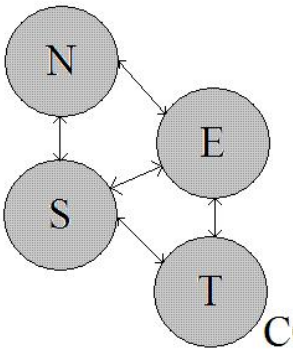

What it means to Communicate

NESTCOM

What it Means to Communicate

Project reference
Contract No: 043374 (NEST)

Discussion of common neural, developmental principles of multimodal integration (WP2)

NESTCOM Report 6

Deliverable 2

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Project Co-ordinator: Professor Stefan Wermter

Project Co-ordinator Organisation: University of Sunderland

Partners: University of Sunderland, Medical Research Council, Universita degli Studi di Parma

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Table of Contents

1. Introduction

This document describes the collaborative work, investigations and organised workshop between the partners contributing to the second deliverable as part of the NESTCOM project. The main focus is given to the organisation and meeting of researchers to discuss generic principles of multimodal integration including project presentation information. The document follows the following format: a description of deliverable two, the project meetings and laboratory visits followed by information of the organisation and the results of the international workshop including presentation overviews.

1.1. Deliverable

The objective of deliverable two is to integrate results obtained by analysing results from the NEST projects and to bring researchers together to discuss generic principles of multimodal integration by organising lab visits, meetings and through workshops.

Currently, between and beyond the specific STREP NEST projects there is limited analysis of information on multimodal integration of verbal and visual communication based on neural developing models of social action understanding. Where there has been an exchange of information it has been typically limited to groups who are from similar domains and backgrounds, rather than interdisciplinary teams.

We aim to address this overarching topic of multimodal integration of verbal and visual communication based on neural developing models of social action understanding, which needs the input of several NEST projects to develop definitions and a roadmap for new NEST projects. NESTCOM brings together a number of researchers from different countries dedicated to a single scientific goal of describing the neural, cognitive, developmental aspects of multimodal integration.

Furthermore, we have organised meetings and prepared a European workshop. This European multimodal integration workshop has been different from standard workshops. Rather than having a focus on talks only, we had talks and dedicated discussion sessions. The results of the discussion were documented and presented to the overall workshop through the NESTCOM website. Notes and screen shots were taken in a structured manner so that these results directly feed into the later roadmap development of WP3.

2. Project Meetings

Currently two meetings have taken place for the NESTCOM project, an initial partners meeting and a second held subsequent to the European workshop at the ICANN 2007 conference in Portugal. This has enabled partners from different sites to make contacts at a personal level and the opportunity to experience difference aspects of research undertaken at different centres.

2.1. First Nestcom Kick-off Meeting

The first kick-off meeting took place at the University of Sunderland on the 9th February 2007, which gave an overview of the NESTCOM project, started initial discussions and gave the opportunity for all partners to meet face to face. Presentations started with Sunderland providing a background of the project and an overview of NEST projects that come under the "What it means to be human" initiative, which are relevant to communication. Details and explanations of the roles and responsibilities each partner are to provide for the project were also included in the presentation, as well as the project schedule and management, and the work packages involved. The presentation concluded with how using previous research knowledge from the NEST initiative we would develop potential directions for future research resulting in a research roadmap towards research proposals to support future NEST initiatives and new proposals. Cambridge and Parma followed with presentations based on their past related research. Vittorio Gallese gave the presentation for Parma University discussing goal-related neurons in area F5, the premotor system and the mapping of sequential events and syntax. Friedemann Pulvermuller provided the presentation from MRC, Cambridge discussing action-perception networks in speech processing as inferior frontal and premotor/motor cortex activate when speech is heard. The presentations provided by the partners can be found on the NESTCOM website [NESTCOM, Internal].

2.1.1. Agenda

- Project Overview (Sund)
- NESTCOM Goals (Cam)
- NESTCOM Goals (Parma)
- Scientific Discussions
- Organisation and Management of workshop

The full agenda as well as a list of attendees to the first meeting can be found in the appendix and on the internal pages at the NESTCOM website [NESTCOM, Internal].

