

# Open-ended Intelligence

## The Individuation of Intelligent Agents

David Weinbaum (Weaver)  
space9weaver@gmail.com  
Viktoras Veitas  
vveitas@gmail.com

Global Brain Institute  
Vrije Universiteit Brussel

Artificial General Intelligence, Berlin, July 2015

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

## Definition of Intelligence

- ▶ Intelligence has many definitions in diverse disciplines.
- ▶ The most comprehensive collection of definitions of intelligence to date: (Legg and Hutter, 2007).
- ▶ A widely accepted definition of General Intelligence in AGI circles:

The ability to achieve complex goals in complex environments. (Goertzel, 2012)

Let us refer to this kind of intelligence as  
**Goal Oriented Intelligence (GOI)**

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

The Current Understanding  
Critique of the GOI concept  
A New Conceptual  
Approach

Theory of  
Individuation

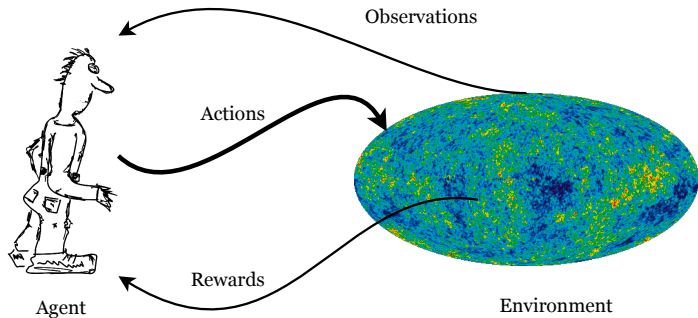
Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# Goal-oriented Intelligence



**Goal-oriented Intelligence** is a measure of an **agent's competence** to match actions to observations such that it will achieve optimal rewards in a variety of environments.

Open-ended intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is Intelligence?

The Current Understanding  
Critique of the GOI concept  
A New Conceptual Approach

Theory of Individuation

Intelligence, Cognition, Sense-making

A Framework for Open-ended Intelligence

Conclusion

References

# Critique of Goal-oriented Intelligence

The definition is based on a few presumptions:

- ▶ A sharp agent-environment distinction;
- ▶ that imply well defined interactions.
- ▶ The environment is initially unknown but is observer independent and *a priori* given;
- ▶ Goals given in terms of reward functions are *a priori* given and unchanging;
- ▶ The agent's computational capacities;

These presumptions **appeal strongly to common sense** and frame the concept of intelligence in a reasonable and pragmatic manner.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

The Current Understanding  
Critique of the GOI concept  
A New Conceptual  
Approach

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

## Limits of the definition

**However**, these presumptions also limit the generality of the concept in at least three profound ways:

- ▶ They disregard processes of **agent-environment differentiation and boundary formation**;
- ▶ They disregard processes of **goal and value formation** – intelligence never starts with solving a problem but much earlier in the formation of the problematic situation;
- ▶ They also disregard **reflexivity**: interactions with other intelligent agents whose goals are unknown and their behaviors are not yet determined.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

The Current Understanding  
Critique of the GOI concept  
A New Conceptual  
Approach

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

## Going beyond the limits

In short:

- ▶ The current definition of intelligence covers only **a well determined kind of intelligence**;
- ▶ But neglects the more profound and difficult to define **process of the emergence of intelligent behaviors**.
- ▶ Therefore, it would be interesting to ask:

What is intelligence prior to anything *intelligible*?

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

The Current Understanding  
Critique of the GOI concept  
A New Conceptual  
Approach

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# Minimizing Constraints

## What if we give up:

- ▶ the clear boundaries and distinctions between agent and environment;
- ▶ the implied observations and actions that are made possible by such boundaries and distinctions;
- ▶ and finally, the definite goals with their associated mapping of rewards.

## It seems as if nothing is left to build upon:

- ▶ If there are no prior distinctions,
- ▶ how is one to make sense out of a non-sense situation where no agents or objects can be identified to begin with?

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

The Current Understanding  
Critique of the GOI concept  
A New Conceptual  
Approach

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# A truly general kind of intelligence

- ▶ By reducing to the minimum the presumptions that constrain the conventional concept, we develop the new concept of **Open-ended Intelligence (OEI)**:

Open-ended Intelligence (OEI) precedes the well characterized concept of Goal-oriented Intelligence (GOI), it makes fewer presumptions and therefore is ***fundamentally more general.***

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

The Current Understanding  
Critique of the GOI concept  
A New Conceptual  
Approach

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References



## A Conceptual Leap

A conceptual leap needs to be taken here:

While the concept of Goal-oriented Intelligence answers the question “what does it mean **to be** intelligent?”,

the concept of Open-ended Intelligence focuses on a prior question: “what does it mean **to become** intelligent?”.

