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Unleashing the Agents: From a Descriptive to an Explanatory Perspective in Agent-based Modelling

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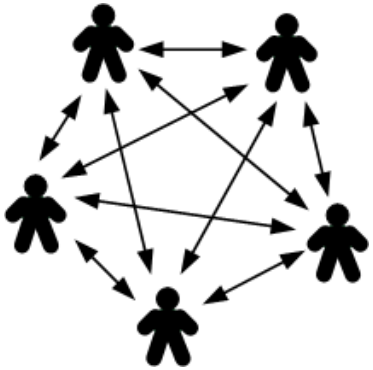
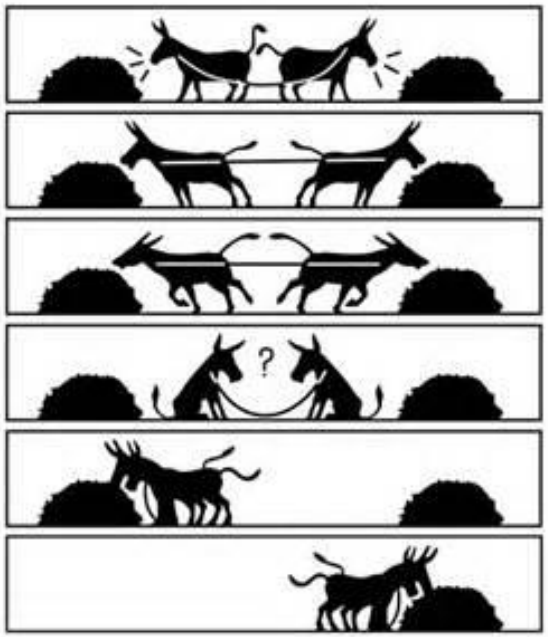
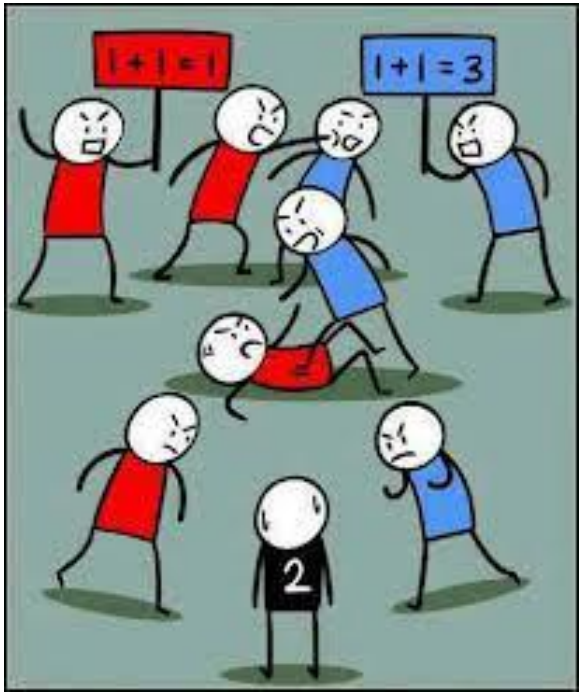


The things we do …



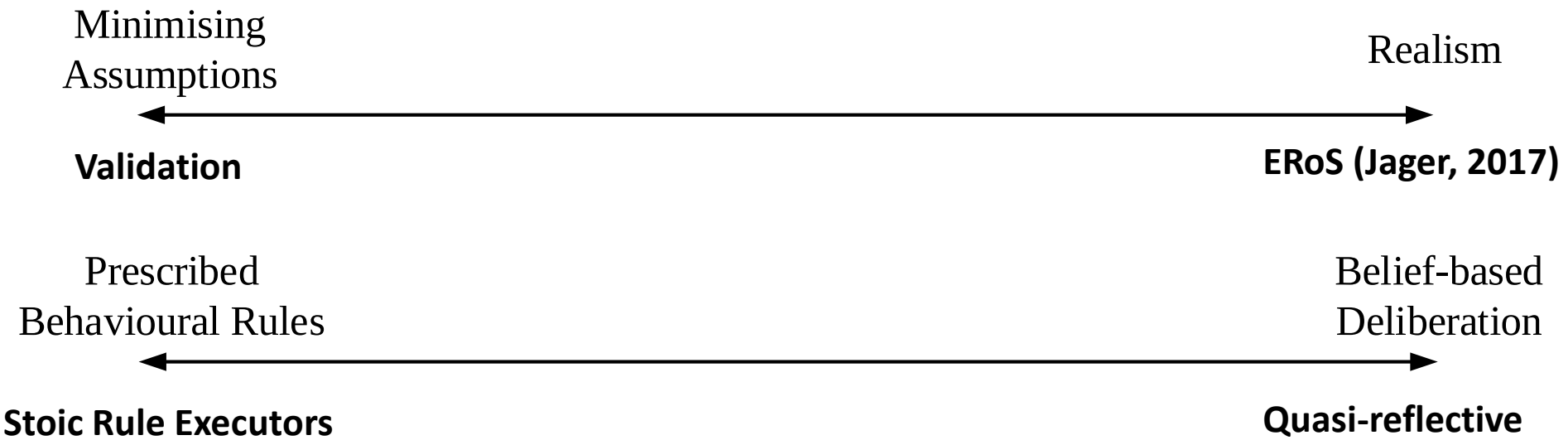


- Agent-based Modelling
  - Complexity
  - Human Metaphor

Images:
http://sethsays.org/index.php/2016/08/26/cooperation-beats-competition-pun-intended-seth-explains-why-part-3/
https://aspergerhuman.wordpress.com/2017/01/14/social-conflict-makes-me-ill/

… when we model …

- Realistic representation of *scenario* important
- But what about the *agents*?



