# An introduction to CybSPEED

## MSCA-RISE #777720

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 777720

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  - Dialog systems and storytelling
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# 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.

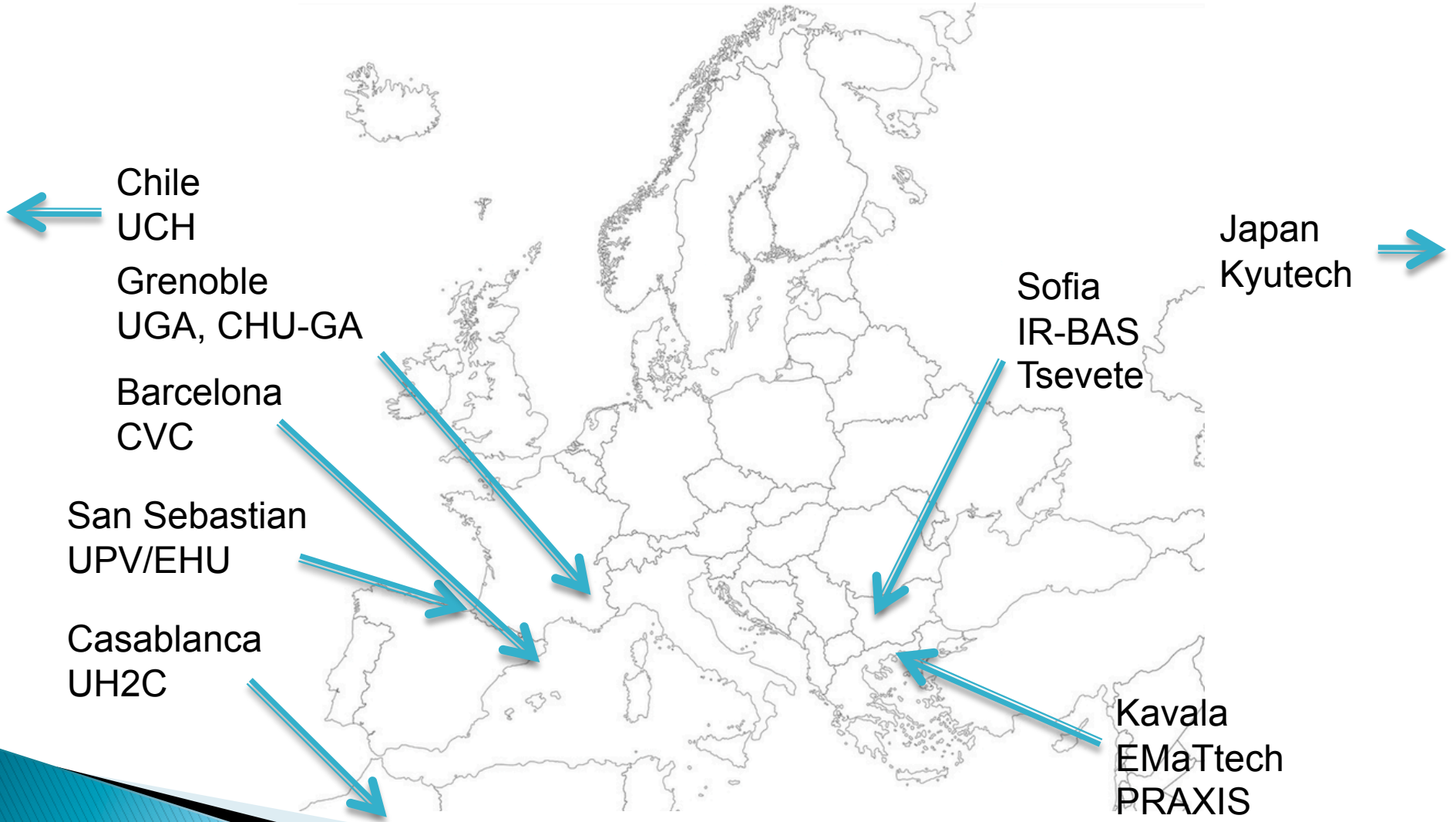
# CybSPEED proposal

- 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.

