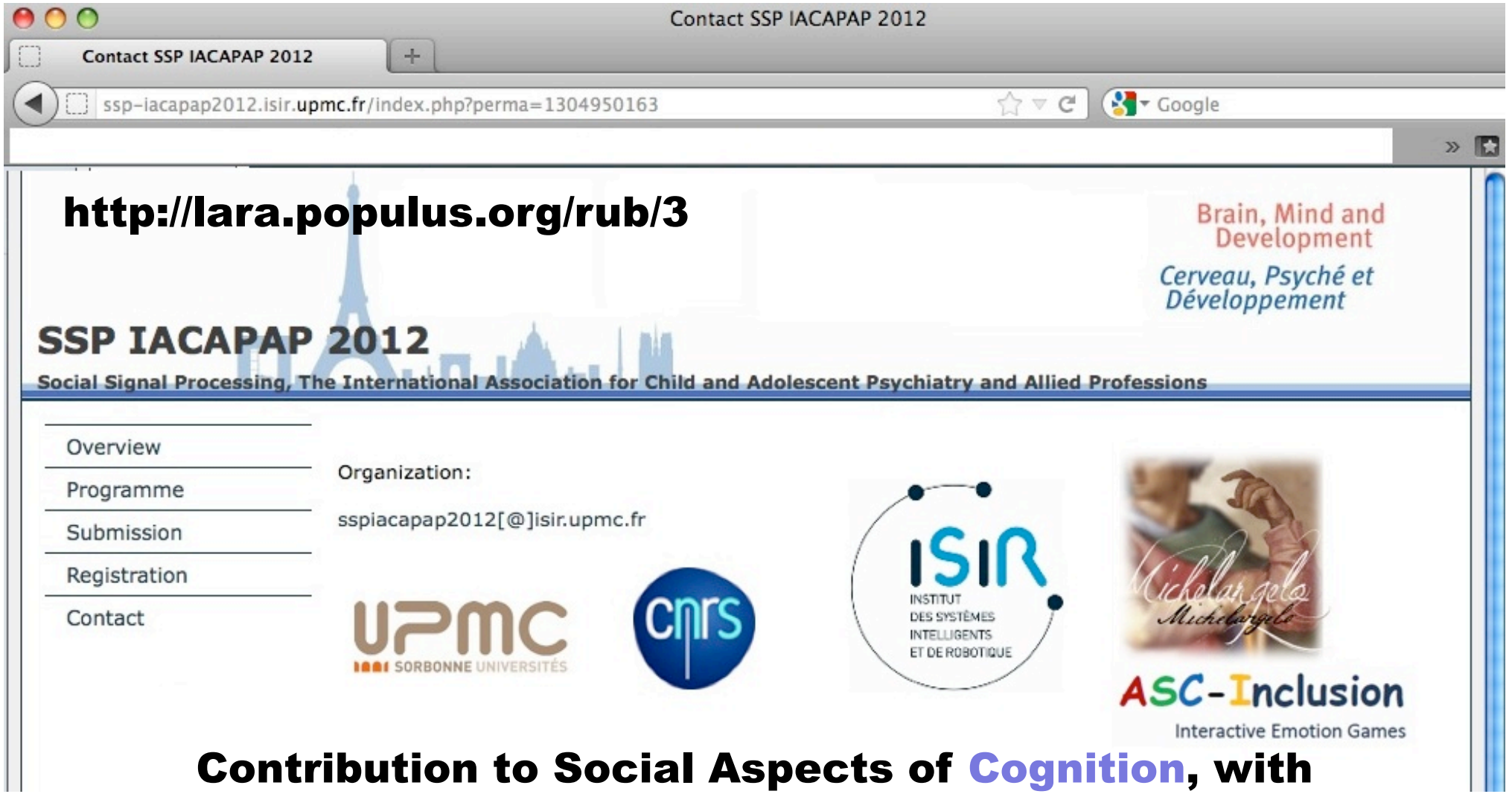


Contribution to Social Aspects of Cognition, with Implementation in Signal Supporting Systems and Intelligent Robots, Capable to Interact with Children in the Real-World

Jean-Daniel.Dessimoz, Pierre-François Gauthey and Hayato Omori

ROOM 252 A

Hes·so
Haute Ecole Spécialisée de Suisse occidentale

heig-vd
Haute Ecole d'Ingénieurs et de Gestion du Canton de Vaud

cetT

Institut d'Automatisation Industrielle LaRA
Laboratoire de Robotique et Automatisation

Contribution to Social Aspects of Cognition, with Implementation in Signal Supporting Systems and Intelligent Robots, Capable to Interact with Children in the Real-World

Jean-Daniel.Dessimoz[1], Pierre-François Gauthey[1] and Hayato Omori

{ Jean-Daniel.Dessimoz or Pierre-Francois.Gauthey } @heig-vd.ch

[1]Hesso // Western Switzerland University of Applied Sciences
Heig-vd // School of Business and Engineering, CH-1400 Yverdon-les-Bains, Switzerland
[2]Chuo University, Tokyo, Japan

Brain, Mind and Development, SSP in IACAPAP 2012 World Congress,(Social Signal Processing in the International Association for Child and Adolescent Psychiatry and Allied Professions), Institut de Systèmes intelligents et Robotique, Universités Paris-Descartes, Pierre et Marie Curie, de la Sorbonne , et al., Palais des Congrès, Paris, July 21-25, 2012.

http://www.heig-vd.ch, **http://lara.heig-vd.ch re. publications**

Keywords: , knowledge, cognition, cognitics, ontology, information, model, memory, service robotics, domestic applications, following and guiding, standardization

Content

1. Introduction
2. High tech for human development
3. Robotics - 2 views (Human clones or functional machines?)
4. Cognition and cognitics
5. Service to children and adolescents
6. Conclusion

References

http://lara.heig-vd.ch re. publications

1. Introduction

Existing technologies

- ICT's
- Robotics
- Automated cognition = Cognitics

Future considered goals

- Child Development Analysis
- Socially Intelligent Processing of Atypical Interactive Situations
- Socially Assistive Robotics for Children

Plan

- High tech for human development
. Robotics - are we looking for human clones or for functional machines?
- Cognition and cognitics
- Service to children and adolescents

Content

1. Introduction
2. High tech for human development
3. Robotics - 2 views (Human clones or functional machines?)
4. Cognition and cognitics
5. Service to children and adolescents
6. Conclusion

References

http://lara.heig-vd.ch re. publications

2. High tech for human development

[5, 6]

- **High-tech** for human development is **here** [e. g. 1-6]
- Make new cognitive proposals **operational** in robots (re. [9]).

[7]

[4]

[8]

A., 2.5 yrs - C.D.

Content

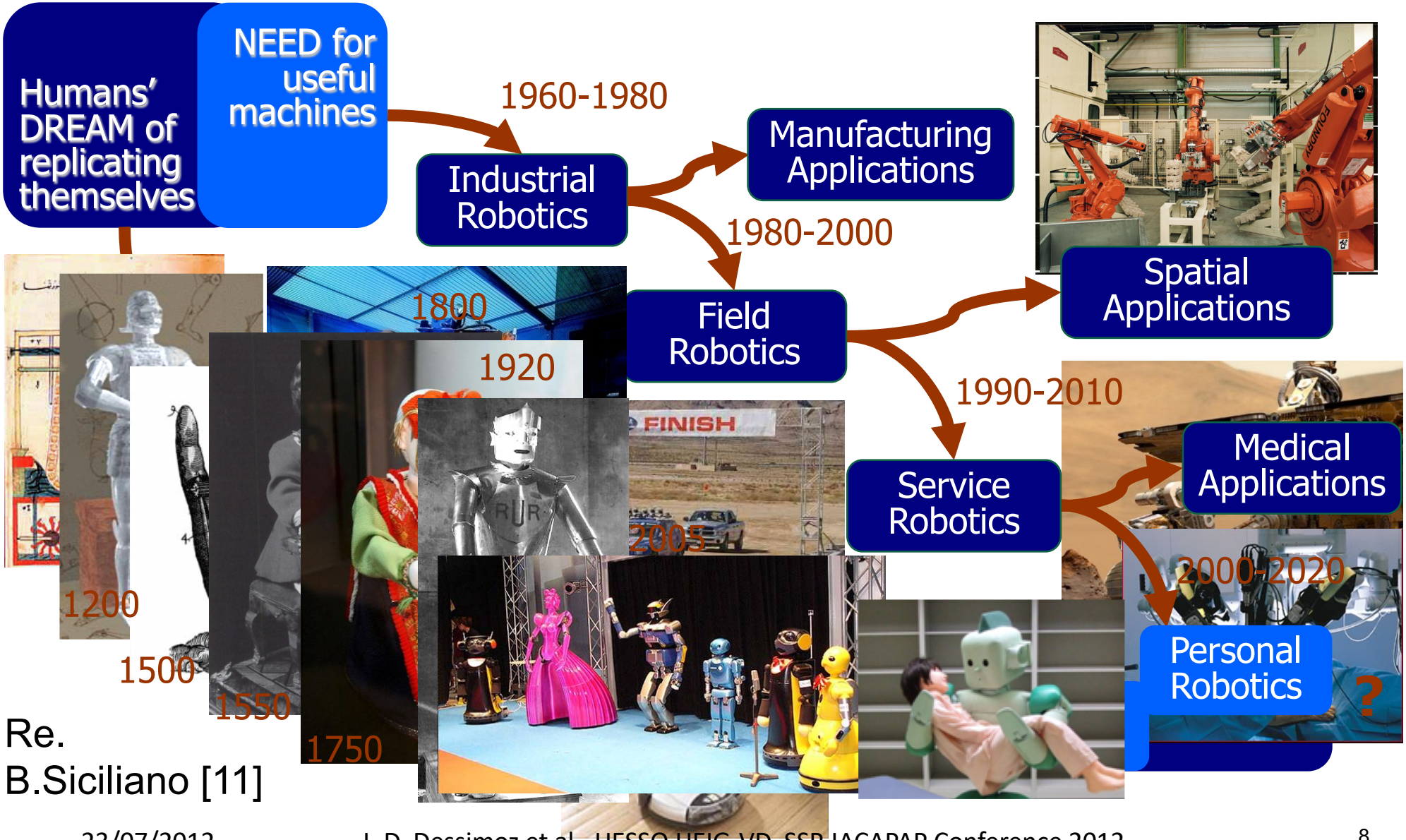
1. Introduction
2. High tech for human development
3. Robotics - 2 views (Human clones or functional machines?)
4. Cognition and cognitics
5. Service to children and adolescents
6. Conclusion