Question

- Can we endow our «pseudo humans» with (at least) «pseudo-reflective» ability?
- Motto: «Don’t tell me *what* you are doing; tell my *why* you are doing it.»
- → 1. Development Process
- → 2. Evaluation

Development Process

- Verification
  - Step-by-step verification
- Standard Debugging/Inspection Tools?
  - State inspections (e.g. variables)
  - Suggestion: mental reconstruction of narrative from states
- While states are helpful, narratives are preferrable.
  - Letting the agents explain what (they think) is happening

Evaluation

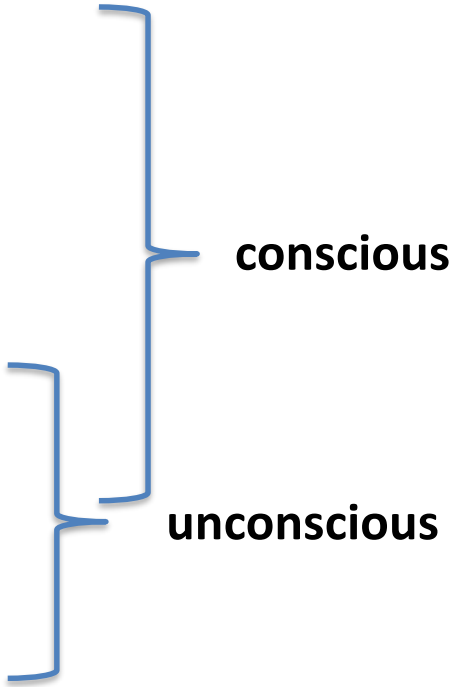
- Temptation to focus on aggregate metrics
- Closing the micro-macro link of analysis
- Uniform and accessible exploration across all levels of social organisation

Challenges

- Minimal set of human abilities necessary?
- Representation?

Fundamental (Human) Abilities?

- Deliberation (reasoning)
- Abstraction (complex language, social constructions)
- Empathy (perspective taking)
- Social learning, referencing
- Experiential learning
- Implicit social cognition (stereotyping)
- ….



Suggestion: (Social) *Institutions* as lowest common denominator of any society

Fundamental (Human) Abilities?

- Deliberation (reasoning)
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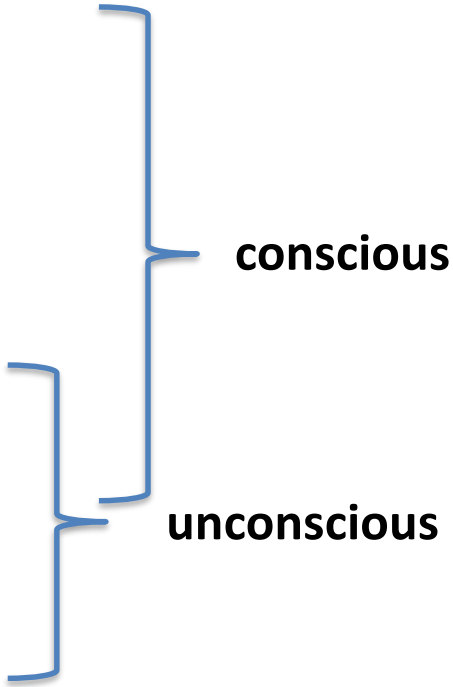


Suggestion: (Social) *Institutions* as lowest common denominator of any society

Institutions ('Manifestations of Social Behaviour')

- **Conventions (Descriptive Norms)**
  - Describe observable behaviour
  - «Drivers drive on the right side of the road.»
- **Social Norms (Injunctive Norms)**
  - Describe obligations, permissions, prohibitions
  - Socially enforced
  - «Drivers must stop at zebra crossing if encountering pedestrians.»
- **Rules (Laws)**
  - Formalised, centrally enforced
  - Traffic law: «Drivers must stop at zebra crossing, or else they face fines.»

Institutional Grammar: Nested ADICO

Frantz et al., 2013/2015; Extension of original 'Grammar of Institutions' by Crawford and Ostrom, 1995

Symbols	A	D	I	C	O
Semantics	Attributes	Deontic	Aim	Conditions	Or else
Pragmatic use	Actor	Duty	Action	Context	Sanction

Spatial, temporal, procedural

- Institution Types:
- AIC (Conventions)
  - Drivers **(A)** drive on the same side **(I)** of the road **(C)**.
- ADICO (Norms/Rules)

