Anticipation and Anticipatory Systems: Humans Meet AI

International Symposium
10-13 June 2019

Örebro, School of Humanities, Education and Social Sciences

MEMEORY SLICES BY ANNA STRASSER

MAPPING ANTICIPATION

Roberto Poli - UNESCO Chair in Anticipatory Systems, University of Trento

Futures Studies: unknowability of the future & effort to use the future for decision-making in the present

→ SYSTEMATIC THEORETICAL FRAMEWORK FOR FUTURES STUDIES

- all forward-looking attitudes and activities = too broad
- anticipatory behavior: 'uses' future in its actual decision process
  - a forward-looking attitude + the use of the former's result for action

Rosen's definition:
An anticipatory system:
system containing a predictive model of itself and/or its environment which allows the system to change state at one instant in accord with the model's predictions pertaining to a later instant.

	MODEL *Mainstream science*	MODEL *New scientific avenues*	Future-based action theory
Level 4	Complicated	Complex	Anticipatory
Level 3	Risk	Uncertainty	Anticipation
Level 2	Megatrend	Exploration	Anticipation
Level 1	Forecast	Foresight	Anticipation

no smooth transition exists between the models

keynote 1

INTERNAL OR EXTERNAL TO THE DECISION SYSTEM

- weather forecast vs. decisions taken according to positive or negative expectations
  - internal models: important for understanding the anticipatory behavior of people

EXPLICIT (AWARENESS) OR IMPLICIT (BELOW THE THRESHOLD OF CONSCIOUSNESS)

  - implicit anticipations: properties of the system, intrinsic to its functioning
    - determining the ways in which the organism looks at its environment
    - schemata are anticipatory → construct anticipations of what to expect → enable the organism to actually perceive the expected information
  - work through **evolution** or **learning** / different time scales, ranging from milliseconds (as in perception) to decades (as for many social and technological issues) and even centuries (as for climate change models)
- 3 main distinctions

internal	explicit	depth of the relevant time window
external	implicit	

ANTICIPATION: CONSCIOUS AND UNCONSCIOUS BRAIN PROCESSES

Sara Saban, Yeditepe University, Istanbul

Cognitive Processes and Brain Dynamics in Anticipation

Anticipation → Slow Negative Cortical Potential (SCP) before all cognitive processes

- during only milliseconds
- not S-R automatic response
- active, intentional, goal-directed
- explicit / implicit

functions:

- speed up, strengthen, facilitate and activate cognitive processes involved / motivation, attention, and arousal functions

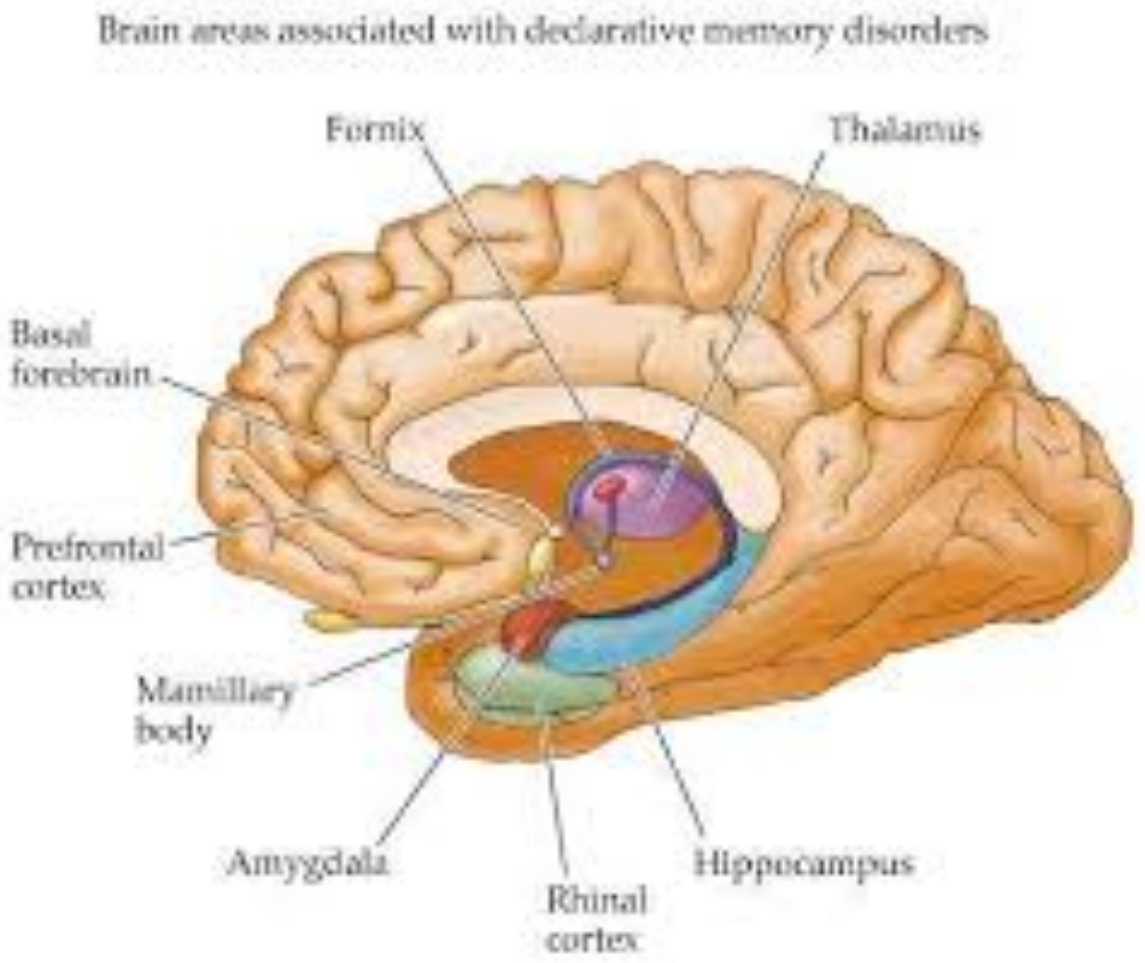
empirical findings: anticipation brainwaves were observed during different cognitive processes

- *Visual attention (Walter et al.,1964), Muscle-movement coordination (Komhuber & Deecke, 1965, Low et al.,1996), Facial expressions and face recognition (Ran et al., 2014), Reward expectations (Van Boxtel & Böcker, 2004), Time estimation (Walter et al., 1964), Feedback about past performance (Brunia & Damen, 1988), Instructions about a future task performance (Gaillar & Van Beijsterveld, 1991), Arithmetic tasks (Chwilla & Brunia, 1992), Affective stimulus (Poli et al., 2007, Simmons et al., 2005)*

PAST & FUTURE in the brain

ANTICIPATION activates brain areas *(Kvegara & Bar, 2007):*

- Thalamus, V1, V4 for Perception
- Hippocampus for Memory (Bar, 2007)
- Frontal Cortex for Visual Processing
- Right Hemisphere for Emotional Processing
- Amygdala/ Hippocampus for Fear Anticipation and for Negative Situations
- Auditory cortex and right frontal cortex for anticipation during auditory task in humans



Model-Based Reinforcement Learning and Acting for Reasons

Patrick Butlin, King's College London

- not all actions are done for reasons)

IS MODEL-BASED REINFORCEMENT LEARNING NECESSARY AND SUFFICIENT FOR THE CAPACITY TO ACT FOR REASONS?

model-based RL:	model-free RL:
representations of learnt action-outcome contingencies → used to anticipate consequences of possible actions *('R-O learning')*	involves learning the value of performing actions under given environmental conditions *('S-R learning')*

TO ACT FOR A REASON:

- act because one takes some consideration to count in favour of so acting
  - influential Humean Theory of Motivation: involves desiring some outcome O, and acting in a way that one believes will make O more likely (Smith 1987)

desires & instrumental beliefs ←→

outcome values & action-outcome contingencies used in model-based RL

- human neural systems have been interpreted as implementing model-based RL

maybe anticipation is not necessary but sufficient?