References

http://lara.heig-vd.ch re. publications

3. Robotics - 2 views 1 of 4

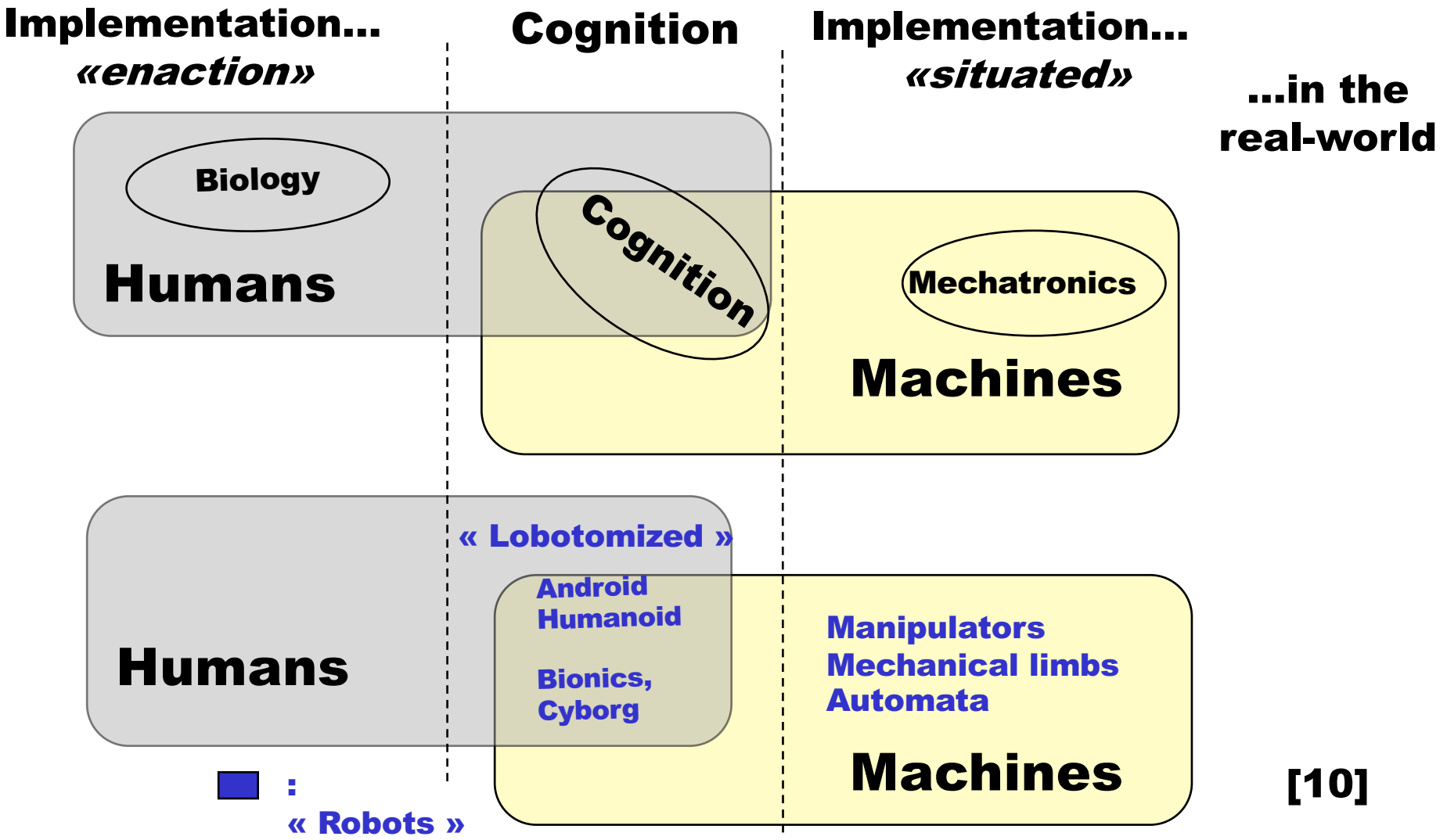
Evolution of Robotics



Re.
B.Siciliano [11]

3. Robotics - 2 views 2 of 4

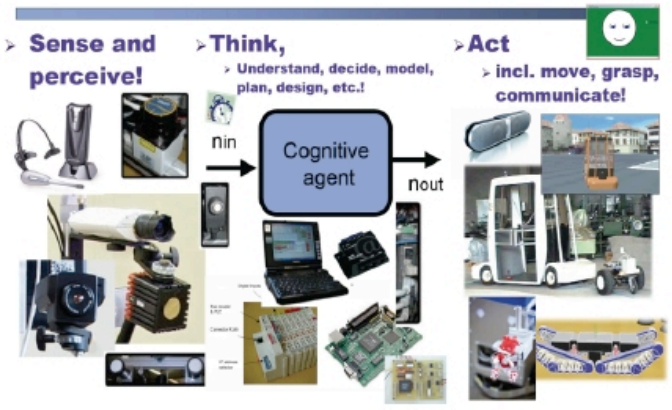
Cognitive sciences and thinking machines



[10]

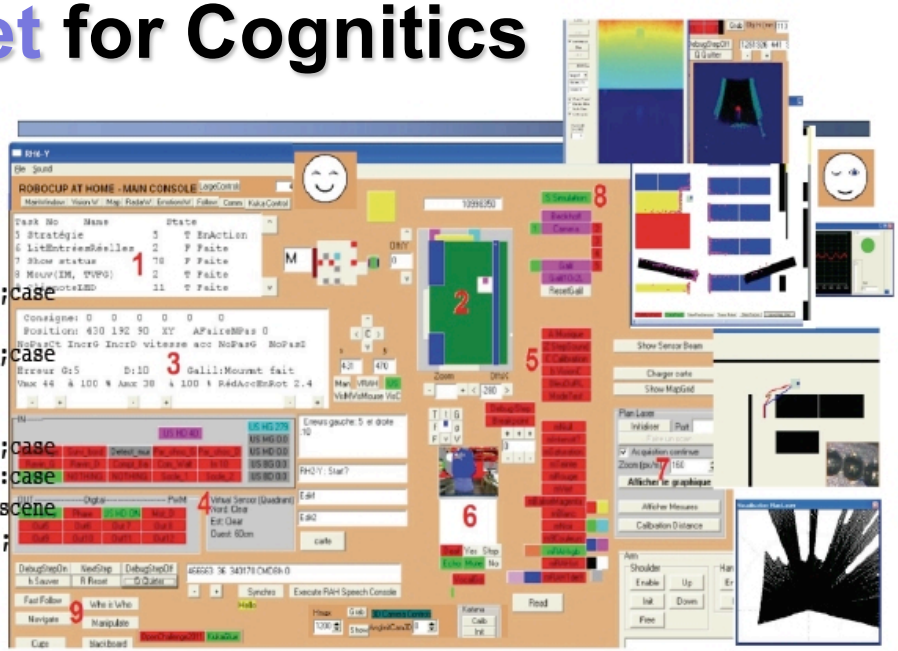
3. Robotics - 2 views 3 of 4

Piaget for Cognitics

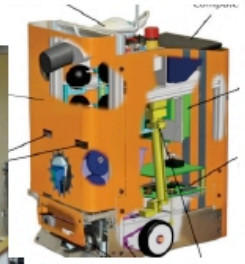


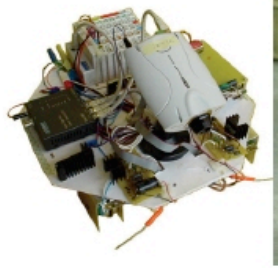

```
12: if(!SignalIn(NSIStart))
      GoState(6);
      else
      GoSTate(20);        break;case

20: ApproAGN(Table,30);   break;case
//Switch light on
21: SignalOutAGN(NSOLamp,true)
                          break;case
22: SleepAGN(0.05);       break;case
//Visual analysis of a row in scene
23: WatchRowAGN(R,CStart,Cstop);
```



Smart Systems in the Real World; and Piaget (*center and right*)





heig-vd
Haute Ecole d'Ingénieurs et de Gestion du Canton de Vaud

Hes·so
Haute Ecole Spécialisée de Suisse occidentale

3. Robotics - 2 views 4 of 4

- Robotics and AI:
  - Robocup (soccer) and Robocup@Home (domestic help, [13])
  - Examples of HEIG-VD contributions [14] in latter context

