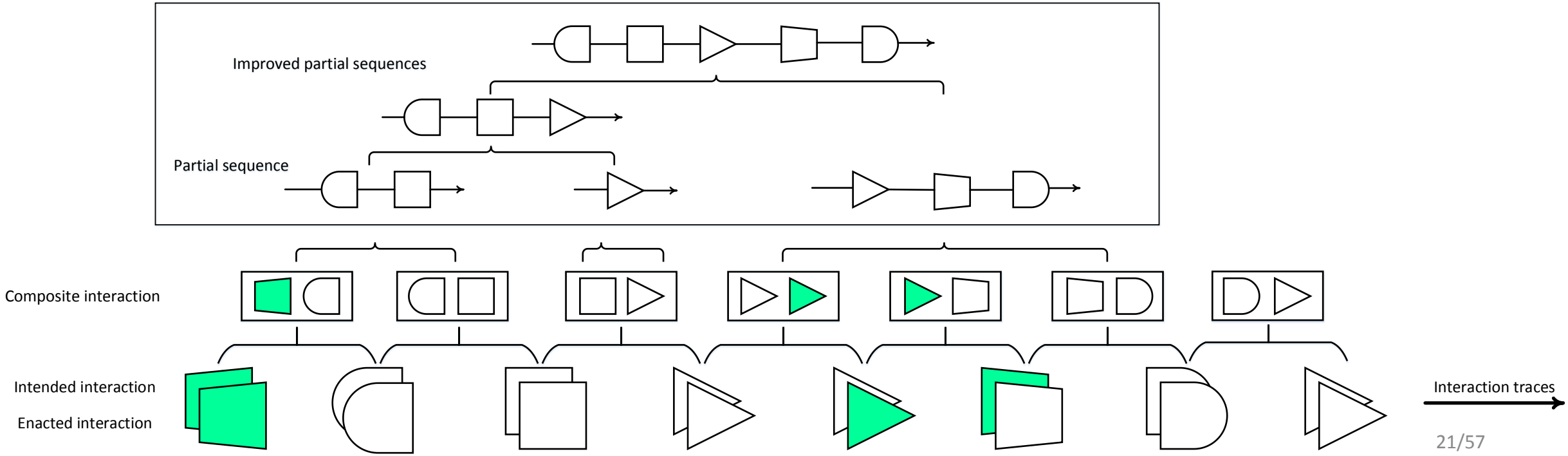

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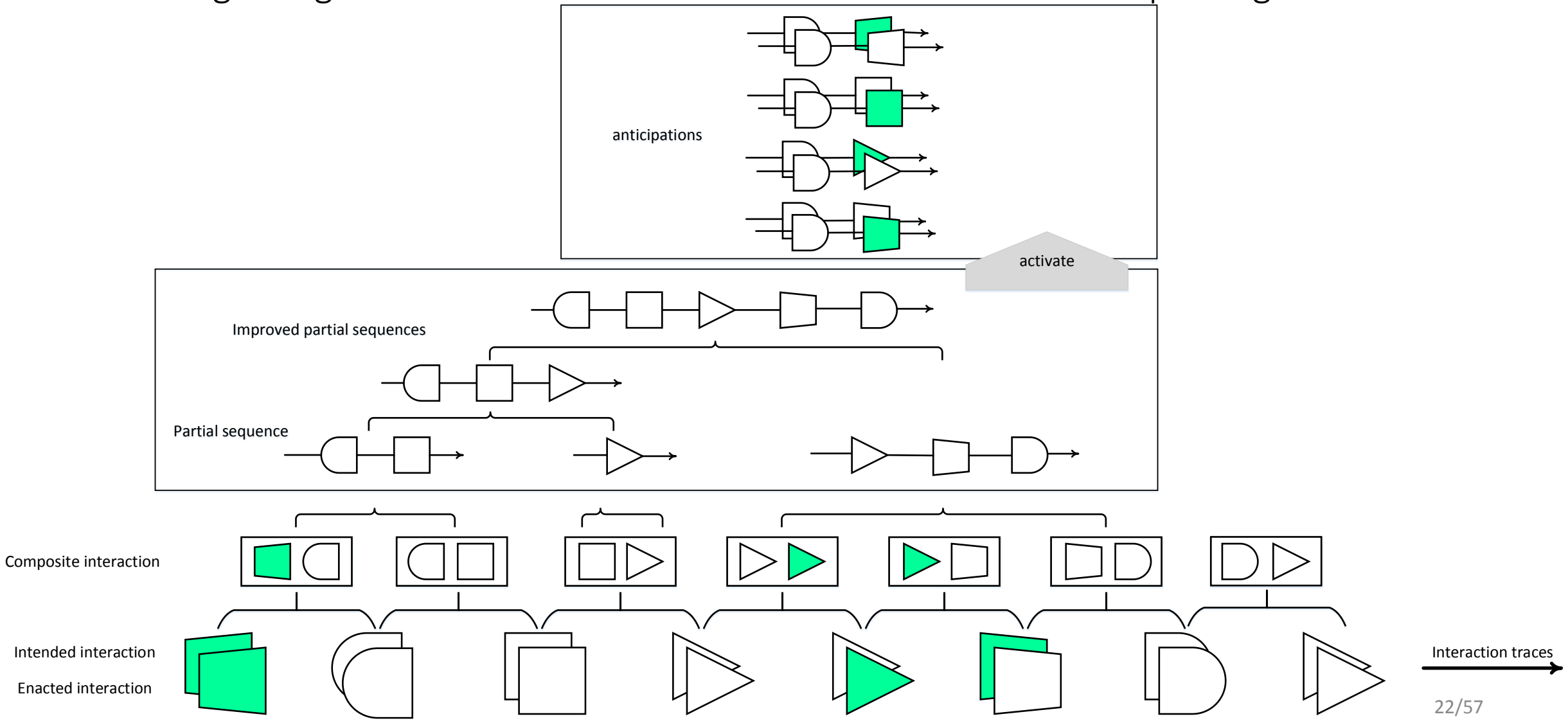

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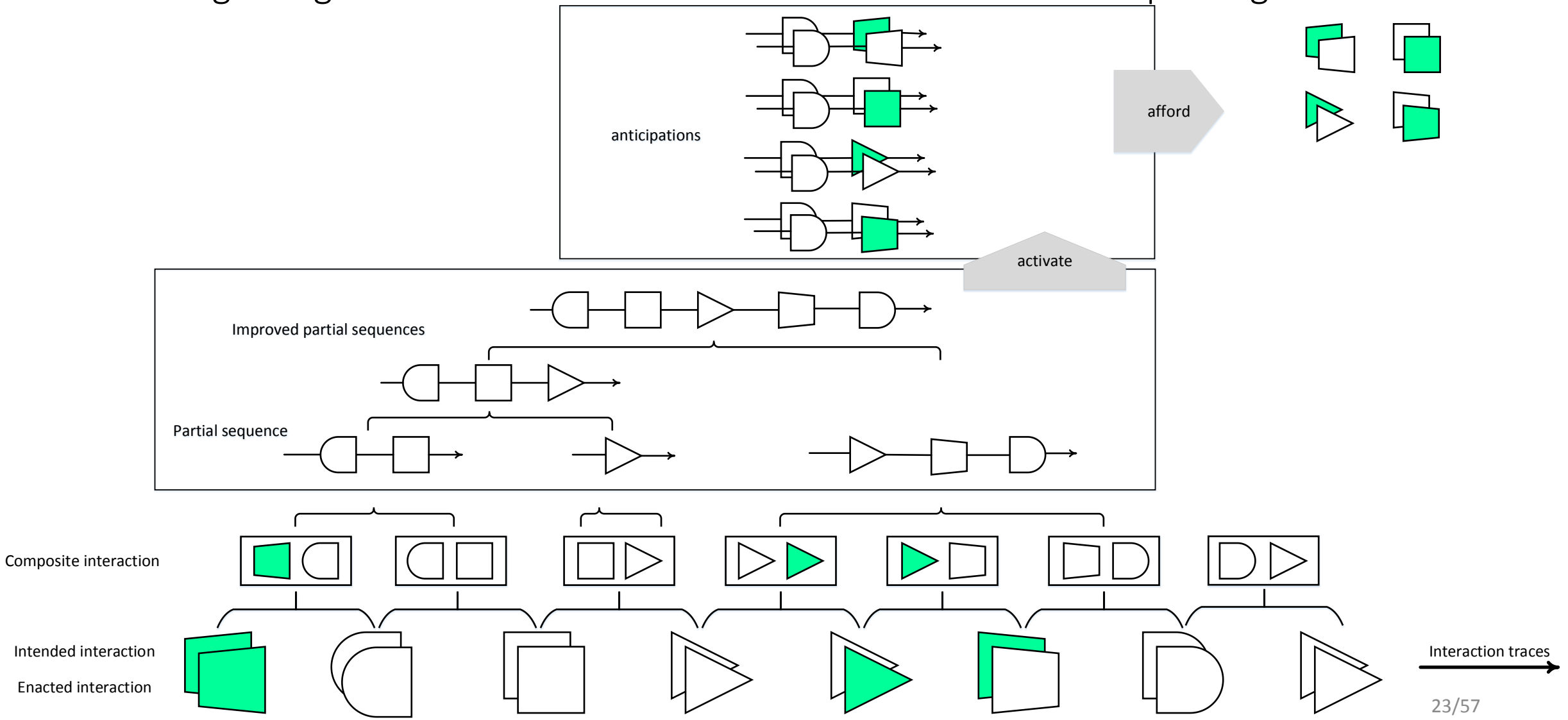

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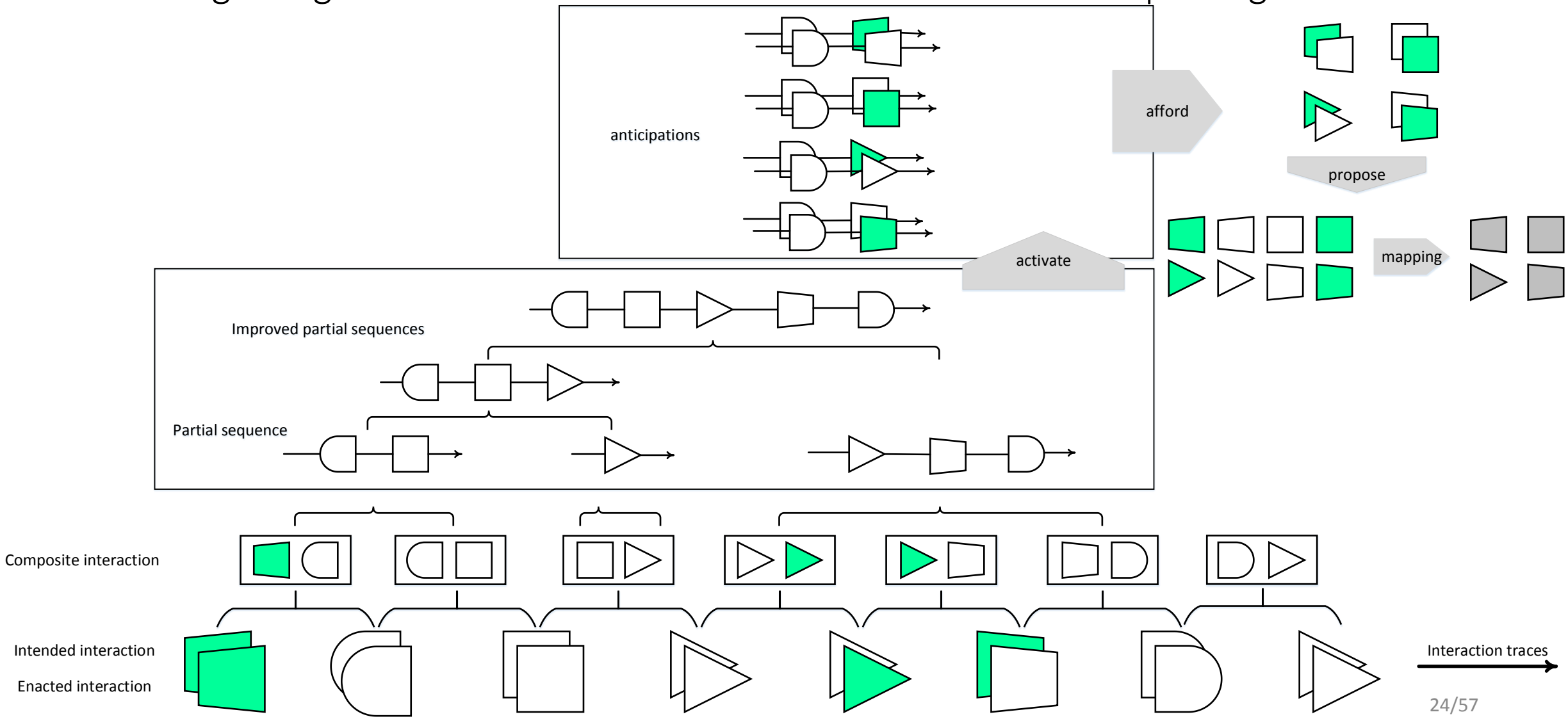