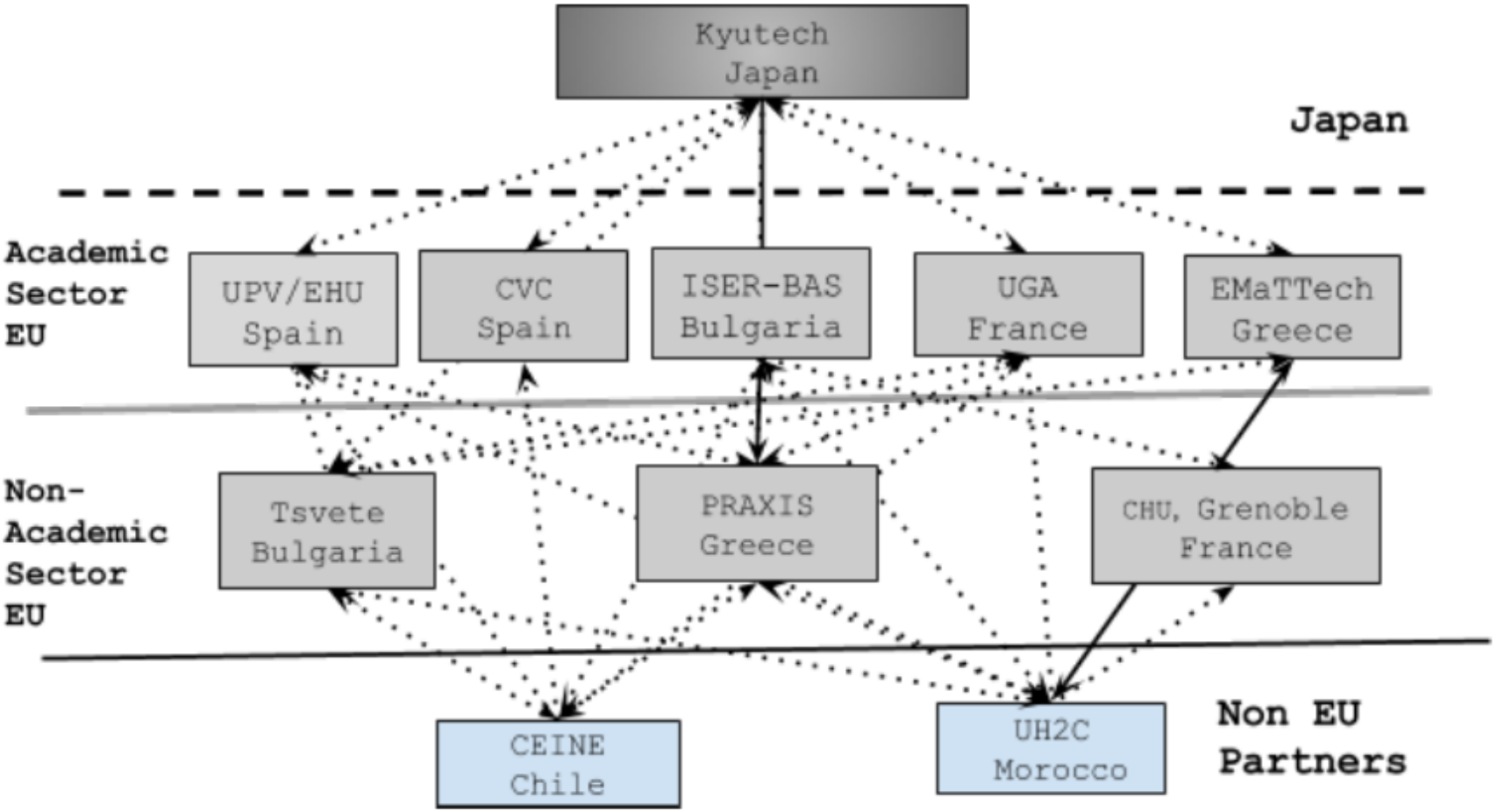
# CybSPEED proposal

- Technical Research on three levels
  - Analysis of cognitive biometrics signals,
  - 
  - Modeling 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



# Consortium and partners



# Consortium numbers

- Budget +1.2M€
- 4 years 12/01/17 to 11/31/21
- +200 months of secondment
- First year:
  - +120 months of secondment realized
  - 2 workshops in Japan realized
  - 3 small size conferences in San Sebastian
  - 2 trainings (Sofia, Kavala)
  - Open access software and publications in zenodo.org