Content

1. Introduction
2. High tech for human development
3. Robotics - 2 views (Human clones or functional machines?)
4. Cognition and cognitics
5. Service to children and adolescents
6. Conclusion

References

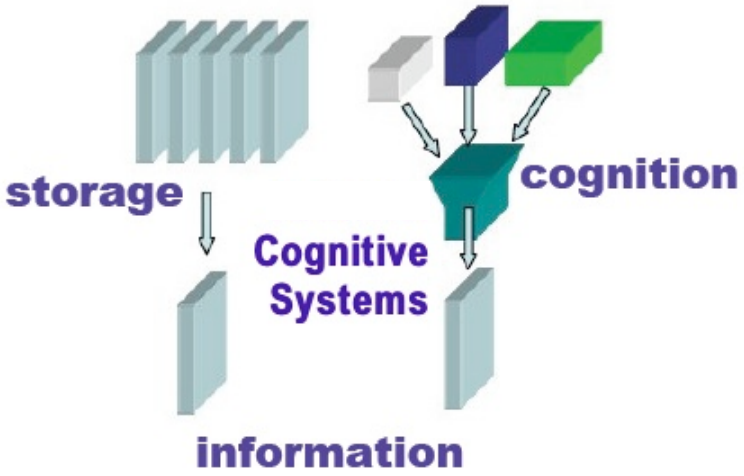
http://lara.heig-vd.ch re. publications

4. Cognition and Cognitics (1 de 12)

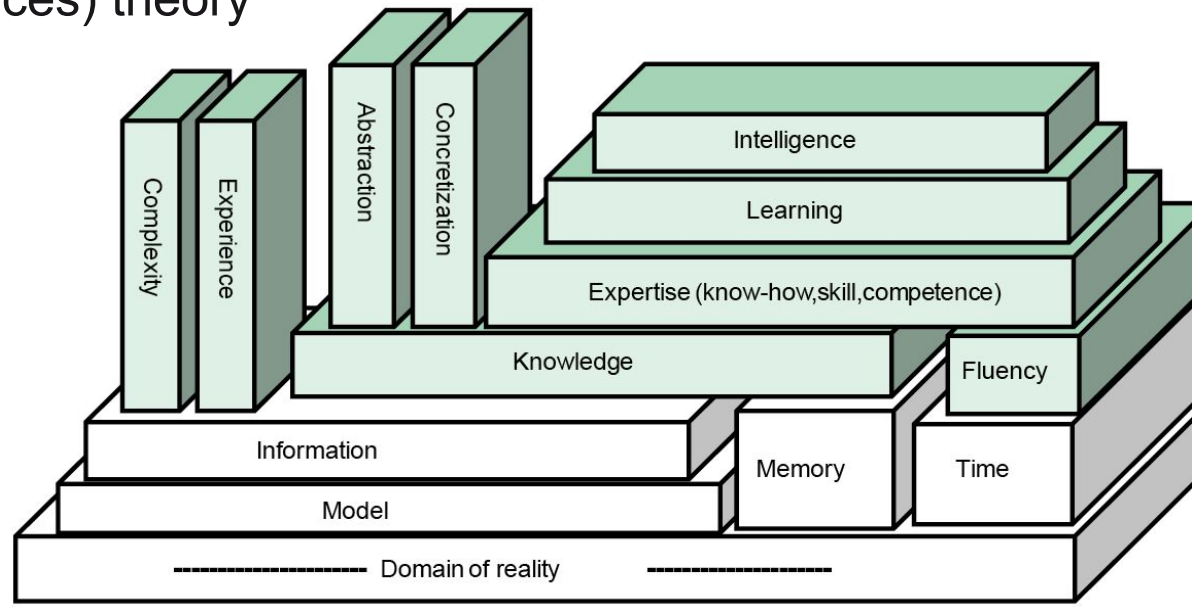
Definitions and metrics

Content:

- « Classical » notions
  - Logarithm
  - Model (2000 years and more; revisited)
  - Information (50 years and more; revisited)
- MCS (Model for cognitive sciences) theory
  - Complexity
  - Knowledge
  - Expertise
  - Learning
  - Intelligence
  - Scalability
  - Dynamics



[9]



4. Cognition and Cognitics (2 de 12)

Definitions and metrics

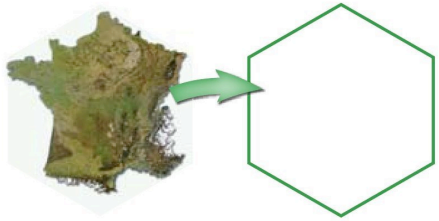
Logarithm: re. counting the digits! Ex. : 6-figure salary .

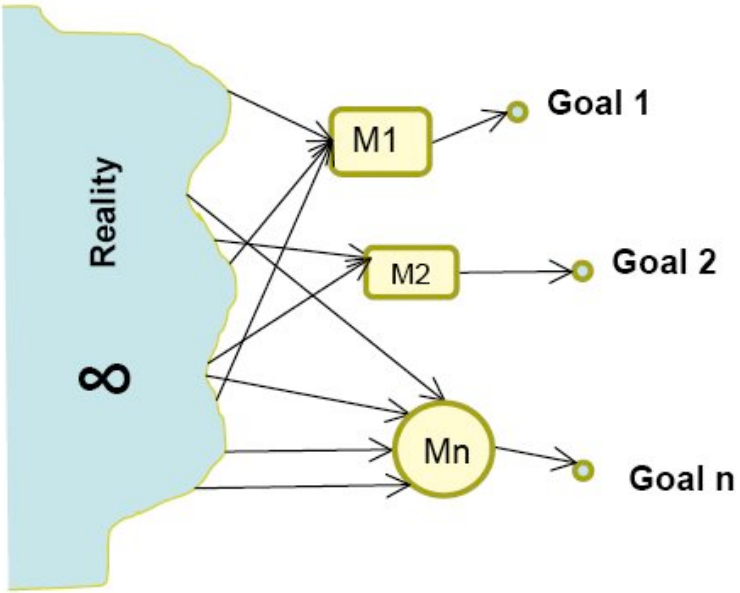
Number	*Log_{10} : dit*	*Log_2 : bit*
1	0	0
2	0.3	1
3	0.5	1.6
4	0.6	2
8	0.9	3
10	1	3.3
100	2	6.6
1000	3	10.0
1000000	**6**	**19.9**

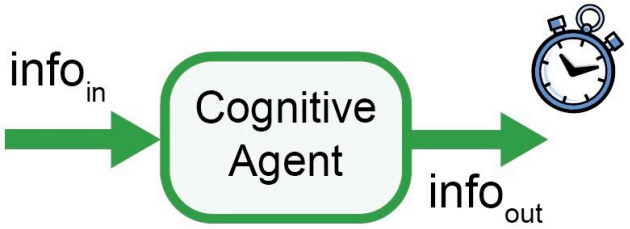
4. Cognition and Cognitics (3 de 12)

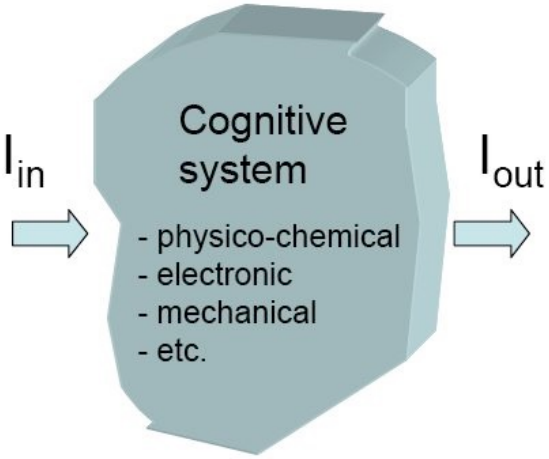
Definitions and metrics

- **Model** (2000 years and more; revisited)
- Information (50 years and more; revisite
- MCS (Model for cognitive sciences) theory
  - Complexity
  - Knowledge
  - Expertise
  - Learning
  - Intelligence
  - Scalability
  - Dynamics









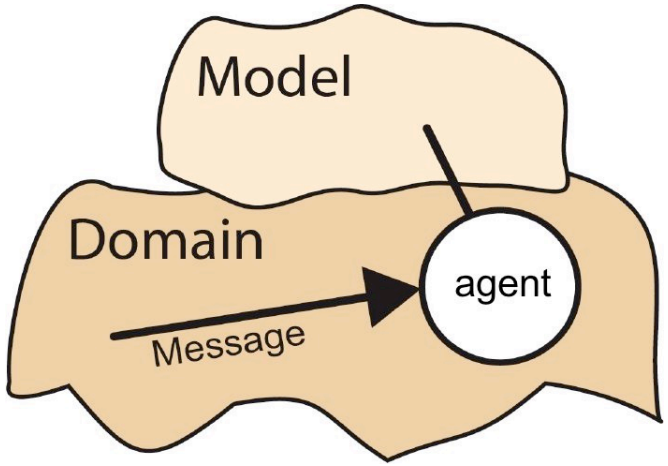
Simple representation of reality

Revisited:

- **0_+ relative complexity**
- **goal specific**, possibly good

4. Cognition and Cognitics (4 de 12)

Definitions and metrics



- **Information** (50 years and more)