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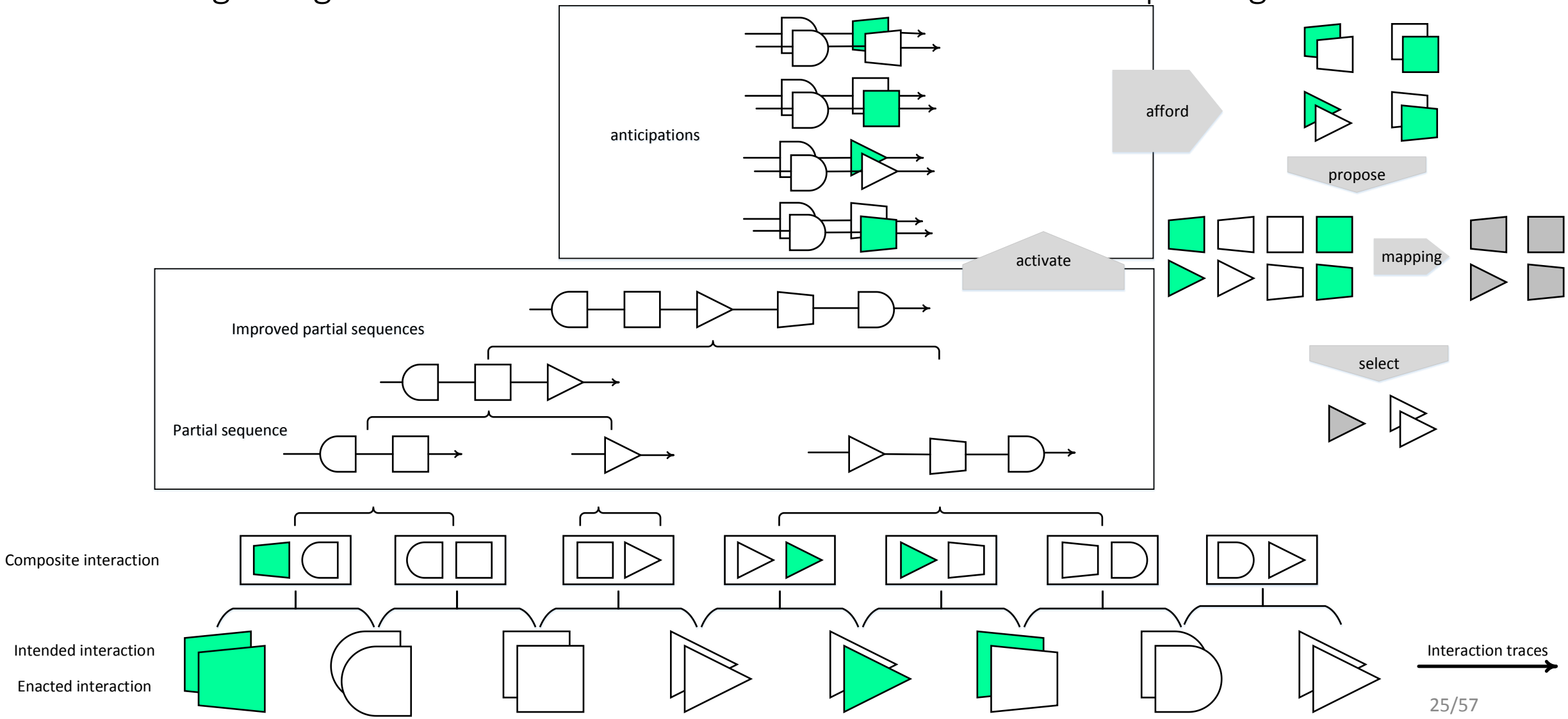

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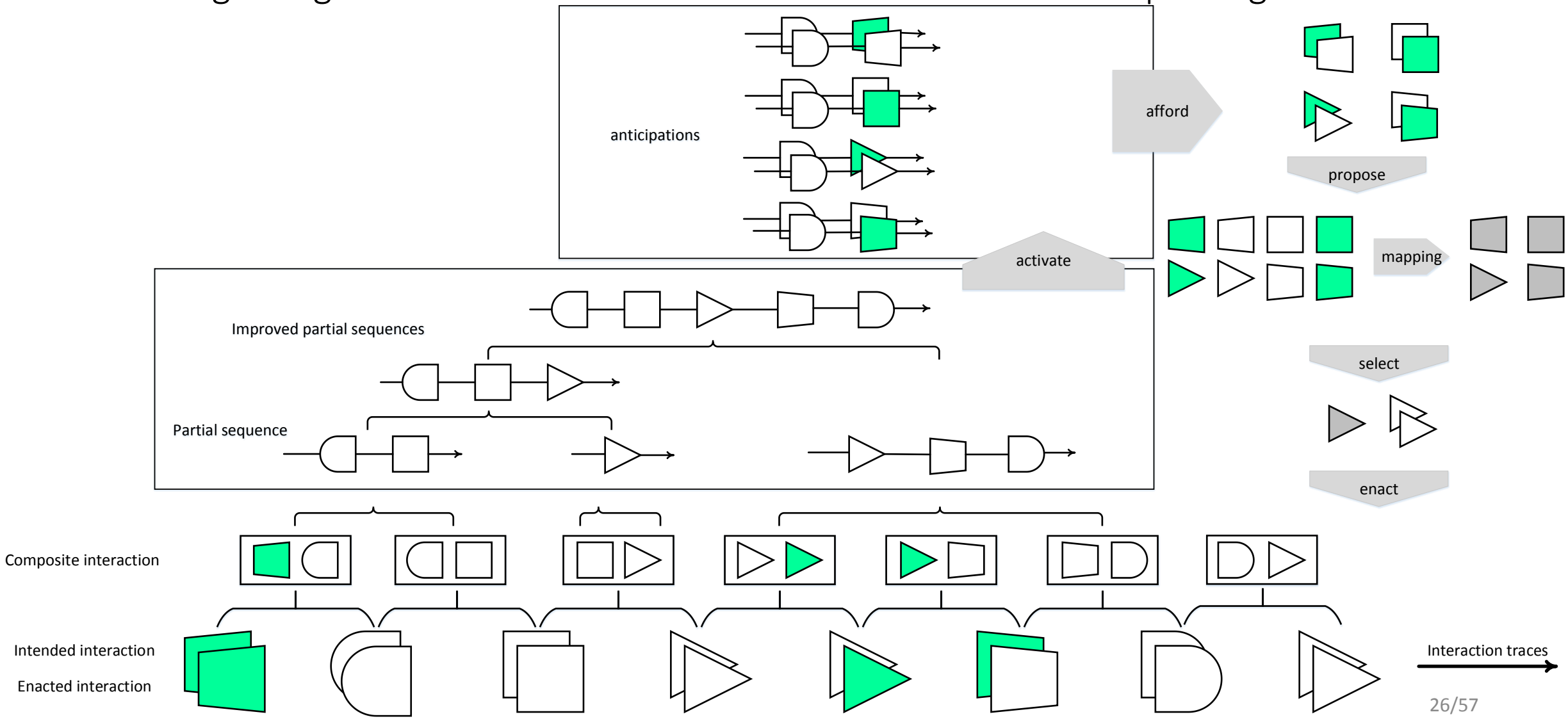

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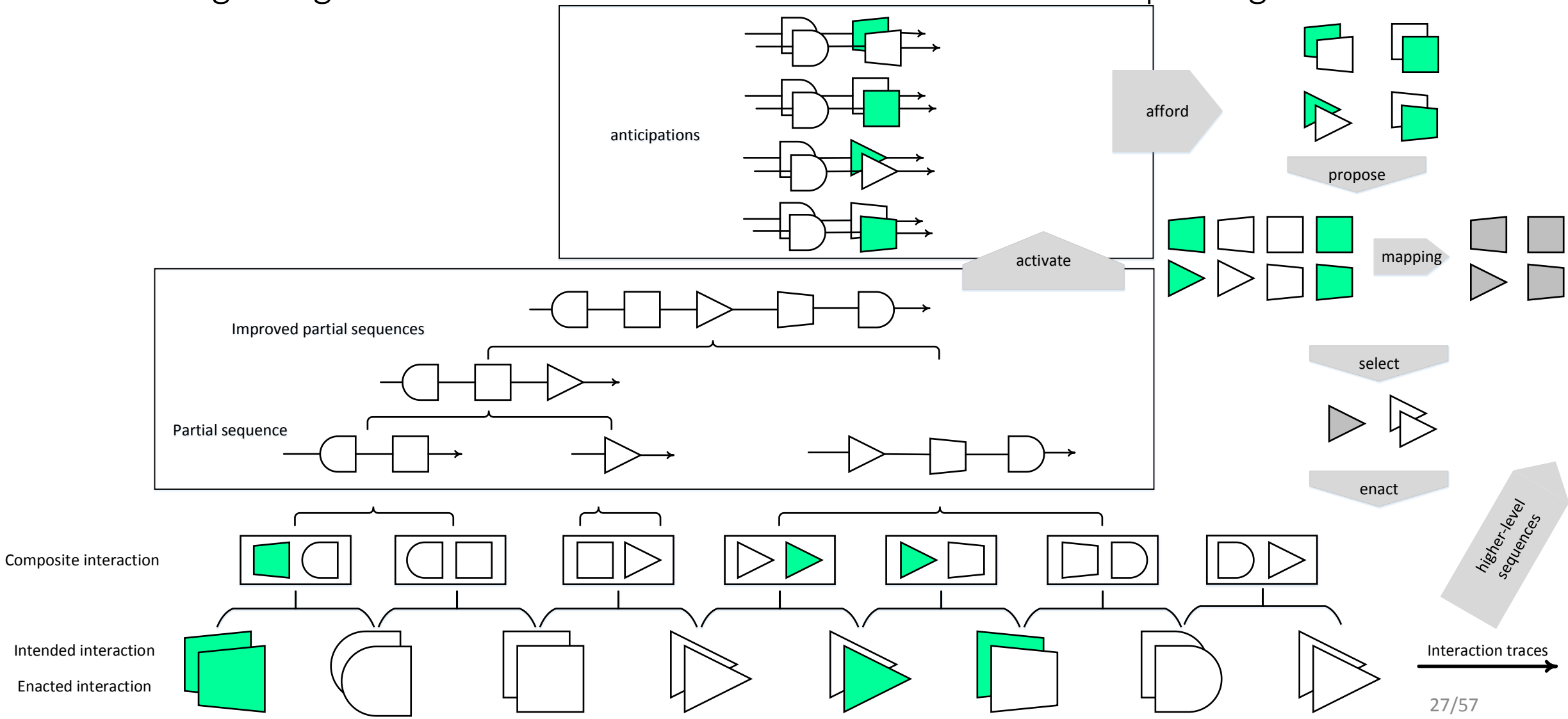
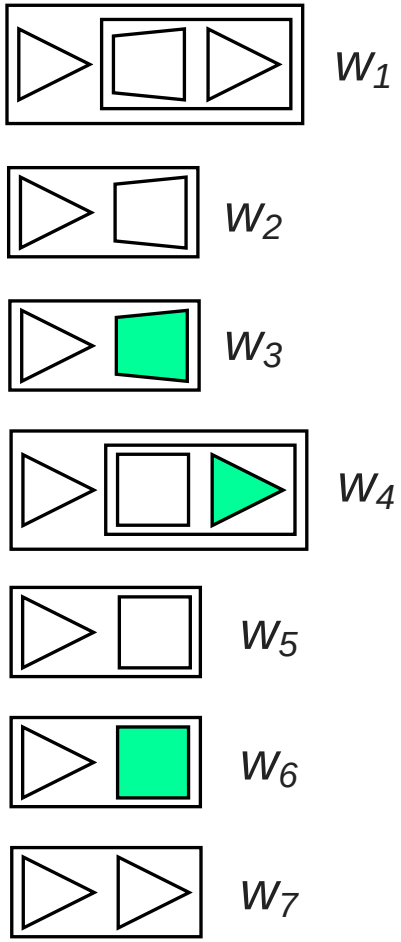


