CybSPEED MSCA-RISE #777720: vision and perspectives

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Index

- An overview of project proposal
  - Statement
  - Beneficiaries and partners
  - Experiments
- Specific research topics:
  - Dialog systems and storytelling
  - Computational neuroethology
- Conclusions and discussion

CybSPEED

Project proposal

RISE call

- RISE : Research and Innovation Staff Exchange
  - Main objective is the exchange of staff (secondments)
  - Between academia and industry
  - Working on a common research and innovation topic
- Output of the project
  - Training (secondments achieved)
  - Publications
  - Experimental results

CybSPEED proposal

- **Cyber-Physical Systems for PEdagogical Rehabilitation in Special Education**
- Aim : to advance a novel framework for
  - analysis, modelling, synthesis and implementation
  - of Cyber-Physical Systems
  - for pedagogical rehabilitation in special education,
- based on a combination of
  - brain-aware robotics, cognitive biometrics, computational intelligence and reasoning in
  - humanoid and non-humanoid robots for education.

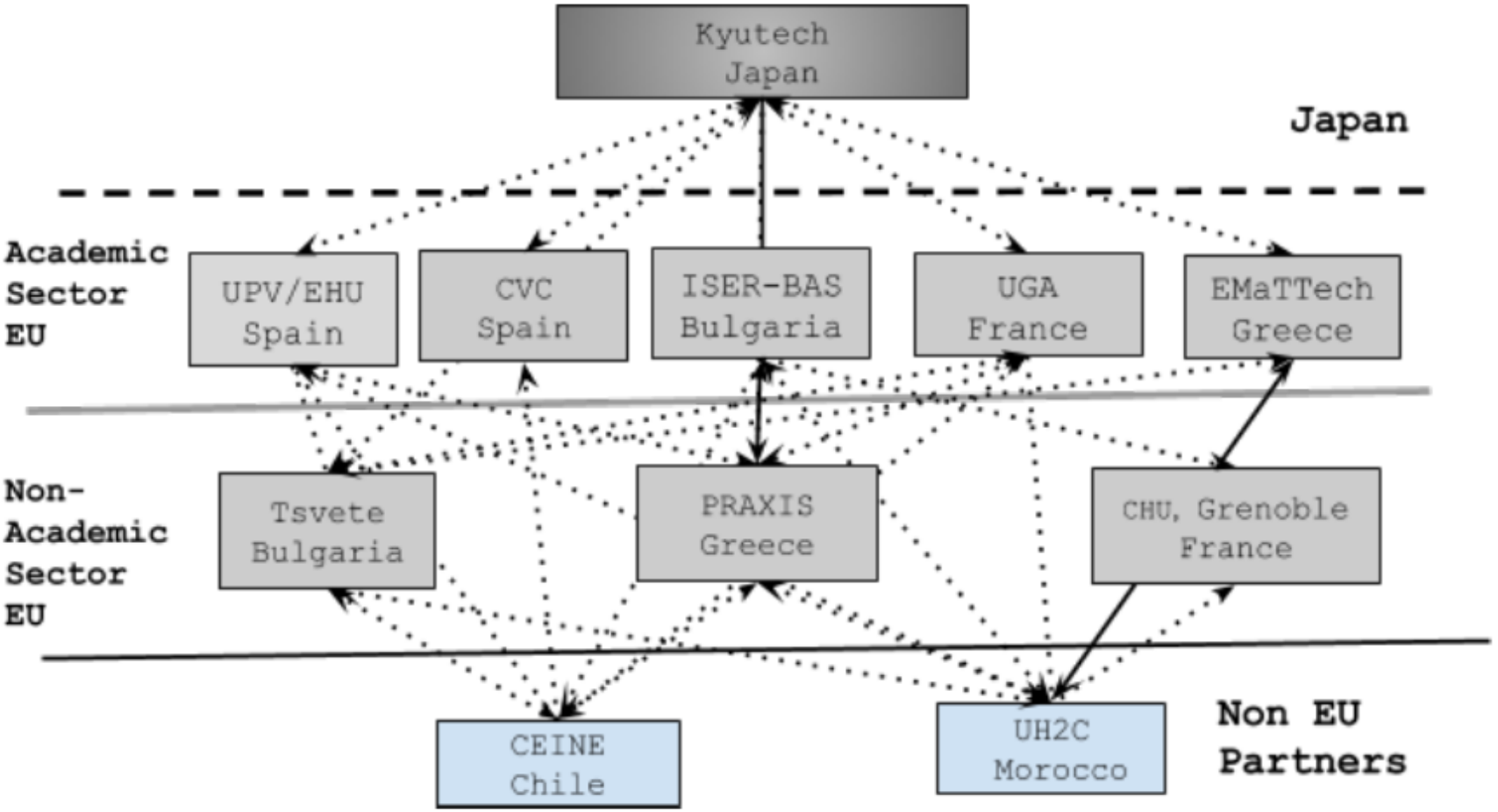
CybSPEED proposal

- CybSPEED project emphasizes the intrinsic-motivational approach to learning
  - by designing human-robot situations
    - (games, pedagogical cases, artistic performances)
  - And advanced interfaces
    - (brain-computer, eye-gaze tracking and virtual reality)
- Where students interact with the novel technology
  - to enhance the underlying self-compensation and complementarity of brain encoding during learning.

CybSPEED proposal

- Research on three levels
  - analysis of cognitive biometrics signals,
  -
  - modeling of the learner-robot interaction and
  - development of novel instruments
    - towards an optimal design of Cyber-Physical Systems
    - for improved pedagogical rehabilitation in education

Consortium and partners



UPV/EHU

- University of the Basque Country
- Manuel Graña (coordinator)
- Computational Intelligence Group
  - Data analytics
  - Image processing
  - Neuroscience data processing
  - Social Robotics:
    - Nao story telling

IR-BAS

- Institute of Robotics, Bulgarian Academy of Sciences
- Maya Dimitrova (original coordinator in proposal)
- Interactive robotics lab
- Social robotics for special education
  - Nao robot
  - Working with daycare centers
  - Experimental experience in children-robot interaction
  - Observation tools: kinect, EEG

EMaTTech

- Easter Macedonia and Trace Institute of Technology
- Vassilis Kaburlasos
- Machine Learning and Lattice Computing
- Social robots in special education
- Signal processing and face recognition

CVC

- Computer Vision Centre, Autonomous University of Barcelona
- Bogdan Raducanu
  - Experts in computer vision
  - Person Monitoring
  - Face and emotion recognition

UGA

- University of Grenoble-Alpes, GIPSA-Lab and G-SCOP
- Peter Mitrouchev
- Industrial partnership experience
- Rehabilitation technologies, specif. hand
- Virtual reality technologies

PRAXIS

- Pediatric Rehabilitation Center, Kavala,
- Yannis Aggelidis
- Special education professional experts
  - Autism Spectrum Condition
  - Attention deficit
  - others

Tsevete

- Teatar Tsevete
- Experts in dramatization for educational purposes
- Design of scenarios
- Storytelling expertise

CHU

- Centre Hospitalier Universitaire de Grenoble
- Francois Motet
- Rehabilitation and muscle reeducation
- Hand surgery
- New human machine interfaces for rehabilitation

UH2C

- Hassan II University of Casablanca
- Omar Bouattane
- Signaux Systèmes Distribués et Intelligence Artificielle
- Image and signal processing
- Robotics
- Internet of things and embedded systems

UCH

- University of Chile, Reseach center on business intelligence
- Sebastian Rios
- Big data and data analytics
- Previous experience in biotechnical projects

Kyutech

- Kyushu Institute of Techonology
- Hiroaki Wagatsuma
  - Brain-inspired intelligent systems,
  - neurodynamics,
  - interactive robotics and neurorobotics,
  - service robotics and
  - reinforcement learning based robotics