Information is conveyed by messages, which allow cognitive agents **to form and update** their **opinion** (model) relating to some subset of reality (domain)

$$Q = \log_2\left(\frac{1}{p}\right) \text{ bit}$$

Revisited:

- time dependant
- subjective

4. Cognition and Cognitics (5 de 12)

Definitions and metrics

Probabilité, p	*Probabilité, p*	*1/p*	*Log_{10} : dit*	*Log_2 : bit*
1	1	1	0	0
1/2	0.5	2	0.3	1
1/3	0.33	3	0.5	1.6
1/4	0.25	4	0.6	2
1/8	0.125	8	0.9	3
1/10	0.1	10	1	3.3
1/100	0.01	100	2	6.6
1/1000	0.001	1000	3	10.0
1/1000000	**0.000001**	**1000000**	**6**	**19.9**

4. Cognition and Cognitics (6 de 12)

Definitions and metrics

- MCS (Model for cognitive sciences) theory
  - **Complexity**
  - Knowledge
  - Expertise
  - Learning
  - Intelligence
  - Scalability - from thinking to group behavior
  - Dynamic behavior

Complexity is the property to require a lot of information for an exhaustive description. Quantitatively, complexity is the amount of required information for this description. The measurement unit is therefore the same as for information (the bit)

4. Cognition and Cognitics (7 de 12)

Definitions and metrics

- MCS (Model for cognitive sciences) theory
  - Complexity
  - **Knowledge**
  - Expertise
  - Learning
  - Intelligence
  - Scalability - from thinking to group behavior
  - Dynamic behavior

Knowledge makes systems capable **to generate** the **relevant information**.

$$K = \log_2\left(n_{out} \cdot 2^{n_{in}} + 1\right)$$ **lin**

4. Cognition and Cognitics (8 de 12)

Definitions and metrics

- MCS (Model for cognitive sciences) theory
  - Complexity
  - Knowledge
  - **Expertise**
  - Learning
  - Intelligence
  - Scalability - from thinking to group behavior
  - Dynamic behavior

Expertise is the property of a cognitive system to **quickly** deliver relevant information.

$$E = K \cdot f \quad \textbf{lin/s}$$

Where f is the cognitive speed, in 1/s

4. Cognition and Cognitics (9 de 12)

Definitions and metrics

- MCS (Model for cognitive sciences) theory
  - Complexity
  - Knowledge
  - Expertise
  - **Learning**
  - Intelligence
  - Scalability - from thinking to group behavior
  - Dynamic behavior

Learning is the ability of a CS **to raise** its **level of expertise** over time (t), or more generally speaking, with experience (r).

$$L = E(t_1) - E(t_0)$$ **lin/s**

4. Cognition and Cognitics (10 de 12)

Definitions and metrics

- MCS (Model for cognitive sciences) theory
  - Complexity
  - Knowledge
  - Expertise
  - Learning
  - **Intelligence**
  - Scalability - from thinking to group behavior
  - Dynamic behavior

Intelligence is the **capacity to learn**

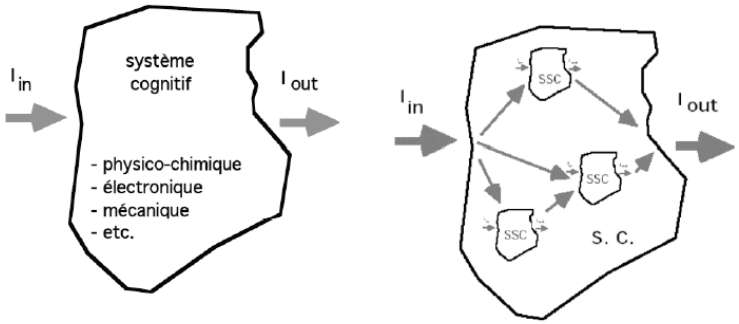
$$i_{I_t} = \frac{L}{R_T} \quad \text{lin/s}^2$$

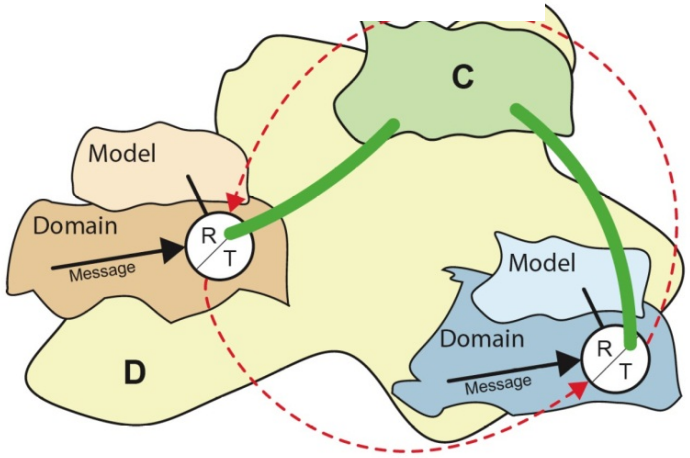
$$i_{I_i} = \frac{L}{R_i} \quad \frac{lin}{s \cdot bit}$$

4. Cognition and Cognitics (11 de 12)

Definitions and metrics

- **Scalability - from thinking to group behavior**



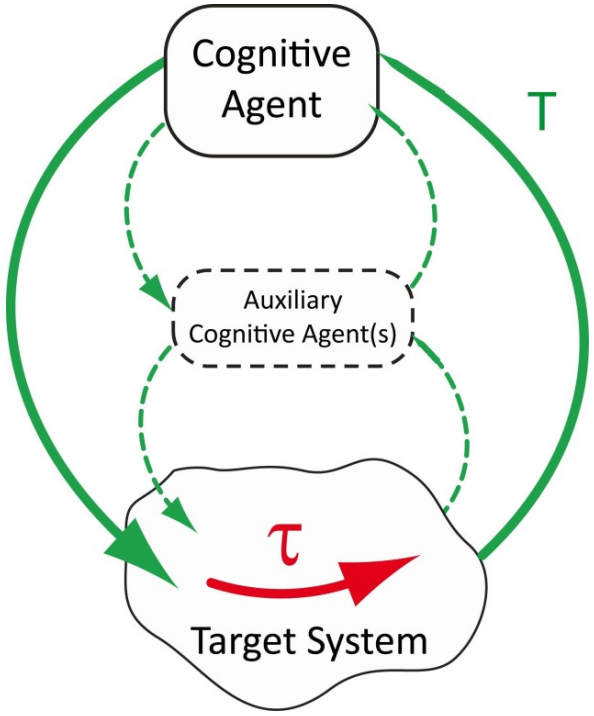


Individual **cognitive agents** (blue, brown) may coordinate each other, and thus **may** collectivety **form a group** . For this purpose, a common culture (C, green), in reference to some common domain of interest (D, yellow) and some communication media are required among agents (R: receive; T: transmit). At a metalevel, the individual members may be considered as merging, to yield a new individual (the group) with its own collective model (C).

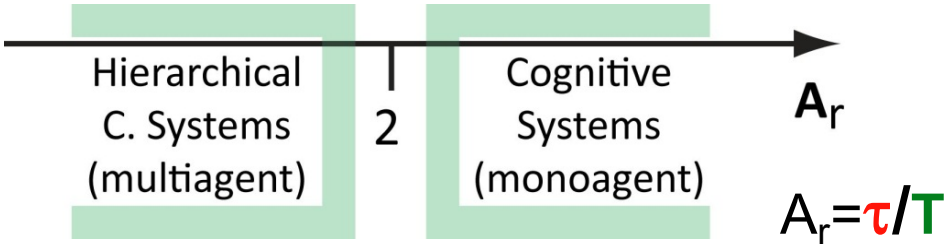
4. Cognition and Cognitics (12 de 12)

Definitions and metrics

- **Dynamic behavior - compensation for disturbances and stability; hierarchies and autonomy**



For successive control, the agility of a cognitive agent must be large relatively to the one of the target system



Content

1. Introduction
2. High tech for human development
3. Robotics - 2 views (Human clones or functional machines?)
4. Cognition and cognitics
5. Service to children and adolescents
6. Conclusion

References

http://lara.heig-vd.ch re. publications

5. Service to children and adolescents

A large spectrum of possible modes:

Cognitive evaluation
- Classical methods (e. g. Dawba) « Plus »
- Direct testing (e. g. Piaget)

Eliza typed chatbox with multiple aspects
- domestic and personal development ontologies
- ludic worlds and games

Interaction in the real-world (incl. Robots)
- « simpler » systems (re. kinematics) yet unique
  - for motions and transport capabilities,
  - as support for emotions,
  - and for multisense stimulation and synaesthesia
- robots as functional machines
- humanoids and androids, as mediators