2.1.2. Initial Discussions

After the presentations, the meeting continued with scientific discussions. This included the discussion of work packages, the NEST projects that would be incorporated into the study, content of the reports and structure, road map structure and future proposals. Future proposals and new potential research directions focused on using Language, Action and Perception and on the level of detail appropriate for scenarios involving language/action, language/perception, multimodal communication and neural representations. Further possible research directions explored the pairing of sound with actions, with the idea of pre-motor/motor cortex activation when a sound is heard, language relating to an appropriate movement or set of movements and visually related words. Additional discussions focused on how an action would be produced relating to specific goals and movement and associative to reward learning using a visual action.

Also discussed were deliverable dates, management meetings, dissemination approaches through the utilisation of the NESTCOM website, workshops and the possibility of producing a journal issue based on NEST projects and papers presented at organised workshops. The structure and content of the NESTCOM website was discussed, information to disseminate to the public and an appropriate internal area for the Nestcom partners to access specific project information and a general area for upcoming meetings and workshops. Initial discussions and organisation of the first European workshop to be held were started and it was determined that we should aim for a workshop at the ICANN'07 International Conference on Artificial Neural Networks on the 9-13 September 2007. It was also decided to aim for a NESTCOM meeting at the venue. Further information on the proposed workshop can be found in section 3 and the NESTCOM website [NESTCOM, Workshop].

A breakdown of the meeting discussions can be found on the internal pages of the NESTCOM website, [NESTCOM, Internal].

2.1.3. Laboratory visit

As part of the Initial Partners meeting, visiting partners could visit the University of Sunderland research laboratories where partners were able to experience demonstrations of the robots from different projects including a demonstration of work carried out on a PeopleBot robot. Also exhibited was a basic robot head (MIRA) newly developed for the Nestcom context that can be used to research the principles of neural network learning, human-robot interaction, language parsing and understanding, vision and vision recognition, auditory localisation, multimodal integration and basic emotions. For more information on both of these projects visit the Hybrid Intelligent Systems website [HIS, Home].

2.2. Second Nestcom Meeting

Partners attending the International Conference on Artificial Neural Networks were also invited to attend a NESTCOM project meeting. The general aim of the meeting was to provide an overview, discuss observations/issues and results of the workshop. Also this was an opportunity to discuss project work package progress and organisation measures needed to complete subsequent work packages. Further directions to be taken to produce a road map including what were the most relevant theories and methods were also considered. The possibility of publishing a journal issue including papers from the workshop contributors and initial planning and organisation of the next workshop were also considered

2.2.1. Agenda

- Introduction
    - Overview of Nestcom
    - Project Schedule

- Work Package List
- Deliverables
- Work Package Description Two
- Work Package Description Three

- Discussions
  - Revisit questions posed to contributors
  - Road map and Future Proposals
  - Publication

A list of attendees to the ICANN Workshop meeting can be found in the appendix and on the internal pages at the NESTCOM website [NESTCOM, Internal].

2.2.2. Workshop and Progress Discussions

Subsequent to the workshop, discussions took place on the workshop success and project progress. It was the opinion of the project partners present, panel contributors and attendees from the ICANN conference that the workshop had generally positive feedback with open and constructive discussions.

It was also thought that for a second proposed workshop it could be improved and more beneficial to try producing a longer workshop providing it met organiser's regulations. It was decided to submit a workshop proposal for the 2008 Annual Cognitive Neuroscience Society Meeting, San Francisco, USA, held on the 12th-15th April. Friedemann Pulvermuller will contact possible speakers to provide a contribution to the workshop, which includes four key note speakers and one chair.

Present progress was subsequently discussed detailing which reports had currently been produced, which were underway and those to be started. Work package two deliverables were being finalised with milestone one completed through the organisation of the international workshop and project presentations from the workshop displayed on the NESTCOM website. Work package three was to be started with University of Parma leading, work packages four to six are close to starting.

Roadmap directions were also discussed with the possibility of grounding imitation work using robot to imitate humans and other robots with the transfer of actions, understanding the other in different contexts, i.e. using hand gestures. Some other possibilities that arose were language-processing, adapting through social interactions using gestures and facial expressions.