Topology of the project

Artificial perception

User awareness

CVC

UCH

Robot soft-adaptation

IR-BAS

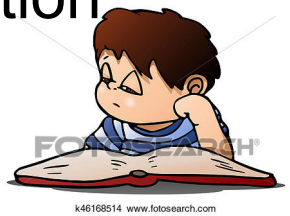
Advanced human-robot interfaces

UPV/EHU

Games and storytelling

Tsevete

Student progression measurement



Kyutech

Behavior measurement

PRAXIS

EMaTTech

UH2C

Neural activity correlation with behavior

UGA

CHU

CybSPEED

Experiments

CybSPEED experiments

- Precise experimental designs with our actual know-how
  - Greece (Praxis)
  - Bulgaria (IR-BAS at several locations)
  - Japan (Kyutech)
  - France (UGA)
- Ethical permissions procurement
  - Ethics is a critical issue in European funded projects
- Experimental setups
  - Protocols of intervention
  - Measurements and analysis

Praxis experiment

- Carried out in actual educational rehabilitation sessions
  - Good ecological validity
- Intervention
  - The child is presented with robot
  - The robot carries out simple game of passing a ball and requesting the child to put it someplace
  - Measurement: time to answer or to make eye contact.
    - Longitudinal study

IR-BAS exp. 1

- Children recruited in a local daycare center
- Automatic memory and attention effects in learning from a Humanoid robot
- Listening to a zoology lesson and story telling by Nao robot
- Measurement of attention by human observer
- ASC, Cerebral Palsy, General Developmental Disorder

Kyutech- IR-BAS exp.

- Students recruited ad hoc
- Automatic memory and attention effects in learning from a Humanoid robot
- Listening to a zoology lesson and story telling by Nao robot
- Measurement of attention by EEG and eye tracking

IR-BAS exp 2

- CHILDREN WITH COMMUNICATION DISORDERS
- Centre of Logopedics at Faculty of Public Health, Health Care and Sport To South-West University "Neofit Rilski" Blagoevgrad
- DayCare Center "Zdravets", Bansko
- Test: Nao versus human

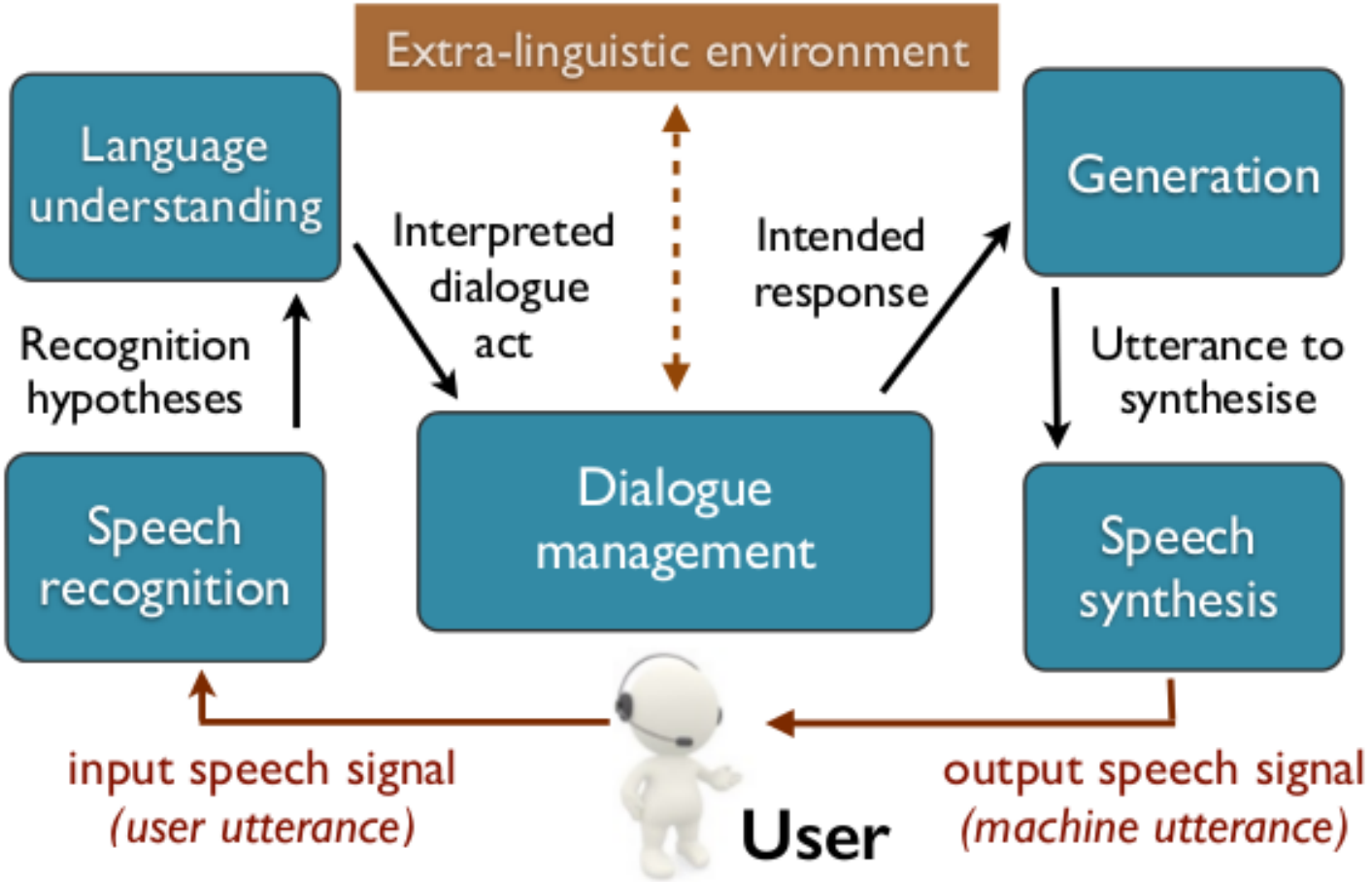
IR-BAS exp. 2 (cont)

- Interactive games following spoken instructions and noises:
  - Shapes
  - Transportation means (train, auto,…)
  - Shopping
  - Emotions (sounds of)
  - Body sounds
- Measurement
  - Human observation
  - Anonymous visual (kinect depth or IR image)