Possible integration of several domains

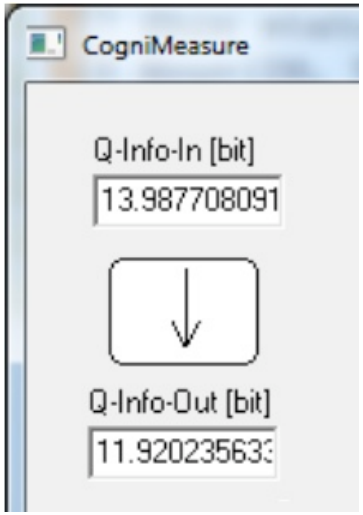
5. Service to children and adolescents

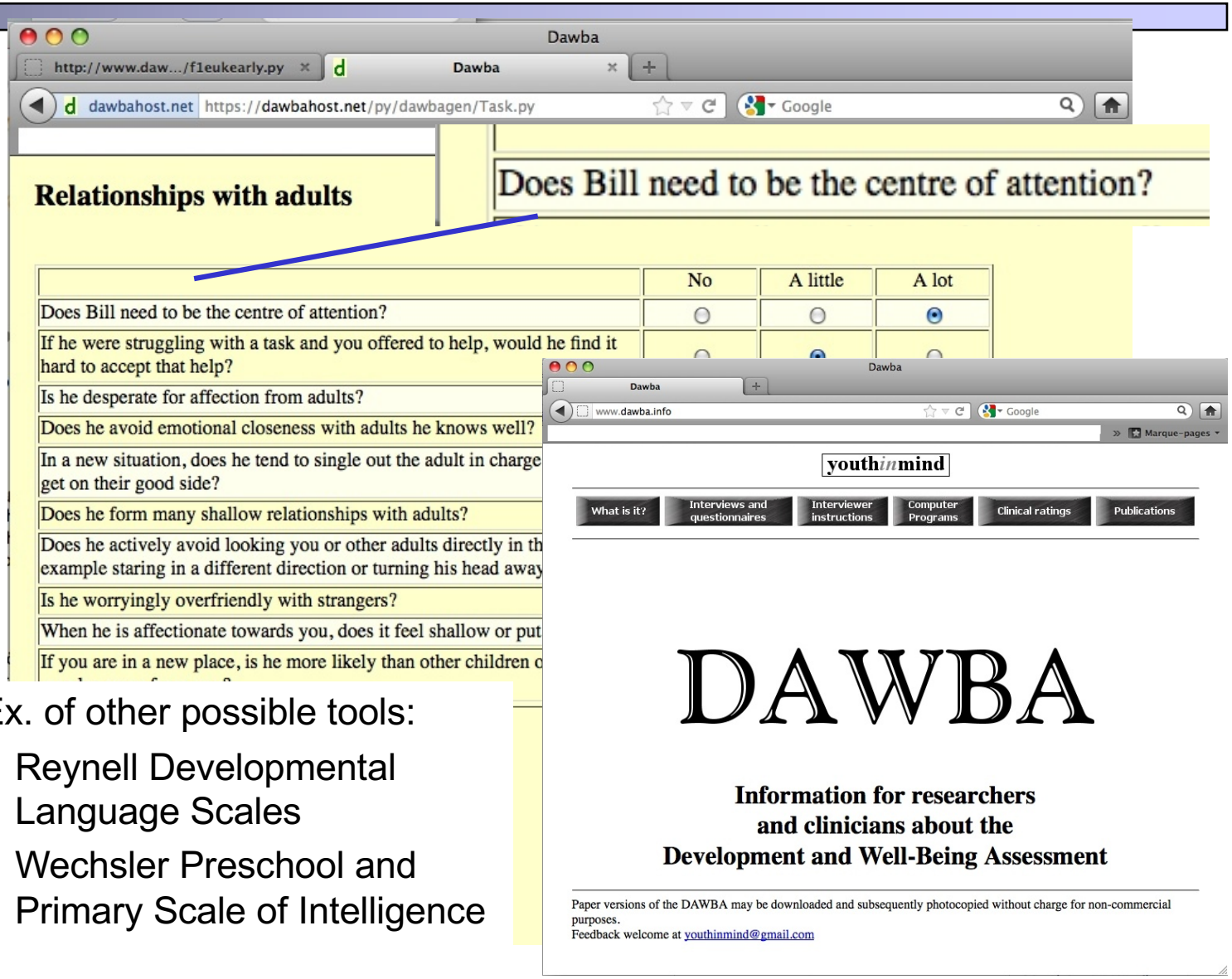
Dawba [14,15] :

e.g. 1 page questionnaire:

Ni≈10*1.6 bit

No≈TBD





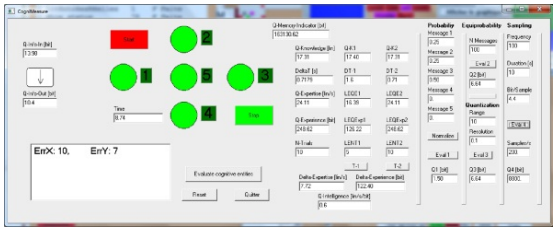
Ex. of other possible tools:

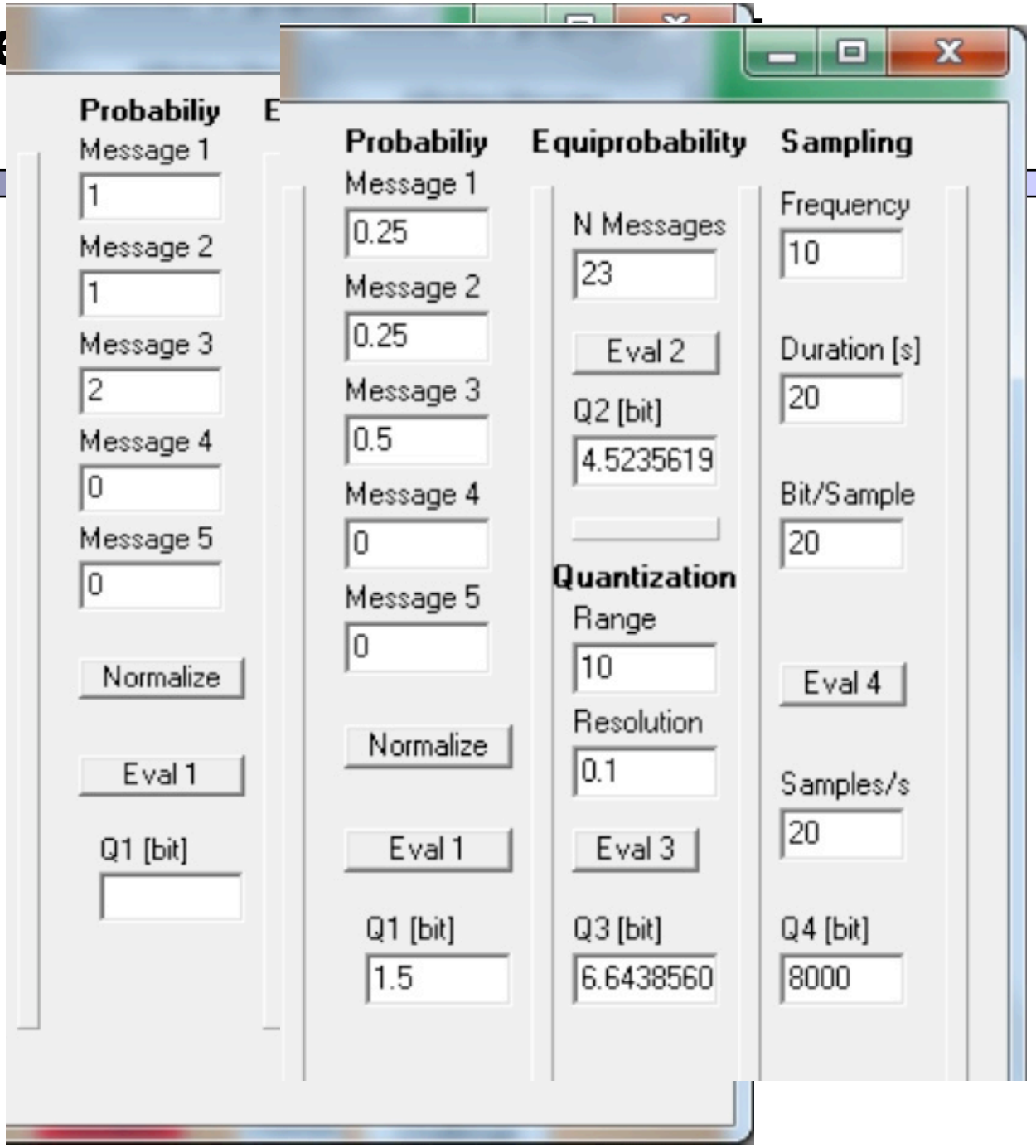
- Reynell Developmental Language Scales
- Wechsler Preschool and Primary Scale of Intelligence

5. Se

Piaget :