# Knowledge topology of the project

Artificial perception

User awareness

CVC

UCH

UPV/ EHU

Robot soft-adaptation

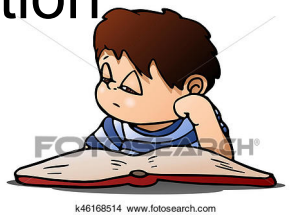
IR-BAS

Advanced human-robot interfaces

Games and storytelling

Tsevete

Student progression measurement



Kyutech

PRAXIS

EMaTTech

Behavior measurement

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
  - Population: children with autism spectrum disorder
  - 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

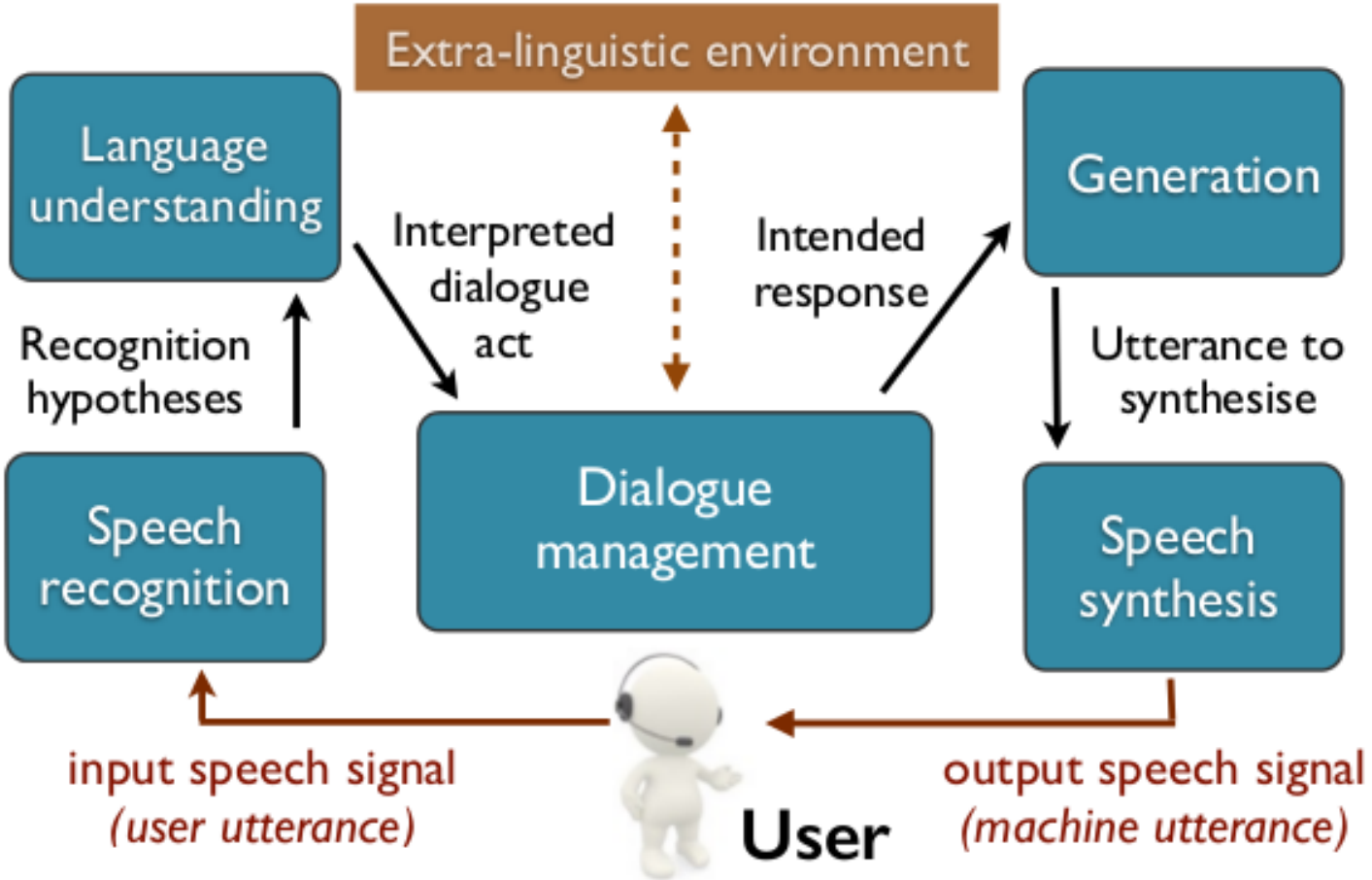
# IR-BAS exp. 2 (cont)