Open-ended Intelligence:

*The process of becoming intelligent* –  
the sense-making that precedes clear distinctions and goals and brings them forth.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

The Current Understanding  
Critique of the GOI concept  
A New Conceptual  
Approach

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

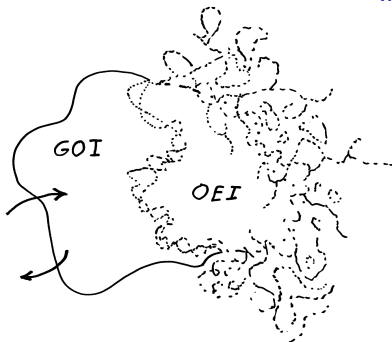
References

# Goal-oriented vs. Open-ended Intelligence

Whereas Goal-oriented Intelligence is the well defined and thus visible tip of the 'intelligence iceberg', Open-ended intelligence is the vast and mostly invisible iceberg itself.

## Goal-oriented Intelligence

- ▶ Definite boundaries
- ▶ Definite goals
- ▶ Definite capacities



## Open-ended Intelligence

- ▶ Fluid boundaries
- ▶ Progressively determined goals and capacities
- ▶ metastable, problematic

Open-ended intelligence

David Weinbaum (Weaver) & Viktoras Veitas

What is Intelligence?

The Current Understanding  
Critique of the GOI concept  
A New Conceptual Approach

Theory of Individuation

Intelligence, Cognition, Sense-making

A Framework for Open-ended Intelligence

Conclusion

References

# Ontology of Individuals

- ▶ To develop a theory of Open-ended Intelligence a new ontology is required.
- ▶ Our conventional system of thought is grounded in entities called *Individuals*.
  - ▶ Individuals are primary ontological elements.
  - ▶ Unambiguously definable (Aristotle's principle of the excluded middle).
- ▶ We understand the world by identifying individuals and relations among them.
- ▶ Everything starts and ends with individuals.
- ▶ The genesis of individuals is merely the manner by which one individual transitions into another.
- ▶ **Stable entities are primary; change is secondary.**

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

The Conditions of  
Individuation  
Transduction  
Assemblages

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# Ontology of Individuation

We base the concept of Open-ended Intelligence on a radically different ontology:

- ▶ Individuals are replaced with **individuation**.
- ▶ The theory of **individuation** is an ontological paradigm shift developed by G. Simondon.
- ▶ Instead of positing individuals as the primary ontological elements,
- ▶ **It posits as primary the process of their becoming i.e. their individuation.**

## Individuation:

Individuation is the formation or becoming of individuals. It is a primal formative process whereas boundaries and distinctions arise without assuming any individual(s) that precede(s) them.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

The Conditions of  
Individuation

Transduction

Assemblages

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# The metastable individual

## In the new ontology:

- ▶ Individuals are merely temporarily stable phases within a continuous process of transformation.
- ▶ An individual is always pregnant with not yet actualized and not yet known potentialities and tensions that may determine future states.
- ▶ Three overlapping conditions of individuation: **metastability, intensity, incompatibility.**

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

The Conditions of  
Individuation  
Transduction  
Assemblages

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

## Metastability

- ▶ Metastability is the condition of a fluid state-space topology where changes in the number of state variables and their relations reform the location and shape of attractors that signify relatively stable individuals.

## Intensity

- ▶ Intensity is a general term for differences that drive structural and state changes in a system.
- ▶ Intensities are context specific and depend on the nature of the system (e.g. temperature, chemical concentration, economic resources distribution, psychological needs, distribution of populations etc.)

## Incompatibility

- ▶ Incompatibility is the situation where a set of interacting elements pose to each other problems that prompt resolution.
- ▶ The **problematic situation** is unstable, non-organized, and lacks coordinated interactions. Does not give itself to a systematic description.
- ▶ Predator-prey relationships is an exemplar of a problematic situation.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

The Conditions of  
Individuation

Transduction

Assemblages

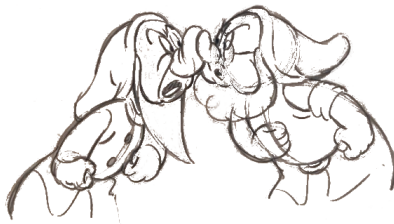
Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