Monitored statement

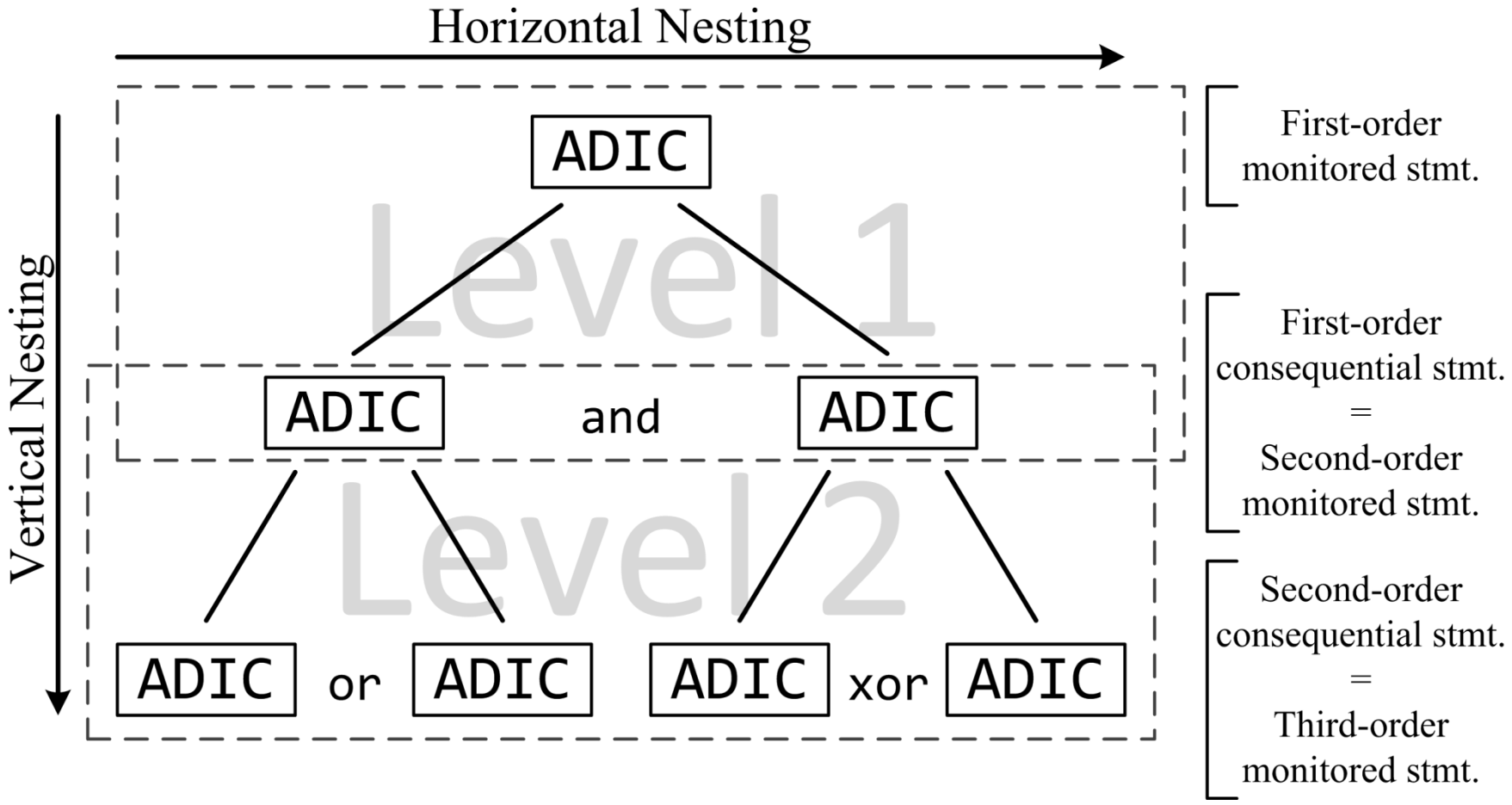
  - Drivers **(A)** ***must*** **(D)** drive on the same side **(I)** of the road **(C)**, ***or else*** drivers **(A)** may **(D)** cause accidents **(I)**.*

Consequential statement

➔ Structure: **ADIC(ADIC)**

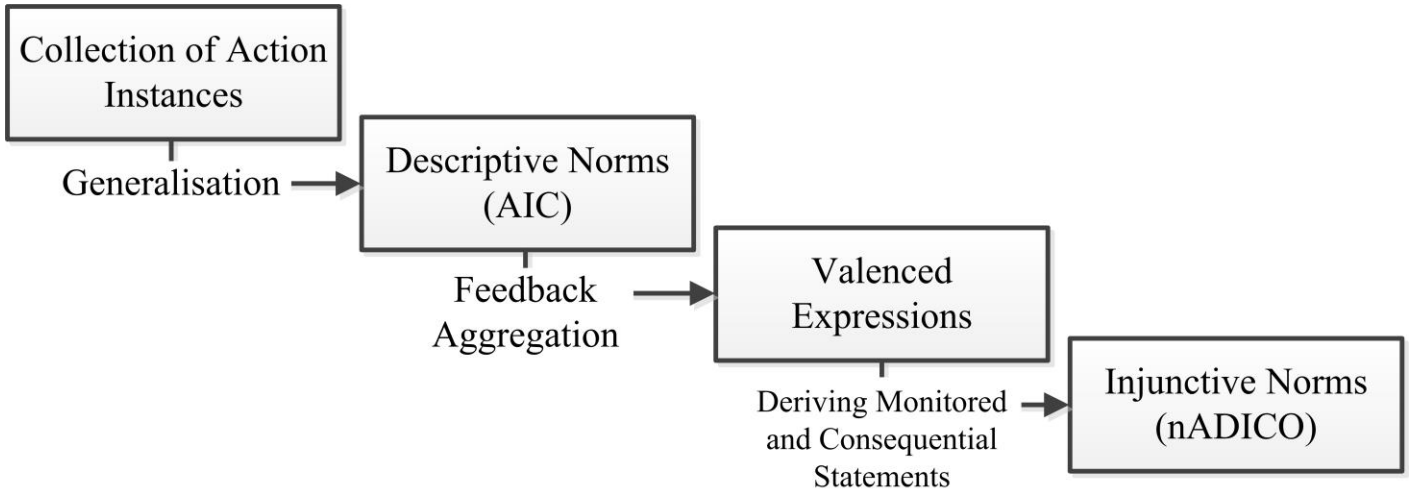
* If unspecified, (C) resolves to 'at all places, at all times'.