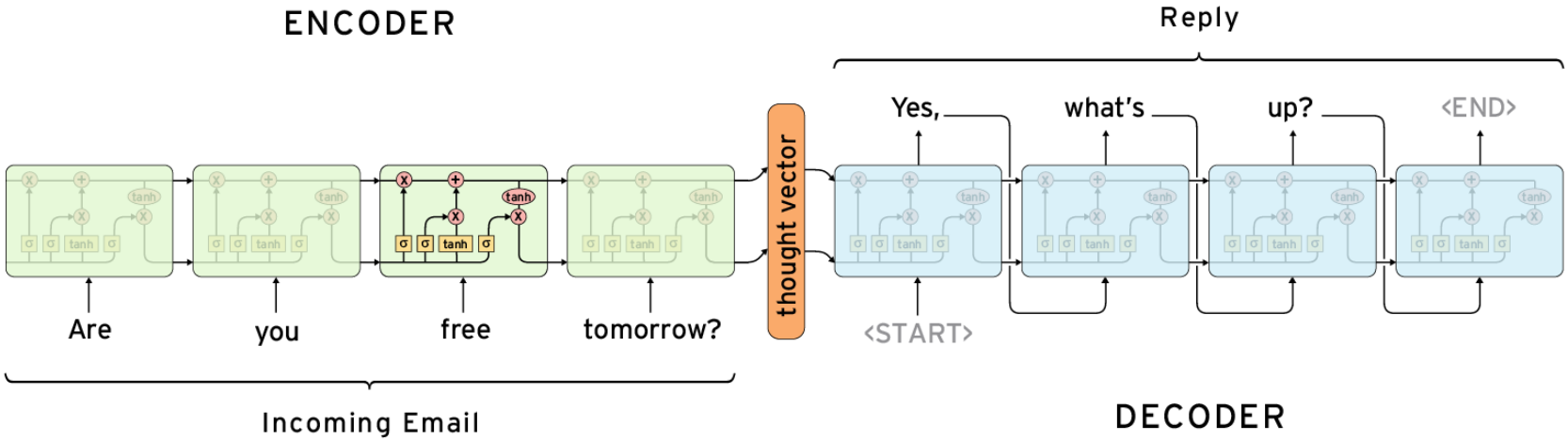
Dialog systems and storytelling

Dialog systems

Dialog systems

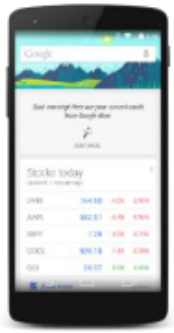


Seq2seq dialog systems



Intelligent assistants

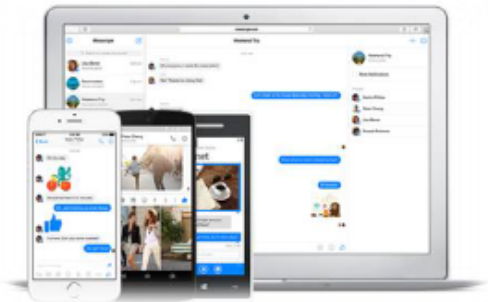
Apple Siri (2011)



Google Now (2012)
Google Assistant (2016)

Microsoft Cortana (2014)

Amazon Alexa/Echo (2014)



Facebook M & Bot (2015)

Google Home (2016)

Apple HomePod (2017)

Example assistant interaction

User

find a good eating place for taiwanese food

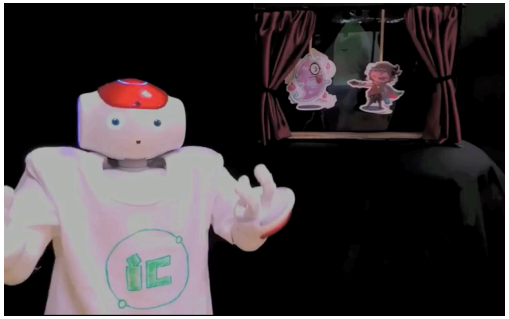
Good Taiwanese eating places include Din Tai Fung, Boiling Point, etc. What do you want to choose? I can help you go there.

Intelligent Agent

Simple taxonomy

- Task oriented:
  - There is a desired outcome of the interaction
  - The progression to the desired end can be traced
  - Success can be measured easily
- Conversational
  - The bot is engaged in open-ended interaction
    - Searching
    - Counseling
    - Assistive for elders
    - Teaching or mentoring

Storytelling with Nao

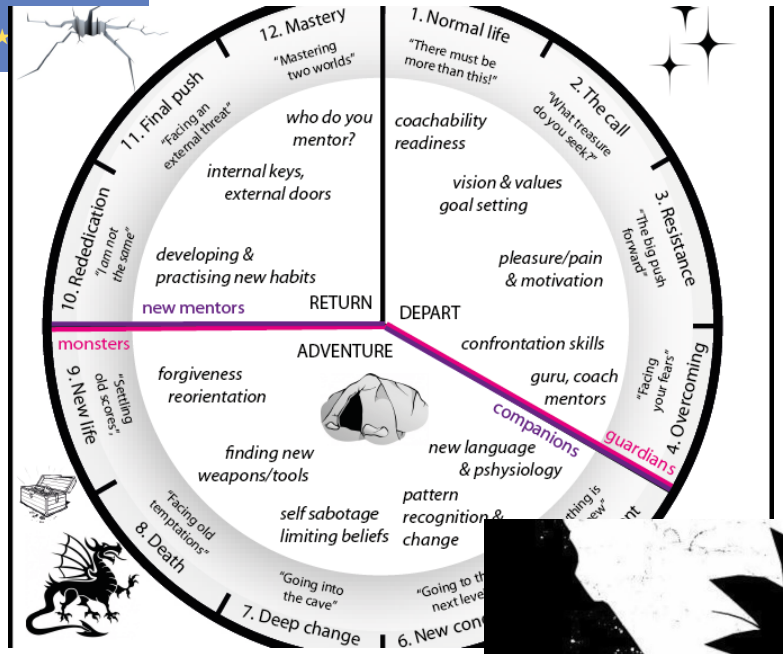


Storytelling

- Offers a structured framework for oriented dialog
  - Aiming towards an end
  - Has a logical sequence yet it may be open
  - Repetition is always welcomed by children
  - It can be entertainment and/or training
  - It is engaging

Story Knowledge representation

- Representation of the overall structure: the plot
- Is there a prototypical structure?
  - Joseph Campbell “The hero’s journey”


1. Normal life
"There must be more than this!"
2. The call
"What treasure do you seek?"
3. Resistance
"The big push forward"
4. Overcoming
"Facing your fears"
5. Reward
6. New con
"Going to the next level"
"Going into the cave"
7. Deep change
8. Death
"Facing old temptations"
9. New life
"Setting old scores"
10. Rededication
"I am not the same"
11. Final push
"Facing an external threat"
12. Mastery
"Mastering two worlds"
who do you mentor?
internal keys, external doors
developing & practising new habits
new mentors
RETURN
DEPART
ADVENTURE
monsters
forgiveness reorientation
finding new weapons/tools
self sabotage limiting beliefs
pattern recognition & change
new language & pshysiology
companions
guardians
confrontation skills
guru, coach mentors
pleasure/pain & motivation
vision & values goal setting
coachability readiness


