ADAPT

IST–2001-37173

Artificial Development Approach to Presence Technologies

Deliverable Item 1.5
Management report

Delivery Date: due March 1st, 2004, actual delivery May 20th, 2004
Classification: Public
Responsible Person: Dr. Giorgio Metta – DIST
Partners Contributed: ALL

Short Description:

Contributors:
DIST: Giorgio Metta, Giulio Sandini
CNRS: Jacqueline Nadel, Arlette Streri
UNIZH: Harri Valpola, Martin Krafft, Gabriel Gomez, Rolf Pfeifer

Project funded by the European Community under the "Information Society Technologies" Programme (1998-2002)

Summary

1 Coordination and collaborative activities

The coordination activity for the past 6 months went on mainly through emails on the project discussion list and a formal meeting held in Zurich on April 16-17th. At the meeting we reported of the progress of the experiments and planned both the next review meeting in June 2004 and the experimental plan for the remainder of this year and the next one.

The planning phase resulted in the definition of some new experiments:

1. Joint experiment between UNIZH and UGDIST on the developmental architecture: this will combine unsupervised and self-supervised learning techniques (see D5.1 for details) in the humanoid robotic architecture.
2. Joint experiment between CNRS and UGDIST. Experiment on the detection of affordances. CNRS will test infants at 6 and 12 months of age on the detection of object affordances and imitation. A similar (in spirit) experiment will be implemented on the robotic platform.
3. Joint experiment between UNIZH and CNRS. Multi-modal (video-sound) sequences of infant-mother interaction will be analyzed using the unsupervised techniques proposed for the robotic architecture.

It was also decided to continue the activity on:

1. Study on the cross-modal transfer. Two additional experiments are planned to show transfer in different situations: i) detection of large numbers (auditory/visual), and ii) under a categorization condition (speech/visual/tactile) (CNRS).
2. Study the detection of contingency and social interaction on children at various age including evaluation of imitation in contingent vs. non-contingent conditions (CNRS).
3. Study of the influence of morphology to grasping behaviors (UNIZH).
4. Robotic grasping (UGDIST).

2 Research activity up to month 18

Since the next review meeting is going to be in about two month time from this reporting period (month 18), the following section will be also reported on the next Periodic Progress Report (D1.6) as it is. D1.6 will be synchronized to the review meeting (June 2004). D1.6 will be possibly updated at month 24.

In particular considering **workpackage 2**, the consortium produced a document (D2.1) where the basic elements of a theory of intentionality have been defined. This effort is the minimum core from which Presence-related specifics will be derived during the prosecution of the project. Also, the validation of the theory[1] or at least a certain degree of congruence is expected between the developmental experiments (WP4) and the theory. One of the goals of WP2 is that of gaining support and evidence for the general theory of intentionality from the results of experiments on young infants on one side, and from experiments on computational modeling (the artificial developmental architecture) on the other. According to our schedule, further prosecution of WP2 is only due towards the end of the project (last 6 months or so).

[1] Perhaps a much wider validation effort should be envisaged. Clearly a single set of experiments could not possibly validate completely the theory given its broad and far looking scope.

We dedicated some more effort from WP1 to try to harmonize these different strains (development, theory, and robotics) into a more coherent multidisciplinary view. More importantly, part of this effort will go into a clearer assessment and evaluation procedure of the results of the project. Additional documentation on this matter will be produced toward the end of year 2.

The first stage of **workpackage 3** came to a conclusion after the first 12 months of the project. We have made a number of major and somewhat minor improvements to the two existing robotic setups: the Babybot in Genoa, and the active vision system and industrial robotic arm located in Zurich.

The most natural and major upgrade of our robotic platform was the realization of a five-finger robotic hand. As described in D3.1 the robot hand fits nicely to the existing humanoid setup in Genoa. We completed a full testing of the hand electronics and mechanics. Sensors include tactile elements (FSR at the moment of writing) and Hall-effect sensors to measure the position of all joints. The setup in now completed. Along the way, a major revision of the (software) control architecture of the robot has been carried out. Some elements of the motor behaviors are not yet integrated back into the system but things are proceeding at a reasonable pace. This preparatory activity merged naturally into some early experiments on manipulation of objects.