Anticipations creation and selection



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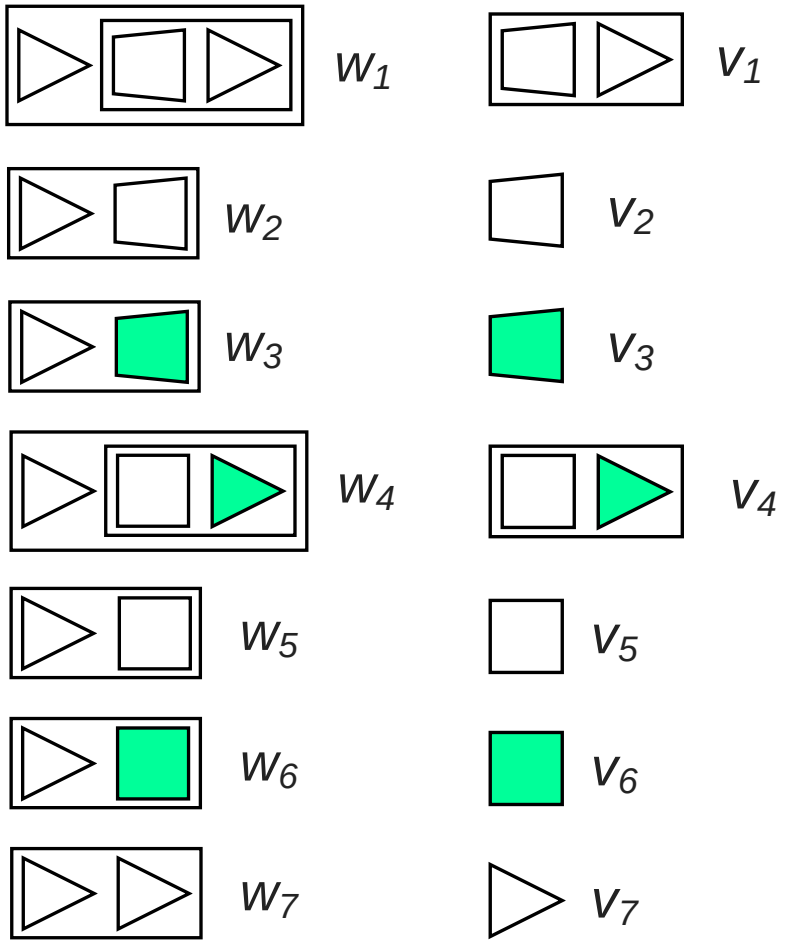

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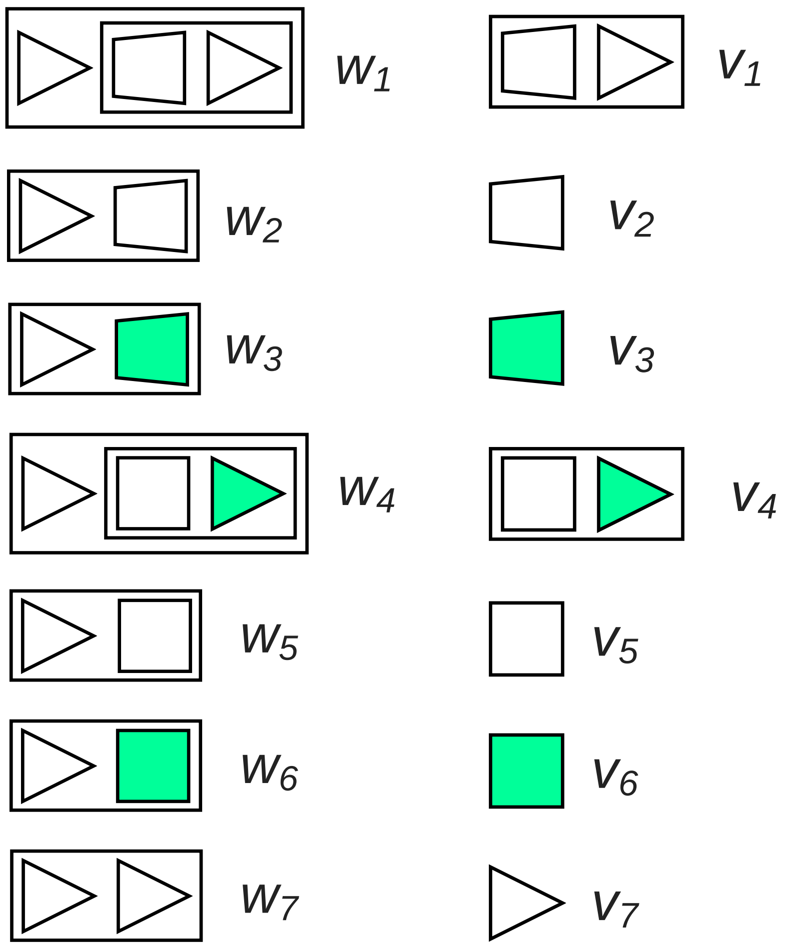


$$p_1 = w_1 \times v_1$$

$$p_2 = w_2 \times v_2$$

$$p_3 = w_3 \times v_3$$

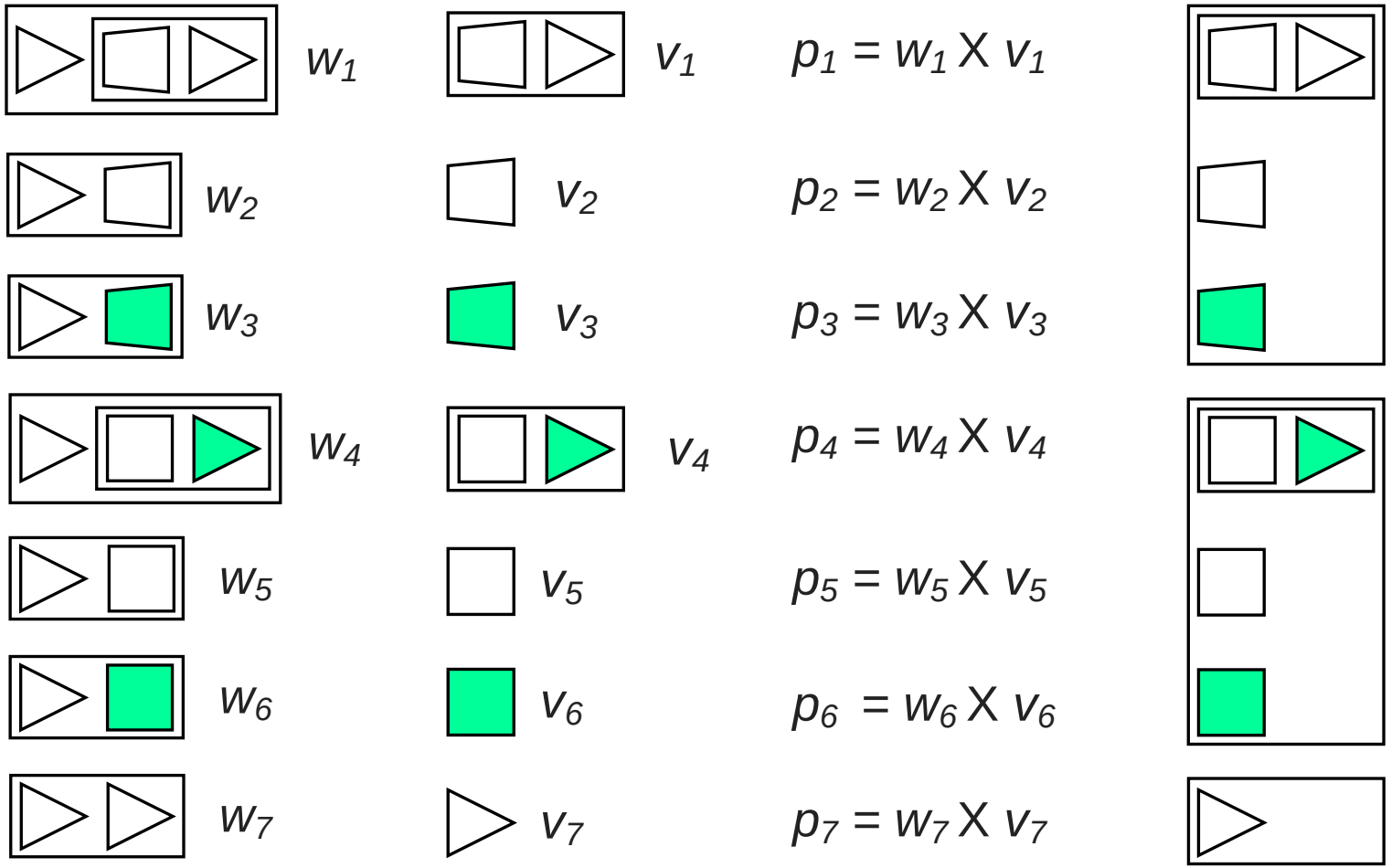
$$p_4 = w_4 \times v_4$$

$$p_5 = w_5 \times v_5$$

$$p_6 = w_6 \times v_6$$

$$p_7 = w_7 \times v_7$$

Anticipations creation and selection



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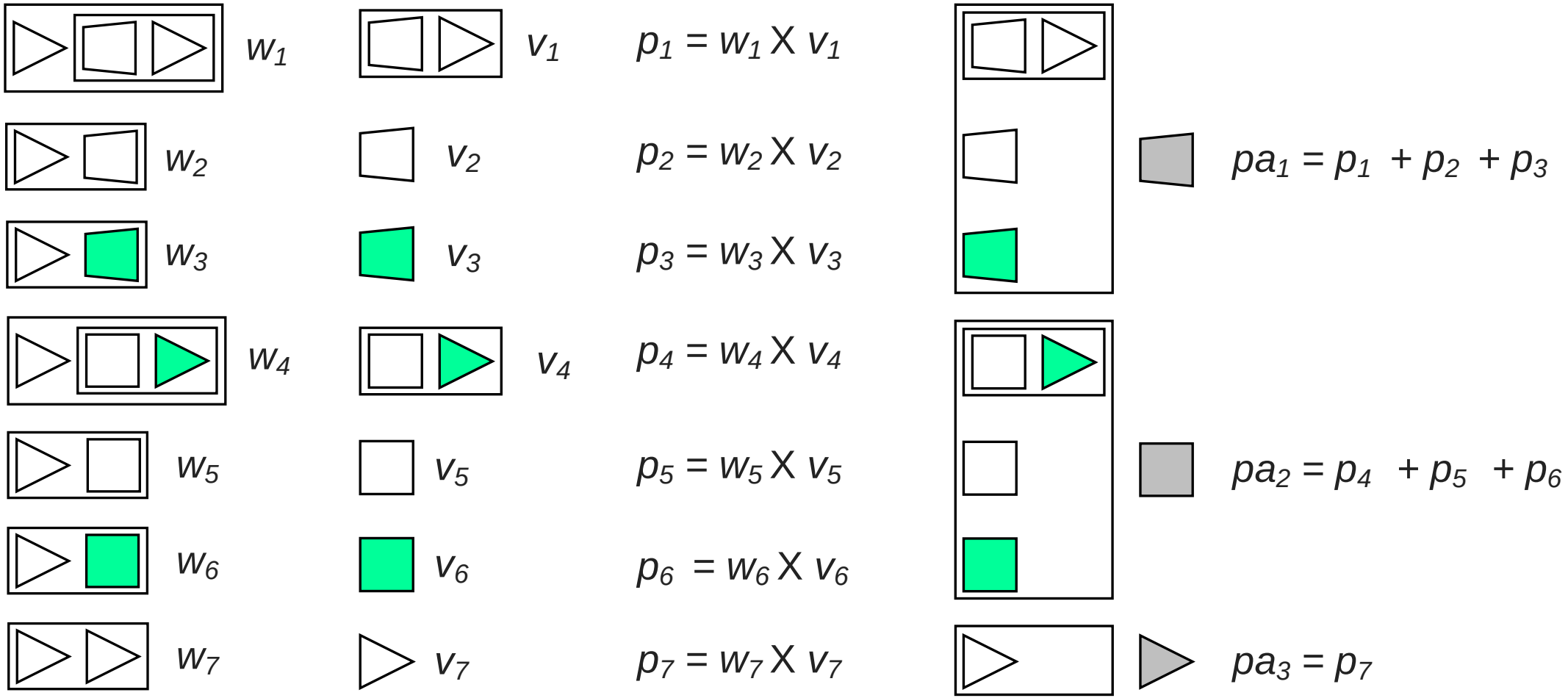