Part 1 - Call to Adventure
Part 2 - Supreme Ordeal/Initiation
Part 3 - Unifi
Part 4 - Road Back/Hero's Return
HEROIC JOURNEY
by Storyboard That
1 The Ordinary World
2 The Call to Adventure
3 Refusal
4 Mentor Helper
5 Crossing the Threshold
6 Test/ Allies/ Enemies
7 pproach
8 Ordeal
9 Reward
10 Road Back
11 Atonement
12 Return
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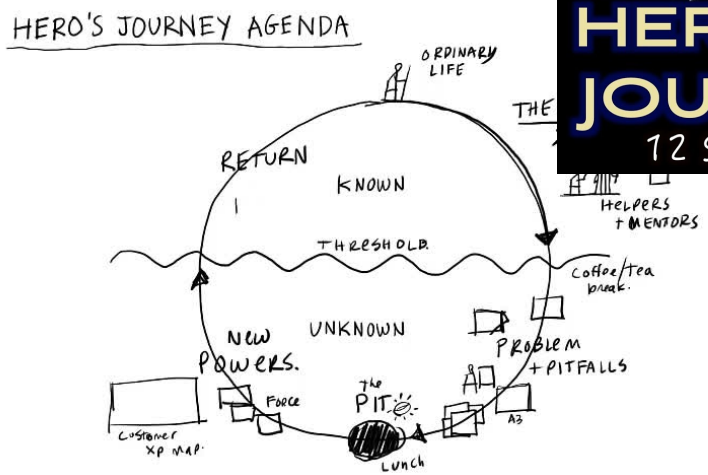
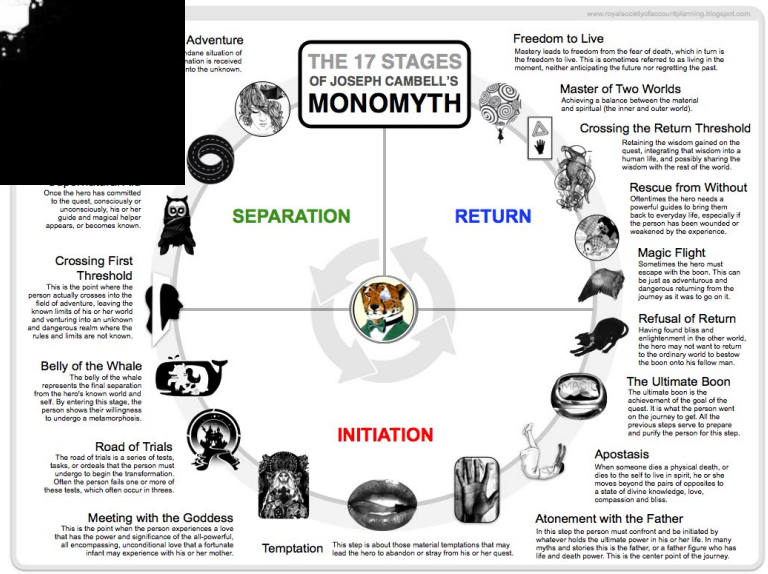
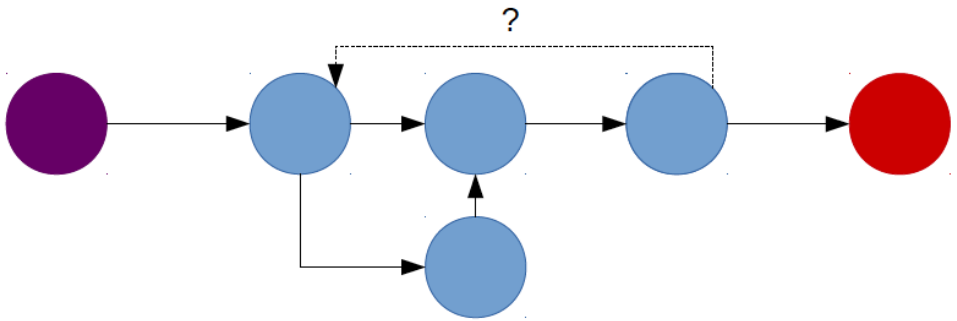
The
HERO'S
JOURNEY
12 Stages


HERO'S JOURNEY AGENDA
ORDINARY LIFE
RETURN
KNOWN
THRESHOLD
HELPERS + MENTORS
Coffee/Tea break.
NEW POWERS.
UNKNOWN
PROBLEM + PITFALLS
Force
THE PIT
A3
CUSTOMER XP MAP
LUNCH


THE 17 STAGES OF JOSEPH CAMBELL'S MONOMYTH
SEPARATION
RETURN
INITIATION
Adventure
Freedom to Live
Mastery leads to freedom from the fear of death, which in turn is the freedom to live. This is sometimes referred to as living in the moment, neither anticipating the future nor regretting the past.
Master of Two Worlds
Achieving a balance between the material and spiritual (the inner and outer world).
Crossing the Return Threshold
Retaining the wisdom gained on the quest, integrating that wisdom into a human life, and possibly sharing the wisdom with the rest of the world.
Rescue from Without
Oftentimes the hero needs a powerful guides to bring them back to everyday life, especially if the person has been wounded or weakened by the experience.
Magic Flight
Sometimes the hero must escape with the boon. This can be just as adventurous and dangerous returning from the journey as it was to go on it.
Refusal of Return
Having found bliss and enlightenment in the other world, the hero may not want to return to the ordinary world to bestow the boon onto his fellow man.
The Ultimate Boon
The ultimate boon is the achievement of the goal of the quest. It is what the person went on the journey to get. All the previous steps serve to prepare and purify the person for this step.
Apostasis
When someone dies a physical death, or dies to the self to live in spirit, he or she moves beyond the pairs of opposites to a state of divine knowledge, love, compassion and bliss.
Atonement with the Father
In this step the person must confront and be initiated by whatever holds the ultimate power in his or her life. In many myths and stories this is the father, or a father figure who has life and death power. This is the center point of the journey.
Once the hero has committed to the quest, consciously or unconsciously, his or her guide and magical helper appears, or becomes known.
Crossing First Threshold
This is the point where the person actually crosses into the field of adventure, leaving the known limits of his or her world and venturing into an unknown and dangerous realm where the rules and limits are not known.
Belly of the Whale
The belly of the whale represents the final separation from the hero's known world and self. By entering this stage, the person shows their willingness to undergo a metamorphosis.
Road of Trials
The road of trials is a series of tests, tasks, or ordeals that the person must undergo to begin the transformation. Often the person fails one or more of these tests, which often occur in threes.
Meeting with the Goddess
This is the point when the person experiences a love that has the power and significance of the all-powerful, all encompassing, unconditional love that a fortunate infant may experience with his or her mother.
Temptation
This step is about those material temptations that may lead the hero to abandon or stray from his or her quest.

Storytelling as a dynamic process

- System states
- The plot as a graph
- Transitions between states
  - Induced by the audience interaction
  - Automated walk over the plot
- Innovation and creativity?



Attention assessment

- First requirement for interaction
- Assesing by the robot
  - Auditive cues
  - Visual cues
  - Response time from the robot

Robot acting

- The robot needs to enact the story
  - Text to speech with emphasis and prosody
  - Gesture generation
    - Gesture + voice language description
    - Text to gesture + voice
- Acting
  - Dramatic pause
  - Audience querying and interaction

Modeling the audience

- Assessing plot understanding from
  - Queries from the robot to the audience
  - Questions from the audience
- Rewriting the story on the fly
  - Simplification
  - Reformulation
  - Explanations

Computational neuroethology

Contents

- Some definitions
- Elements of computational neuroethology
- Example study
- Resources and Commercial solutions

Ethology

- Ethology: study of animal behavior
  - phenomenological, causal, ontogenetic, and evolutionary aspects
    - Its relation with brain function is increasingly interesting
  - its core is the description and characterization of behavior,
    - typically of intact freely moving animals in their natural environment.
    - Increasingly quantitative

Observation

- A human observer,
  - rather than simply writing down a description of what he or she sees,
  - will score incidents of specific behaviors
    - defined according to certain generally accepted criteria
- Computational support improves accurate observation
  - Interactive video annotation
  - Statistical data processing

Human observation limitations

- It is slow
- It is imprecise and subjective
- It is low dimensional
- It is limited by the properties of human vision system
- It is limited by human language
- It is dull, extremely boring work

Computational ethology

- Sensing: i.e. Computer vision
  - Segmentation of objects
  - Tracking
  - Identification of sequences
- Data analysis and interpretation: i.e. Machine learning
  - Supervised Learning:
    - Learning from examples selected by the human operator
  - Unsupervised Learning
    - Clustering: discovery of aggregations of similar patterns