- **but acting for reasons is not about anticipation:**
  - **specific valuable features of one' action need not to be an anticipated consequence & must be more specific than anticipation of reward**

“It’s a poor sort of memory that only works backwards”

Anticipation as the Essence of Cognition

David Vernon, Carnegie Mellon University, Africa Rwanda

self-regulation (homeostasis & allostasis)

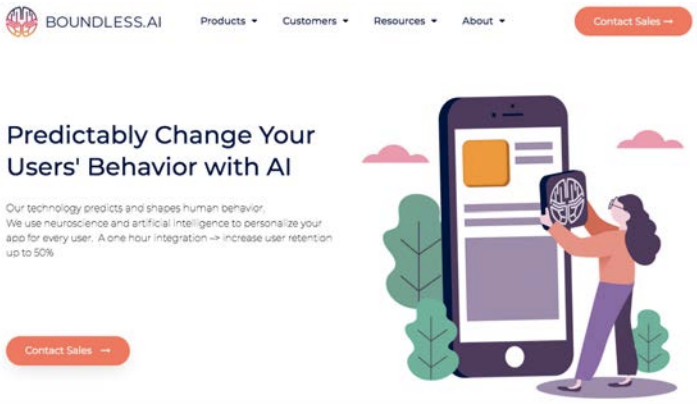
anticipation in perception / action / learning /adapting

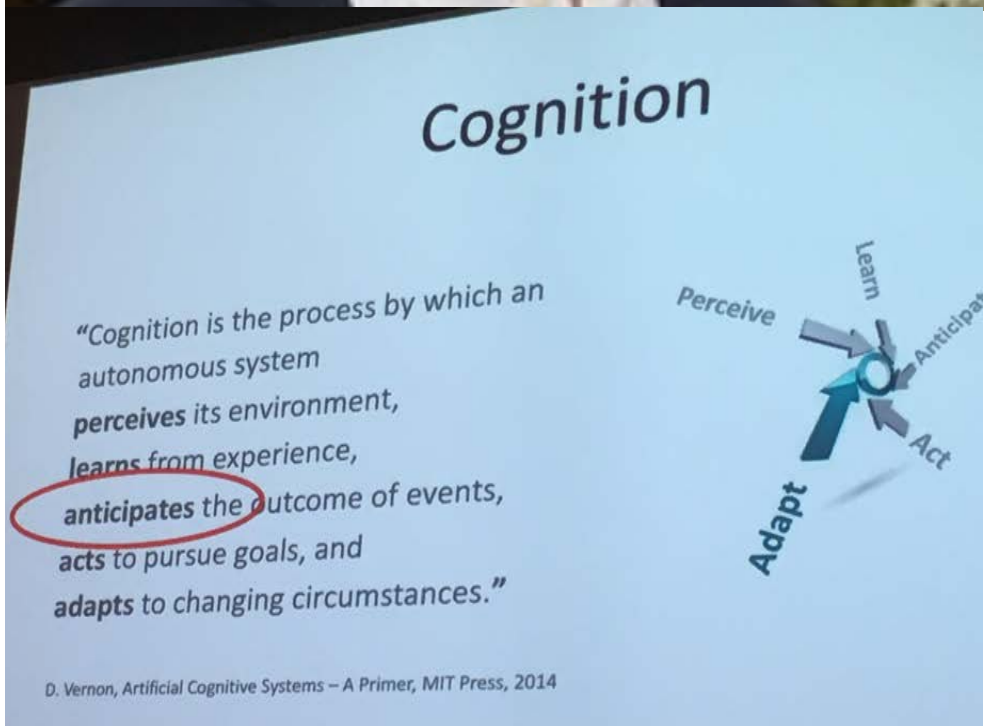
INTERNAL SIMULATION – **MEMORY** – LANGUAGE

episodic future thinking --- → memory is prospective

- AI meets humans – humans meet AI

using anticipation to manipulate behavior

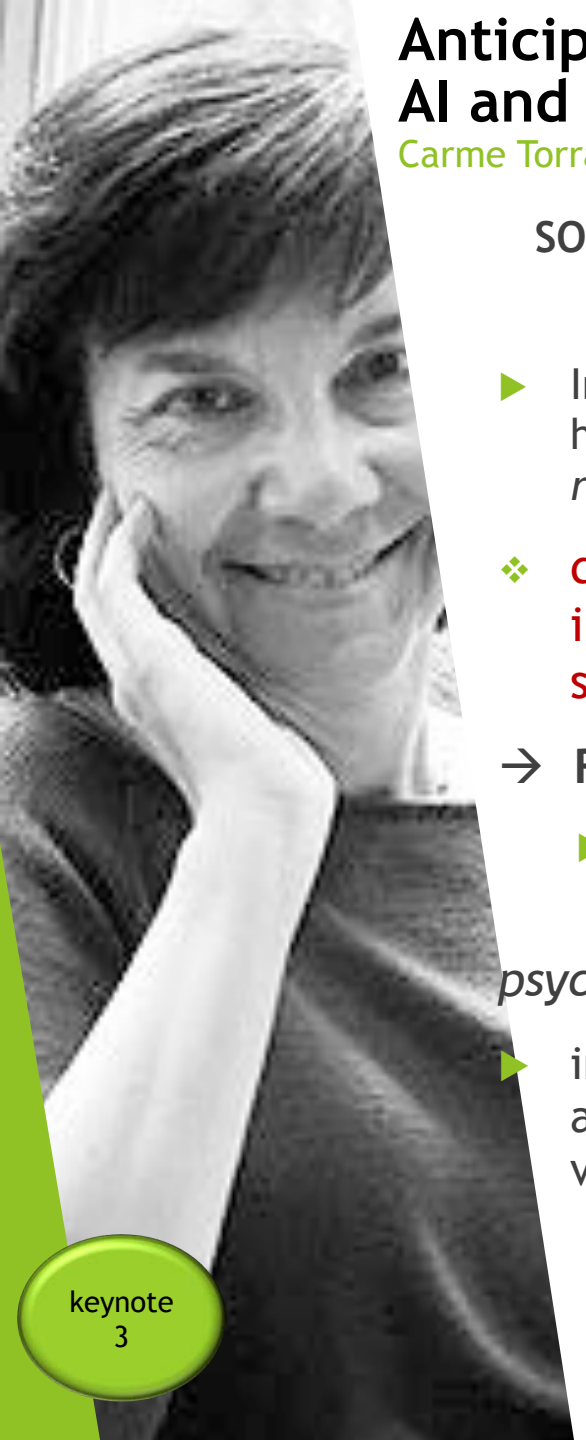




keynote 2

Anticipatory science fiction to foster ethical debates on AI and robotics

Carme Torras, Institut de Robòtica i Informàtica Industrial (CSIC-UPC), Barcelona



keynote 3

SOCIAL IMPLICATIONS OF NEW TECHNOLOGICAL DEVELOPMENTS / BENEFITS AND RISKS OF INFORMATION TECHNOLOGIES

- Internet of things, influencers, programs that learn by interacting with humans, assistive and companion robots → *modify job market, flip someone's reputation, transform a district, change our relationships*

- difficult to predict the influence that hyperconnectivity and increasing interaction with machines will have on the evolution of society, the economy, and on people's daily lives

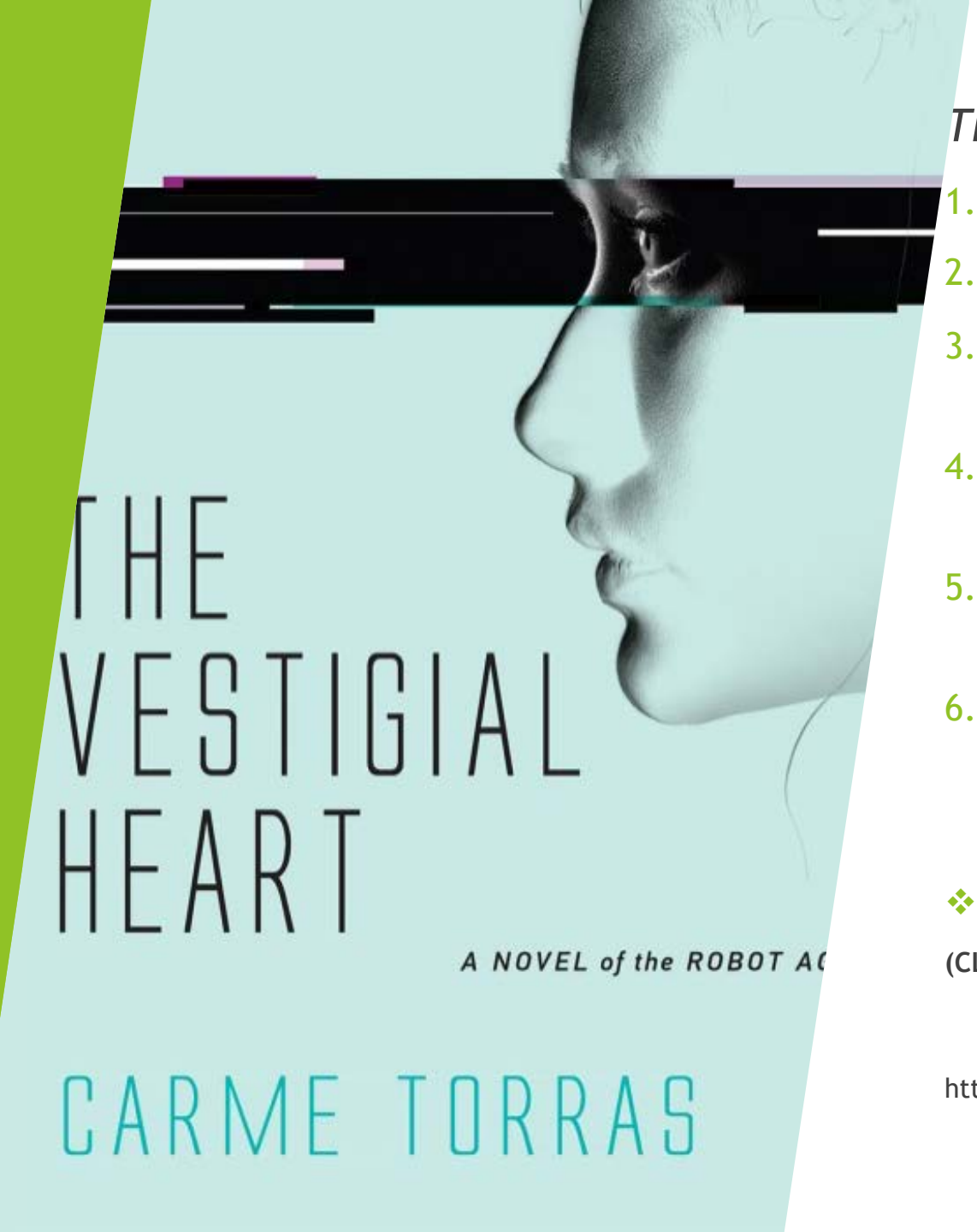
→ **ROBOETHICS**

- Asimov, Dick, Bradbury, *Real humans, Surrogates, The windup girl, Robot and Frank*

psychological and social issues related to

- intensive use of cellphones, widespread interaction in social networks, automatic decision-making based on artificial intelligence, immersive virtual reality games, learning algorithms using big data