## Example: an argument



- ▶ An argument is an **individuating** system.
- ▶ It goes through various semi-stable states such as partial agreements or crises and therefore it is a **metastable** situation harboring unrealized potentials of change in personal relations.
- ▶ The parties desire to each hold to her own convictions and persuade the other to change his. This desire is the **intensity** that drives and animates the interaction.
- ▶ Thinking differently about a situation that requires a joint coordinated action is a **problematic situation**. The **incompatibility** in perspective between the parties **must be resolved** at least to a degree that allows the necessary joint action.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

The Conditions of  
Individuation

Transduction

Assemblages

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# Transduction - the mechanism of individuation

- ▶ Consider interactions among a collection of initially incompatible agents.
- ▶ The outcome of interactions is unpredictable as they do not follow systemic development.
- ▶ Prior to, and in the course of the actual interactions, the outcome is said to be **determinable but not yet determined**.
- ▶ **Transduction** is a process of ongoing **progressive co-determination** among agents.
- ▶ Progressive determination necessitates the actual localized and contextualized interactions where the participating agents reciprocally determine the behavioral and structural aspects of each other.
- ▶ As incompatibilities are resolved and intensities are relaxed, coherent structure and dynamics stabilize and an **individual** emerges as an **assemblage** of simpler agents.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

The Conditions of  
Individuation

Transduction

Assemblages

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References



# From individuation to individuals

## Assemblages

Networks of interacting heterogeneous individuals that have established partial compatibility among them.

(Developed by Deleuze and Guattari (1987) and further extended by De Landa (2006))

- ▶ Assemblages possess an intrinsic though metastable individuality; an individuality that does not depend on an external observer but only on the relations that have been stabilized among their elements.
- ▶ Individuals as assemblages are characterized by:
  - ▶ **Identifying properties** – that define them as the individuals that they are (and subject therefore to their own individuation).
  - ▶ **Capacities to interact**– to affect and be affected by other external elements.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

The Conditions of  
Individuation

Transduction

Assemblages

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

## The open-endedness of individuals

- ▶ While the individual's properties are more or less stable and independent, the set of its interactive capacities is open and inexhaustible.
- ▶ It depends on the actual and contingent encounters with other individuals and the relations formed as a consequence.
- ▶ Since there is no limit to the number and kind of relations, the set of capacities to interact is **open-ended and unpredictable**.
- ▶ What becomes determined in transduction are **the actual interactive capacities**.
- ▶ This is why the actual interaction is necessary for the determination and why the resulting relations cannot be predicted *a priori*.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

The Conditions of  
Individuation

Transduction

Assemblages

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

## Implication: The individuation of knowledge

- ▶ Individuation has a profound impact on epistemology:
- ▶ According to the ontology of individuation, knowledge is not discovered but individuates.
- ▶ Acquiring knowledge involves the formation of a new assemblage:
- ▶ The subject of knowledge, the object of knowledge and the relations between them arise together in the course of a process where incompatibilities are resolved and coherent relations are established.
- ▶ These come to constitute **individuated knowledge** as both object and subject co-determine each other.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

The Conditions of  
Individuation

Transduction

Assemblages

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# Open-ended Intelligence (OEI)

## Our thesis:

The formative processes that bring forth individuals as 'solutions' to problematic situations that are initially unformed, are manifesting Open-ended Intelligence (OEI).

## From a philosophical perspective:

Open-ended Intelligence manifests all around us and at many scales. General systems whether natural like galaxies, stars, rivers, chemical compounds, weather systems etc., or artificial such as tools, machines, wars, mathematical algorithms, AIs etc. are formed individuals that manifest an intrinsic and identifiable intelligence (GOI).

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# OEI in cognitive systems

- ▶ We are not interested in such consolidated manifestations of intelligence but rather in their (process of) individuation.
- ▶ We draw the lines that **connect Open-ended Intelligence to the individuation of cognition and cognitive systems**, whereas cognition is understood in the broadest sense.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# Cognition

- ▶ Cognition is complex.
- ▶ Cognition involves agents operating in their environments.
- ▶ Ongoing problem-solving activity.
- ▶ The roots of cognition is in a problematic situation:
  - ▶ Requires resolution by action.
  - ▶ Full of tensions.

Still, how do agents, environments and their dynamic relations that facilitate cognitive activity emerge?