Nesting Principles



Process

- Agents observe their social environment and collect observations (& feedback), and generalise those.
- Inference of *desirable actions* based on feedback




```
act(attributes(Trader1, Seller), aim(trade, goods), *), 17
act(attributes(Trader2, Seller), aim(trade, goods), *),  5
act(attributes(Trader3, Seller), aim(embezzle, goods), *), -3
act(attributes(Trader4, Seller), aim(trade, goods), *), 20
. . .
```

→ Details: Frantz et al. (2015): *Modelling Dynamic Normative Understanding in Agent Societies*. Scalable Computing: Practice and Experience, vol. 16, no. 4, pp. 355-378

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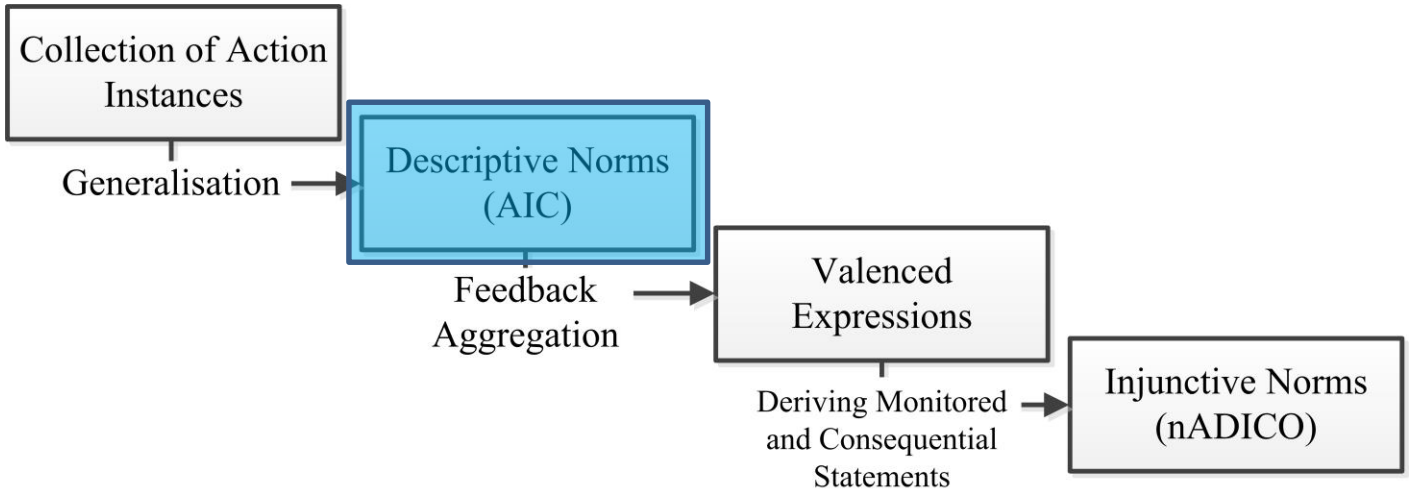


```
aic(attributes(*, Seller), aim(trade, goods), *), 17
aic(attributes(*, Seller), aim(trade, goods), *),  5
aic(attributes(*, Seller), aim(embezzle, goods), *), -3
aic(attributes(*, Seller), aim(trade, goods), *), 20
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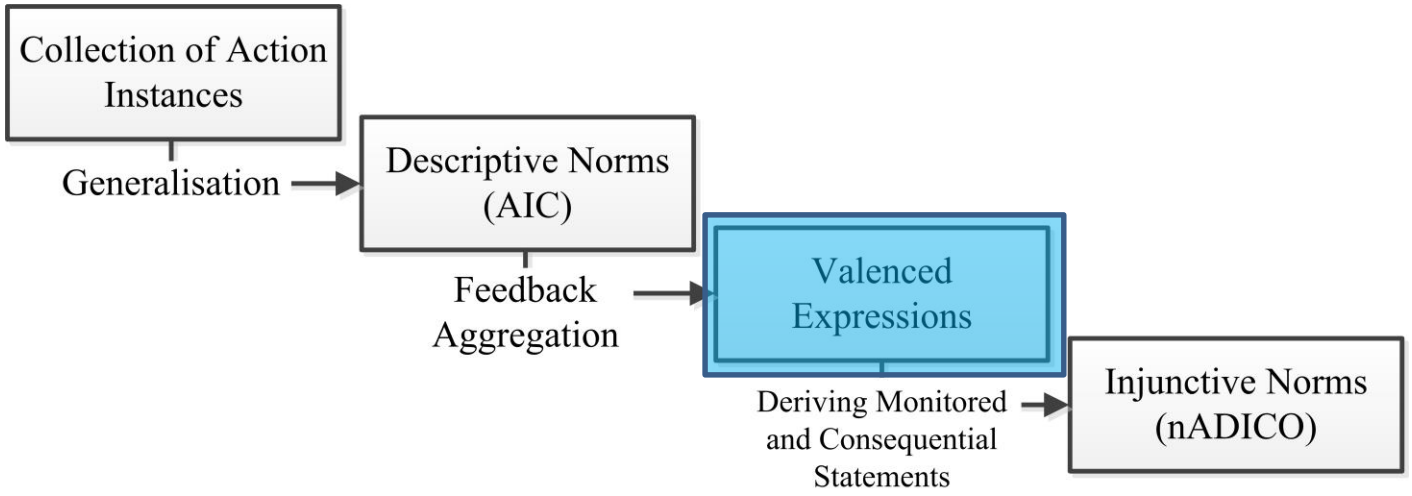