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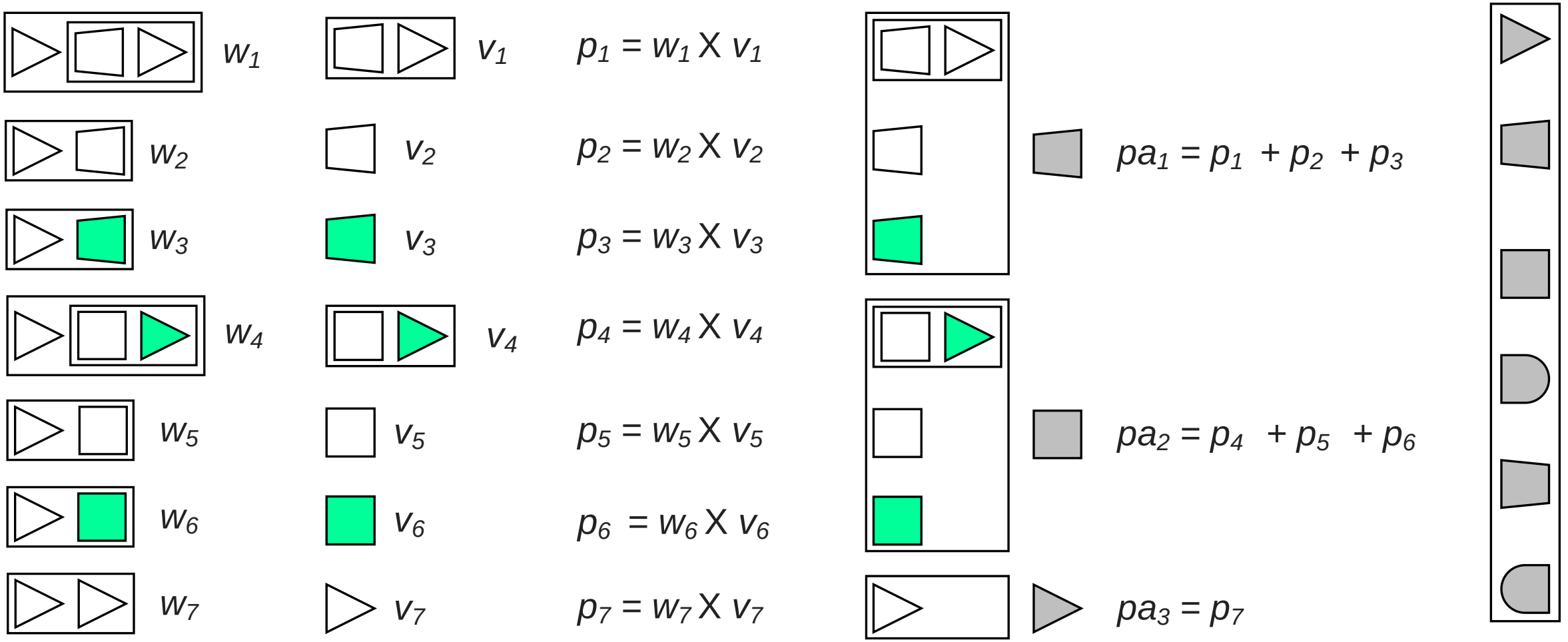
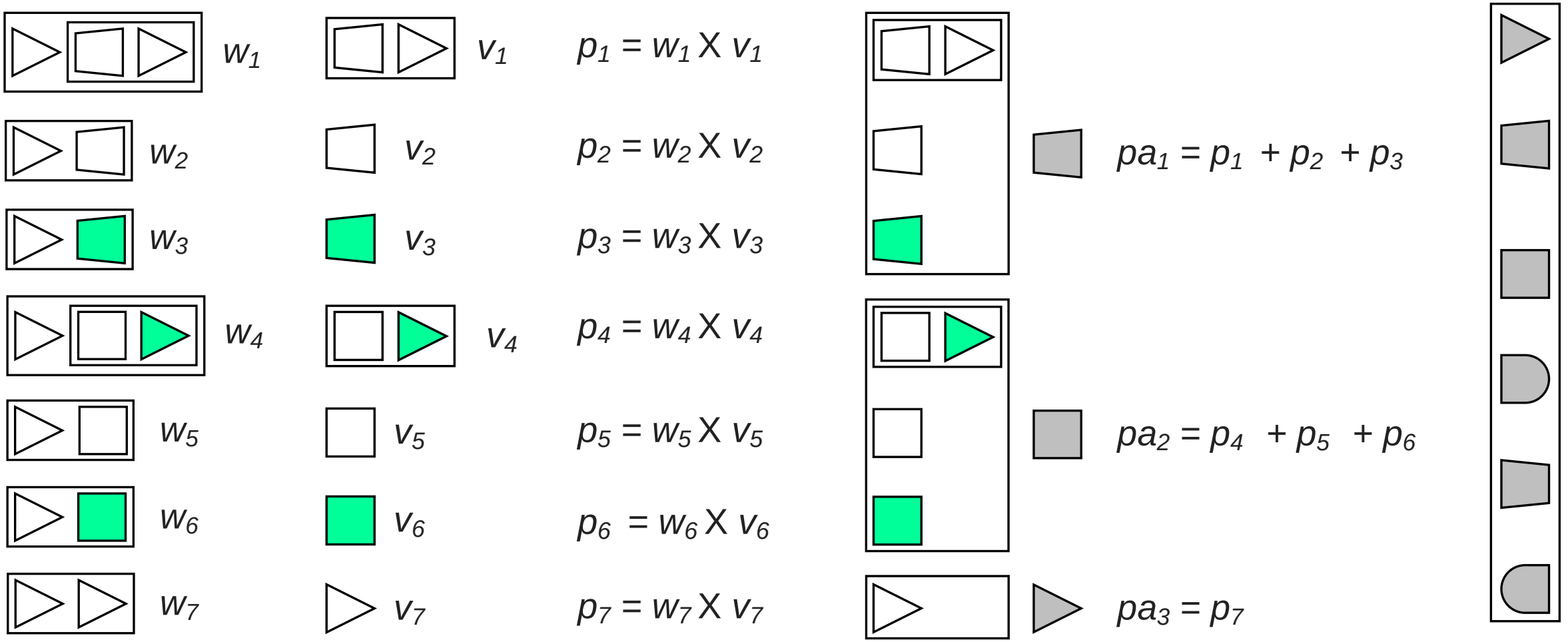
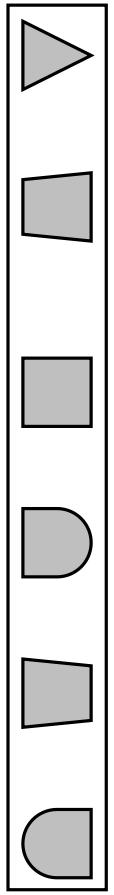


Anticipations creation and selection



Enacting intended Interaction



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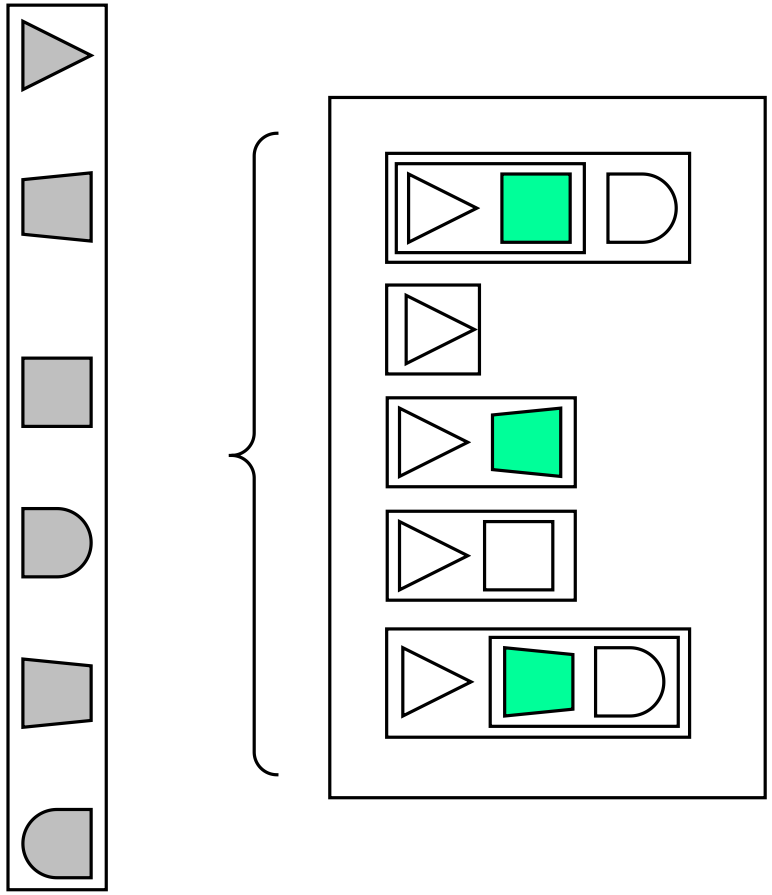