It was the preference of Friedemann Pulvermuller to use a journal for the dissemination of communication research as there is greater potential to reach a wider audience; appropriate possibilities suggested include: Connection Science, Neural Network.

The next meeting shall take place early in the new year, with a preliminary location of the meeting to be held at Cambridge. A breakdown of the meeting discussions can be found on the internal pages of the NESTCOM website [NESTCOM, Internal].

3. Open international Acquisition Workshop

The NESTCOM project relies on close collaboration between the participants and extensive exchange of knowledge and results. Therefore, we had decided to build in dedicated milestones as workshops at month 10 and month 20. The results from the work packages will be presented to the other work packages (partners). At these points, the collected results will also be evaluated so that feedback can be provided to the researchers.

3.1. Workshop Description

This workshop focused on the neural, computational and cognitive principles of communication. A wealth of new knowledge has been produced by recent research for instance as part of the EU NEST initiative "What it means to be human". The goal of this workshop was to explore relevant research to focus on the question "what it means to communicate". The general aim was to understand the neural, cognitive, social, computational and developmental features that have led to communication differences between humans and animals.

A number of interesting and successful research directions have been supported including learning by imitation, examining the origin of human rule based reasoning, studying the neural origins of language, exploring the evolutionary origins of the human mind, researching into verbal and nonverbal communication, using and interpreting signs, characterising human language by structural complexity, and representing abstract concepts. To complement this, the NESTCOM project aims to understand the results of these projects and integrate them with a neural multimodal understanding of verbal and visual communication for embodied action understanding. This workshop explored the characteristics of human communication and their relationship to the role of networks of mirror neurons. Mirror neurons appear to be central to action understanding, imitation and communication development and as such may go some way to explaining and unifying the results of earlier research. The workshop included invited introductory talks, short presentations by panel members and a discussion session with the workshop participants.

Contributors were asked to consider addressing the following three questions as part of their short panel statement. We encouraged short, precise statements plus a longer discussion at the end of the workshop took place. The suggested questions were:

1. What does it mean to communicate at a neural, psychological or social level?

2. What are the theories that could be used to advance computational models of multimodal communication?

3. What new representations and processes are needed to support more sophisticated models of multimodal communication in the future?

Some further suggested questions posed for the possibility of addressing during the discussions are below:

- What does it mean to communicate?
- What are they key topics in multimodal integration?
- What are the next steps needed to achieve bioinspired communicating robotics?
- What are current developmental approaches to communication?
- What is the role of imitation in communication?
- What role do signs and gestures in communication?
- What is the role of mirror neuron system and its mechanisms?
- What are the key mechanisms for learning of action understanding?

3.2. Venue Information

The workshop was held at the ICANN 2007 conference in Porto, Portugal. The first and last day were devoted to tutorials and workshops respectively, with the main Conference taking place from 10 to 12 September. The NESTCOM workshop took take place on the 13th September.

3.3. Workshop Contributions

Several contributor participants are from NEST projects who discussed their work and further advances made during and after the projects. The following participants provided a presentation to the workshop; those involved with a NEST project have the project title included:

- Frederic Alexandre - Coordination, attention, communication
- Giovanni Buccino - Modulation of the motor system during language processing
- Didem Gökçay - Investigating behavioural problems in text-based communication by deriving an analogy between brain damage and media richness
- Ludwig Huber - The Evolution, Development and Intentional Control of Imitation - **EDICI**
- Günther Palm - A computational learning perspective - **MIRRORBOT**
- Albert Postma - The neurocognition of spatial categorization and spatial language processing - **Wayfinding**
- Friedemann Pulvermüller - Embodiment of words, rules, and meaning in minds, brains, and automata - **MIRRORBOT**

In the next section there will be a brief overview of each of the workshop contributors presentations, their full presentations can be found on the NESTCOM internal website as well as some accompanying videos. A list of attendees to the workshop can be found in the appendix.

3.4. Workshop Presentations

Name: **Giovanni Buccino**
Contribution Title: **Modulation of the motor system during language processing**

Buccino's presentation was on the "embodied language" approach, in which language processing is mediated by the same neural substrates involved in perception and motion.
Recent studies were performed involving participants listening to sentences expressing actions executed with the hand, the mouth or the foot. The studies showed that different sectors of the premotor cortex, largely overlapping those involved during the execution and observation of those same actions became active.