In parallel, the group in Zurich designed a new robotic head to address the limitations of their current active vision system. The plan is to duplicate to a certain extent (functionally) the setup in Genoa so that experiments could be performed independently or jointly on both sites. The head, which already features 6 degrees of freedom and stereo vision, is soon to be extended with audition and a gyroscope. Furthermore, the design of an anthropomorphic torso-shoulder-arm-hand combination has been commenced. Four people are working on the computer interface for the robot. The design of the robot as well as the interface is done with flexibility and modularity in mind, so as to allow for later replacement of physical and logical parts, as required for morphology research.

After completion of the arm design, our focus for the prosecution of WP3 will be the study of the morphology of the haptic modality. We have completed initial studies on FSR sensors but we are now looking at an improved method employing the same technology at a higher density. Furthermore, we are going to investigate strain gauges and a combination of those with FSR sensors. Finally, we are strengthening the cooperation with Zurich's AMOUSE team, which is exploring whiskers as a sensory modality. Our goal is to be able to detect both, pressure and texture. Part of this investigation shall be concerned with the material used for the fingers, which has to be suitable for gripping as well as the integration of appropriate haptic sensors. We expect additional experiments on morphology further down the road. Deliverable 3.2 (in preparation) will describe the experimental setup that will be used for conducting the experiments on morphology.

Clearly, given the overall time scale and effort devoted to this last activity we do not expect to fully integrate the new sensors into the existing robotic experimentation plan. For instance, it is not realistic to expect the integration of the strain gauge based tactile sensors into the robotic hand in Genoa. Instead, we believe that these results can potentially shed some new light on the relationship between morphology and manipulation (and possibly be used in some future implementation).

Workpackage 4 is devoted to the study of the developmental time course underlying the acquisition of the multimodal representation of objects. Research of WP4 is aimed at testing two hypotheses: the hypothesis of a primitive unity of senses at birth and the understanding of the "rules" of cross-modal transfer, and the hypothesis of a later access to a general intersensory integration through perception-action coupling, and in particular through experiencing the specific properties that objects afford to action. In-line with the project plan, we are now involved in testing further the first hypothesis. This is the starting point of development (time zero) and it is clearly required in defining the initial state of any developmental model.

As detailed also in deliverable 1.4, the first experiment of WP4 was carried out on 12 newborn infants. After visual habituation to an object (prism or cylinder), infants received in their right hand the familiar shape and the novel shape. A longer holding time for the novel shape than the familiar shape was expected. Results did not show transfer from vision to touch. The conclusion is that the characteristics of the shape of the object do not transfer bi-directionally: i.e. we observed transfer from touch to vision but not from vision to touch.

Texture is also an amodal property and in adults it is well processed by touch. Moreover, texture does not need (to our knowledge) a different mechanism of processing whether it is either visually or haptically perceived. We tested rough vs. smooth objects. A group of 16 newborns participated to the experiment on cross-modal transfer from vision to touch and 16 newborns participated to the experiment on cross-modal transfer from touch to vision. The procedure was the same as in the previous experiment. There were two phases: the habituation phase in one modality and the test phase in the other modality. In this case the general results show that texture shows bi-directional transfer: i.e. the object is recognized both visually and haptically irrespective of the habituation situation. Intermodal transfer is being tested in different situations: in newborns within the context of recognition of sequences of events, and in 20-month-olds in the context of categorization.

The detection of social contingency implies building relationships between ones' own behavior as perceived via proprioceptive information and the behavior of others perceived through vision, sound, etc. It requires establishing relationships between what we perceive the other person doing and what we might feel if we had been doing the same action/behavior (cross-modal transfer between perception and proprioception). We have been testing these relationships as described in D4.1 and D4.2.

Fifteen two-month-olds reacted to non-contingent episodes by a decrease of gazing to mother, disappearance of smile, and a dramatic increase of frowning, thus replicating Nadel's previous results. In a new experiment, exploring which parameters account for such a precocious detection of non-contingency, we found that the infants did not imitate during a non-contingent episode, whilst numerous imitations were observed during contingent episodes. We interpret this results as providing evidence that non-contingent behavior is an obstacle for addressing the infant's own perception of certain behaviors (i.e. experiencing other's agency in their mirroring of one's own behavior), which in turn is an obstacle to experience one's own agency in mirroring the other's behavior.

Newborns turn their head toward a sound. It is seen as the first example of an intersensory integration. However, an unexpected phenomenon is the temporary disappearance of visual orientation toward auditory sources around 1 to 2 months of age and its reappearance around 3 to 4 months. This phenomenon remains largely unexplained. A way to study further the early aspects of intersensory integration is to present to the infants social stimuli that violate the normal intermodal matching between visual and auditory channels. An experiment is in progress following this idea.