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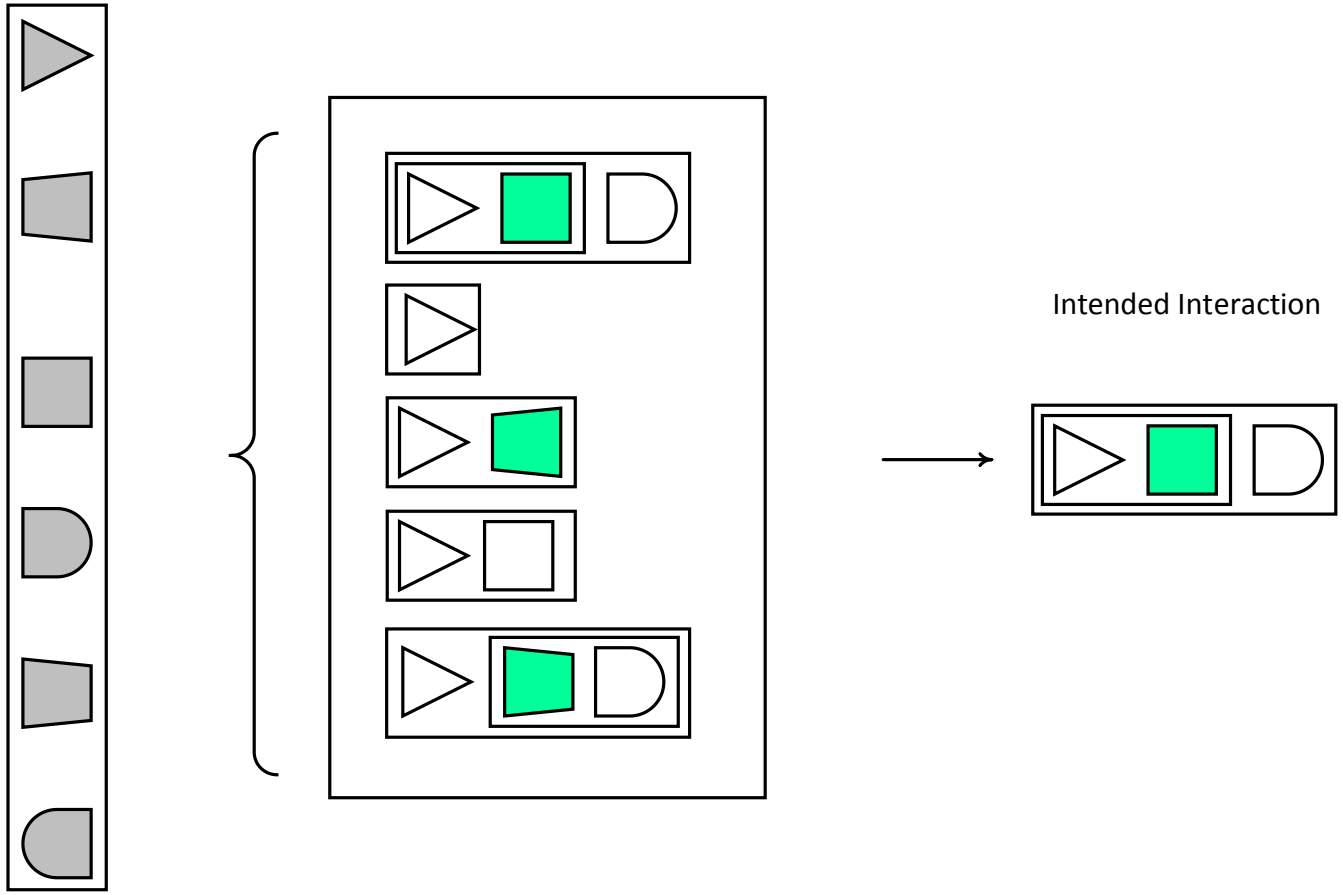

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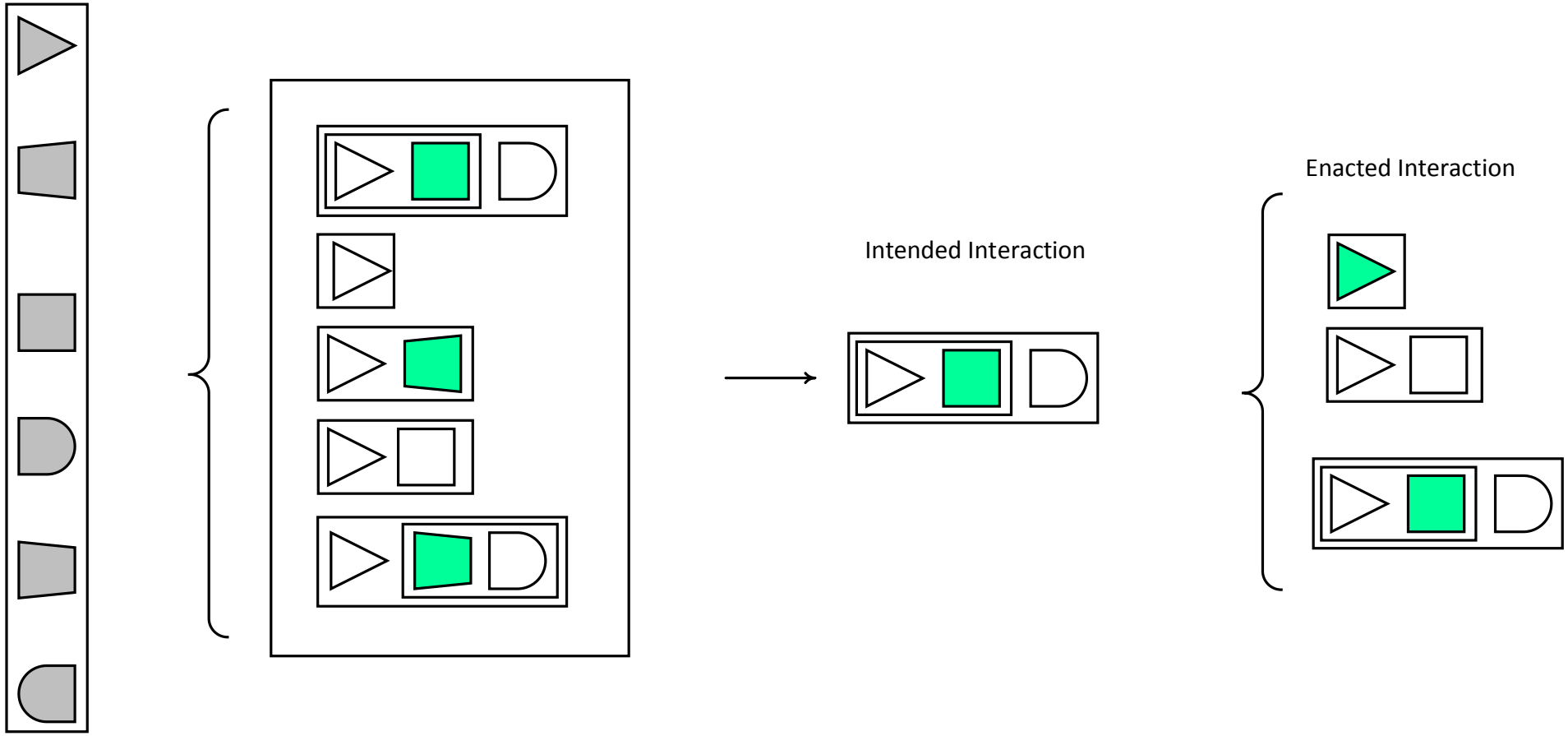
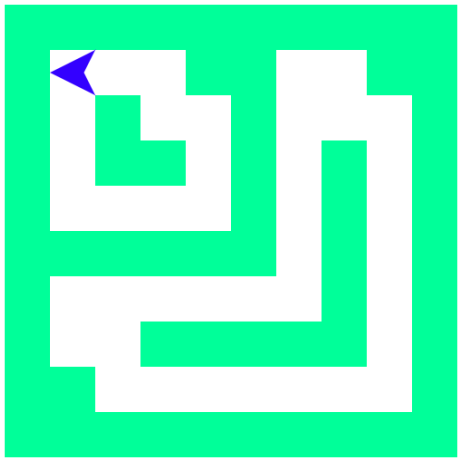
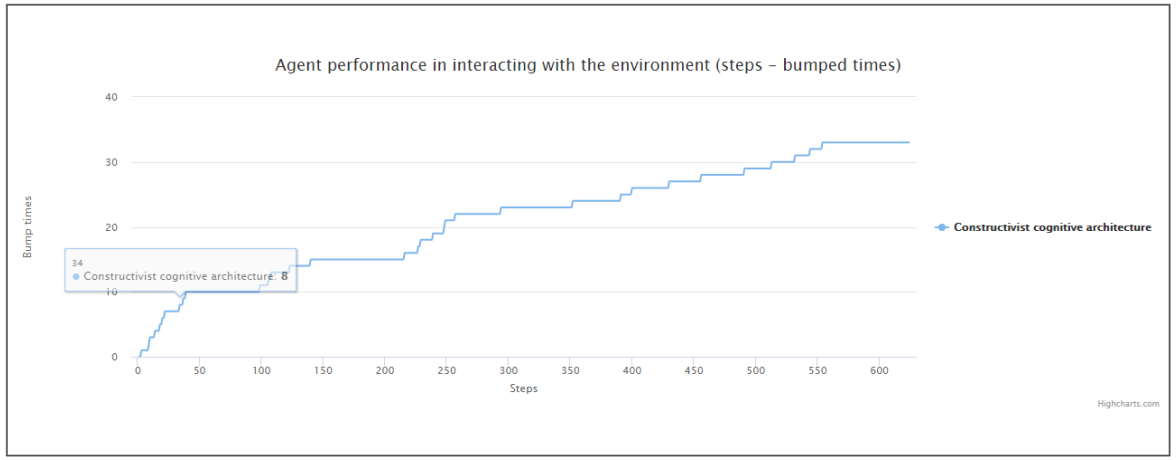
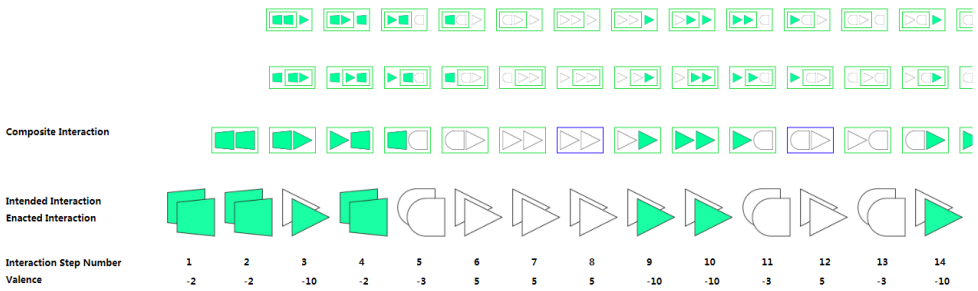


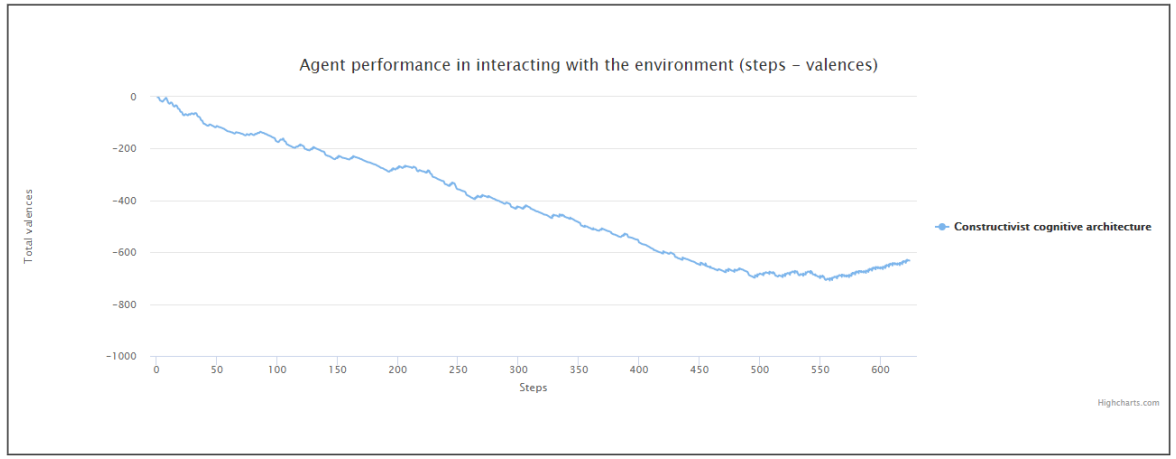
Research process (3):
Generating and Analyzing Interaction Traces toolkit (GAIT)



Parameters		
move forward:	5	
bump:	-10	
turn:	-3	
feel empty:	-1	
feel the wall:	-2	
time interval:	500 ms	Speed up / Slow down
actionType:		0
Total Valence:	0	
loop num:	0	
Start / Stop / Reset		