Answer: Sense-making

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# Sense-making

## What is sense-making?

- ▶ **Sense-making** is the bringing forth of a world of distinctions, objects and entities and the relations among them.
- ▶ Even primary distinctions such as 'internal – external', 'self – other' or even 'real – unreal' are part of sense-making.
- ▶ We understand sense-making as the individuation of cognition itself.
- ▶ **It precedes the existence of individual identities and is actually a necessary condition to their becoming.**

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References

# Synthetic Cognitive Development

- ▶ In the context of cognition, sense-making is synonymous with Open-ended Intelligence.
- ▶ It corresponds to the acquisition of novel cognitive capacities i.e. to **cognitive development**.
- ▶ Open-ended Intelligence therefore generalizes the concept of cognitive development beyond its conventional psychological context.
- ▶ **We aim to understand and construct systems capable of cognitive development i.e. manifesting Open-ended Intelligence.**

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References



# A Framework for Open-ended Intelligence

- ▶ Actual sense-making is a continuous process of integration and disintegration of individuals taking place in a distributed network of agents and their interactions.
- ▶ There is no *a priori* subject who ‘makes sense’.
- ▶ Both subjects and objects, agents and their environments co-emerge in the course of sense-making.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfoldment of  
Individuation

Phases of individuation

Coordination

Stratified structure

Conclusion

References

# Preindividuals, Individuals, Fluid Individuals

Three phases of individuation can be distinguished based on the general characteristics of the ongoing interactions under consideration:

- ▶ Preindividual boundary formation
- ▶ Fluid identities
- ▶ Fully formed individuals (identities)

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfoldment of  
Individuation

Phases of individuation

Coordination  
Stratified structure

Conclusion

References

## Preindividual boundary formation

- ▶ Preindividual boundaries arise due to the non-uniformity of affective interactions within a population of agents.
- ▶ **Information integration** can be used to delineate boundaries: the information integration of a set of interacting agents is a relative measure of how strongly their states have become mutually correlated in comparison to their correlation with the rest of the population.
- ▶ Groups of agents that contingently affect each other more strongly or frequently than they are affected by the rest of the agents in the population, tend to clamp together and form a boundary that distinguishes them from the rest of the population (that becomes their environment).

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfoldment of  
Individuation

Phases of individuation

Coordination

Stratified structure

Conclusion

References

## Fully formed individual identities

The consolidation of individual identities requires interdependent closures between agents and recurrence in their interactions:

### Interdependent closure:

An identity is generated as a network of interdependent agents become operationally closed. The conditions necessary for the existence of each agent critically depend on the interactions with other agents in the network.

### Recurrence:

For an identity to become stable, the state transitions and interactions must become recurrent by that allowing the continuity of the closure.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfoldment of  
Individuation

Phases of individuation

Coordination  
Stratified structure

Conclusion

References

## Fluid Identities

- ▶ The phases of sense-making form **a continuum of change** spanning from ultimate disparity (disorder) to highly organized cognitive agents.
- ▶ **Fluid identities** form a thick borderline between preindividual entities and fully formed identities with balanced proportions of coordinated and contingent interactions.
- ▶ Fluid identities are the rule rather than the exception; fully formed identities are mere idealizations.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfoldment of  
Individuation

Phases of individuation

Coordination  
Stratified structure

Conclusion

References

## Fluid Identities and OEI

- ▶ Fluid identities are volatile entities whose defining characteristics change across time;
- ▶ but without losing their overall distinctiveness in the long run.
- ▶ From the perspective of Open-ended Intelligence **fluid identities is where new sense emerges out of non-sense**;
- ▶ but in association with previously established sense objects.
- ▶ Fluid identities is where intelligence expands.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfoldment of  
Individuation

Phases of individuation

Coordination  
Stratified structure

Conclusion

References

## Coordination

- ▶ In the course of transduction agents spontaneously **coordinate** their interactions and by that increase their compatibility forming new assembled individuals.

### Coordination:

The reciprocal regulation of behavior given in terms of exchanging matter, energy or information among interacting agents, or, between an agent and its environment.

- ▶ Open-ended Intelligence (OEI) is associated with the **process of achieving coordination**.
- ▶ The intelligence of a newly formed individual (GOI) is associated with the **coordination achieved** by initially disparate groups of agents in the course of their interactions.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfoldment of  
Individuation

Phases of individuation

Coordination

Stratified structure

Conclusion

References

# The Conditions of Coordination

## Feedback:

- ▶ Mutual modification of behavior in coordination requires direct or indirect feedback among agents.
- ▶ If agent *A* affects the behavior of agent *B*, but is not affected by the modifications of behavior it has initiated, there is no real sense in speaking about progressive resolution of incompatibility.