Workpackage 5 is devoted to the realization of the architecture for the robotic implementation of the developmental model. The architecture is described in D3.1 and D5.1. D5.2 describes the details of the implementation and initial experiments of learning of multi-modal features. In particular we are considering the role of motoric information in the selection of visual features through unsupervised learning mechanisms.
The results are still pretty much "work in progress" although early testing and partial results have been collected into D5.1, D5.2, and D5.3 (forthcoming). We expect, now that also the experimental setups are fully available, to quickly further the implementation.

To improve the design of common experiments we have implemented an interface between Matlab and our robotic architecture that will allow quickly developing learning algorithms and importing existing code to the robotic platform. We started working on the neural network algorithm for learning coherent multi-modal representations. There has been some progress and the theory and initial implementation of the model are now in place (D5.3 will contain the latest results). We still haven't done experiments with the actual robot data (which should be reported later on D5.4).

On the pure robotic side, we have implemented a number of behaviors that now allow precise reaching (required for manipulating objects) and started an experiment on manipulation (although a simple one). We are now evaluating a simple set of data according to the neural network model proposed in D5.1/D5.2. We expect the first real experiment on the acquisition (unsupervised) of multi-modal object features to be ready by the end of August 2004.

2.1 Assessment and analysis of results

This reporting period has seen a large effort to complete some of the delayed deliverables. In particular, of all deliverables due to date only three of them are still uncompleted. Two of them (D3.2 and D5.3) are in preparation and will be available in about one month time. D5.4 will be probably delayed further since it should include results from experiments which are not completed at the moment of writing. The research activity is in line with the Technical Annex.

2.2 Deliverables

The following table lists all the deliverables due at month 18. We included also the list of deliverables that are delayed. The status, at the moment of writing, is reported below:

Number	Title	Type	Due month	Expected
D1.3	Management report	Document	6	6 (rev1) 12 (rev2)
D1.4	Periodic progress report Y1	Document	12	12
D1.5	Management report	Document	18	20
D2.1	A tentative theory of intentionality and the sense of being there	Document	7	12
D3.1	Definition and implementation of a human-like robotic setup	Document	12	12
D3.2	Hardware and software in place to run experiments on changing morphologies (e.g. changing resolution and motor precision)	Prototype	15	20
D4.1	Definition of experimental paradigm	Document	12	13
D4.2	Definition and implementation of setup for the investigation on child development	Prototype	12	13
D5.1	System's architecture specifications and design	Document	6	14
D5.2	Basic unit design and implementation	Prototype	9	14
D5.3	Initial implementation of the integration model	Prototype	12	14
D5.4	Initial experiments with multiple sensory modalities integrations	Document	18	22-23

Submitted [yellow]. This document [cyan]. To be delivered [white].

3 Effort and cost

Participant Code	One person-month corresponds to N hours
C1 – DIST	141
P2 – UNIZH	179
P3 – CNRS	135
P4 –UPMC	

Work-Package ID	Title		Reporting period
WP1	Project management		1.10.2003 – 30.05.2004
Participant Code	Spent (person-months)	Planned (person-months) Total	Start date / End date Month 1 / Month 36
C1 – DIST	1.0	3	
P2 – UNIZH[1]	0.2	1 (1)	
P3/P4 – CNRS/ UPMC	0.3	1.2	

Work-Package ID	Title		Reporting period
WP 2	Theory of intentionality and the sense of being-there		1.10.2003 – 30.05.2004
Participants Code	Spent (person-months)	Planned (person-months) Total	Start date / End date Month 1 / Month 36
C1 – DIST	4.3	12	
P2 – UNIZH[1]	0.0	10 (5)	
P3/P4 – CNRS/ UPMC	2.0	4	

Work-Package ID	Title		Reporting period
WP 3	Embodiment and body morphology		1.10.2003 – 30.05.2004
Participants Code	Spent (person-months)	Planned (person-months) Total	Start date / End date Month 1 / Month 30
C1 – DIST	3.2	12	
P2 – UNIZH[1]	6.0	24 (10)	
P3/P4 – CNRS/ UPMC	4.3	12	

Work-Package ID	Title		Reporting period
WP 4	Development of Coherent Representations		1.10.2003 – 30.05.2004
Participants Code	Spent (person-months)	Planned (person-months) Total	Start date / End date Month 1 / Month 31
C1 – DIST	4.5	14	
P2 – UNIZH[1]	8.0	25 (10)	
P3/P4 – CNRS/ UPMC	12.9	26	

Work-Package ID	Title		Reporting period
WP5	System's architecture		1.10.2003 – 30.05.2004
Participants Code	Spent (person-months)	Planned (person-months) Total	Start date / End date Month 1 / Month 33
C1 – DIST	2.2	12	
P2 – UNIZH[1]	4.0	12 (3)	
P3/P4 – CNRS/ UPMC	2.0	4	

The number between brackets report the persons/month spent by permanent staff at UNIZH and not charged to the project.