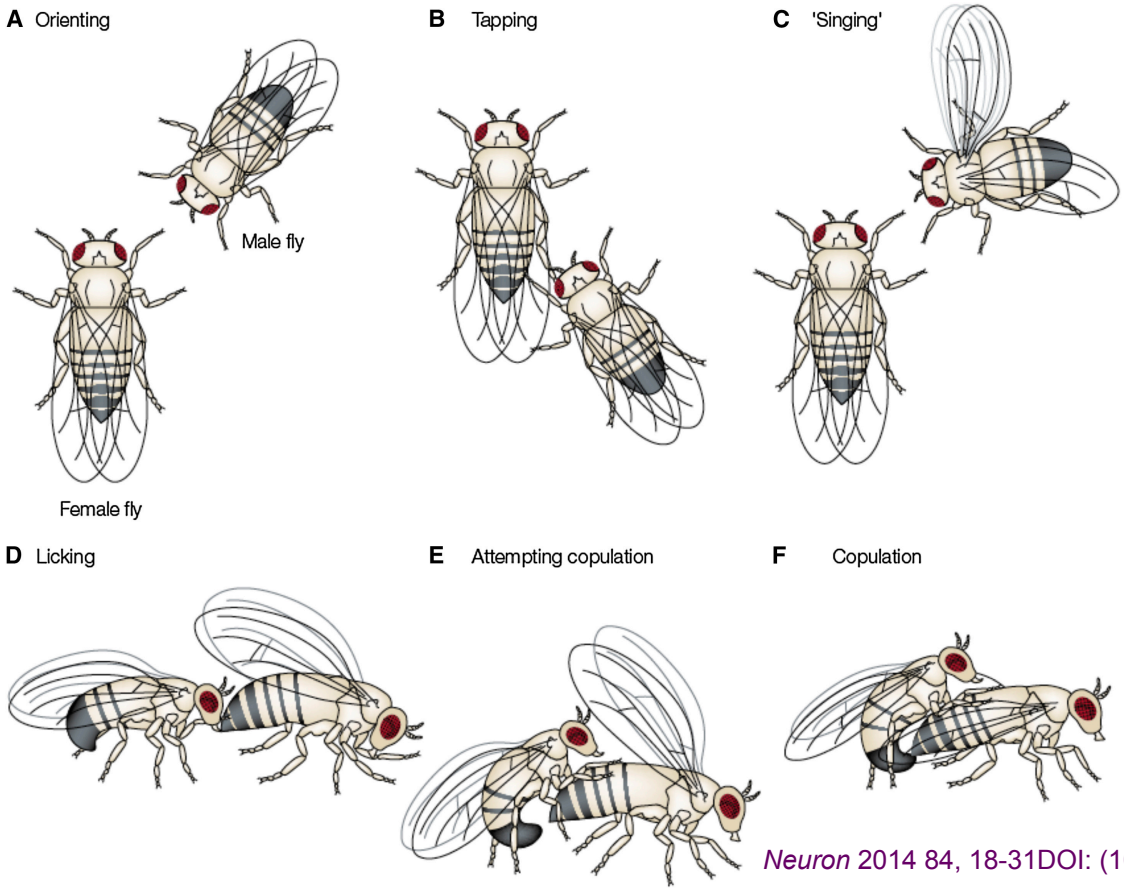
Example 1

- Toward a Science of Computational Ethology
  David J. Anderson and Pietro Perona
  Neuron *84*, October 1, 2014

Target species

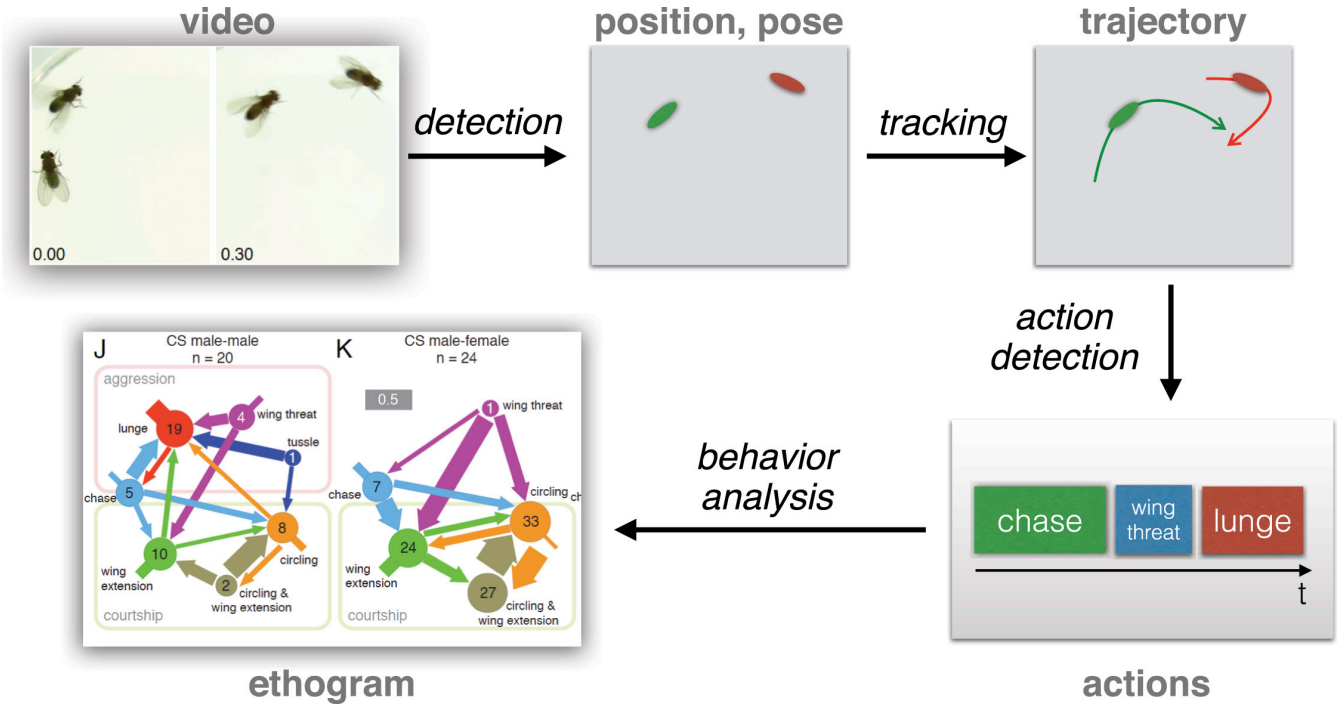
- *Drosophila melanogaster.* Vinegar fly
  - dyadic (pairwise) interactions such as male-female courtship and male-male aggression,
  - higher-dimensional interactions within large (>10) groups of flies
  - How are they encoded in DNA?
- Courtship: (highly variable) series of actions
  - Humans use an aggregate measure: “courtship index” (CI)
    - similar CI values may reflect different underlying behaviors

Sequence of human observer-defined actions in courtship behavior. The actions may vary in their duration and the length of the interval between them. The sequence is not necessarily irreversible.