## Recurrence:

- ▶ A new sense consolidates only when 'discovered' coordinated interactions become recurrent i.e. 'forming a habit'.
- ▶ The tendency towards the formation of recurrent patterns of interactions is not given *a priori*.
- ▶ It is itself an outcome of individuation.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfoldment of  
Individuation

Phases of individuation

Coordination

Stratified structure

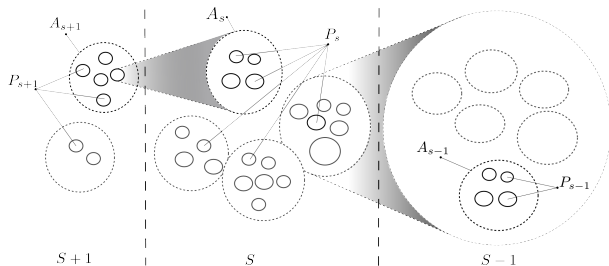
Conclusion

References



## Strata of assemblages

- ▶ A stratified architecture of populations of individuals.
- ▶ Populations are heterogeneous and diverse.
- ▶ Each stratum provides the “raw material” for the stratum immediately above it.
- ▶ New individuals are assemblages – sets of “raw material” agents that established recurrent and coherent interactions.
- ▶ Every stratum is a unique field of individuation with specific intensities and incompatibilities.
- ▶ **Individuation takes place in parallel at all strata simultaneously.**



Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfolding of  
Individuation

Phases of individuation

Coordination

Stratified structure

Conclusion

References

## Scalable recursive structure

- ▶ The hierarchical relation of assemblages unfolds recursively both upwards and downwards.
- ▶ Lower strata are populated by successively simpler elements and higher strata are populated by successively more complex elements so different strata in the hierarchy are of a different scale of complexity both in structure and dynamics.
- ▶ There is no end, in principle, to the possible expansion of Open-ended Intelligence via the emergence of new strata of individuation.
- ▶ The emergence of every new stratum is **a phase transition in sense-making**. A new plane of 'sense-objects' becomes available to cognition.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

The unfolding of  
Individuation

Phases of individuation

Coordination

Stratified structure

Conclusion

References

# Open Questions and challenges

- ▶ What are the conceptual implications of OEI on the understanding of general intelligence?
- ▶ GOIs are by definition 'tools' but OEIs are not.
- ▶ GOIs focus on control and purpose while OEIs are creative and unpredictable. Can we really control GI and if we can, should we?
- ▶ Understanding the evolution of complex individuals such as corporations, social institutions, distributed autonomous organizations, open-value networks, etc...
- ▶ Applications?
- ▶ ...

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

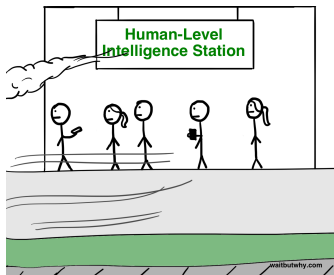
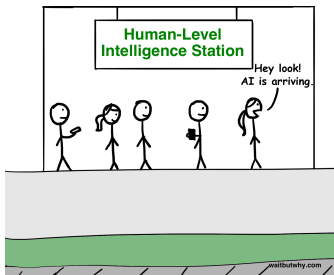
A Framework for  
Open-ended  
Intelligence

Conclusion  
Open Questions  
Further Information

References

## Further Information

- ▶ Open Ended Intelligence:  
<http://arxiv.org/abs/1505.06366>
- ▶ Synthetic Cognitive development:  
<http://arxiv.org/abs/1411.0159>



Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

Open Questions

Further Information

References

# References (short list)

- De Landa, M. (2006). *A new philosophy of society: Assemblage theory and social complexity*. Continuum Intl Pub Group.
- Deleuze, Gilles and Félix Guattari (1987). "A thousand plateaux". In: *Trans. Brian Massumi*. Minnesota: University of Minnesota Press.
- Goertzel, Ben (2012). *CogPrime: An Integrative Architecture for Embodied Artificial General Intelligence*. Wiki.
- Legg, Shane and Marcus Hutter (2007). "A Collection of Definitions of Intelligence". In: *Advances in Artificial General Intelligence: Concepts, Architectures and Algorithms*. Ed. by Ben Goertzel and Pei Wang. IOS Press.

Open-ended  
intelligence

David Weinbaum  
(Weaver)  
&  
Viktoras Veitas

What is  
Intelligence?

Theory of  
Individuation

Intelligence,  
Cognition,  
Sense-making

A Framework for  
Open-ended  
Intelligence

Conclusion

References