- 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)

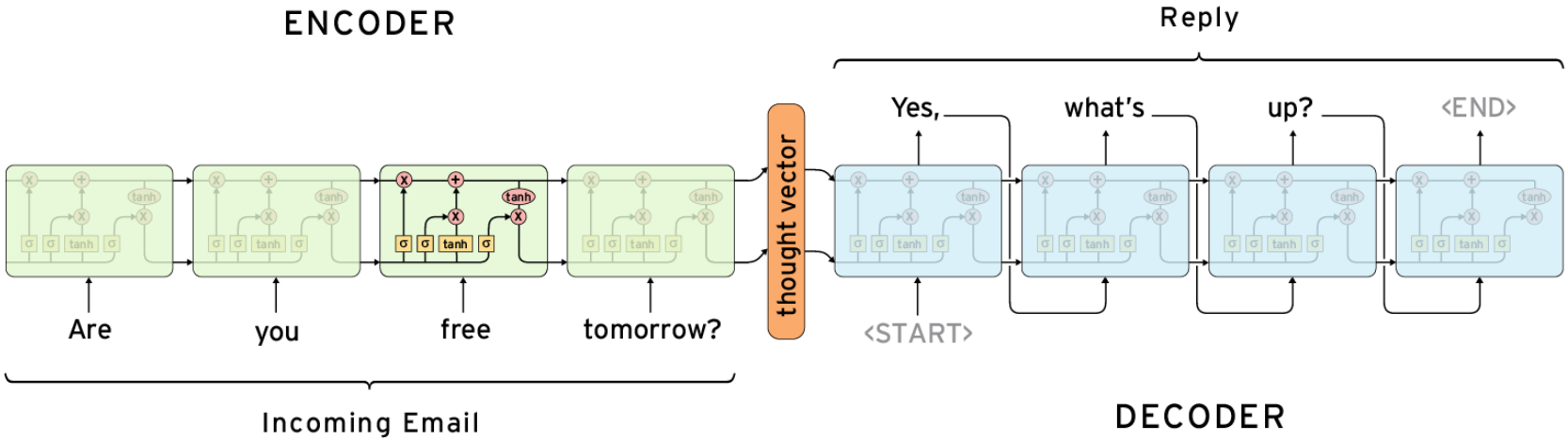
# Dialog systems and storytelling

# Dialog systems

# Dialog systems

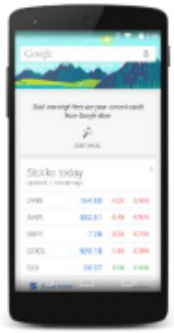


# Seq2seq dialog systems



# Intelligent assistants

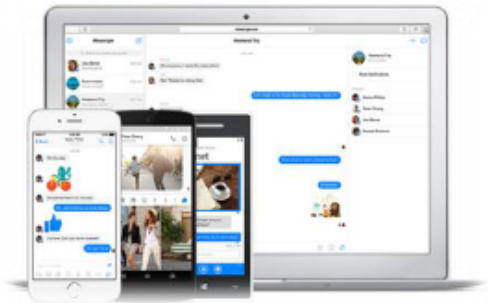
Apple Siri (2011)



Google Now (2012)
Google Assistant (2016)

Microsoft Cortana (2014)

Amazon Alexa/Echo (2014)

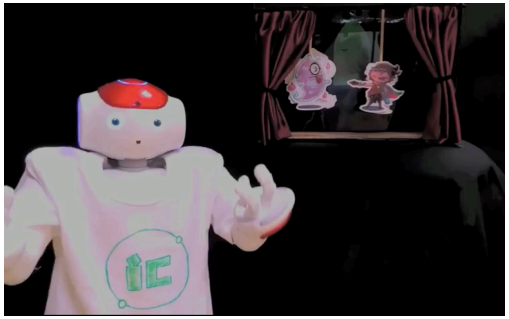


Facebook M & Bot (2015)

Google Home (2016)

Apple HomePod (2017)