Neuron 2014 84, 18-31DOI: (10.1016/j.neuron.2014.09.005

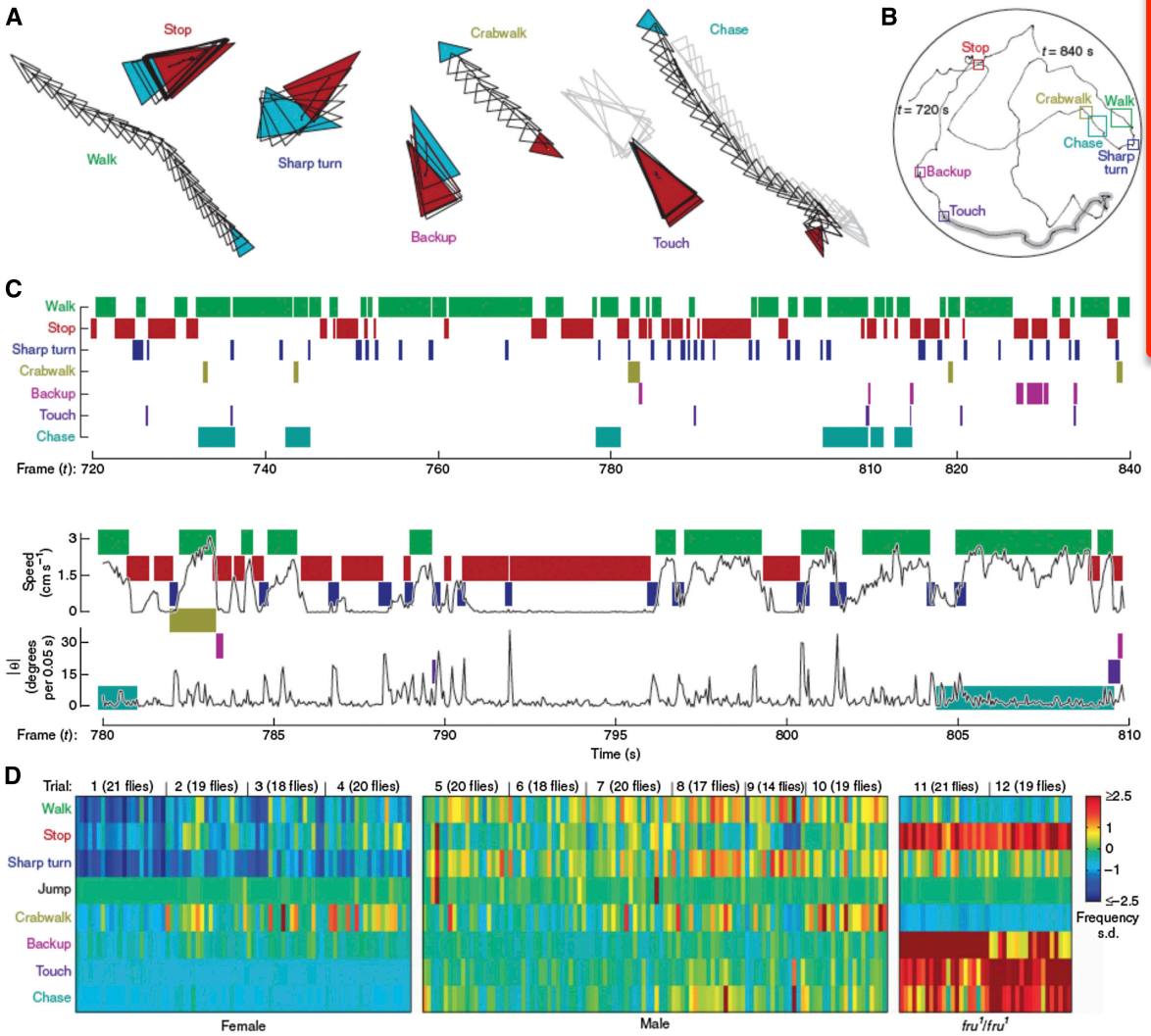
Summary of Steps in the Automated Analysis of Social Behavior
Each of the four steps (detection, tracking, action detection, and behavior analysis) requires validation by comparison to manually scored ground truth. The ethogram illustrates different behaviors performed during male-male and male-female social interactions.



Neuron 2014 84, 18-31DOI: (10.1016/j.neuron.2014.09.005

Increasing the throughput of behavioral analysis

tracking systems to measure the individual trajectories of dozens of flies simultaneously in an arena



Eight different behaviors (A) were automatically scored from video recordings of 20 flies walking in an arena. (B) Two minute trajectory of a single male fly detected among 20 in the arena. (C) Upper: raster plot for behaviors exhibited during the trajectory in (B); lower: translational and angular velocities superimposed on a 30 s segment of the raster plot. (D) Behavioral "vectors" for female, male, and fru1/fru1 mutant male flies. Each column represents a single fly and each row a single behavior. Numbers at top refer to experiment and number of flies tracked.

Neuron 2014 84, 18-31DOI: (10.1016/j.neuron.2014.09.005

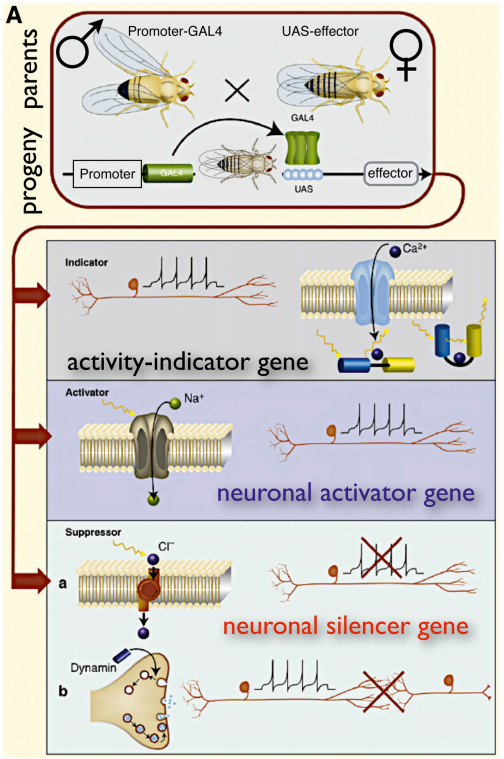
Neuroethology

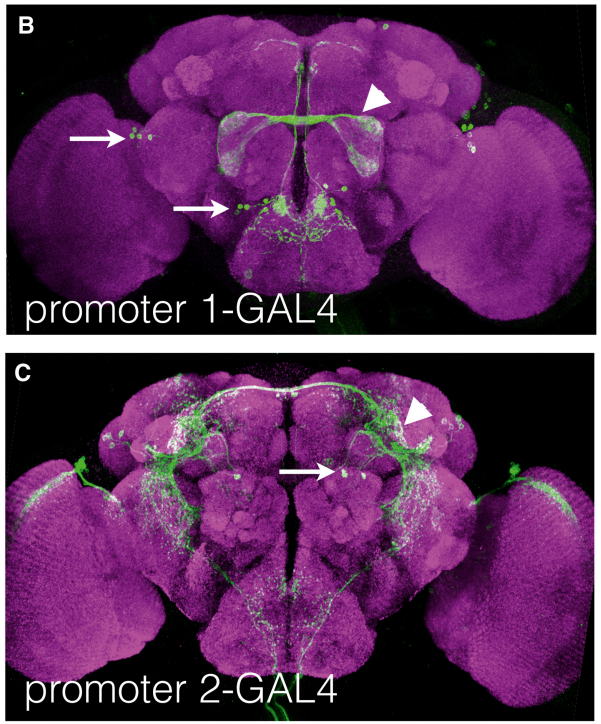
- Looking for correlations between
  - behavior observation and
  - neuronal structure and activity
- Traditional works:
  - neural anatomy differences between species, genres, etc
    - Relation between brain size in frogs and ambient weather seasonality
- Recent works:
  - Neural activity differences: EEG, fMRI

Ethology and brain science

- **In summary,** the clever use of
  - virtual reality, machine learning, and miniaturized recording devices
- has the potential to dramatically increase our understanding of how neuronal activity underlies cognition and behavior.
- This path can be enabled by developing technologies to
  - quantify and interpret animal behavior,
    - at high temporal and spatial resolution,
  - reliably, objectively, over long periods of time,
  - under a broad set of conditions, and
  - in combination with concurrent measurement and manipulation of neuronal activity
    - Brain manifesto
    - P 36 http://www.nih.gov/science/brain/2025/index.htm.

new technologies for mapping, monitoring, and manipulating neural activity based on genetic targeting of specific neuron subtypes





study of aggression in *Drosophila*

temperature-dependent manipulations of neuronal activity to identify a small cluster of neurons that controls aggression

Neuron 2014 84, 18-31DOI: (10.1016/j.neuron.2014.09.005

→beyond correlation to establish causal relationships between neural circuit activity and behavior.