Various (classical) ways to estimate **information quantities**





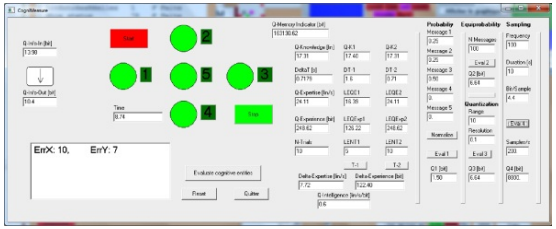
5. Service to adoles

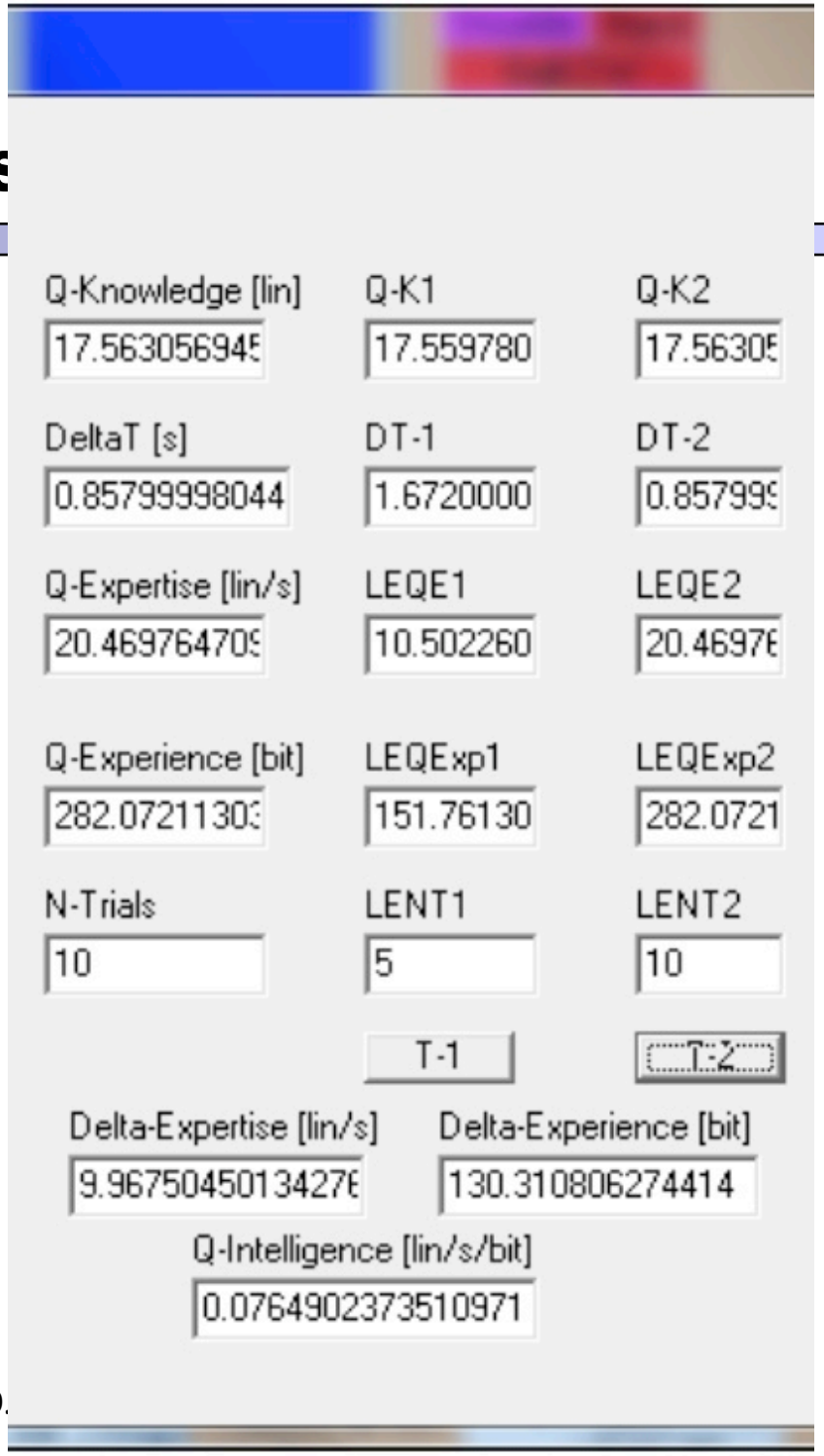
Piaget and MCS :

Original way to estimate **cognition quantities**

Information:	$n = \sum p_i \log_2(1/p_i)$ [bit]
Knowledge:	$K = \log_2(n_{out}\, 2^{n_{in}}+1)$ [lin]
Fluency:	$F = 1/\Delta t$ [s^{-1}]
Expertise:	$E = K \cdot F$ [lin/s]
Learning:	$\Delta E = E(t_1)-E(t_0)$; >0 [lin/s]
Experience:	$R = r(n_{in}+n_{out})$ [bit]
Intelligence:	$I = \Delta E/\Delta R$ [lin/s/bit]
relative Agility:	$A_r = \tau/T$

T: Fluency^{-1} and communication delays
τ: Reaction time of target system, to be controlled



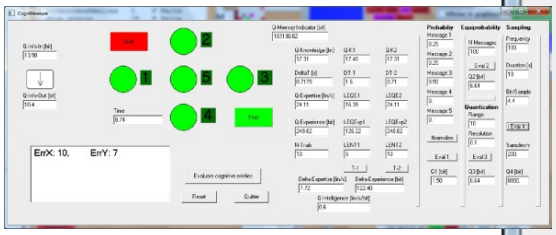


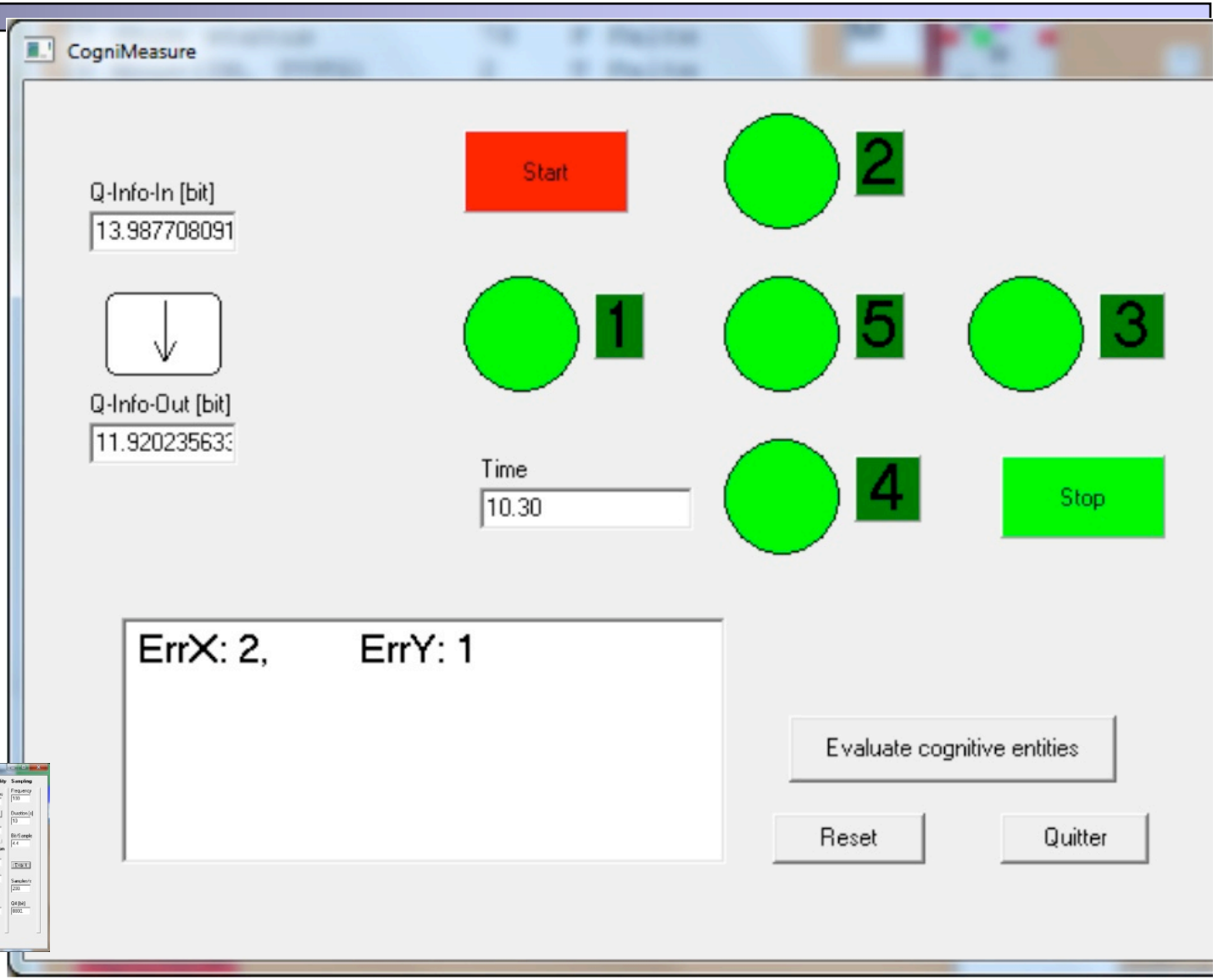
5. Service to children and adolescents

Piaget :