# Storytelling with Nao

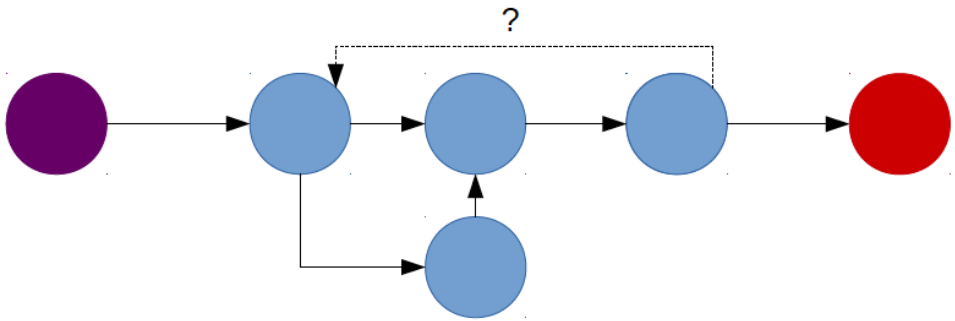


# Storytelling

- 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

# 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

# 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

# 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

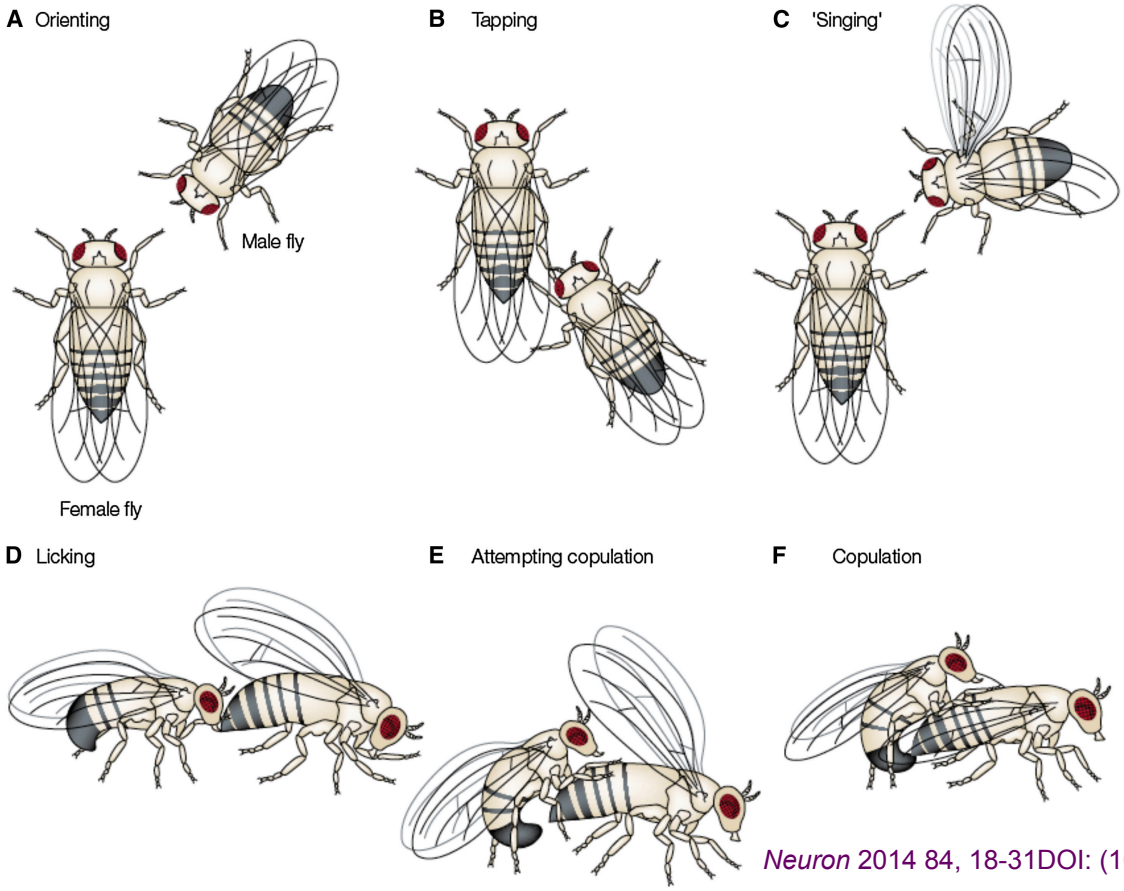
# Example 1

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