  - Black Mirror, *Her*, Hoffmann's *The sandman*



The Vestigial Heart (Torras, 2018)

1. how to design the «perfect» assistant
2. importance of robot appearance
3. simulation of emotions for the acceptance of robots
4. the role of AI programs in the workplace and in the classroom
5. dilemma between automatic decision-making and human freedom and dignity
6. civil responsibility versus programmed «morals» in robots

- **checkout CLOTHILDE**

(**CLOTH** manIpulation **L**earning from **DE**monstrations)

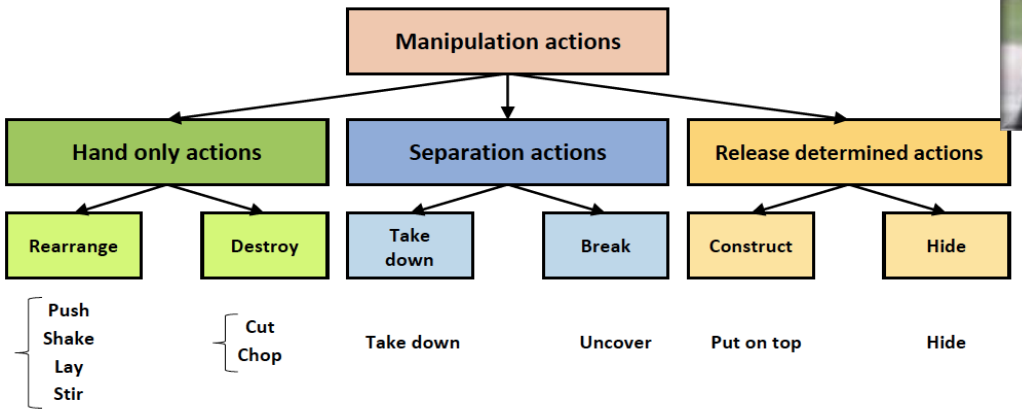
https://www.iri.upc.edu/project/show/187

Who Can Predict Faster? Human or Robot?

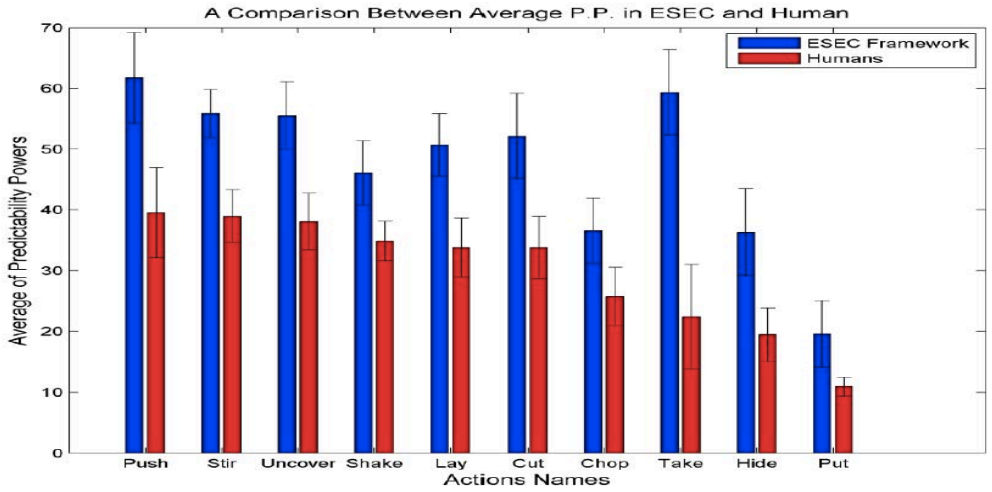
Fatemeh Ziaeetabar, Göttingen

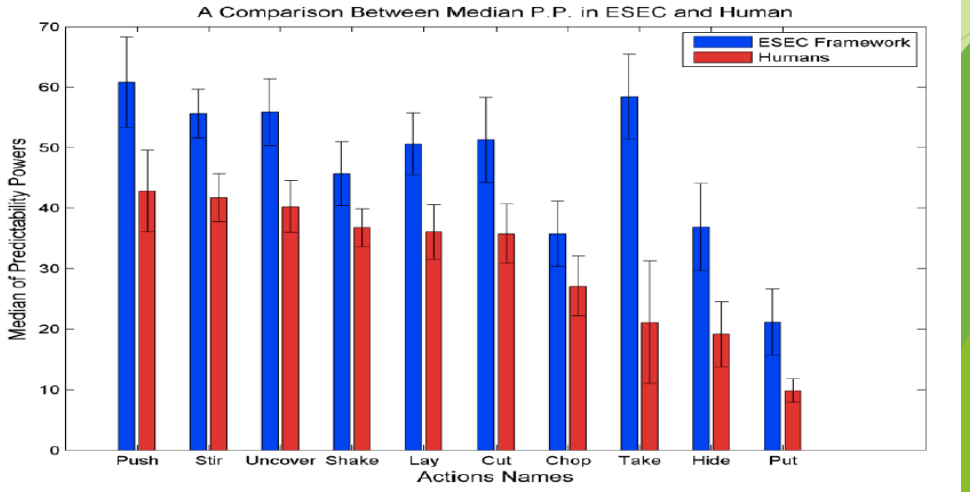
SPATIAL REASONING - SEMANTIC REPRESENTATION OF MANIPULATION - ACTION PREDICTION

- *Static Spatial Relations:* above/below, around, inside/surround
- *Dynamic Spatial Relations:* moving - halting together, Fixed-Moving together, getting close, moving apart, stable



- compare the predictability power of manipulations between ESEC and humans in a Virtual Reality (VR) experiment





A Prehistory to Prescience: The Rational Recollection of Futurity

Thomas Moynihan, University of Oxford

RECONSTRUCT LONGEST-TERM HISTORICAL AND INTELLECTUAL CONDITIONS

NOW: 'culture of prediction' characterized by incrementally long-range & high-resolution models

- *'integration of the future into the present'* → 'futures literacy' Riel Miller [2018]
- *shift to the 'future perfect mode' in contemporary science* Gramelsberger [2011]

HISTORY: sensitization to futurity is always a question of reflective self-legislation and self-regulation before it can procure objective or declarative range as a matter of factual prediction or prospection

- learning: necessary and progressive phase of humanity's intellectual maturation → discovery of contingency that is not itself entirely contingent
- 'what thought is due' = anticipation
- Rescher [1998]: serious futurology presupposes historicism
- Koselleck [2004] 'historical consciousness' emerges from 1750-1850, wherein the 'horizon of expectation' became delaminated from the 'space of experience'

ONE MUST BE A HISTORICIST TO ANTICIPATE THE FUTURE AS UNCERTAIN AND OPEN

= root of such self-awareness → source of modernity's future-orientation and our contemporary apparatus of planetary prediction

- Cardano, c.1552: 'Games of Chance'
- **innovation: relying on prior breakthroughs concerning modal semantics (language to express possibility)**

express possibilities

- counterfactual reasoning / notion of possible worlds
- 'could have been otherwise' →'anticipation' is nothing but the infliction of this higher-order semantic awareness to our experience of the empirical world and its affordances
- modernity-defining projects of prediction, mitigation → self-determination

'ANTICIPATION' TEACHES US THAT FINITUDE IS ALWAYS AS MUCH A PRACTICAL MATTER AS A THEORETICAL ONE

Riel Miller

1. TACIT TO EXPLICIT
2. LEARNING TO LEARN – REFRAINING
3. NEW QUESTIONS

PHASE 1

- imagine a probable future

your best guess about what the nature, role, positions of anticipatory system thinking in 2050 (35 min)

describe in present tense – 3-5 bullet points – talk 1 min

- Imagine a preferable or desired furture (20 min)

REFORM FOR INNOVATION @ UNESCO

MY REFORM STORY

www.unesco.org/reform

UNESCO Pioneers Futures Literacy

Riel Miller

for example group 2

WHAT WE THINK 'WILL'

- increased social division
- anticipatory systems curriculum
- specialized use of anticipatory systems
- anticipatory sensory suit
- expert anticipatory system '+' religion what we 'want'

WHAT WE WANT

- anticipatory systems curriculum
- ecological stability
- anticipatory as what we are, vs. what we do
- future-oriented intergenerational responsibility
- crime and war prevention