```
aic(attributes(*, Seller), aim(trade, goods), *), 14
aic(attributes(*, Seller), aim(embezzle, goods), *), -3
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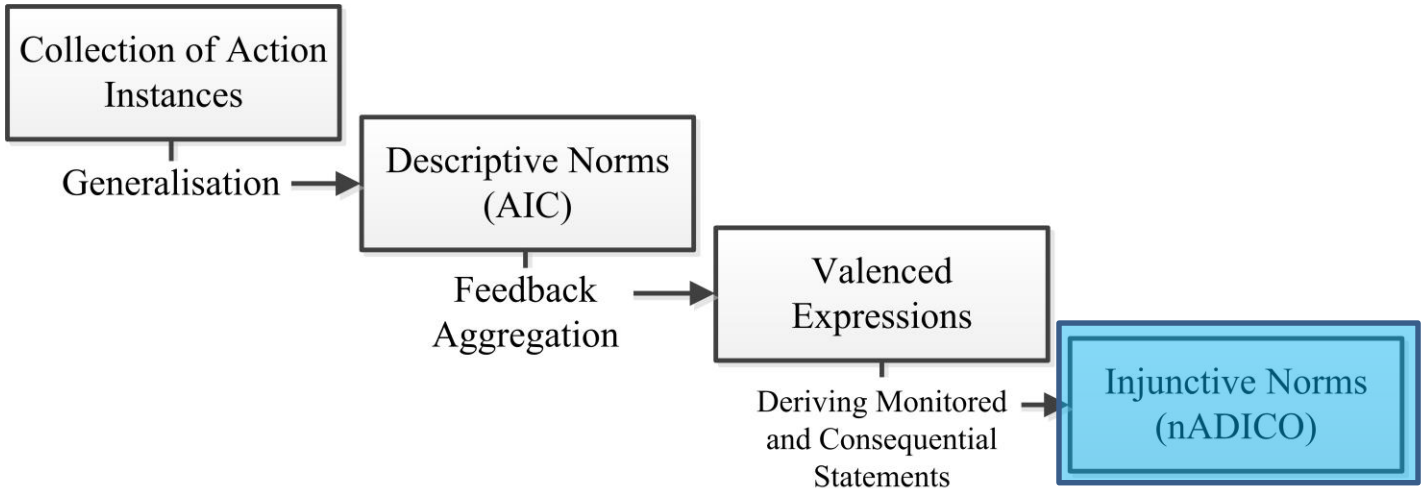

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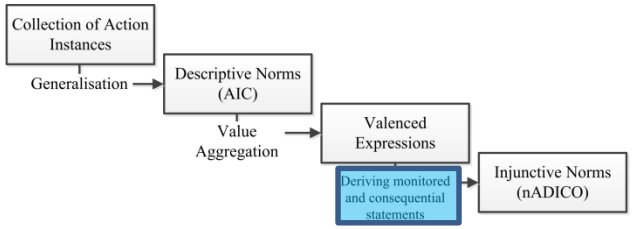
Generating Injunctive Norms




```
aic(attributes(*, Seller), aim(trade, goods),
    conditions(attributes(*, Producer), aim(send, goods), *)), 14
aic(attributes(*, Seller), aim(embezzle, goods),
    conditions(attributes(*, Producer), aim(send, goods), *)), -3
```

