

Task 7.1
***Emergence of Symbol Composition Capabilities:
Robotic Modelling
in Mathematical Cognition***

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University of Plymouth
THINK&TALK node

RobotDoC

Robotics for Development of Cognition

My Background



Experience in industry
(navigation using
mobile devices)



Since 2010: PhD Student
at Plymouth University
(Supervisors: Cangelosi, S. Wermter)



My Training in RobotDoC ITN

- Participation in RobotDoC TMs:
Academic/Research Skills + Key Skills
- Summer Schools & Workshops:
 - Cognitive Science & Machine Learning Summer School MLSS 2010, Pula
 - Marie-Curie Conference 2010, Torino
 - BCS-SGAI Workshop on Bio-inspired and Bio-Plausible Cognitive Robotics 2010, Cambridge
- Scientific Conferences:
 - fet11, Budapest
 - CogSci 2011, Boston
- PhD-DoC Programme Chair



My Training in RobotDoC ITN

• Publications (2):

- M. Rucinski, A. Cangelosi, T. Belpaeme (2011), *An Embodied Developmental Robotic Model of Interactions between Numbers and Space*, In L. Carlson, C. Hoelscher, & T.F. Shipley (Eds.), Proceedings of the 33rd Annual Conference of the Cognitive Science Society (pp. 237-242). Austin, TX: Cognitive Science Society
- (in press) F. Stramandinoli, M. Rucinski, J. Znajdek, K. J. Rohlfing, A. Cangelosi (2011), *From Sensorimotor Knowledge to Abstract Symbolic Representations*, Proceedings of the European Future Technologies Conference and Exhibition fet11

• Posters (2):

- F. Stramandinoli, M. Rucinski, J. Znajdek, K. J. Rohlfing, A. Cangelosi, *From Sensorimotor Knowledge to Abstract Symbolic Representations*, The European Future Technologies Conference and Exhibition fet11, 4-6/05/2011, Budapest, Hungary, awarded with **Best Poster, Second Prize**, Budapest 06/05/2011
- M. Rucinski, *Robotic Models of Mathematical Cognition*, Marie Curie Conference, 1-2/07/2010, Torino, Italy

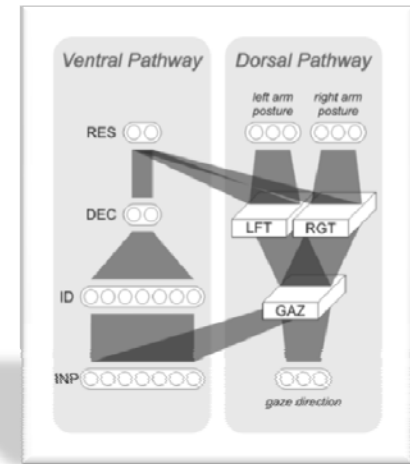
• Talks (4):

- M. Rucinski, A. Cangelosi, T. Belpaeme, *An Embodied Developmental Robotic Model of Interactions between Numbers and Space*, 33rd Annual Conference of the Cognitive Science Society, 20-23/07/2011, Boston, MA, USA
- M. Rucinski, *Robotic Modeling in Mathematical Cognition*, ESA Advanced Concepts Team "Science Coffee" Seminar, 20/05/2011, Noordwijk, NL
- M. Rucinski, *Robotic Modeling of Interactions Between Numbers and Space*, Adaptive Behaviour & Cognition Lab Talk, 03/03/2011, Plymouth, UK
- M. Rucinski, *Robotic Models of Mathematical Cognition*, RobotDoC ITN Project Proposal Workshop, 25-27/10/2010, Bielefeld, Germany

T 7.1 Robotic Models in Mathematical Cognition

Modelling results:

- Neural Network model of Spatial-Numerical Associations
- Reproduces effects found in humans
- Provides developmental explanation for SNA (body + culture)