Interaction traces analysis

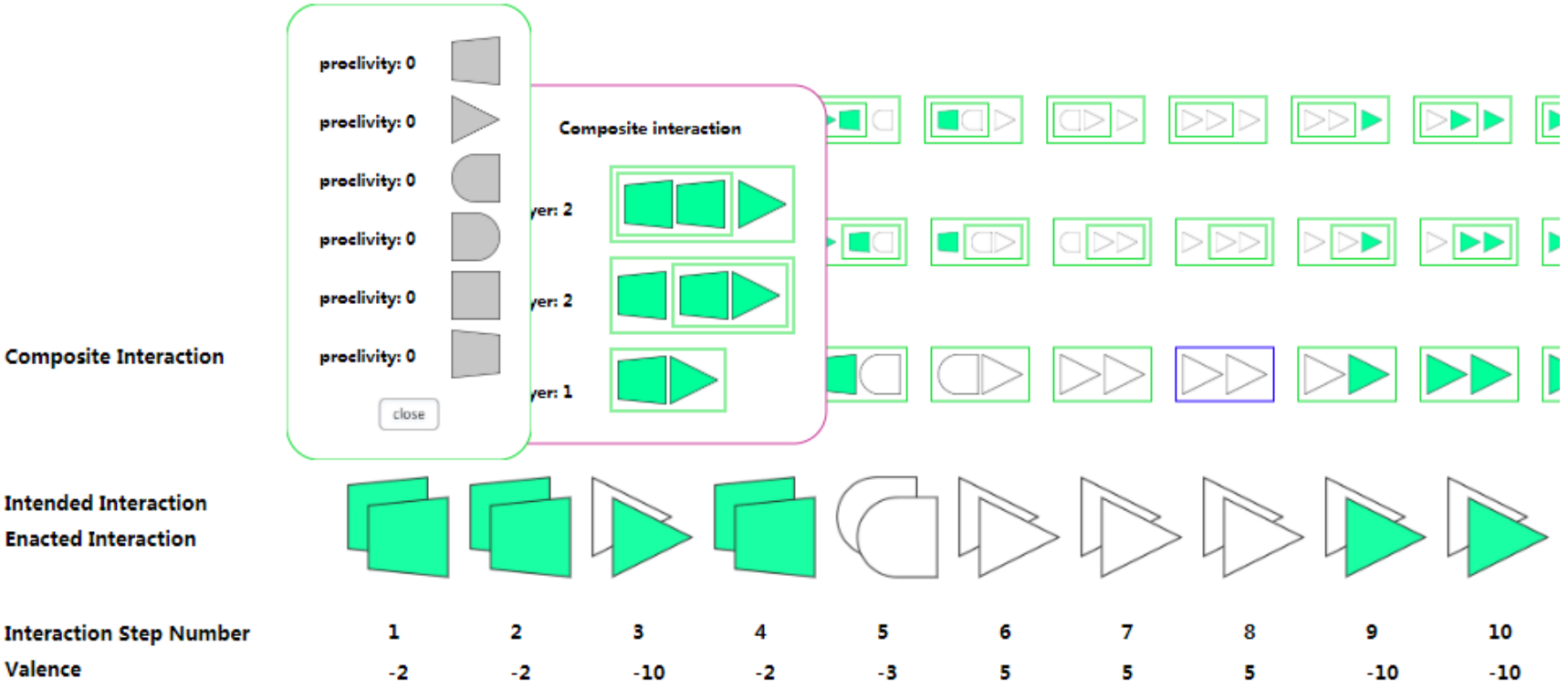


Fig 7. The first interactions and the construction of composite interactions.

Interaction traces analysis

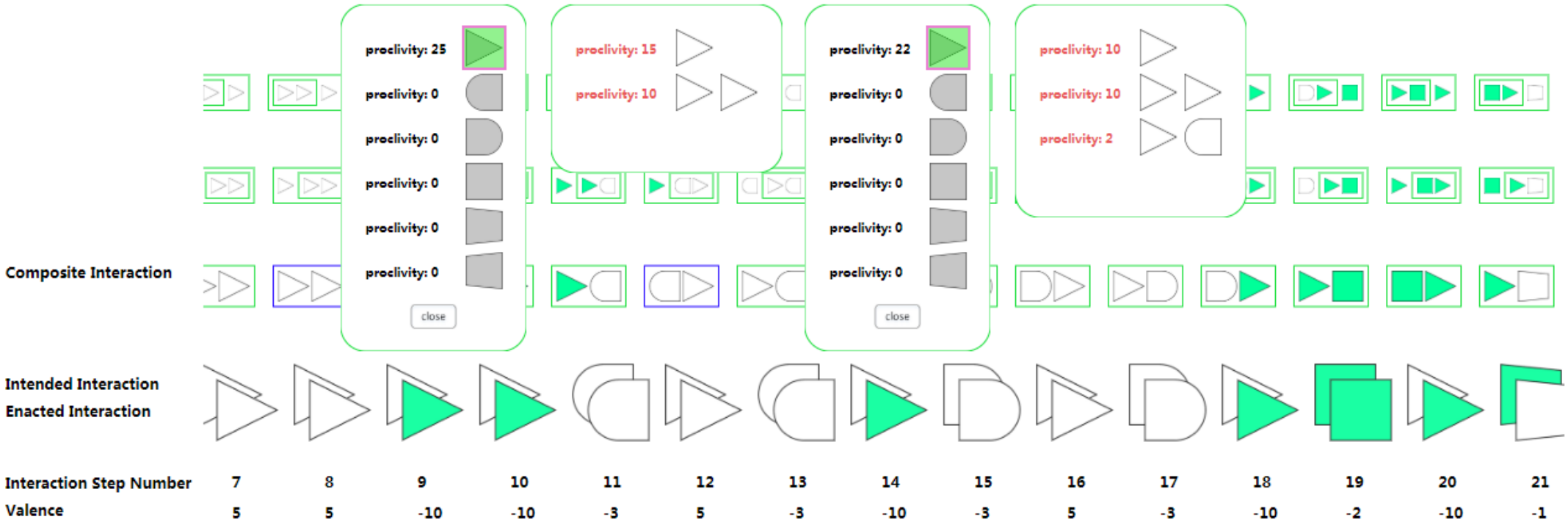


Fig 8. Enacting same intended interaction with different feedbacks.

Interaction traces analysis

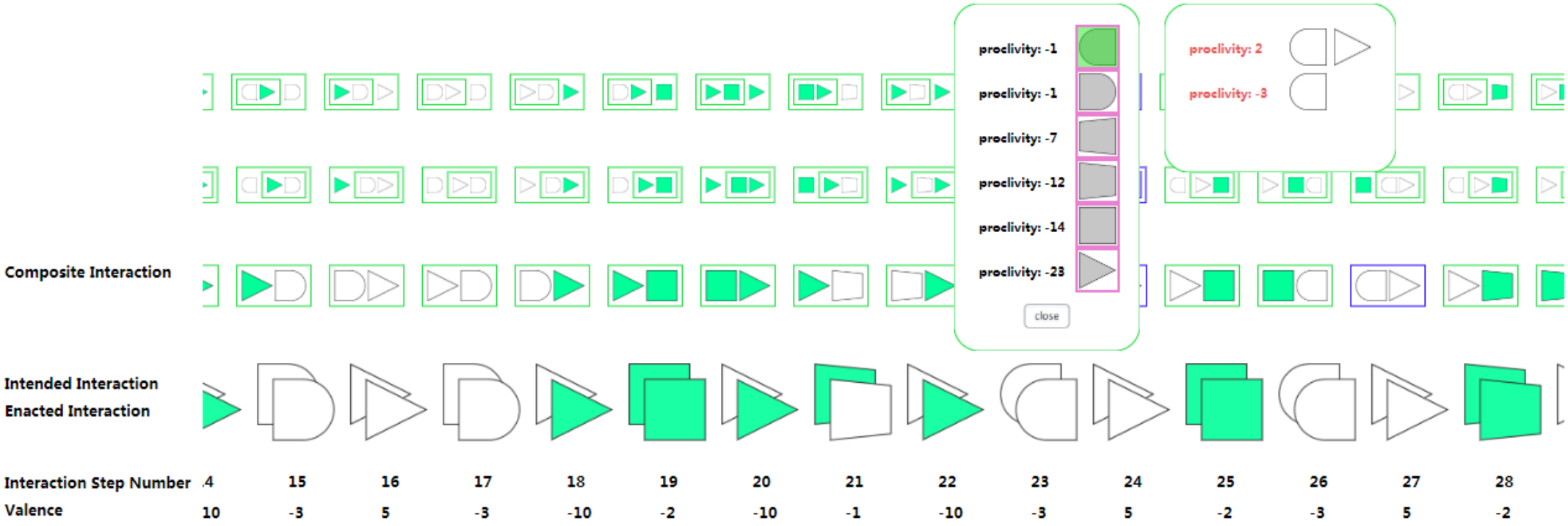


Fig 9. The enacted composite interaction's weight is lest than the threshold.

Interaction traces analysis

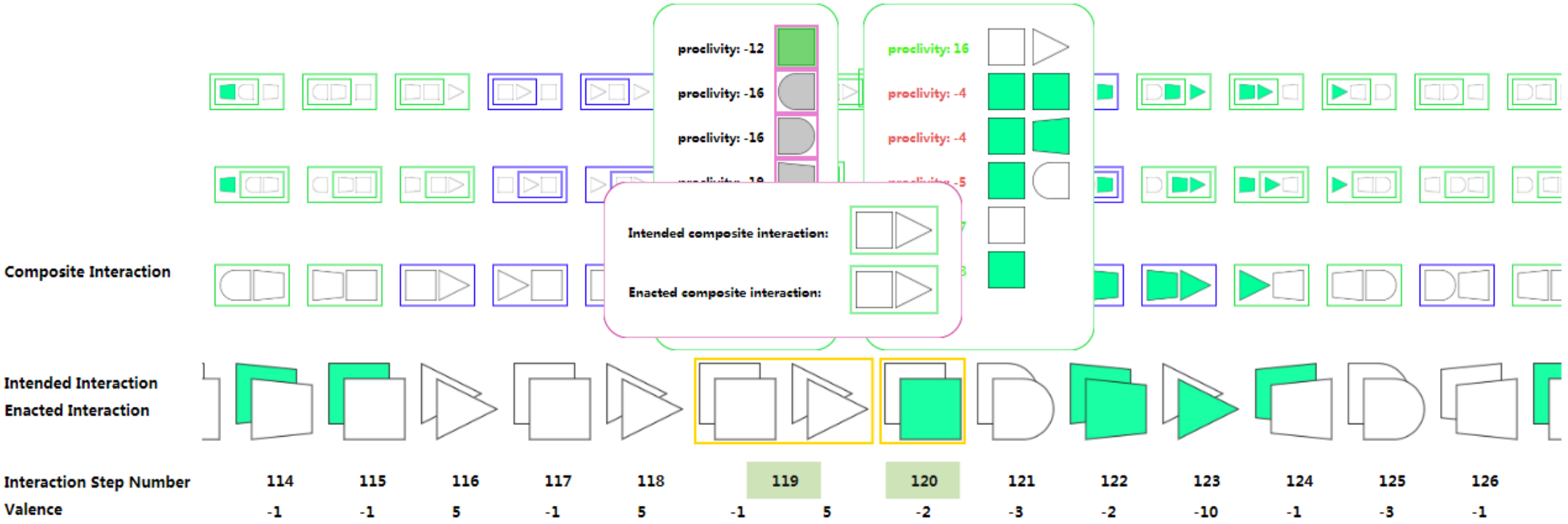


Fig 10. The agent successfully enacts composite interaction and constructs higher-level composite interaction