Riel Miller

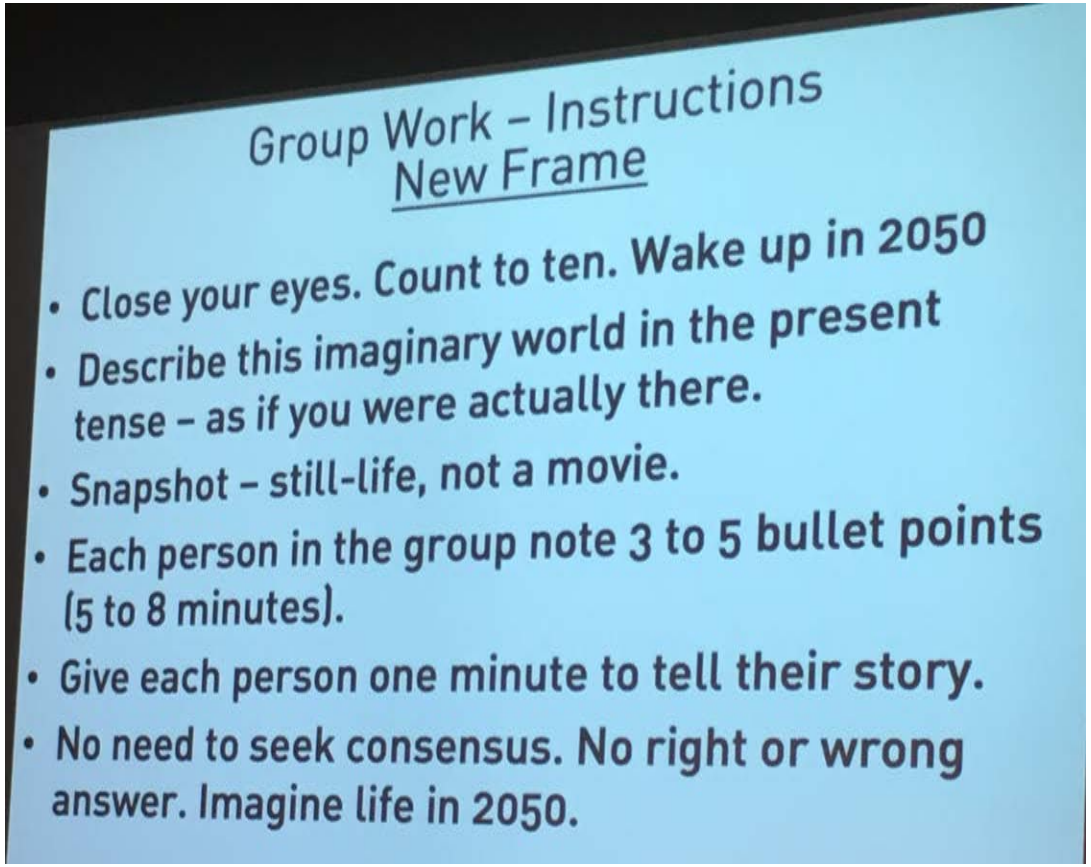
1. TACIT TO EXPLICIT
2. LEARNING TO LEARN - REFRAINING
3. NEW QUESTIONS

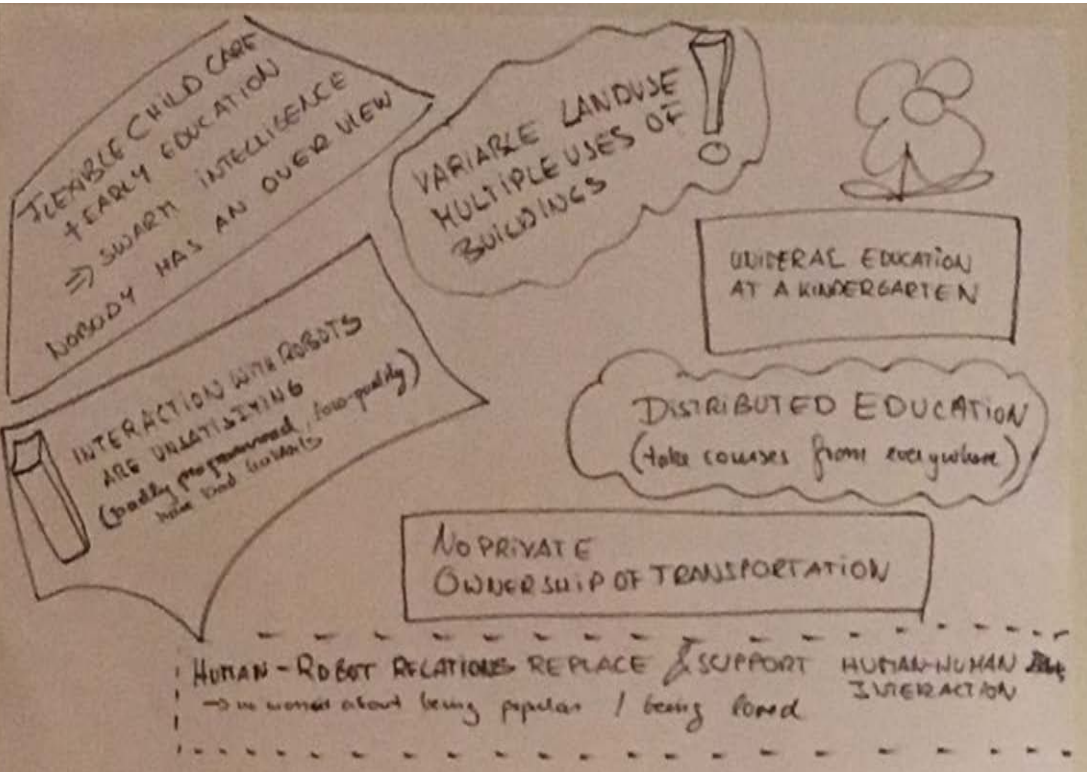
PHASE 2 reframing

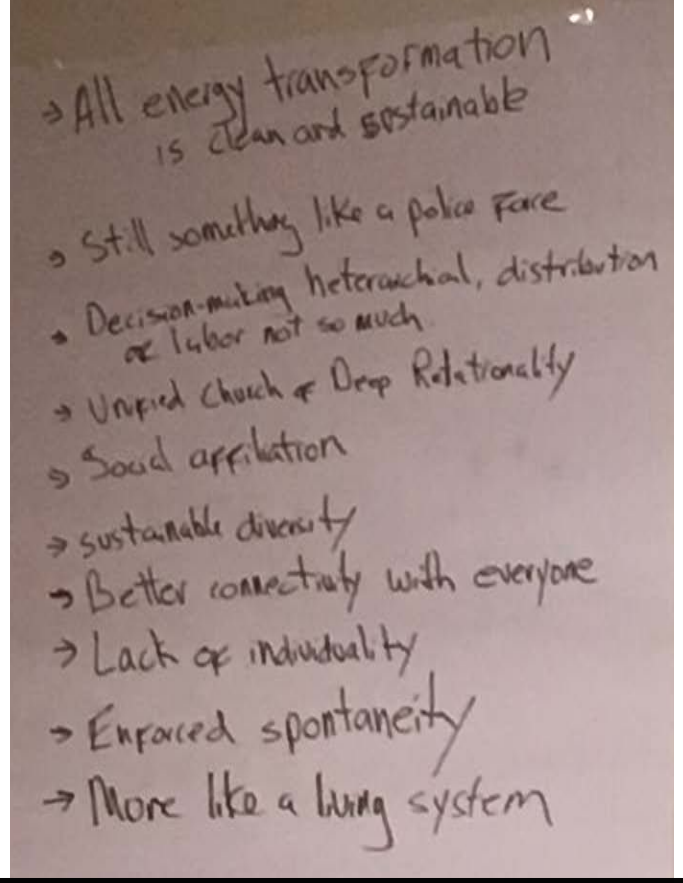
- presentation of reframing -murmuration, jazz, improvisation …
- narrative and analytic elements for a discontinuous frame
-

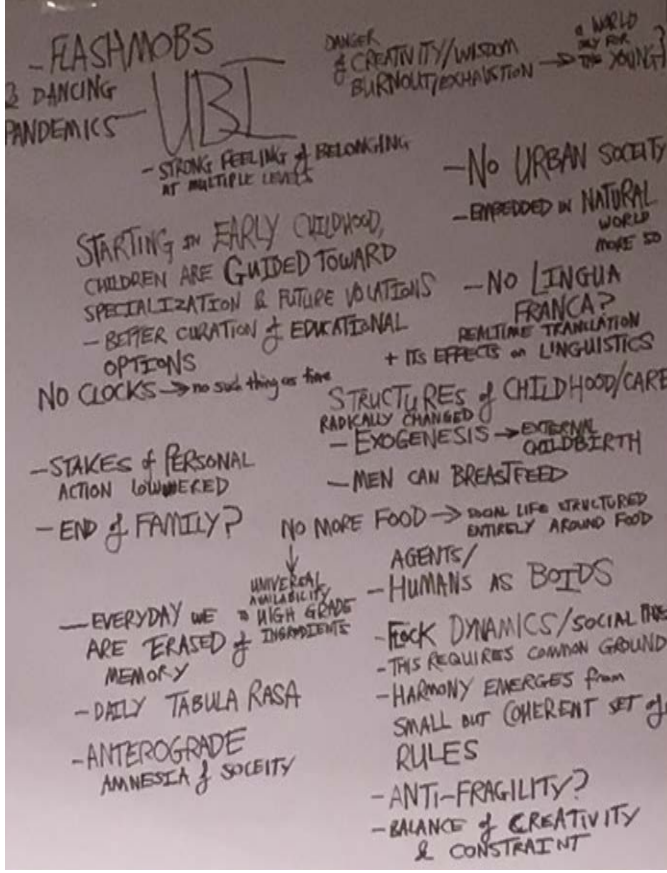
UNESCO Pioneers Futures Literacy

Riel Miller









results of the group work

Stories as Anticipatory Models

Dr Claire Craig (Royal Society, UK) and Dr Sarah Dillon (University of Cambridge)