T 7.1 Robotic Models in Mathematical Cognition

Development



Behaviour

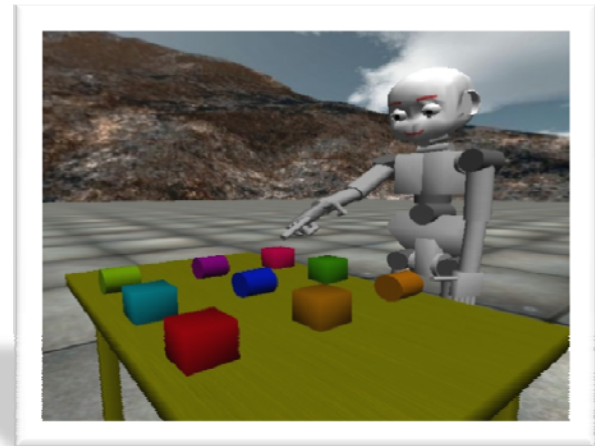
SNARC Effect Simulation
in the Humanoid Robot iCub

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T 7.1 Robotic Models in Mathematical Cognition

Future Work

- Create a model of learning to count
- Explore embodied contribution of gestures in l.t.c.



My Future

- In RobotDoC ITN:
 - I'm developing and acquiring **new skills**: mathematical cognition, experimental psychology, personal communication, scientific writing...
 - I'm immersed in **leading scientific community** and expanding my scientific network by participating in important intl conferences
 - I work **abroad** and with **international** partners
- I expect to become a valuable member of the **European scientific community**
- Short-term plans:
 - Visit to Hamburg University (Sep 2011)
 - MC Researchers Symposium (Sep 2011)
 - Invited Talk at A. Mickiewicz University, PL (Jan 2012)
 - VVV Summer School (Jul 2012)

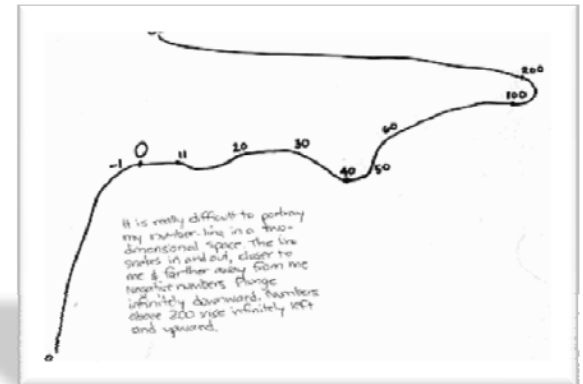


The End

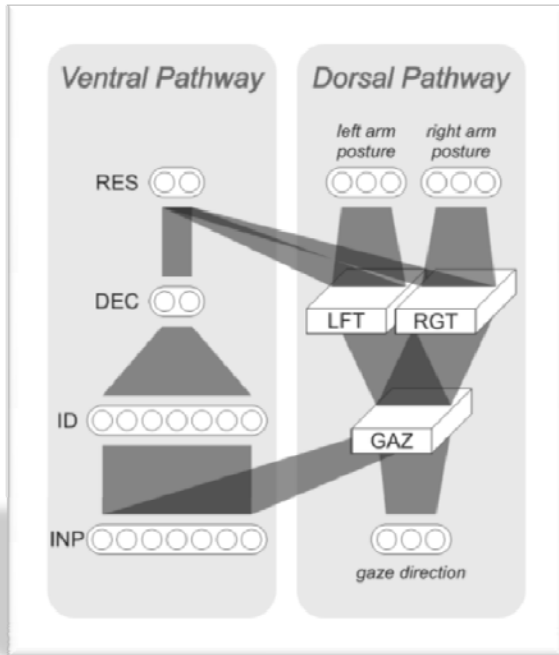
Thank you for your attention!