Integrated estimation of cognitive properties

Ex.: Learning to reach 5 target centers





5. Service to children and adolescents

Eliza typed chatbox

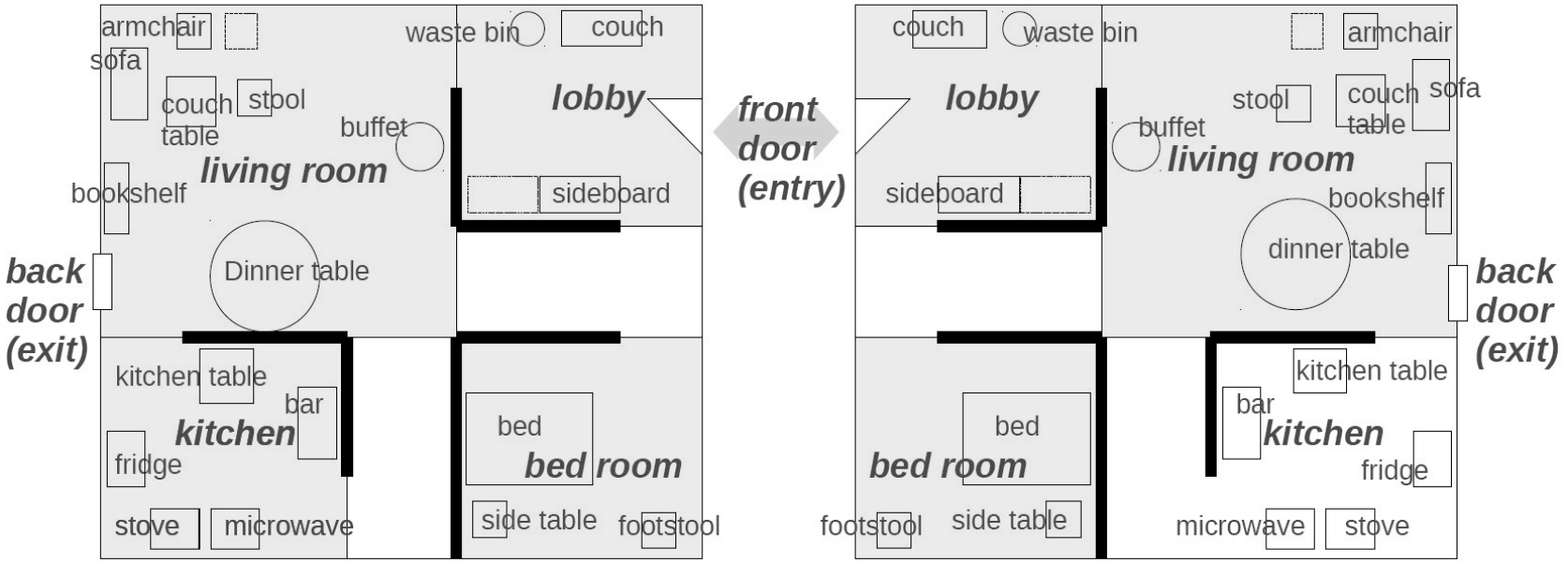
- domestic and
- personal development

ontologies

[17]

5. Service to children and adolescents

Standards and domestic ontology (Robocup @Home 2012):



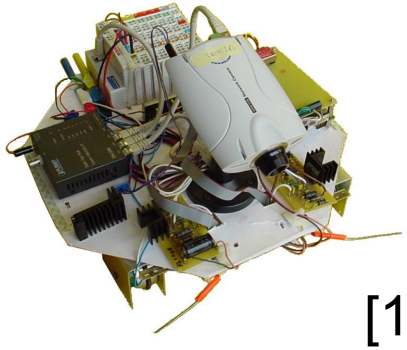
#	location	category	manipulation in GPSR	category placing
1	sofa	seat	no	
2	couch table	table	yes	
3	armchair	seat	no	
4	stool	seat	no	
5	dinner table	table	yes	
6	bookshelf	shelf	yes (2nd height)	
7	buffet	shelf	yes	
8	fridge	appliance	yes	
9	stove	appliance	no	
10	microwave	appliance	yes (table)	

#	location	category	manipulation in GPSR	category placing
11	kitchen table	table	yes	food
12	bar	shelf	yes	drinks
13	couch	seat	no	
14	sideboard	shelf	yes	snacks
15	wastebed	seat	yes	
16	side table	table	yes	
17	waste bin	bin	yes (placing)	unkown
18	bed	seat	yes	bath stuff
19	side table	table	yes	
20	footstool	seat	no	

5. Service to children and adolescents

Interaction in the real-world (incl. Robots)

- « simpler » systems (re. kinematics) yet unique
  - for motions and transport capabilities,
  - as support for emotions,
  - and for multisense stimulation and synaesthesia
- robots as functional machines
- humanoids and androids, as mediators



[14]

[8]

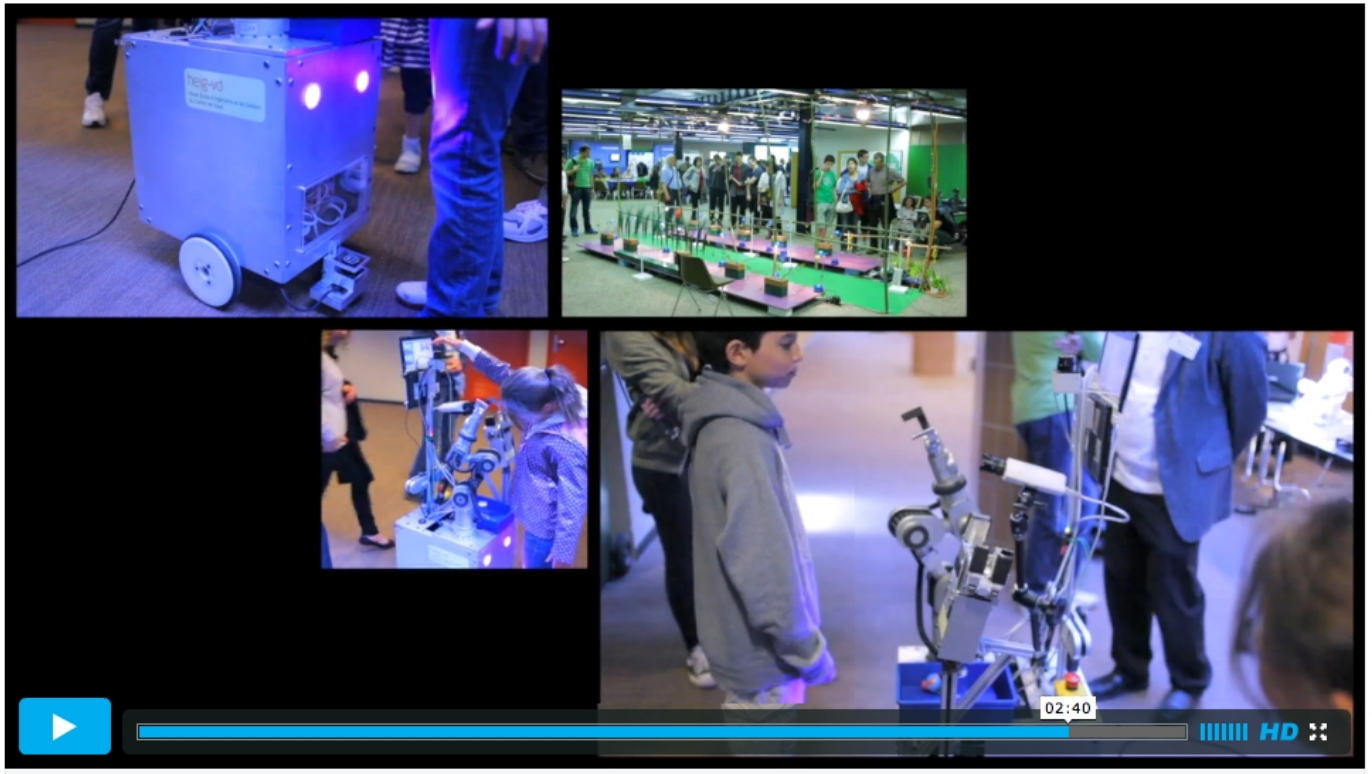
[18]

5. Service to children and adolescents

Interaction in the **real-world** (incl. Robots)
- …
- robots as functional machines
- humanoids and androids, as mediators

[19]

Festiv. 2012 :



5. Service to children and adolescents

Interaction in the real-world (incl. Robots)

- …
- humanoids and androids, as **mediators**

Festiv. 2011 :

5. Service to children and adolescents

Interaction in the real-world (incl. Robots)

- …
- humanoids and androids, as mediators

JPO 2011 :

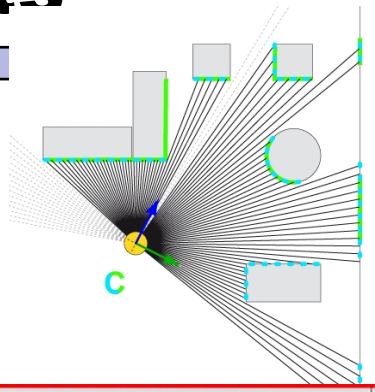
5. Service to children and adolescents

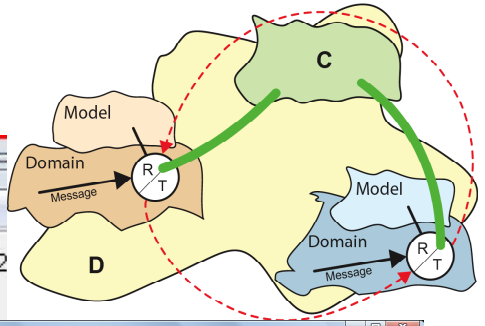
Interaction in the real-world (incl. Robots)

- …
- humanoids and androids, as mediators

Festival de Robotique, 5 May 2012, (EPFL) :

5. Service to children and adolescents





Concept validation

Robot Group, 3-D correlation of 2-D maps (ex. of conscience), graphic programming and **Piaget** communication for NAO