ROLE OF STORIES AS ANTICIPATORY MODELS IN RELATION TO ARTIFICIAL INTELLIGENCE

Function 1: Communication

- conceptualized as mimetic, represent reality / form of communication/ conveying information about the world between social actors in it

scientists are increasingly aware that they are storytellers

- → aiming to communicate knowledge & implications for the future
  → signal as fiction to illustrate → communicate implications of the science

Demis Hassabis / Illah Reza Nourbakhsh's Robot Futures / The Turing Option, Marvin Minsky's collaboration with SF novelist Harry Harrison

Function 2: Individual and collective identity formation

- development of a life story: present identity & their projected identity in the future (collective identities)
- definition of AI: challenging notions of identity, explore identities abound

HOW STORIES FUNCTION TO CREATE A COLLECTIVE IDENTITY FOR AI RESEARCHERS

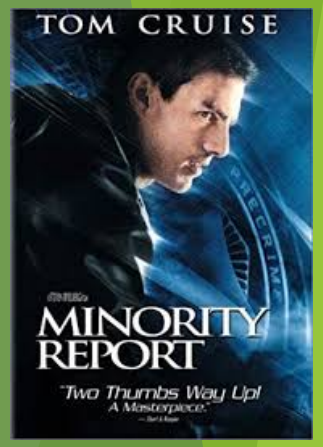
keynote 4

Function 3: Exercise of empathy and theory of mind

- ability to imagine what it might be like to be someone other than oneself?
  - BUT evidence proves only a correlation between theory of mind and reading fiction

→ anticipatory access to the emotional implications of AI technologies (utopia or dystopia)

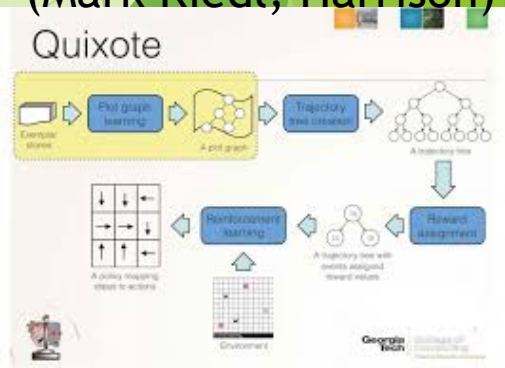
HOW STORIES COULD ENCOURAGE AI RESEARCHERS TO ANTICIPATE THE SOCIAL IMPLICATIONS OF THE TECHNOLOGIES THEY ARE CREATING



(Mark Riedl, Harrison)

Function 4: The development, repository, and transmission of social knowledge

- make humans more expert in social situations
- speeding up their capacity
  - to process patterns of social information
  - to make inferences from other minds and from situations fraught with difficult or subtle choices



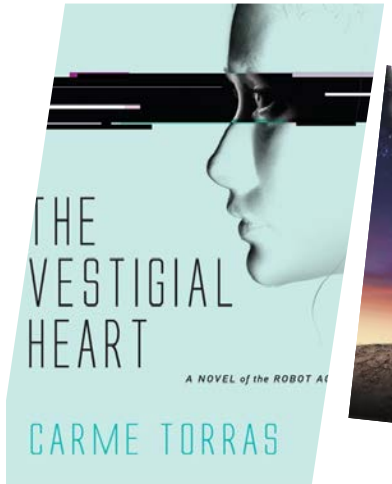
Function 5: Simulation and modelling for decision-making

- enable people to understand the social world through an ostensibly contradictory combination of complexity and abstraction
- way of identifying options that can then be filtered for the purposes of decision-making
- enable the reader to gain empathetic insights into the consequences of that future for themselves or for others and therefore some sense of its intuitive desirability (or attractiveness)

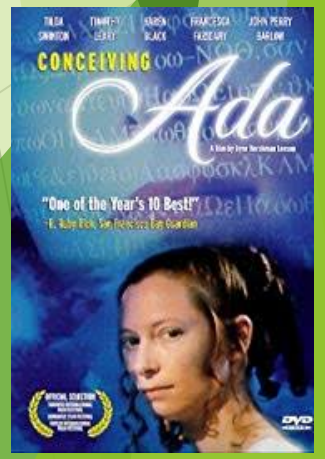
Function 6: Persuasion

- weapons of mass persuasion (manipulative and distortive OR inspiring and motivating)

MOTIVATION OF THE STORYTELLER AND THE CONTEXT OF THE STORYTELLING



NEW FORMS OF ANTICIPATION WILL REQUIRE THE CAPABILITY OF LEARNING FROM LISTENING TO STORIES.



no memory slice (I was talking)

Reverse Hierarchy Theory and the Role of Kinematic Information in Semantic Level Processing and Intention Perception / Paul Hemeren - University of Skövde, Sweden

PERCEIVING INTENTIONS OF OTHER HUMANS

- high-level semantic processing in the visual perception of biological motion
  - predicted from fairly simple kinematic patterns in biological motion sequences

→ Reverse Hierarchy Theory (Ahissar & Hochstein, 2004)

- begins at high perceptual levels (vision-at-a-glance) as a result of fast implicit feedforward processing
- results in conscious perception with greater exposure and expertise, access to lower-level information can be triggered when vision-at-a-glance fails
  - critical feature of this theory is that high-level representations "facilitate the identification of ecologically relevant elements,"

<u>experiments: psychophysical methods / recordings from interactions with objects in natural settings</u>

incidental processing of biological motion (Veto et al., 2013), social gesture recognition (Hemeren et al., 2016) kinematic patterns of cyclists and driver's accuracy to predict the cyclist's intentions in traffic (Hemeren et al., 2014)

<u>results:</u> clear effects of

- "low-level" biological motion factors, such as opponent motion, on the incidental triggering of attention in basic perceptual tasks
- "higher-level" top-down perception in the intention prediction of cyclist behavior

INTERPLAY BETWEEN EXPECTATION MEDIATED (TOP-DOWN) AND STIMULUS DRIVEN EFFECTS OF VISUAL PROCESSING IN THE CONTEXT OF HUMAN INTERACTION

→ critical relationship between action kinematics and judgments of grasping and the social quality of the hand/arm gestures

- *intention-from-movement understanding (e.g., Ansuini et al., 2014; Becchio et al., 2018; Koul et al., 2019; Sciutti et al., 2015)*

- holistic/global processing is involved in the visual perception of biological motion → Eureka effect (Ahissar & Hochstein, 2004), in which learning is governed by top-down control and single exposures and has long-lasting effects

EXAMPLE: predicting the intentions of cyclists in traffic (Hemeren et al., 2014).

- human observers showed a clear reliance on a few critical movement parameters for predicting cyclist intent (head turning and pedaling) / context-based parameters allow to anticipate cyclist behavior

→ can be used to inform (semi-)autonomous systems of human intentions in traffic

- human kinematic motion can be processed implicitly using fast feedforward connections that lead to a high-level semantic understanding of human movement, which includes categorizing actions and perceiving social communication

→ CREATING RELIABLE INTELLIGENT SYSTEMS FOR PREDICTING HUMAN BEHAVIOR AND INTENTIONS WILL HAVE TO FOCUS ON ACHIEVING THIS HIGH-LEVEL UNDERSTANDING OF HUMAN MOTION IN RELATION TO PAST AND CURRENT ENVIRONMENTS

AI for Anticipation: a Possible Means, a Necessary Purpose

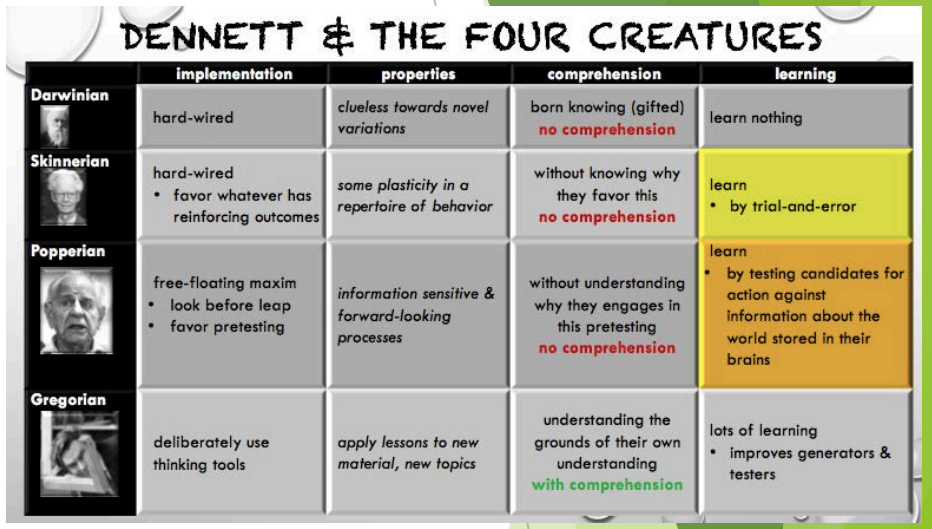
Malik Ghallab, LAAS - CNRS, Univ. of Toulouse, France