➔ critically dependent on the ability to assess quantitatively, and with a high degree of spatiotemporal precision, the behavioral consequences of neural circuit manipulations

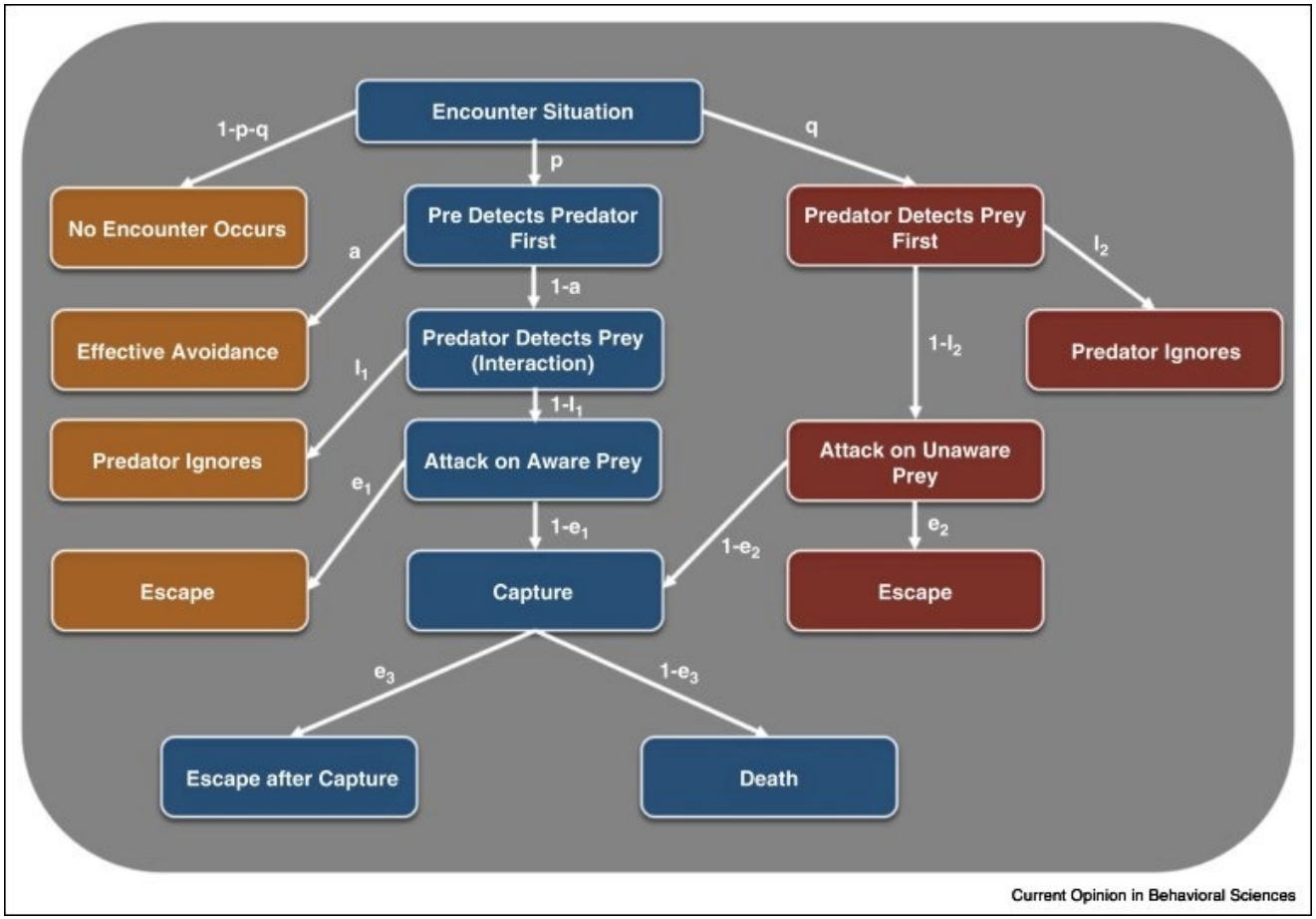
Example 2

- Neuroethological studies of fear, anxiety, and risky decision-making in rodents and humans
  Current Opinion in Behavioral SciencesVolume 5, October 2015 , Pages 8-15

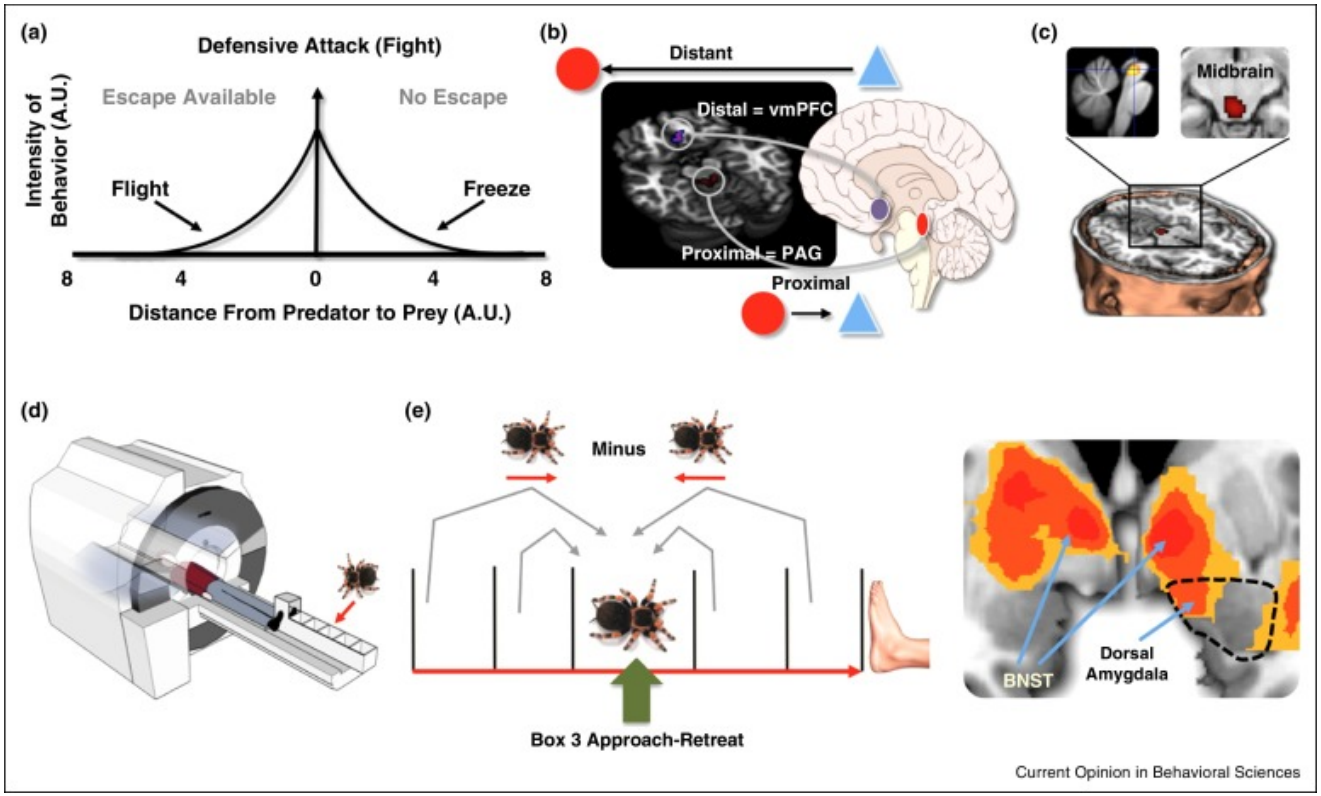
Highlights

- Neuroscience has ignored the natural conditions under which anti-predation evolved.
- Survival circuits underlie dynamic threat reactions and decisions-making actions.
- Threat signals flow through corticolimbic to midbrain circuits.
- Ethologically inspired paradigms provide an insightful window into fear and anxiety.