5. Service to children and adolescents

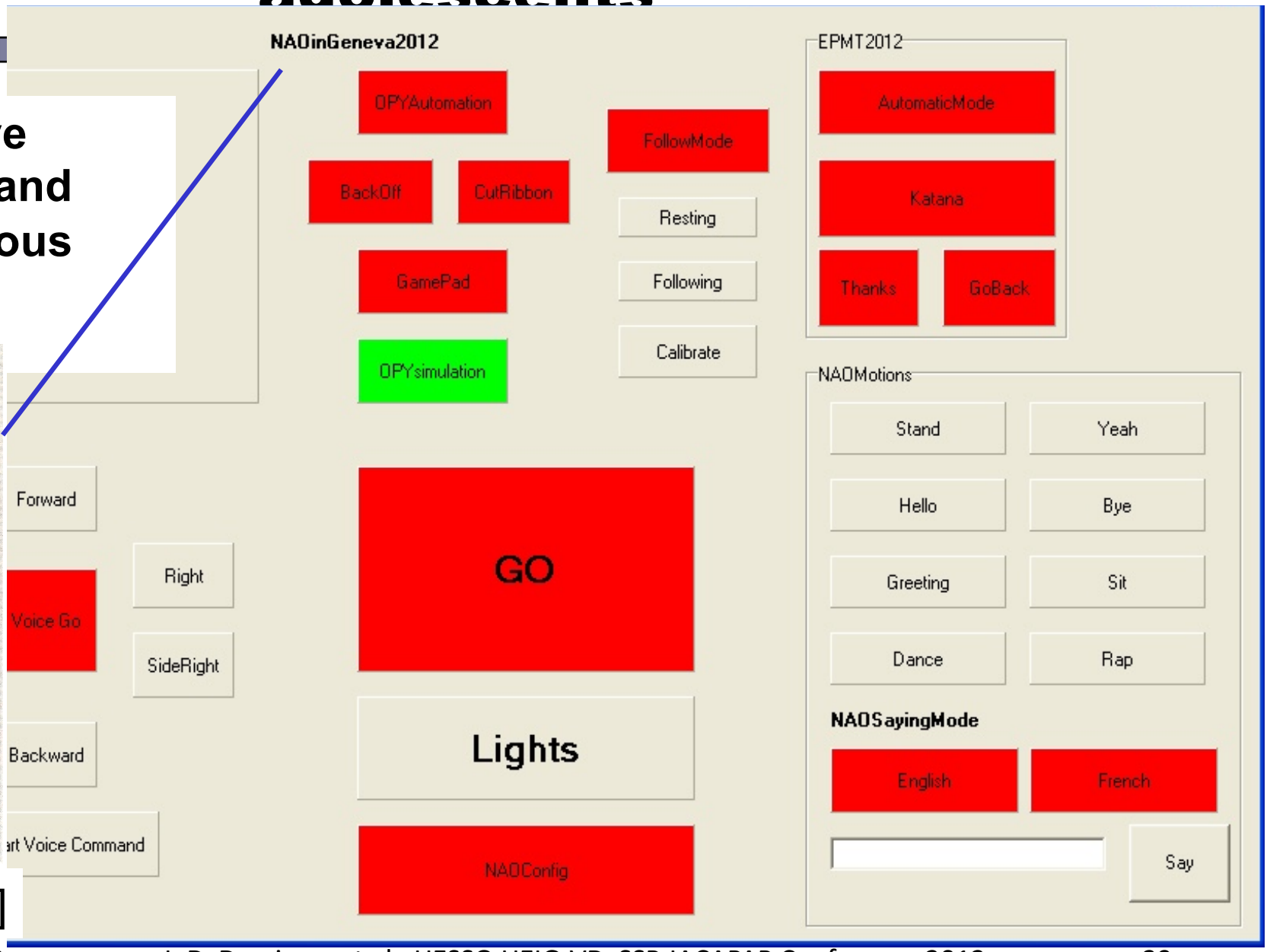
Interactive controls and autonomous actions

sée glissante, provoquant deux accidents. La victime a été percutée lors du second choc.

Le salon des records

GENÈVE. Le 40e Salon des inventions a fermé hier sur une foule de records. Non seulement celui d'exposants (789) et de pays représentés (46), mais aussi celui de visiteurs. Quelque 64 000 personnes s'y sont pressées.

[20]



[21]

5. Service to children and adolescents

- **Possible benefits in three domains:**
  - Experimental validation of new **formal concepts** in cognition,
  - Understanding of children nature, and directions for **new standards** in personal and social development
  - Possibility to **sense and act in the real-world**, allowing for multisensory communication and conviviality
  - Robot and intelligent system assistance in **correcting and/or coping with** some disorders

Content

1. Introduction
2. High tech for human development
3. Robotics - 2 views (Human clones or functional machines?)
4. Cognition and cognitics
5. Service to children and adolescents
6. Conclusion

References

http://lara.heig-vd.ch re. publications

6. Conclusion

- Consider ICT, robots and cognitics for the benefit of children and adolescents
- High tech has already proven useful for human development
- Robots have long been considered in 2 very different ways: towards human clones or towards more elaborated functional machines. We favor the second.
- The **MCS theory of cognition** is useful, providing formal definitions and quantitative assessment means for human and machine-based cognition, with continuity between macro-scale (society of individuals) and micro-scale (brain as a set of subunits).
- Our **"Piaget" environment** is mature for programming and developing real-world cooperating robots and cognitics. In particular, it has been demonstrated for various domestic applications, in world-level benchmarks.
- **New potential benefits** are at hand, in particular **for children and adolescents**:
  - Measuring cognitive and cooperating capabilities in children
  - Gradually, like in constructivism, defining a standard for personal and social development.
  - Simultaneously, making the new cognitive proposals operational in robots (cognitics).
  - Helping children and adolescents develop by robotic assistance in the real world, correcting, and/or coping with, selected disorders.

References 1 of 3

1 Communication privée, Lausanne, Switzerland, April 2012

2 Communication privée, Lausanne, Switzerland, May 19, 2012

3 « Wie der Schuster im Mittelalter oder computerbasiert? Praktische Anwendungen der Computertechnologie in der Kinder- und Jugendpsychiatrie », Symposium 4, SGKJPP Jahreskongress / SSPPEA Congrès Annuel, Détection et intervention précoces en cas de troubles psychiques chez l'enfant et l'adolescent, 30. - 31. August 2012, Universität Zürich http://www.sgkjpp.ch ; last downloaded on 20 June 2012.

4 Communication privée, Jürg Unger-Köppel, Chefarzt Kinder- und Jugendpsychiatrischer Dienst, KJPD Aargau, Aarauspital, 4 Juni 2012

5 http://www.treasurehunt.uzh.ch/ Veronika Brezinka et al., KJPD Zürich, last downloaded 012.06.20

6 Brezinka, V. and L. Hovestadt (2007). Serious games can support psychotherapy of children and adolescents. USAB 2007, Lecture Notes in Computer Science 4799. A. Holzinger. Berlin, Springer: 359-366

7 Comment combattre la Dyslexie, Journal de 20h, TF1, 7 juin 2012

References 2 of 3

8 http://www.aurora-project.com/ , last dwonloaded on 25 June 2012

9 "Cognitics - Definitions and metrics for cognitive sciences and thinking machines", Dessimoz, Jean-Daniel, Roboptics Editions, Cheseaux-Noréaz, Switzerland, ISBN 978-2-9700629-1-2, pp169, January 2011, http://cognitics.populus.ch .

10 J.-D. Dessimoz, «Sciences cognitives et machines pensantes, Définitions de base, Méthodologies de recherche, et Exemples », 2ième Journée HEP-HEIG-VD de Méthodologies de Recherche, HESSO-HEIG-VD, Yverdon-les-Bains, Switzerland, 16 mai 2012, pp. 84 (slides)

11 Bruno Siciliano, « Robots Moving Closer to Humans », Eurobot Conference 2010, Rapperswil, Switzerland, 28 May 2010.

12 Jean-Daniel Dessimoz, Pierre-François Gauthey, and Hayato Omori, "Piaget Environment for the Development and Intelligent Control of Mobile, Cooperative Agents and Industrial Robots", accepted for publication, ISR 2012, International Symposium for Robotics, Internat. Federation of Robotics, Taipei, Taiwan, Aug.27-30, 2012

13 Wisspeintner, T., T. van der Zant, L. Iocchi, S. Schiffer, “RoboCup@Home: Scientific Competition and Benchmarking for Domestic Service Robots”, Interaction Studies, 10(3):393--428, 2009. ISSN: 1572-0373

14 HEIG-VD Contributions to Robocup@Home, re. videos on http://rahe.populus.ch

References 3 of 3

15 Goodman R, Ford T, Richards H, et al. (2000) The Development and Well-Being Assessment: Description and initial validation of an integrated assessment of child and adolescent psychopathology. Journal of Child Psychology and Psychiatry, 41, 645-55

16 Website Dawba, http://www.dawba.com, last downloaded on 21 June 2012

17 Website of Eliza-typed chatbox, Artificial Intelligence Foundation, www.alicebot.org, last downloaded on 25 June 2012

18 « Toys-R-Us To Bring Autism Therapy Robot To Masses ». Shaun Heasley. http://www.disabilityscoop.com/2011/08/19/toys-r-us-robot/13774/ last downloaded on 21 June 2012

19 Festival de robotique 2012, Guillaume J. Lauzier, video, 3 min, at http://vimeo.com/guillaumelauzier/festival-robotique , last downloaded on 22 June 2012

20 « Le salon des records », Journal 20-Minutes, Genève, Suisse, ed. 20 June 2012.

21 « NAO in Piaget context », Promphan Ounchanum & Sudarat Tangnimitchok, HESSO.HEIG-VD, Western Switzerland University of Applied Sciences, iAi-LaRA, confidential report, 13 June 2012, 16pp

http://lara.populus.org/rub/3

re. Publications, including these slides

Thanks for your attention!