# Target species

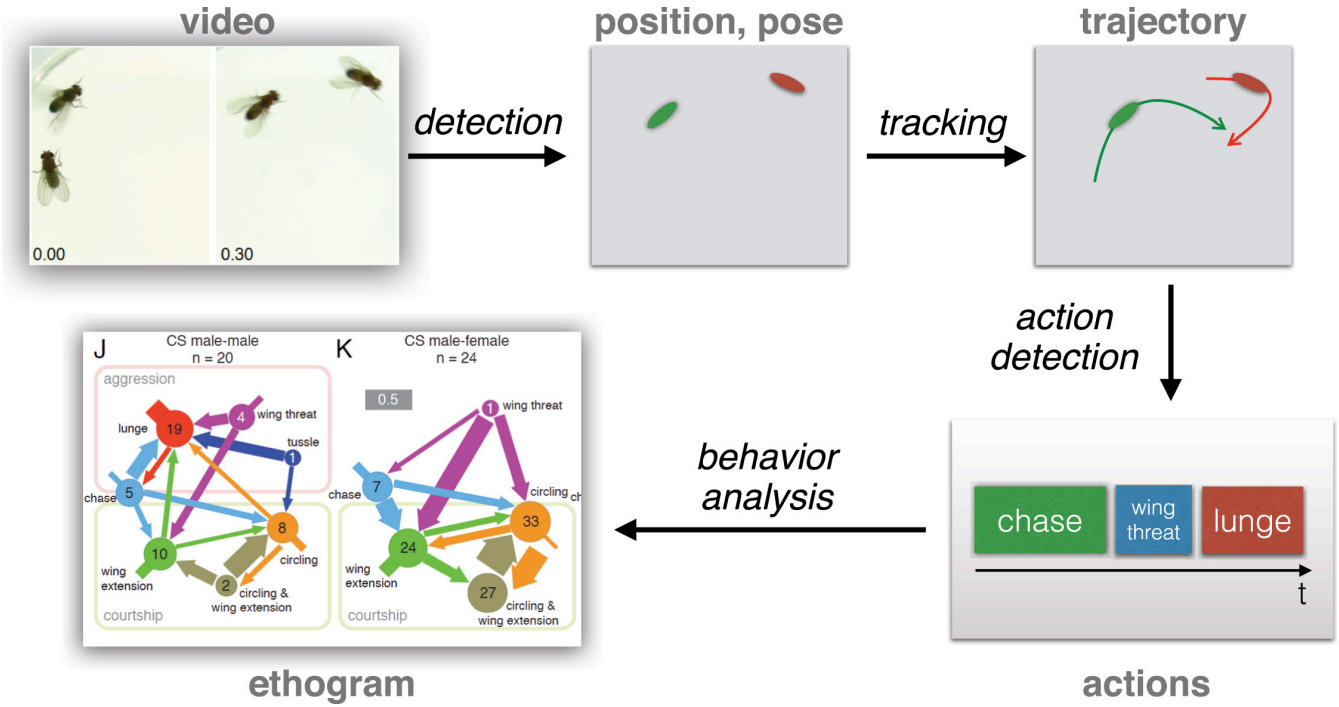
- *Drosophila melanogaster.* Vinegar fly
  - dyadic (pairwise) interactions such as male-female courtship and male-male aggression,
  - higher-dimensional interactions within large (>10) groups of flies
  - How are they encoded in DNA?
- Courtship: (highly variable) series of actions
  - Human observers 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.