Predator-prey scenarios



Experiment design



Example 3

- Challenge

  https://paris-saclay-cds.github.io/autism_challenge/

IMPAC

IMaging-PsychiAtry Challenge: predicting autism

A data challenge on Autism Spectrum Disorder detection

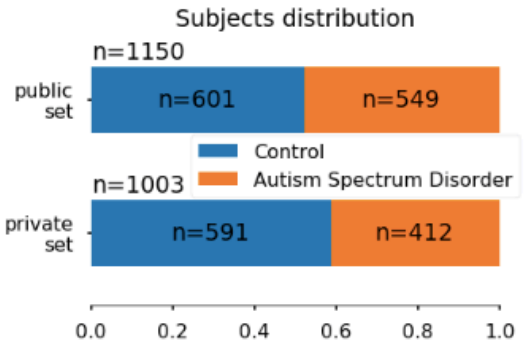
Deadline: July 1, 2018 - 8 pm (UTC)

44	16	32	32
Days	Hours	Minutes	Seconds

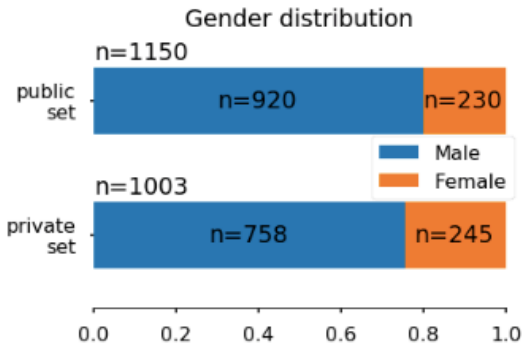
A big data challenge

Brain images from more than 2000 individuals

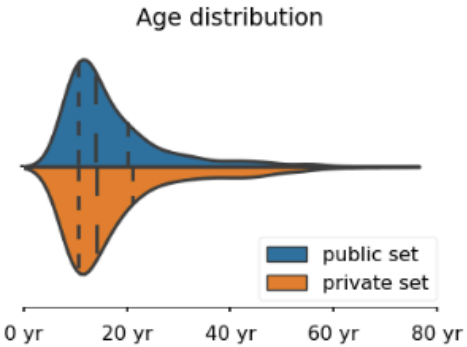
Patient vs Control distribution



Gender distribution



Age distribution



Multimodal imaging data

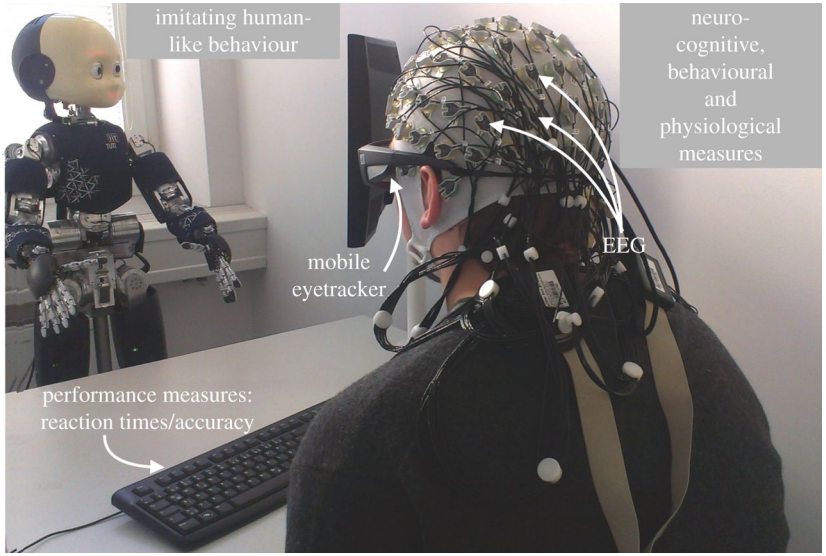
Structural MRI

- Preprocessed with FreeSurfer and FSL
- Gray matter volume, area, and thickness
- Average for each Desikan cortical parcel.

Functional MRI

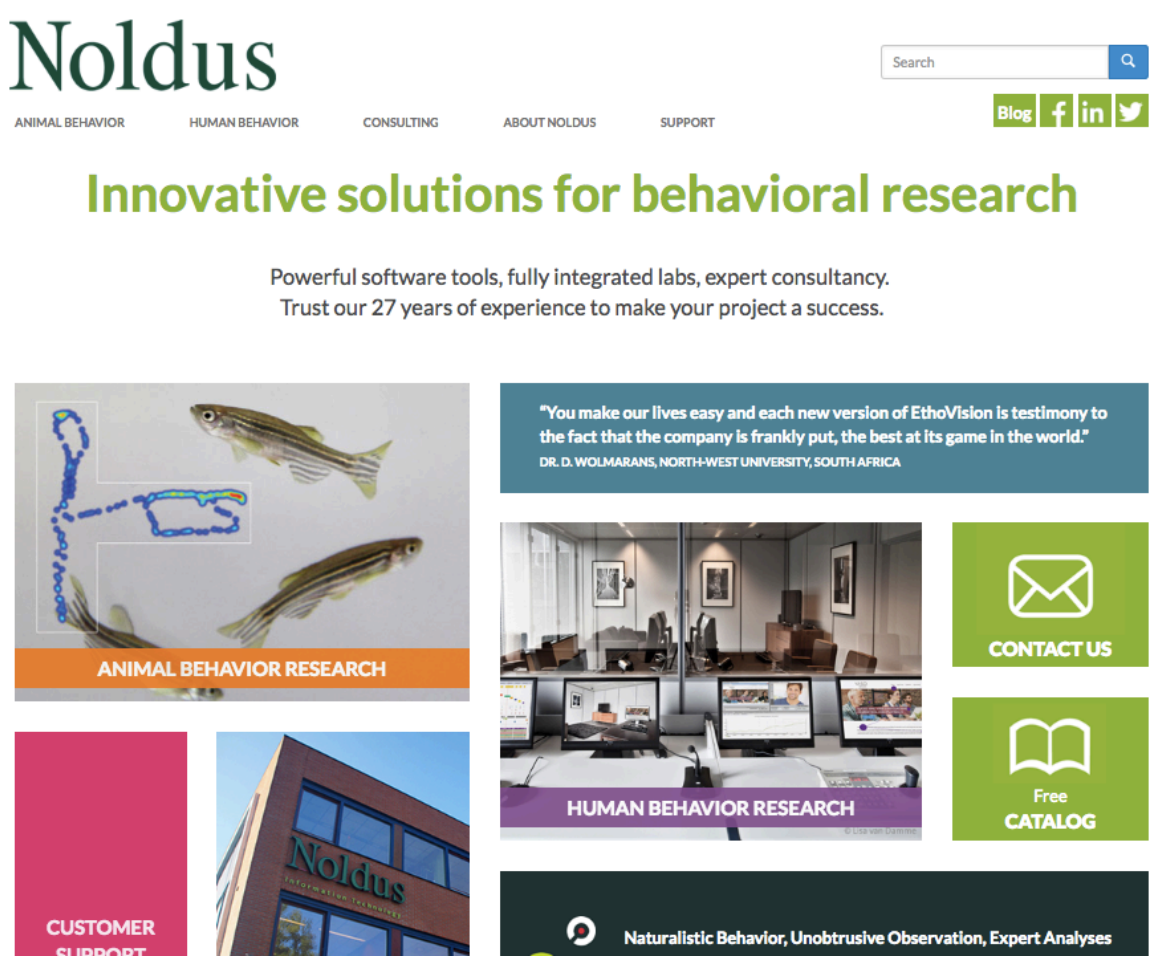
- Resting state fMRI
- Time series extracted on different atlases

An experimental setting for neuroethological human robot interaction



Too far from ecological validity in special educational needs!

Commercial products



Conclusions

- CybSPEED involves quite diverse beneficiaries and partners
- We are in the consolidation starting phase
  - Solving bureacratic issues
  - Translating general statements of the project proposal into precise working lines

Conclusions

- We are carrying out experiments using our current know-how
- We are developing new tools for
  - Smart interaction
  - Behavior measurement
  - Correlation of behavior measurement and neural activity

Discussion

- Bringing Computational Neuroethology into the school
  - Ethics questions
  - Technological questions
  - Scientific questions