Title				Reporting period		
Cumulative effort				1.10.2003 – 30.05.2004		
Participants Code	SPENT HOURS	Spent (person-months)	Planned hours 2nd year	Planned person-months 2nd year	Planned hours (TOTAL)	Planned person-months (TOTAL)
C1 – DIST	2143.2	15.2	2496	17.7	7488	53
P2 – UNIZH	3258	18.2	4296	24	12888	72 (29)
P3/P4 – CNRS/UPMC	2902	21.5			6372	47.2

4 Publications

M. Lungarella, G. Metta, R. Pfeifer, G. Sandini. *Developmental Robotics: A Survey.* Connection Science. 15(**4**), pp. 151-190. 2003.

L. Natale, G. Metta and G. Sandini. *Learning haptic representation of objects.* International Conference on Intelligent Manipulation and Grasping. Genoa - Italy July 1-2, 2004.

H. Valpola and J. Särelä. *Accurate, fast and stable denoising source separation algorithms.* In Proceedings of the 5th International Conference on Independent Component Analysis and Blind Signal Separation, ICA 2004, Granada, Spain. (2004) In press.

J. Särelä, H. Valpola. *Denoising source separation.* (2004).
On: http://cogprints.ecs.soton.ac.uk/archive/00003493/

H. Valpola. *Behaviourally meaningful representations from normalisation and context-guided denoising* (2004) Technical Report, Artificial Intelligence Laboratory, University of Zurich.
On: http://cogprints.ecs.soton.ac.uk/archive/00003633/

G. Gómez, and P. Eggenberger Hotz. *Investigations on the robustness of an evolved learning mechanism for a robot arm.* In Groen, F., Amato, N., Bonarini, A., Yoshida, E., and Kröse, B., editors (IAS 8): Proceedings of the 8th International Conference on Intelligent Autonomous Systems, Amsterdam, The Netherlands, pp. 818-827. (2004).

G. Tarapore, M. Lungarella, and G. Gómez. *Fingerprinting Agent-Environment Interaction Via Information Theory*. In Groen, F., Amato, N., Bonarini, A., Yoshida, E., and Kröse, B., editors (IAS 8): Proceedings of the 8th International Conference on Intelligent Autonomous Systems, Amsterdam, The Netherlands, pp. 512-520. (2004).

G. Gómez, and P. Eggenberger Hotz. *An Evolved Learning Mechanism for Teaching a Robot to Foveate.* In Sugisaka Masanori and Tanaka Hiroshi, editors (AROB 9): Proceedings of the 9th Int. Symp. on Artificial Life and Robotics, Beppu, Oita, Japan. pp. 655-658. (2004).

A. Streri. *Discrimination of large numbers.* Presented at the 14th biannual International Conference on infant Studies (ISIS), Chicago, Illinois. May 5-8th, 2004.

5 Activity within Omnipres

Adapt reported periodically about its activities to Omnipres as planned (three-monthly). We also contributed with two chapter's extended abstracts to the planning of the Handbook of Presence. Since the two abstracts are interesting in themselves they are included in this document (see below).

5.1 Contribution to the handbook of presence

Sensori-motor learning and object representations [robotics]

Auhtors: R. Pfeifer, H. Valpola, G. Metta, G. Sandini

Based on some of the theoretical premises [cross-reference to "A developmental theory of intentionality and the sense of being there", J. Nadel, R. Manzotti, G. Sandini] we designed and implemented a neural network based developmental architecture. The goal is to generate a general-purpose system that, with some limitations, develops following an epigenetic pathway similar to the one observed in human infants. In particular we will analyze how the robotic system can learn to manipulate different types of objects and what sort of multimodal representation would emerge when the robot is free to interact with the environment.

The robotic system is shaped as a humanoid. It consists of a head, arm, hand, and it is equipped with vision, audition, proprioception, and touch. The experiments presented here are aimed at validating some of the questions emerged during the investigation on small infants. Our goal was to uncover some of the mechanisms of development by employing a "synthetic methodology". This chapter would integrate evidences from different disciplines starting from philosophy of mind through developmental psychology and terminating in a robotic implementation.