Mathematical Cognition, SNARC

- Cognitive processes that underlie math abilities
- Spatial-Numerical Associations
 - Synaesthesia
 - Hemispatial neglect
 - Brain imaging
 - Experimental effects: SNARC, Posner-SNARC



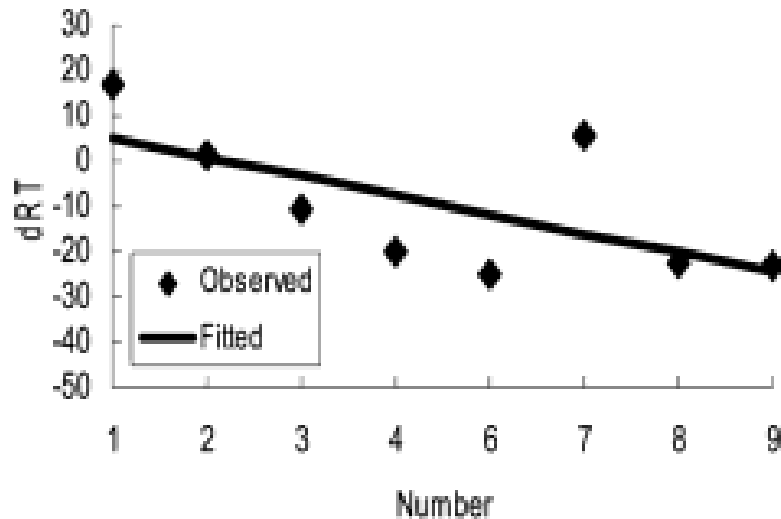
The Model



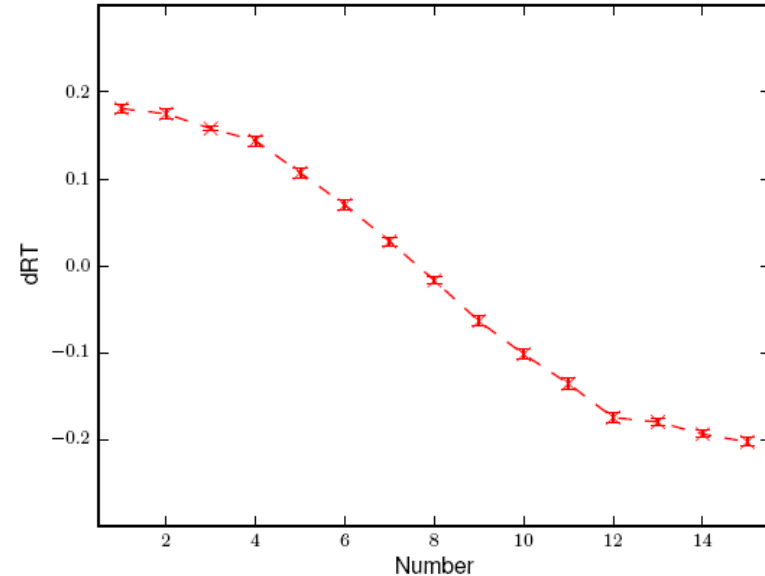
- Feed forward MLP with temporal aspect, ODE
- Two pathways
- Development:
 - Spatial representations
 - Numbers and their meaning
 - Learning to count
 - Numerical tasks
- Behavioural assessment: measuring Response Times

Behavioural Results

A: Parity Judgment



Parity



- Reproduced effects: size effect, distance effect, SNARC, Posner-SNARC

Experiment 1 Summary

- First robotic modelling in math cognition
- Less arbitrary model
- Embodied explanation of number space interactions:
 - Body morphology leads to specific patterns of connectivity
 - Culture establishes the links



Experiment 2

- Role of motor circuits in learning to count
- Pointing / touching gesture:
 - Omnipresent, spontaneous
 - Affects accuracy
 - Developmental role
 - Active vs Passive – not only keeping track
- Hypotheses:
 - Coordinative role (spatial & temporal aspect)
 - Reduction of cognitive load (WM, principles)
 - Social learning (feedback to the teacher)