TREMENDOUS CHALLENGES WITH RESPECT TO LONGER TERM & SOCIAL ASPECTS OF ANTICIPATION

- simple simulation forecasts of linear deterministic models
  - integrating various types of models & representations: nonlinear, nondifferentiable, discrete, and nondeterministic

challenges:

- **how to go beyond correlation toward causality**
- **how to grasp very rare events that can trigger significant changes**



DENNETT & THE FOUR CREATURES

	implementation	properties	comprehension	learning
Darwinian	hard-wired	*clueless towards novel variations*	born knowing (gifted) no comprehension	learn nothing
Skinnerian	hard-wired • favor whatever has reinforcing outcomes	*some plasticity in a repertoire of behavior*	without knowing why they favor this no comprehension	learn • by trial-and-error
Popperian	free-floating maxim • look before leap • favor pretesting	*information sensitive & forward-looking processes*	without understanding why they engages in this pretesting no comprehension	learn • by testing candidates for action against information about the world stored in their brains
Gregorian	deliberately use thinking tools	*apply lessons to new material, new topics*	understanding the grounds of their own understanding with comprehension	lots of learning • improves generators & testers

AUTOMATED PLANNING: SIMULATION + SEARCH

- combine nondeterministic or probabilistic algorithms → innumerable possible scenarios analyzed for desirability and likeliness using a profusion of data

challenges

- **how to address the coupling issues between dependent elementary steps**
- **how not to bias planning toward myopic**

keynote 5

17 sustainable goals

risks

- **political** *(e.g., easier manipulation of opinions and threats to democracy)*
- **economical** *(e.g., high frequency trading, algorithmic pricing)*
- **social** *(e.g., labor transformation, feeling of being unneeded, quest for social purpose, cohesion and tension problems)*
- **global relations** *(e.g., broad spreading of dual-use AI techniques in military systems)*

POSSIBLE EFFECTS OF AI ON SOCIETY SHOULD BE THE PURPOSE OF SOCIAL EXPERIMENTS AND RESEARCH

Synthetic Anticipation: On the Evolution of Wild Meaning

J. Scott Jordan, Department of Psychology, Illinois State University

ANTICIPATION AS FORWARD-LOOKING INFORMATION: ANTICIPATORY - VIRTUAL - ESTIMATION

- forward-looking approaches (new science of prospection): Seligman, Railton, Baumesiter, Sripada

anticipation:= PROSPECTIVE CONSTRAINT OF CONTEXT

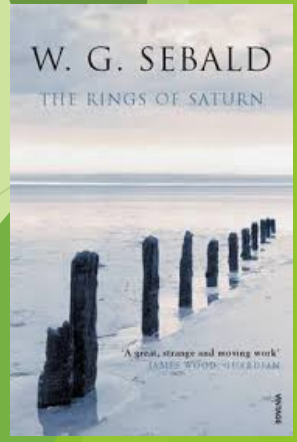
What if anticipation is what we are not what we do?

(Rosen 1985; Hofmeyr 2007; Kauffman 1995; Maturana & Varela 1980)

Wild Systems Theory (WST):

- **self-sustaining systems** that constitute embodiments of context (Jordan, 2013, 2017)
- ability to pre-specify and constrain the dynamic possibilities of its nested transformation systems
  - evolved from small scale contexts constrained by a single cell
  - systems that phylogenetically entailed it (i.e., organisms) were simultaneously energy-transformation systems whose status as such rendered them a possible energy source for potentially emergent energy transformation systems (e.g., plants and herbivores)
  - self-sustaining embodiments of context, such systems are naturally and necessarily 'about' the contexts they embody
  - → **WILD MEANING** → consciousness, self-awareness

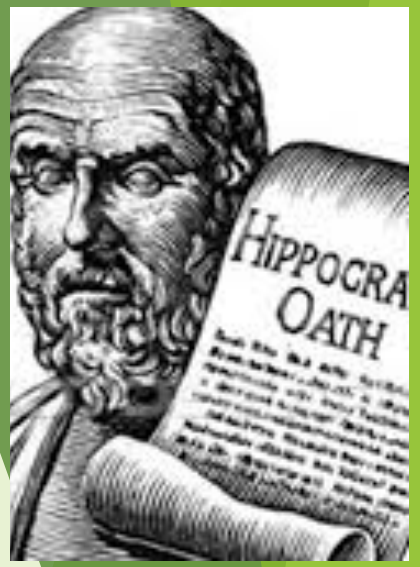
PHYLOGENETICALLY SCALED-UP RECURSION OF THE SELF-SUSTAINING PRE-SPECIFICATION AND CONSTRAINT OF NESTED, DYNAMIC POSSIBILITIES WE SEE IN SINGLE CELL ORGANISMS



keynote 6

Revisiting Hippocrates' "On Ancient Medicine" To Inform Natural and Artificial Anticipation

Fabian Labra-Spröhnle, Nelson Marlborough District Health Board, New Zeeland



I. Medicine is the anticipatory art par excellence!

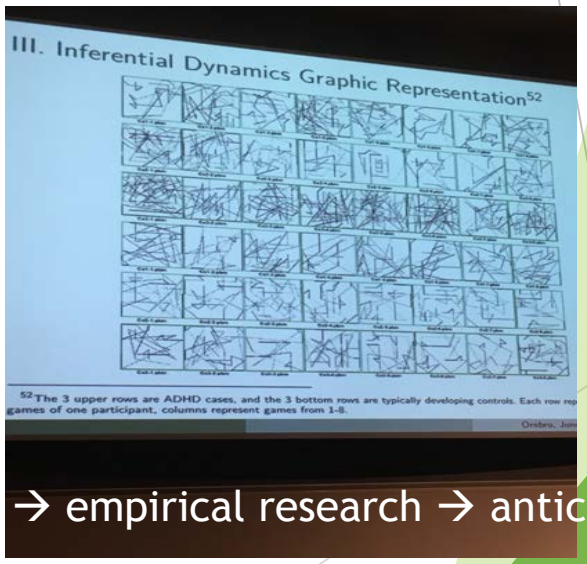
- → *Hippocratic medicine in Ancient Greece*

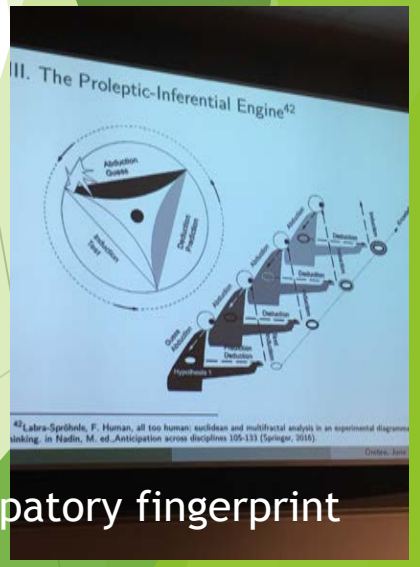
- overlooked by contemporary Anticipation Studies by describing medical practitioners from the perspective of reaction and reductionism

Hippocratic approach could inspire research in Anticipation Studies

Plato (Phaedrus) : *"Hippocrates the Asclepiad says that the nature even of the body can only be understood as a whole."*

- mutual interdependence of the principle of wholeness & relational thinking
  - NOT→ sickness or health is **not** governed by simple linear causal chains of events (→ reductionist accounts are of no use)
  - BUT result of ever changing patterns of manifold elements & relations in which causality is expressed in a network of interactions





→ empirical research → anticipatory fingerprint

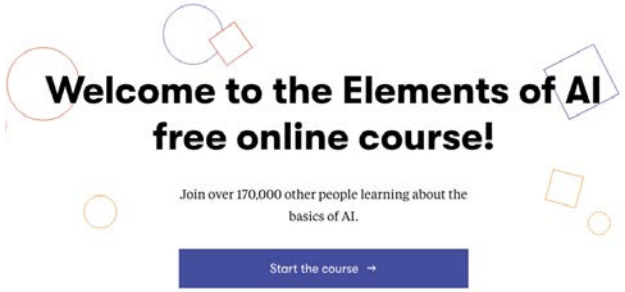
keynote 7

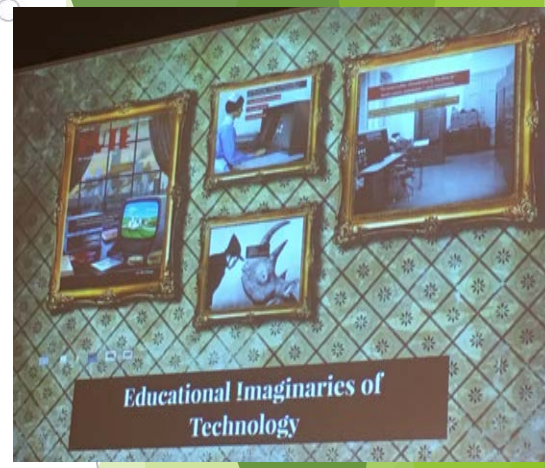
Educational Imaginaries of Technology

Lina Rahm, Linköping University, Sweden

What problems is the digital citizen a solution to?