Interaction traces analysis

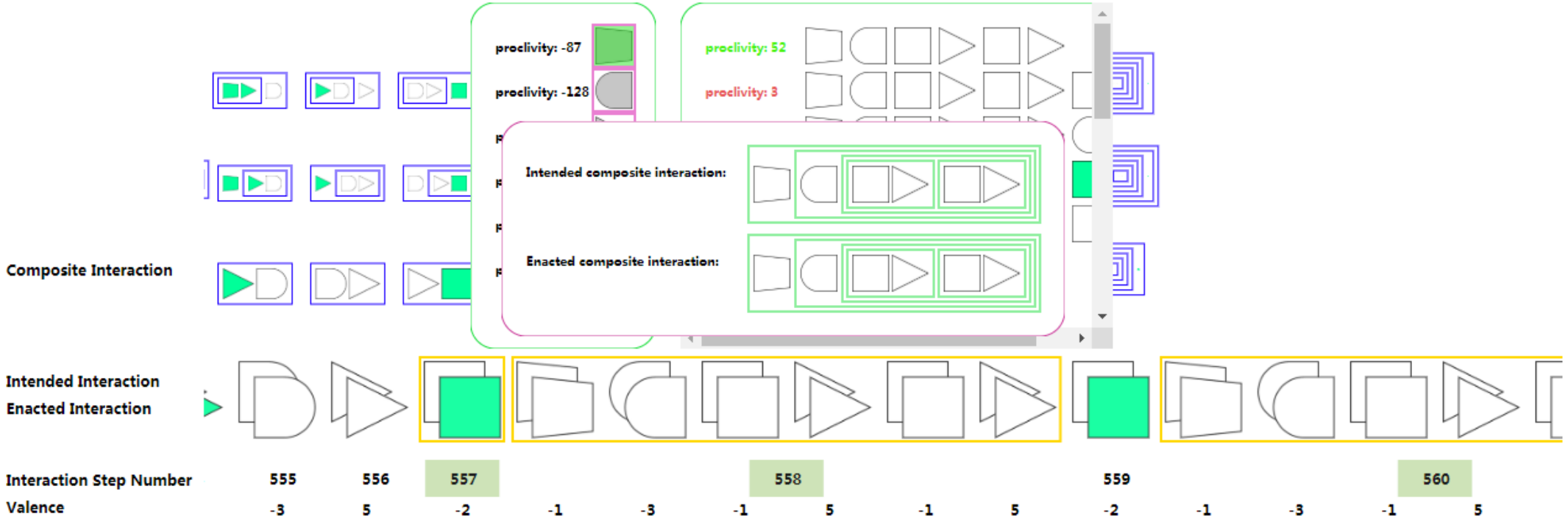
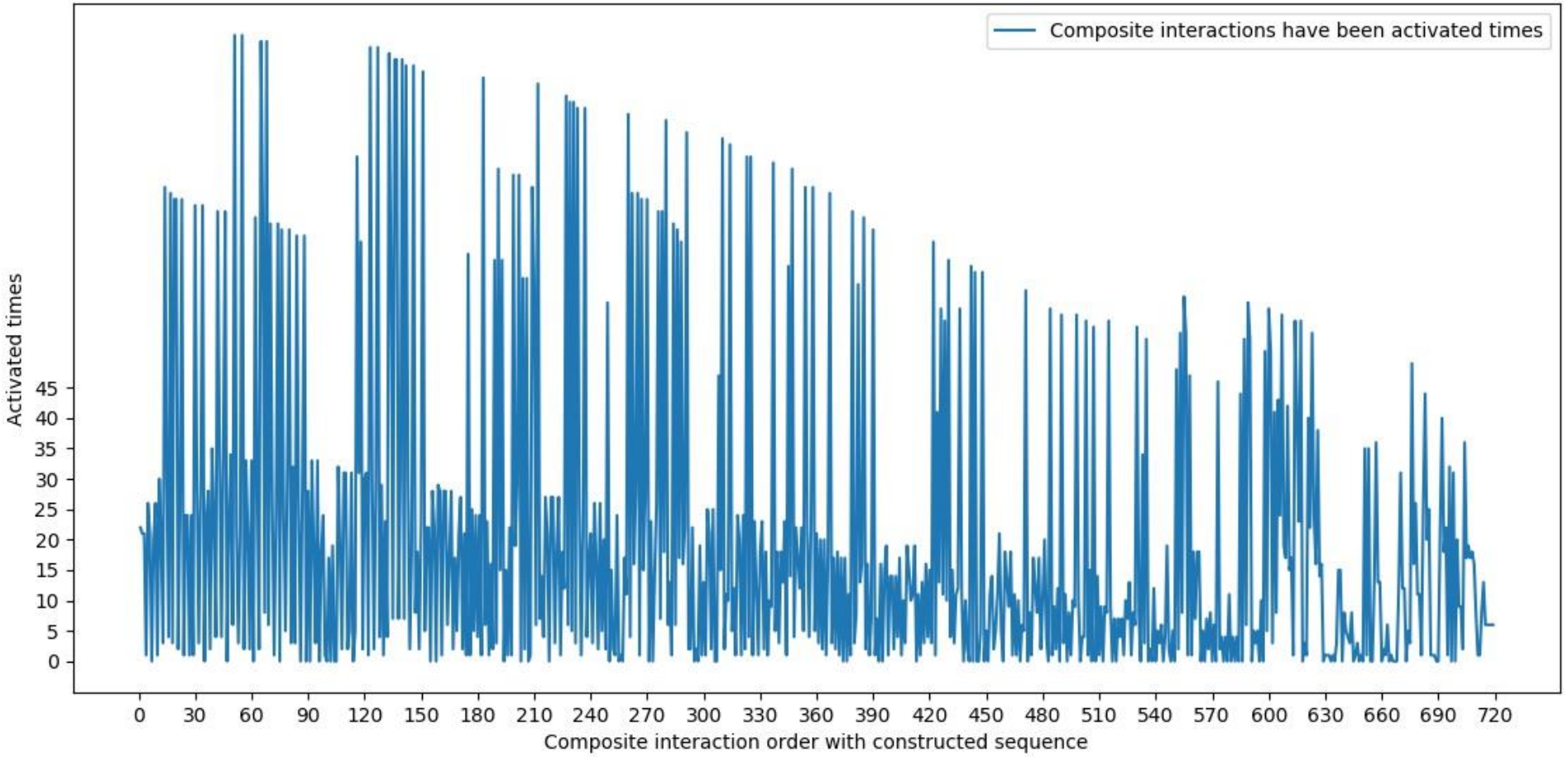
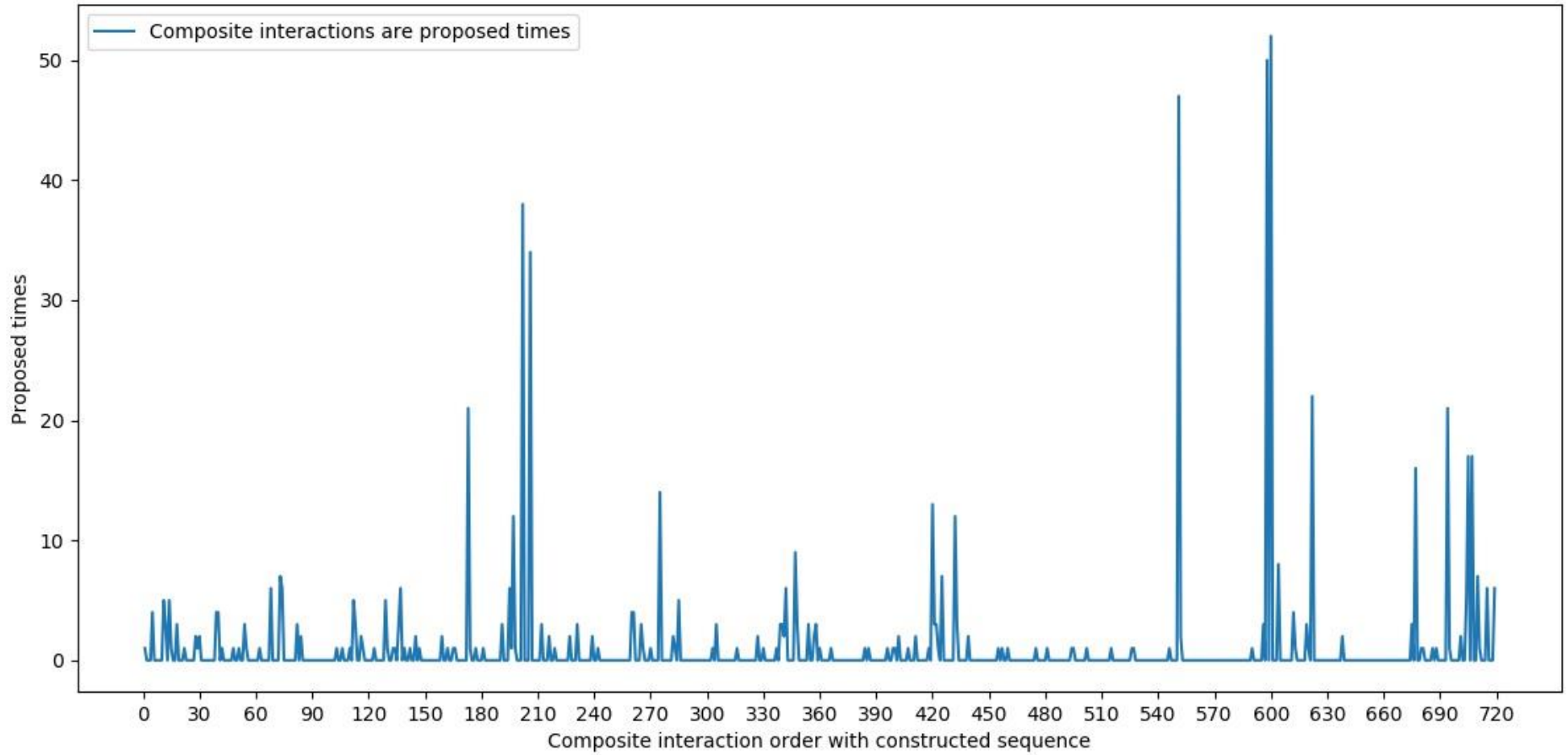


Fig 11. Enacting complicated composite interaction.

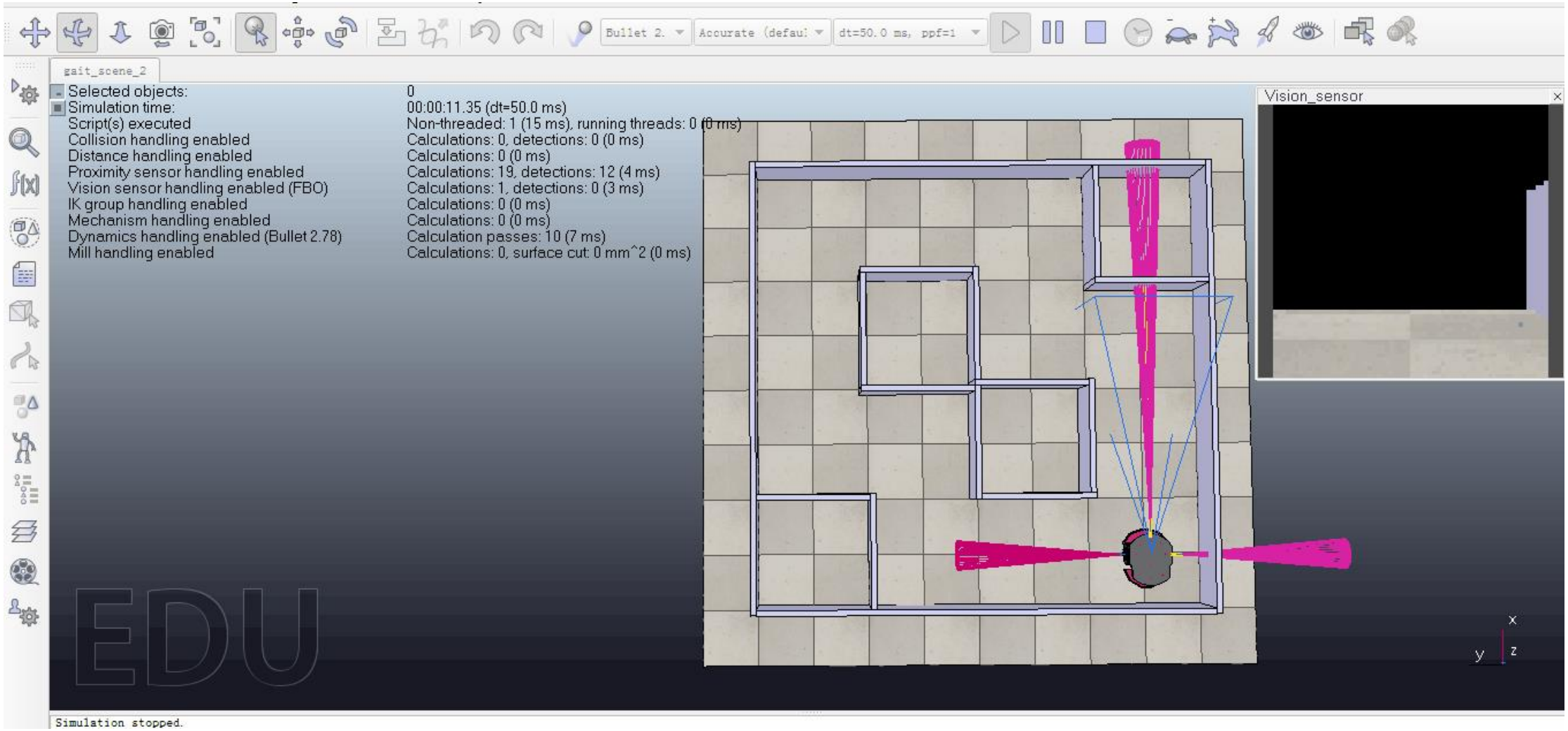
Results: usage rate of the composite interactions