Examples of the experiments we have in mind are "learning about object properties", affordances, and uncovering how a multi-modal representation--autonomously developed by the robot--could be used in solving simple cognitive task (e.g. how to grasp a hammer to properly toll a bell).

1. Goals and methods

Presence--the feeling of being there--arises from the integration of multimodal sensory information. We feel present if this information is in accordance with our learned expectations of sensory information.

Experiments in developmental psychology have shown that a prerequisite for developing a normal perception of space and self is active interaction with the environment. Our senses are active rather than passive. Consequently, coherent sensori-motor interaction is an important factor in forming an experience of presence.

Our goals are:
* general-purpose (robotic) system which learns by experience in interaction with world
* uncover some of the mechanisms of development
* study the emergence of perception and the sense of presence

We plan to do this by:
* analysis of the emergent multimodal representations and skills
* comparison with infant experiments

2. Robot design

Body morphology and sensory systems affect how the robot perceives its environment and itself and how the robot interacts with its environment. Our robot is shaped as a humanoid torso with head, arms and hands and is equipped with vision, hearing, proprioception and touch. Anthropomorphic design will make it easier to relate the robotic experiments with studies with human infants. The robot has a modular distributed control architecture which relies on interplay between innate capabilities and inclinations and learning through interaction with the environment.

2.1 Morphology

* Head, neck, shoulders, arms and hands
* Proper choice of morphology and materials facilitates control (e.g. compliant fingers with rubbery surface make picking easier)

2.2 Sensors

* Two cameras with two degrees of freedom each
* Two microphones
* Touch sensors embedded in the fingers and palm

2.3 Control architecture

* Reflexes
* Classical conditioning (predictive control)
* Operant conditioning (reinforcement learning)
* Learning unified sensorimotor representations; hierarchy of increasingly abstract representations

3. Experiments

* using multimodal representations to solve simple cognitive tasks
* learning about object affordances e.g. how to grasp a hammer to properly toll a bell

---

A developmental theory of intentionality and the sense of being there

J. Nadel, R. Manzotti, G. Sandini

General outline

Drawing on developmental psychology evidence and on philosophy of mind theories this chapter/section presents a novel theory of intentionality founded on development, embodiment, and explicitly takes into account the interaction of the agent with the environment.

The feeling of being there is only conceivable in a conscious being. A conscious being is a system that experiences (feels) something. This capability of feeling something depends on what is called the aboutness of phenomenal states, a property which is related to the intentionality of mental states. In order to understand the feeling of being there [or Presence] we need to understand the nature of aboutness and intentionality in a conscious being. This task can be profitably approached if we leave behind the dualist framework of traditional Cartesian substance metaphysics and adopt a process-metaphysical stance. We begin by sketching the outline of a process-ontological scheme whose basic entities are called 'onphenes'.

From within this scheme a set of constraints defining the architecture capable of intentionality and aboutness is formulated. An architecture abiding by these constraints is capable of epigenesis driven by onphenes. Since an onphene is a process in which the occurrence of an event creates the conditions for the occurrence of another event of the same kind, an onphene-based architecture allows for external events to provoke the repetition of other events of the same kind. In an artificial system, this propensity to repeat events can be considered as a functional reconstruction of motivation.

The theory is used to devise a sound experimental plan aimed on the one hand at supporting and validating the theory itself, and, on the other, at casting a set of experiments conducted on young infants in a broader framework.

Structure of the chapter

The chapter should be divided in the following sub-sections:

1. Presence and phenomenal experience
A brief historical introduction on the relation between the concept of Presence and a series of strictly related concepts like phenomenal experience, consciousness, awareness, intentionality, aboutness, and the feeling of being there. The literature on the topic is briefly reviewed. Does it

make sense to deal with Presence without a corresponding phenomenal experience of what takes place? What are the differences and the similarities between the concept of Presence and the concept of Consciousness? Is it possible to naturalize consciousness and Presence in such a way to deal empirically with them? What are the empirical constraints of a scientific theory of Presence?

2. Phenomenal experience as a process: Presence as a unity between the external world and the brain

At the core of Presence there is phenomenal experience. However phenomenal experience has to be grounded in some kind of physical process whose causal, functional, and teleological role could be significant in the development of an agent. An hypothesis is presented and, as a paradigmatic case, the rainbow is described. A series of physical processes that play a role during the development of cognitive capabilities are discussed. Presence is analyzed in term of the interactions between a developing agent and its environment. Various kind of causal relations are considered. The counterfactual nature of the process of cognitive development is criticized. A model of the relevant kind of process is eventually proposed and the name of onphene is proposed.