- ‘digital citizenship’ as a fundamental requirement for democratic participation





- How the digital citizen has been construed over time (3 periods in time: the 1950s, the 1980s, and today)
  - e.g. problem of control with respect to government or economy (1970)
  - How governance of the digital citizen has changed across history:

SHIFT FROM GOVERNMENTAL CONTROL RELYING ON SPECIFIC IMAGINARIES OF TECHNO-UTOPIANISM
TOWARDS
COMMERCIALLY DRIVEN, AND ABSTRACT, DIGITAL INCLUSION

ambition has always been to bring all citizens on board

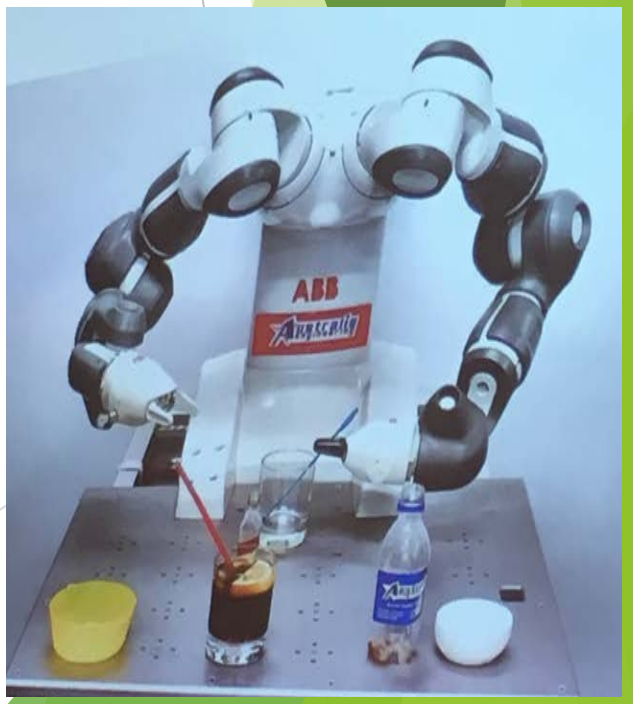
Proactive eye-gaze in human-robot interaction

Erik Billing University of Skövde, Sweden

- How can robot read social queues and vice versa …

ANTICIPATION → to reduce risk of accidents, improve team efficiency improved UX (transparency, readability)

- Under which circumstances do we anticipate motion of robots as agents, as biological motion (not as artefacts)?
  - Humans' ability to anticipate the actions of others is believed to stem from the mirror-neuron system (MNS) and provides a direct matching of observed actions onto the observer's own motor system (Flanagan and Johansson, 2003).
- proactive eye gaze (=mirror system reactions?) without certain stimuli such as having a head / hands etc.
- proactive eye gaze can be caused by many influential factors



Perception from inside out

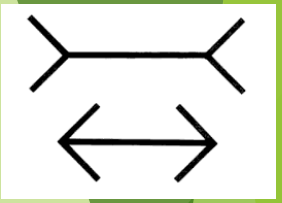
Liliana Albertazzi, LabExP, University of Trento

INFERENTIALIST APPROACH CONCEIVES ANTICIPATION AS AN ACTIVITY OF SCOREKEEPING

unquestioned assumptions:

- ontologically unique objective reality / perception of reality is ruled by psychophysical laws / predictive models are a product of causally efficient laws / perception of qualities is not a matter for scientific analysis, because it is subjective and not explainable in terms of third person account.

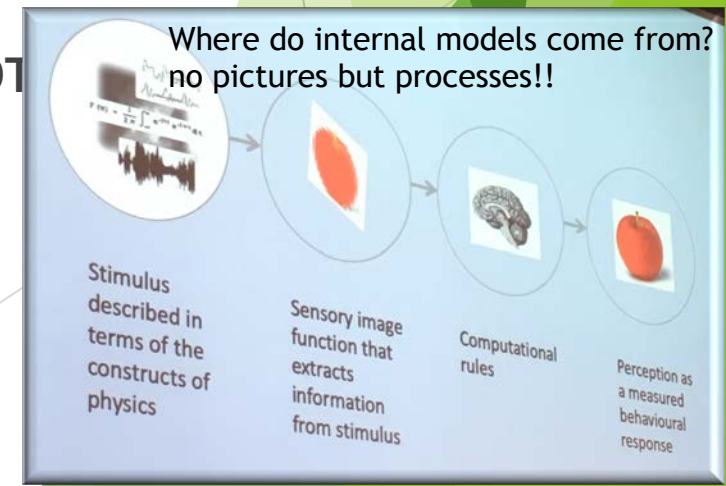
phenomena in visual and acoustic perception show: → presence of future as a basic microgenetic dimension of perceiving



- anticipatory structures: in stereokinetic phenomena, perception of causality, perceptual transparency, temporal acoustic dislocations
- reorganization of the stimuli sequence in awareness according to meaningful units →

WE LIVE NEITHER IN A STATIC PRESENT NOR IN A SERIES OF UNRELATED SNAPSHOT

- unity of consciousness is an assumption necessary to explain our conscious life
- implies anticipatory processes already in its microstructure



NETWORKED ANTICIPATORY SYSTEMS

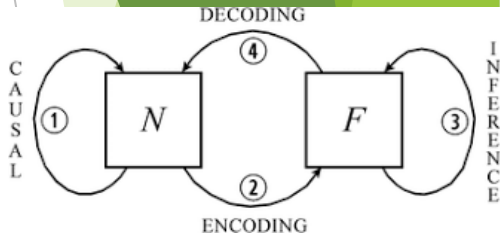
Andrzej M.J. Skulimowski AGH University of Science and Technology, Chair of Automatic Control and Robotics, Decision Science Laboratory, Kraków, Poland

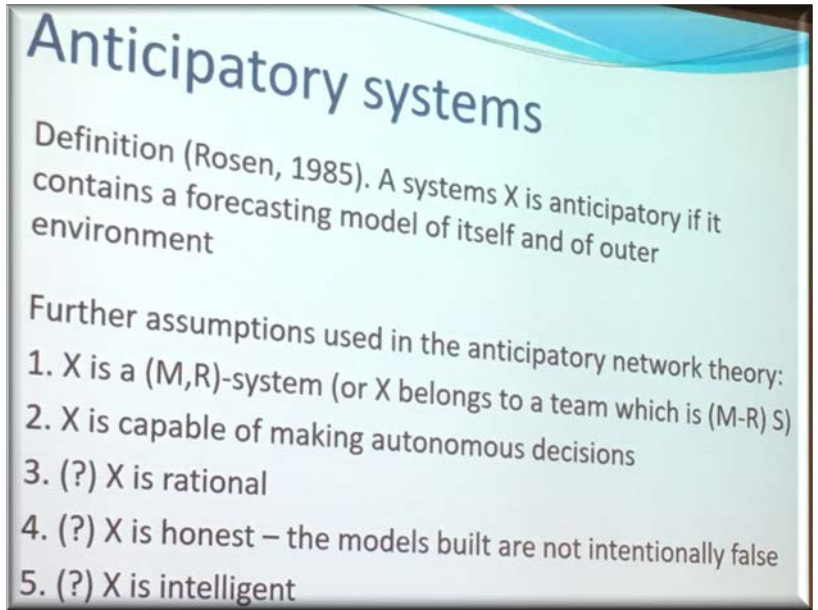
ANTICIPATORY NETWORKS (ANs):=
connected directed multigraph *G* with nodes *corresponding to anticipatory systems* & edges *modelling the relations between them (causal & anticipatory feedback)*

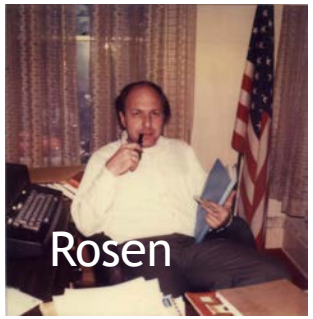
LINKING ANTICIPATED FUTURE WITH PRESENT-DAY DECISIONS – MAKING DECISIONS TODAY IN THE CONTEXT OF ANTICIPATED FUTURE – QUANTIFYING SOME ASPECTS OF ANTICIPATION

HERE: *superanticipatory systems* theory: interactions between artificial anticipatory decision makers /various applications of ANs as impact modelling tools in MULTICRITERIA strategic planning / foresigh

- preference structures embedded in ANs to derive anticipatory decision-making principles
- construct and filter scenarios corresponding to rational and sustainable future visions