Results: proposed rate of composite interactions



A simulation GAIT with robot in VREP



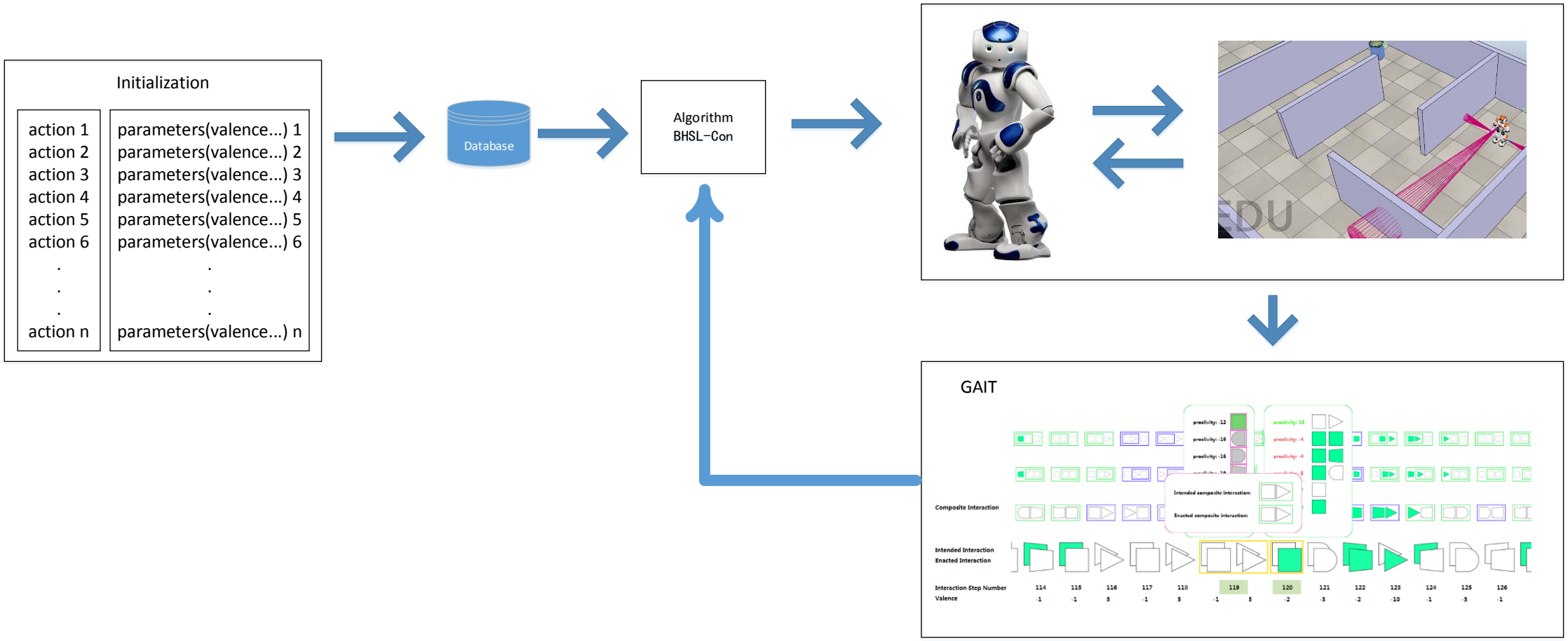
Contributions

- Propose a bottom-up hierarchical sequence learning algorithm with constructivist paradigm, as a solution for autonomous and continuous learning of environment representations and agent's self-adaptation.

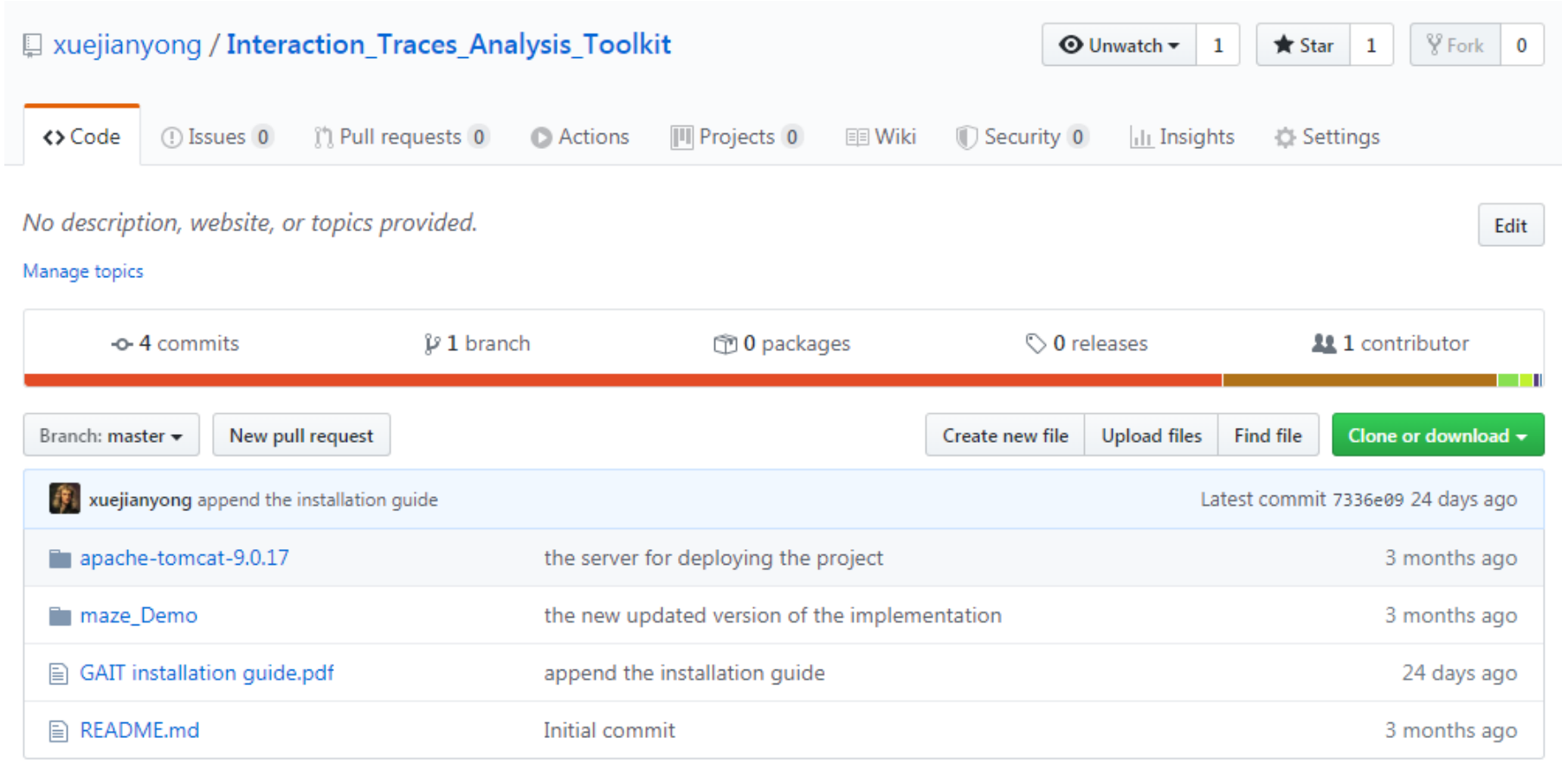
- Design and develop an implementation of toolkit for agent autonomously generating and analyzing interaction (GAIT) at run-time, which facilitates to observe the detailed learning process for agent interacting with the environment and each structured behaviors it has learned within each decision-making.

Applications

Application of algorithm and GAIT



The project of INIT



The project of Hoomy

Unhappy

Parameters		
Happy:	1	
Unhappy:	-1	
Current Mood:	happy	
Rotation	Front	
Loop Number:	0	
Start Stop Reset		

Study and training process

- Ethique de la recherche(cours en ligne, en cours), 11/02/2020, volume horaire: 15 heures.
- La 12èeme édition de la Journéee des Thèeses, 21/11/2019.
- Meetup #15 - IA & déeveloppement de l'enfant : des inspirations mutuelles, Thursday, July 18, 2019
- Participation of the second edition of workshop on “Emotionally Intelligent Social Robots” ,organized in SIDO 2019.
- The communication with company Hoomano. A presentation of Generating and Analyzing Interaction Traces (GAIT) and the development of GAIT with Robots interaction.
- Group meeting with student in UCLy, the presentation learning process with Constructivist Paradigm, and the application of Hoomy.

Trainings Hours:

30 hours + 6 hours + 42 hours + 12 hours + 21 hours = 111 hours. (Satisfied with the requirement)

Publications

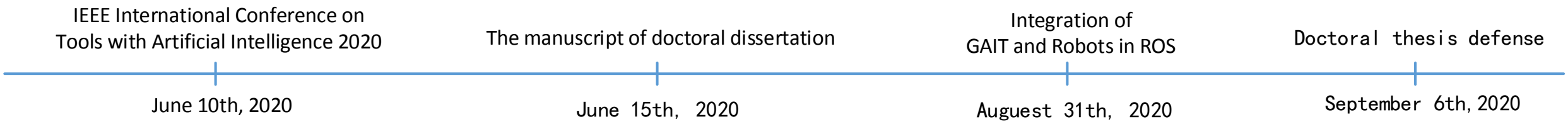
- **XUE, Jianyong**, GEORGEON, Olivier L., et GILLERMIN, Mathieu. Causality Reconstruction by an Autonomous Agent. In : *Biologically Inspired Cognitive Architectures Meeting*. Springer, Cham, 2018. p. 347-354.
- **XUE, Jianyong**, WU, Kehe, et ZHOU, Yan. A risk analysis and prediction model of electric power GIS based on deep learning. *International Journal of Computational Science and Engineering*, 2019, vol. 18, no 1, p. 39-43.
- Olivier L. Georgeon, Paul Robertson, et **Jianyong Xue**. Generating Natural Behaviors using Constructivist Algorithms. *The first annual International Workshop on Self-Supervised Learning*, 2020.

- **Jianyong XUE**, Olivier Georgeon, *. A Model of Bottom-up Hierarchical Sequential Learning with Constructivist Paradigm (This paper has finished, preparing for publishing)

Perspective

- Agent has to retrospect all previous learned composite interactions to retrieve the ones whose pre-interactions are matched with the current enacted interaction in each decision-making. With interactions continuing, the recorded enacted interaction traces progressively grow longer, then the agent will spend long time to activated all eligible composite interactions for anticipations.
- The valence assignment for different experiments is an important issue in constructivist learning. The optimal allocation strategy could apparently accelerate and improve the learning process, otherwise it slows down agent's interaction and even interferes with the learning process.
- With memorizing patterns that could improve the learning efficiency and eliminating composite interactions that probably will not use to simplify the activation and proposition processes in the future.
- Application of GAIT: Prepare the interfaces for the Integration of algorithm and framework GAIT with Robots in ROS, in the project of “INIT” with UCLy.

Timeline


IEEE International Conference on
Tools with Artificial Intelligence 2020
June 10th, 2020
The manuscript of doctoral dissertation
June 15th, 2020
Integration of
GAIT and Robots in ROS
Auguest 31th, 2020
Doctoral thesis defense
September 6th, 2020

Merci