3. The variable causal geometry of phenomenal experiences

Different cases of conscious experience are considered: direct perception, virtual reality, object constancy, color constancy, memory, dreams, and mental imagery in general. The proposed model of the onphene is tested against each of them. The proposed process is capable of being structured according to different causal geometry that could explain the different kind of conscious experience. In particular, given the ecological and epigenetic causal nature of the proposed process, an outline of an architecture capable of hosting is envisaged. In particular the onphene has a geometry that resembles closely the development of new goals and motivations.

5. Motivations, intentionality and development

What is the role of motivations in shaping the kind of processes related to phenomenal experience? And what is the relation between intentionality and motivation? What is the difference between aboutness and intentionality? Onphene are here proposed as the foundation for an agent capable of developing new motivations and new goals. A model for developing new goals on the basis of the interaction with the environment is presented. A taxonomy of agents – based on their capability of learning not only how to achieve something but also what has to be achieved – is presented. The relation between the capability of developing new goals and the capability of having phenomenal experience is investigated. The theory is used to devise a sound experimental plan aimed on the one hand at supporting and validating the theory itself, and, on the other, at casting a set of experiments conducted on young infants in a broader framework.

6 Notes of the meeting held in Zurich – April 16-17th, 2004

Attended by:
UGDIST: Giorgio Metta, Giulio Sandini, Francesco Orabona
UNIZH: Rolf Pfeifer, Martin Krafft, Harri Valpola, Grabriel Gomez
CNRS: Jacqueline Nadel, Ken Prepin

Jacqueline's presentation

- intermodal transfer

    - experiment on texture:
    - newborns
        - transfer of knowledge from vision to touch
        - "touch to vision" experiment is in progress

        = in Munich, present the whole experiment?

    -> comment on "noise" (less at birth, different meaning from what we consider noise)

    - an experiment on intermodal transfer of shape is in progress with 2 month olds
        = intermodal transfer appears to be unstable

    - tentative explanation:
        = the amount of "amodality" is what allows tranfer (shape is more difficult than texture)
        = remember discussion on 2D vs. 3D information, easier to transfer 2D?

    - contingent vs. non-contingent (2-6 mo. old)
        = disrupted communication (delay - 30seconds)
        = can the child understand the mismatch between his behavior and that of the mother?
        - sinchrony interaction, early ability of detect sinchronicity
        - partially contingent - vision and audition delayed (not coupled) -> 6 mo. old
            -> my consideration: important for learning!
        - measure imitation events (what we see to what we do, matter of multimodal integr.)
            -> link to the sense of "agency"

        - harry's suggestion. having 4 different conditions:
            contingency and coherence are the parameters

Harri’s presentation

- context guided learning of representation
    - coherent representation, efficient ways of learning features under contextual guidance
    - theoretical work on attention (feature extraction, task-guided attention)

- predictive motor control taught by innate reactive responses ("reflexes")
    -> control emerges from low-level principles -> prediction

- RL, how to incorporate RL into the system

- contextual learning:
    - it is not obvious how stereo should be built -> if you act, the world is intrinsically 3D
    - Learn complex cell in V1 by temporal context (?)
    - Learn translation invariance istantaneously -> learn complex cells

- more on the self-supervised learning

Martin’s presentation

- self-organizing neural network -> task selection implicitly
- select the task and then select the network solving that task

- Ideas: neuromodulators and receptors & neurotransmitters
    - neuromodulators are meta-controllers
    - neurotransmitter for communication between nueurons

- multi-task kind of neural net

Plan for next year:

--->
Jacqueline experiment (2-6 mo old)

- anticipation according to shape of the object
- 2 conditions:
    - affordant, no imitation
    - non-affordant, imitation, biasing the grasping

- also 9 and 12 mo old are likely to be required

--->
Harri & Genoa exp

- robotic experiment:
    - context guided development of visual features
    - self-supervised learning

    - learn features from the grasp -> build prediction -> control grasping (?)
        - features at low level will be edges (almost sure)
        - features are extracted from the analysis (statistical) of the data

    - potential exploration based on the inital reflex (give the object to the robot)
    - learn to predict

- ?action inclusion?

--->

- 2nd exp. put the object on the table and
  the robot predicts the type of grasp that applies to the object

- future: grasp with object use in mind