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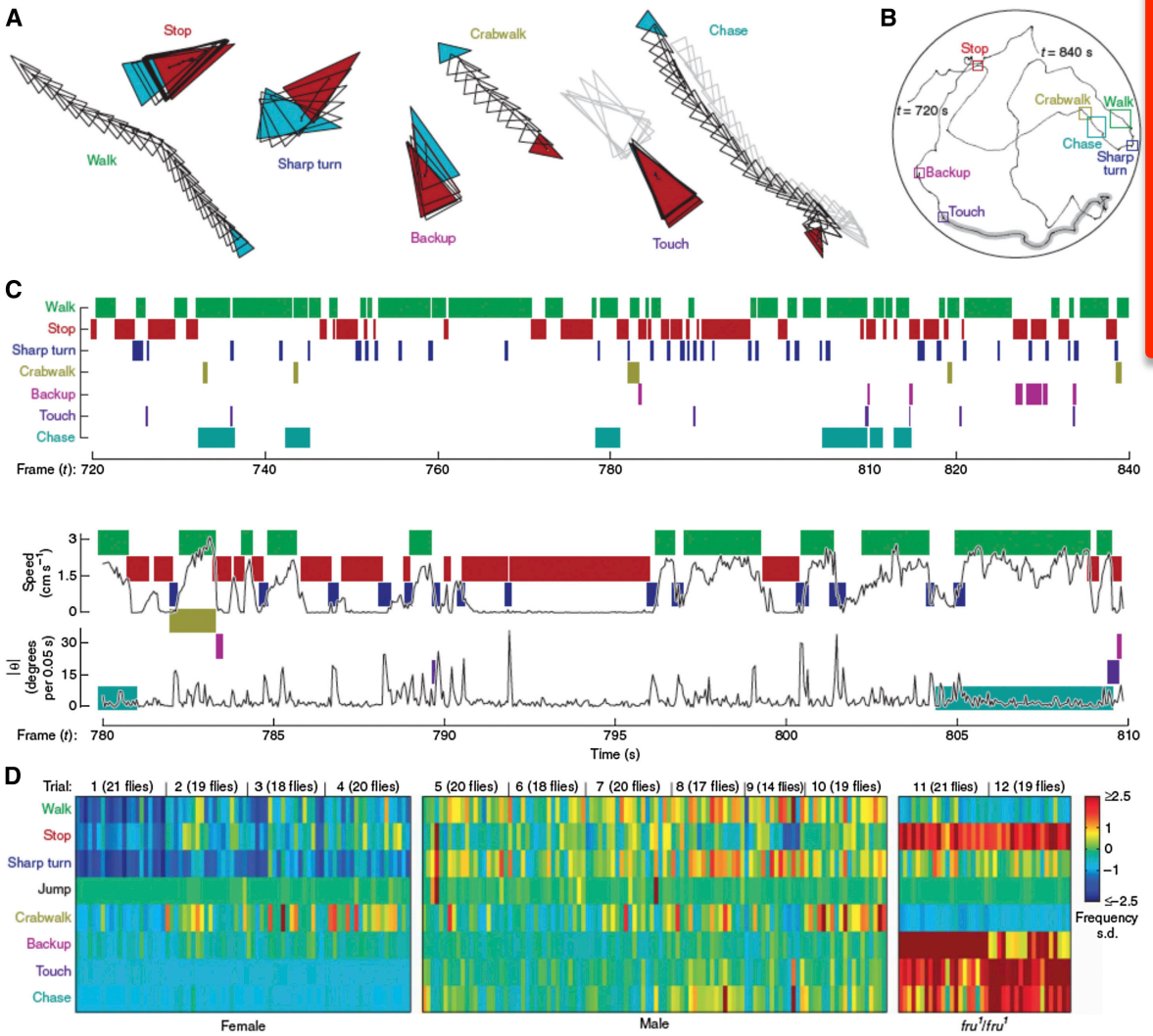
# *Increasing the throughput of behavioral analysis*

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.