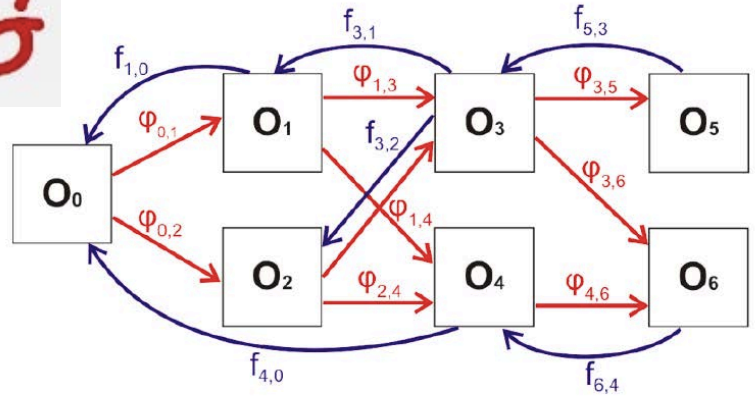


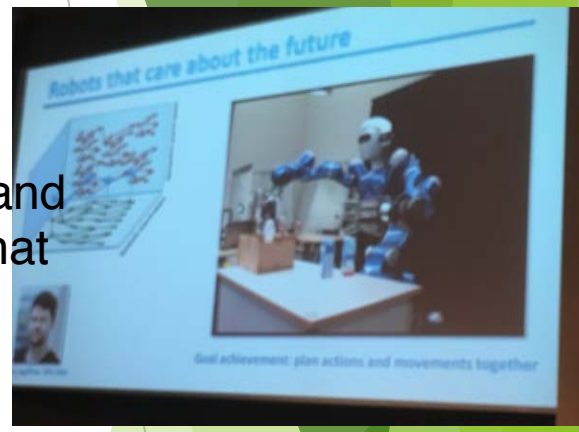
Fig. 1. *An example of an anticipatory network of decision units: the nodes O_i, i=0,...,6, denote multicriteria decision units, red arcs denote causal influence relations and temporal order between the decision units, blue arcs denote anticipatory information feedback that indicates which future decisions are relevant to decision makers preceding the corresponding decision units in the temporal order* (source: [8])

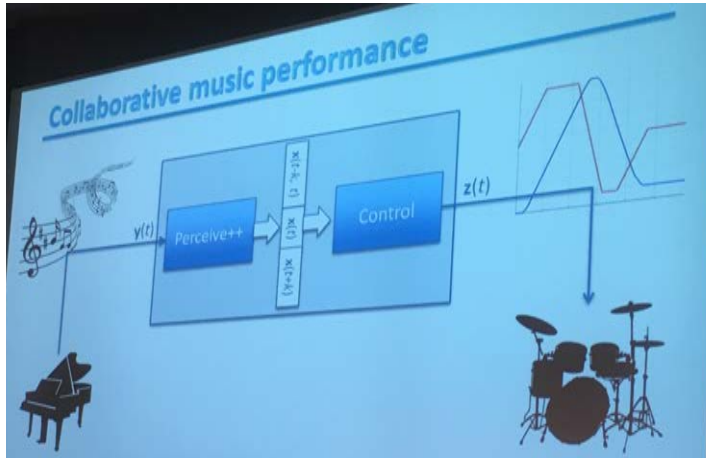
Some Notes on Anticipation in AI and Robotics

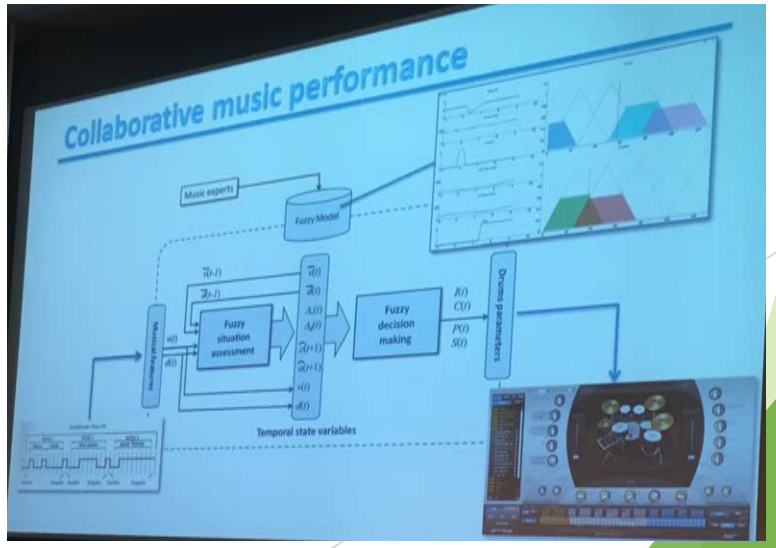
Alessandro Saffiotti, AASS Cognitive Robotic Systems Lab, Örebro University

TO REASON BEYOND THEIR TEMPORAL HORIZON, ROBOTS USE PREDICTIVE MODELS
= anticipatory systems

- **Anticipatory control.** feedforward control & modelpredictive control
- **Goal achievement.** Automatic planning techniques use predictive and causal models
- **Proactive behavior.** use predictive models to forecast the possible future evolutions and how the robot's actions may affect them, and to proactively decide to initiate actions that lead to desirable evolutions or that avoid undesirable ones





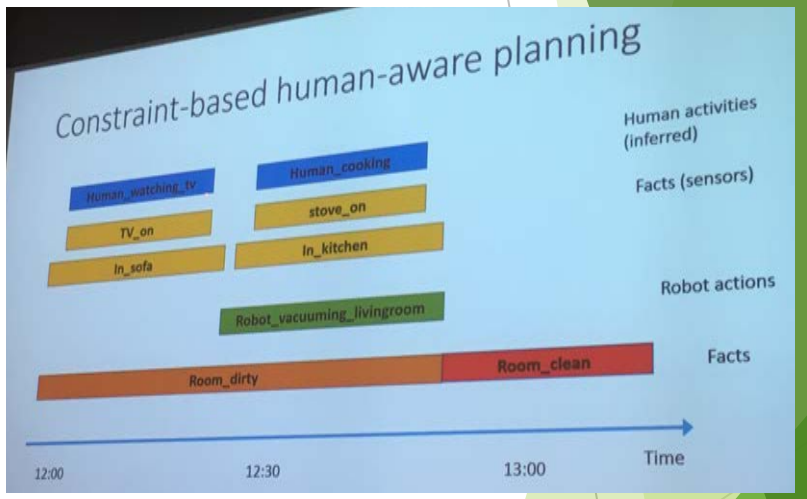


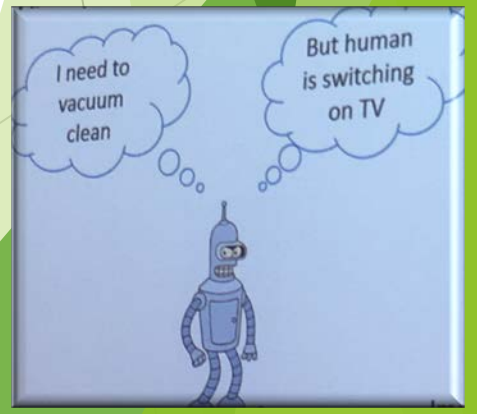
Anticipation and Planning in Human-Aware Robotics

Lars Karlsson & Uwe Köckemann AASS, Örebro University

- ROBOCENTRIC ANTICIPATION: human-aware planning

1. Probabilistic contingency planning under consideration of possible human agendas
2. Interaction constraints for modelling which interactions between robot and human activities are permitted and which are prohibited
3. Context/activity recognition for understanding human activities in the environment
4. Constraint-based human-aware planning system with features for social constraints, pro-activity, and context-awareness
5. Culturally aware and personalized robotic planning and execution





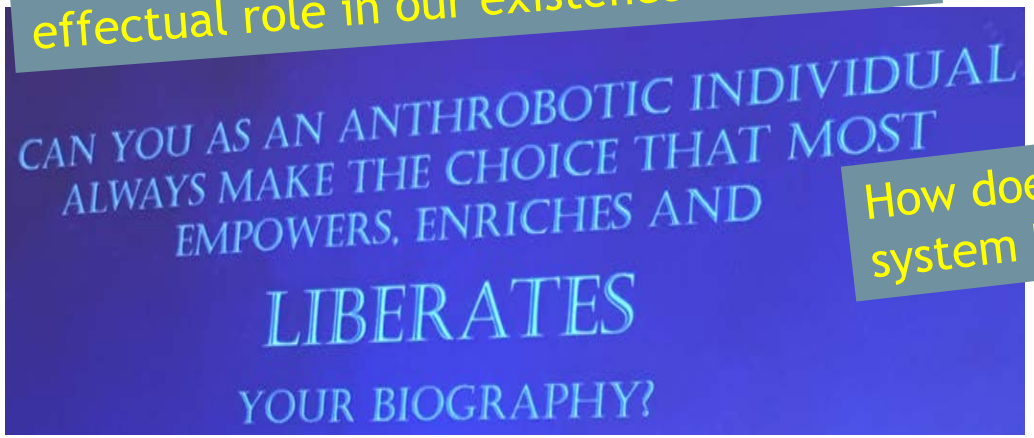
Effectual Anticipation: Analytical, Dialectical and Crealectical Moments

Luis de Miranda, Örebro University / CREA

MANY QUESTIONS:

What and how should we anticipate regarding artificial intelligence?

Which form of anticipation does play an effectual role in our existence?



How does an anthrorobotics system know what is important?

Anticipation: causal role in the actualization of our models and futures

ANALYTICAL INTELLIGENCE - THE REAL- THE CREAL (HYPERDIALECTICAL) – AGNOSIS – SYNTAX AND SEMANTICS

DO (NO)THING