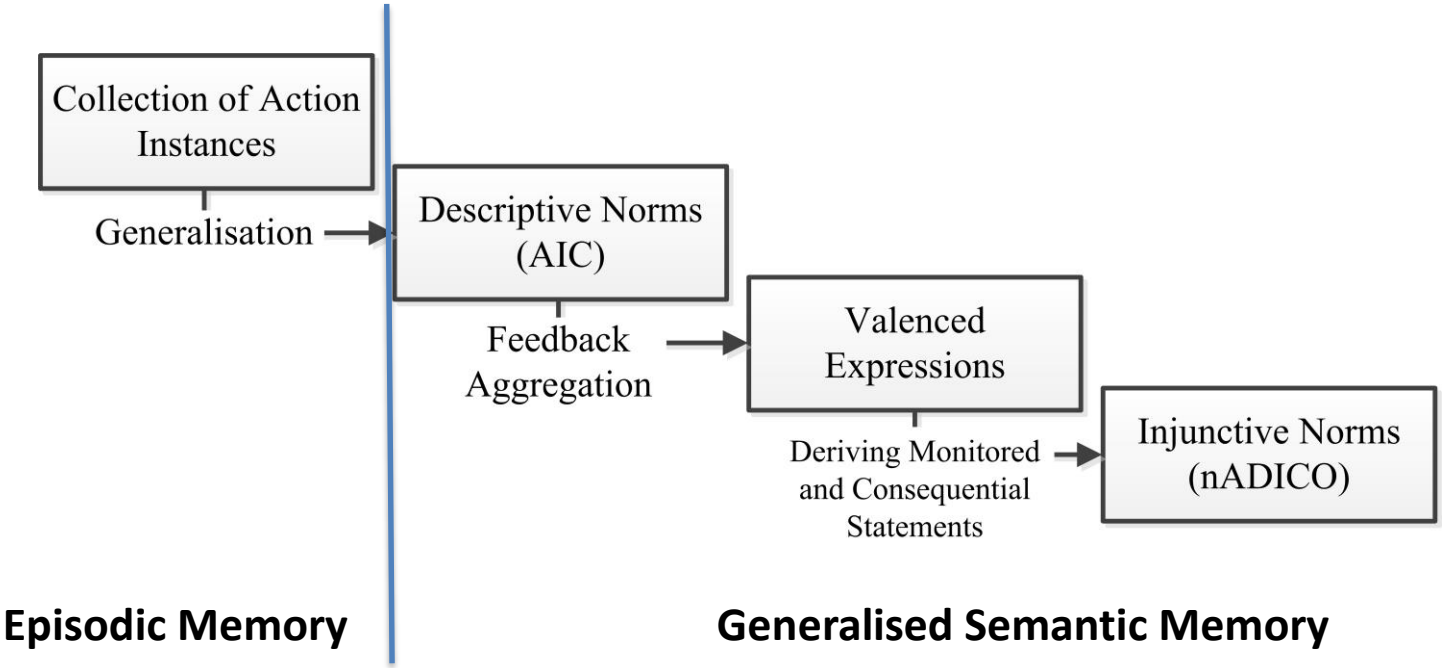
Action 2

Action 1 (previous action)

- → Mapping to ADIC(ADIC or ADIC) :
- `nadico(adic(attributes(*, Producer), should (11), aim(send, goods), *),`
  - **`orElse(`**
    - `adic(attributes(*, Seller), will not, aim(trade, goods), *)` **or**
    - `adic(attributes(*, Seller), will not, aim(embezzle, goods), *))`

→ Details: Frantz et al. (2015): *Modelling Dynamic Normative Understanding in Agent Societies*. Scalable Computing: Practice and Experience, vol. 16, no. 4, pp. 355-378

Process



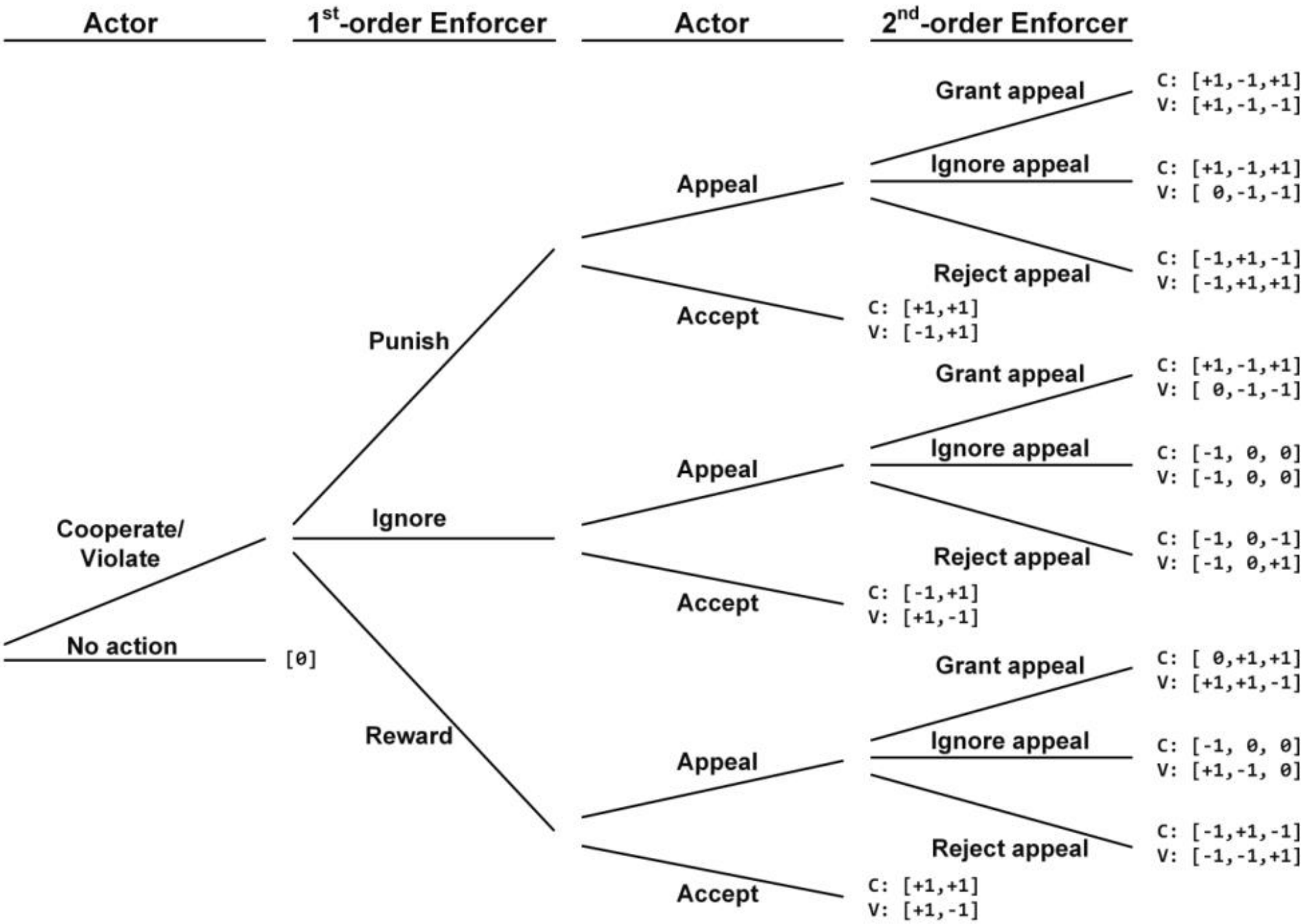
- Performed in real time
- For each agent