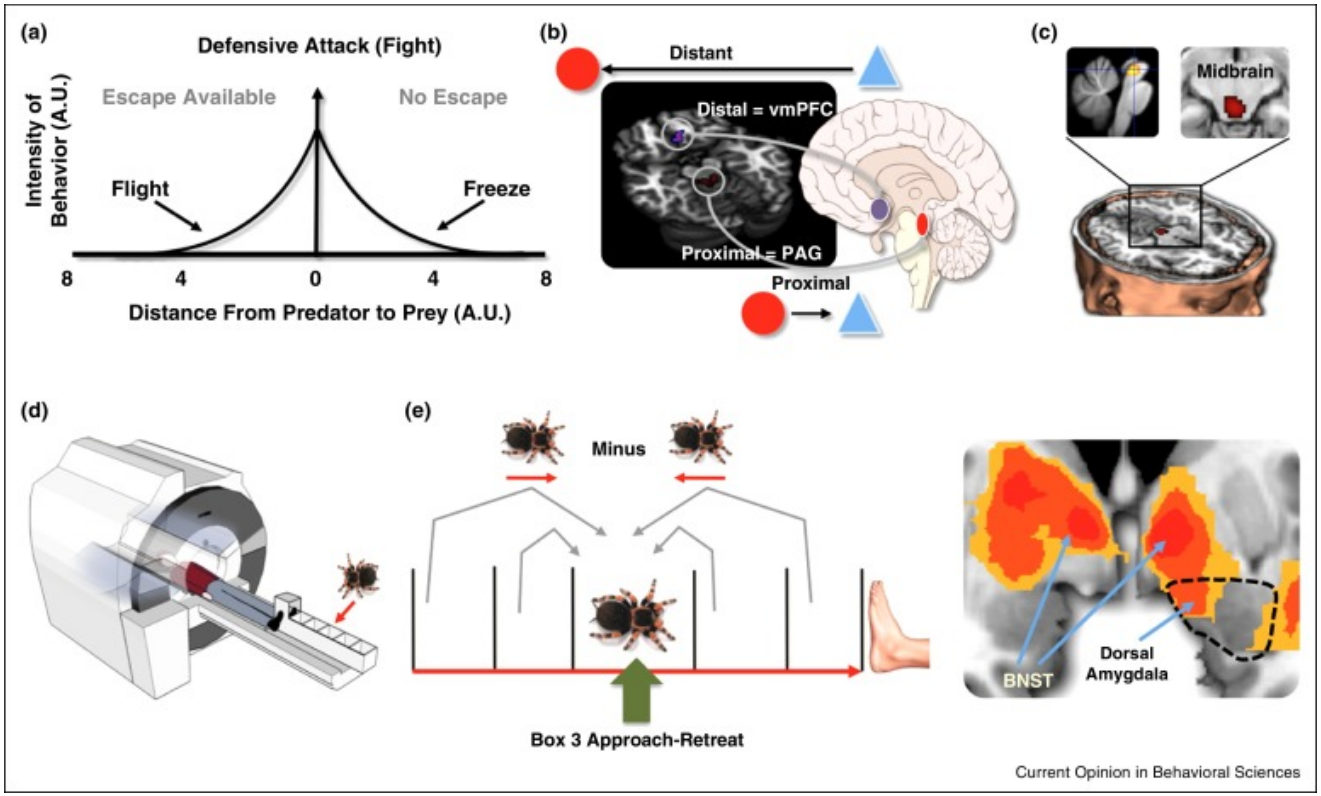
# Example 2

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

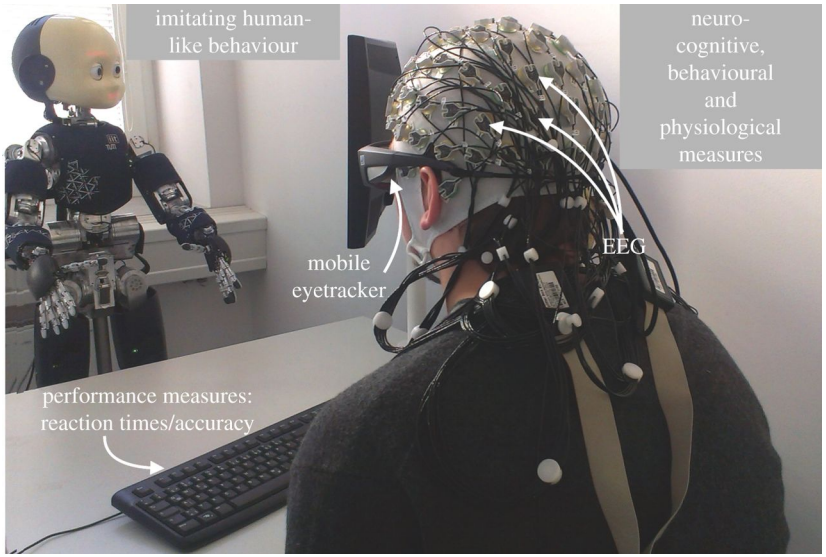
# Highlights

- 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.

# Experiment design



# An experimental setting for neuroethological human robot interaction?




Too far from ecological validity in special educational needs!

# 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 seek new tools for
  - Smart human robot interaction
  - Behavior measurement
  - Correlation of behavior measurement and neural activity

# Discussion

- Bringing Computational Neuroethology out of the lab (into the school)
  - Ethics questions
  - Technological questions
  - Scientific questions