Experiment

- Corruption Game – Cooperation game of moderate complexity; variation of double-sided metanorms game

- Stylised interaction between citizens and enforcement personnel (monitoring and punishing transgressions)

- Third party monitoring and appeals process
  - Enforcers monitor citizens, and are monitored themselves
  - Representation of Structural Institutional Regress



Feedback Syntax: *[citizen[,1stOfficial[,2ndOfficial]]]*; C → Cooperate; V → Violate

Parameters

Parameter	Value Range and Step Size
Number of Citizens	25 – 75; step size: 25
Number of Officials	25 – 75; step size: 25
Exploration Probability	0.1
Cheater Fraction	0.3 – 0.7; step size: 0.2
Cheating Probability	0.5 (fixed)
Weight for Observations	0.5 (fixed)
Memory Length	100 (fixed)

Correlation between parameters and cooperation decisions

Parameter	COOPERATE	VIOLATE	INACTIVE
Number of Citizens	0.22	0.25	0.51
Number of Officials	0.36	0.55	0
Quota of Cheating Citizens	−0.3	0.45	0
Social Learning	−0.03	0.03	−0.25
Social Learning Separated by Role	0.32	−0.22	−0.35
Ignoring Actions	−0.38	0.36	0.51
Appealing	0.33	−0.14	−0.33

Drilling down: Correlation between statement inference and role-separated social learning

Index		Statement	Correlation
1	+	OFFICIAL: REJECT_APPEAL – CITIZEN: APPEAL – OFFICIAL: SANCTION – CITIZEN: VIOLATE	0.38
2	o	CITIZEN: ACCEPT – OFFICIAL: IGNORE – CITIZEN: APPEAL – OFFICIAL: SANCTION – CITIZEN: VIOLATE	0.25
3	--	OFFICIAL: GRANT_APPEAL – CITIZEN: APPEAL – OFFICIAL: SANCTION – CITIZEN: VIOLATE	0.25
4	+	CITIZEN: ACCEPT – OFFICIAL: REWARD – CITIZEN: COOPERATE	0.38
5	--	CITIZEN: ACCEPT – OFFICIAL: IGNORE – CITIZEN: APPEAL – OFFICIAL: IGNORE – CITIZEN: COOPERATE	0.26
6	--	OFFICIAL: REJECT_APPEAL – CITIZEN: APPEAL – OFFICIAL: IGNORE – CITIZEN: COOPERATE	0.26
7	+	OFFICIAL: GRANT_APPEAL – CITIZEN: APPEAL – OFFICIAL: IGNORE – CITIZEN: APPEAL – OFFICIAL: SANCTION – CITIZEN: COOPERATE	0.13
8	--	OFFICIAL: REJECT_APPEAL – CITIZEN: APPEAL – OFFICIAL: SANCTION – CITIZEN: COOPERATE	0.26
9	+	OFFICIAL: GRANT_APPEAL – CITIZEN: APPEAL – OFFICIAL: SANCTION – CITIZEN: COOPERATE	0.23
10		CITIZEN: IGNORE	−0.35

Micro-level Statements

+

A=A(*, {ROLE=[CITIZEN]}), D=3.0, I=I(APPEAL, *), C=C({PREVIOUS_ACTION=L0: A=A(*, {ROLE=[OFFICIAL]}), I=I(SANCTION, *),
C=C({PREVIOUS_ACTION=L0: A=A(*, {ROLE=[CITIZEN]}), I=I(VIOLATE, *), C=C(*), O=(null)}), O=(null)}),
O=(L1: A=A(*, {ROLE=[OFFICIAL]}), D=-3.0 (inv), I=I(GRANT_APPEAL, *), C=C(*), O=(null))

--

A=A(*, {ROLE=[CITIZEN]}), D=-1.0, I=I(APPEAL, *), C=C({PREVIOUS_ACTION=L0: A=A(*, {ROLE=[OFFICIAL]}), I=I(SANCTION, *),
C=C({PREVIOUS_ACTION=L0: A=A(*, {ROLE=[CITIZEN]}), I=I(VIOLATE, *), C=C(*), O=(null)}), O=(null)}),
O=(L1: A=A(*, {ROLE=[OFFICIAL]}), D=1.0 (inv), I=I(REJECT_APPEAL, *), C=C(*), O=(null))

--

A=A(*, {ROLE=[CITIZEN]}), D=-0.5, I=I(APPEAL, *), C=C({PREVIOUS_ACTION=L0: A=A(*, {ROLE=[OFFICIAL]}), I=I(REWARD, *),
C=C({PREVIOUS_ACTION=L0: A=A(*, {ROLE=[CITIZEN]}), I=I(VIOLATE, *), C=C(*), O=(null)}), O=(null)}),
O=(L1: A=A(*, {ROLE=[OFFICIAL]}), D=0.5 (inv), I=I(REJECT_APPEAL, *), C=C(*), O=(null))

+

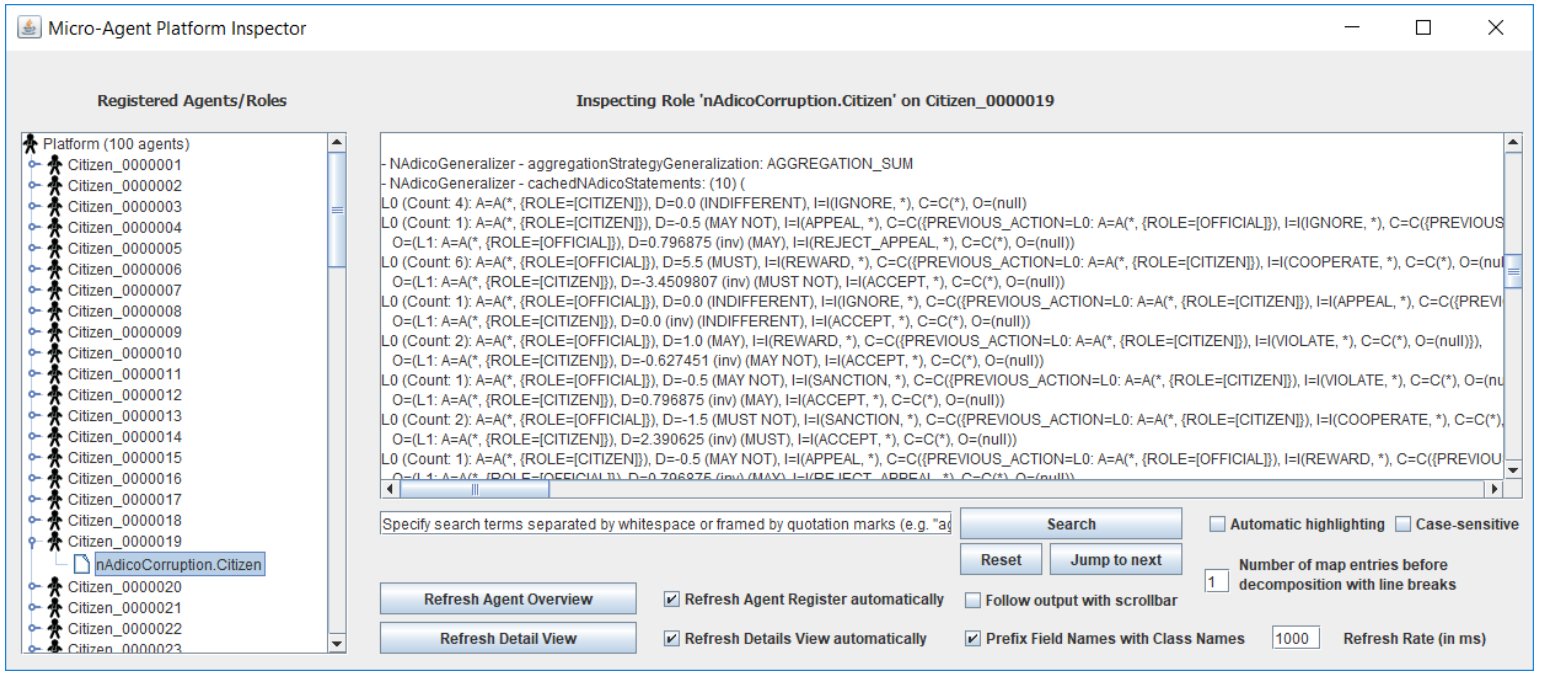
A=A(*, {ROLE=[CITIZEN]}), D=0.5, I=I(APPEAL, *), C=C({PREVIOUS_ACTION=L0: A=A(*, {ROLE=[OFFICIAL]}), I=I(REWARD, *),
C=C({PREVIOUS_ACTION=L0: A=A(*, {ROLE=[CITIZEN]}), I=I(COOPERATE, *), C=C(*), O=(null)}), O=(null)}),
O=(L1: A=A(*, {ROLE=[OFFICIAL]}), D=-0.5 (inv), I=I(GRANT_APPEAL, *), C=C(*), O=(null))

Summary

- Leveraging agents to explain scenarios
  - «Institutional narratives»
- Drilling across all levels of social organisation
  - Micro, meso, macro
- Generic approach
  - Identify attributes (social markers), actions, feedback
- Use cases
  - «Cheap deliberation» → injection of results into decision-making
    - Intrusive
  - Inspection of scenario from agent perspective
    - Non-intrusive

Challenges & Outlook

- Readability
- Performance (Memory)
- Explore application in policy analysis
- Provision as plug-in



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Questions/Thoughts?

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