It was stated that more recently it has been shown that the modulation of the motor system also occurs during processing language material related to abstract content. In this study participants were required to read sentences expressing a "transfer" of either a concrete or an abstract object (Antonio gives you some pizza; Antonio gives you a piece of news). As control, they read sentences where this "transfer" was lacking (Antonio watches TV with you). MEPs recorded from hand muscles increased during reading sentences expressing a concrete or an abstract transfer as compared to sentences where this transfer was lacking.

Figure 1. Effector's z-score to sentences

Name: **Günther Palm**
Contribution Title**: A computational learning perspective**

Günther states that in order to communicate, one has to master language, whether it is spoken, written or sign language with three main points to consider.

- To be flexible one should be able to learn language including aspects such as extending the vocabulary by learning (learning the meaning of new words) and learning syntax (learning new syntactical structures).

- To be robust one should be able to resolve ambiguities in spoken sentences. Besides language abilities this may require understanding the pragmatic context.

    - Ambiguities have to be resolved at different levels, sometimes in the same sentence:
    - Words can be ambiguous on the **phonological**, the **semantic,** and the **syntactic** level.

- To be human one should be able not only to understand a spoken utterance, but also the pragmatic context and the underlying emotions. Putting a sentence into its pragmatic and emotional context requires.
    - the ability to recognize emotions and
    - a dynamical representation or model of the complete situation including the speaker's intentions and motivations.

These problems present major important challenges to robotics, if robots should be able to communicate with humans in a flexible and human way on a cognitive level without having to be reprogrammed explicitly all the time.

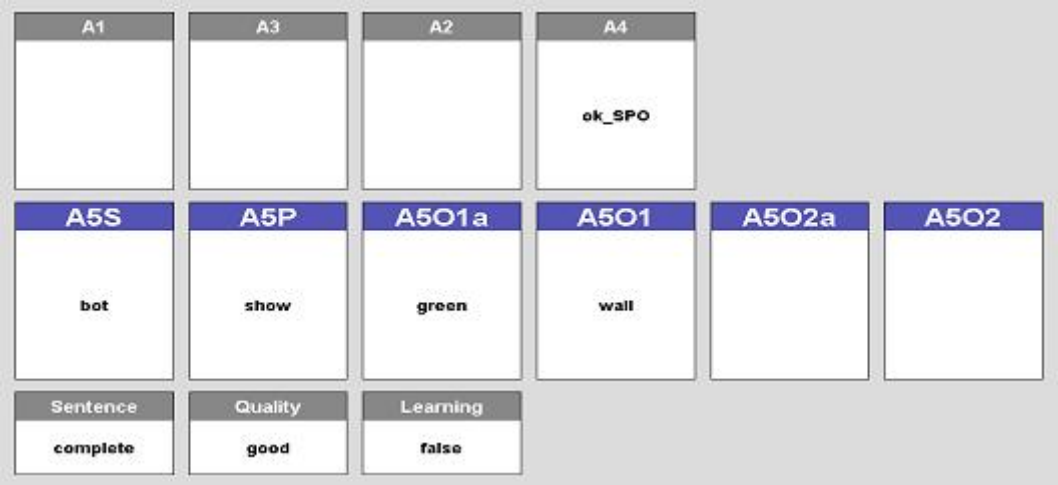

Figure 2. The language system

- Each area (box) is a cortical module (with auto-associative memory)
- Hetero-associative connections
- "Spike Counter Populations" using sparse representations
- Each module has 400 to 2500 neurons, summing up to 18 000 in total

The language model has been implemented into a cortex model used to produce behaviours for a robot; the cortex model includes areas such as vision, action and

motored areas. When a statement said to the system has been understood this can be associated to appropriate motor output commands for the robot.

Name: **Albert Postma**
Contribution Title: **The neurocognition of spatial categorization and spatial language processing**

Postma's contribution was research undertaken as part of the Wayfinding project under the NEST PATHFINDER initiative. The presentation was on spatial cognition (spatial categorisation and spatial language processing): - perceiving, remembering and communicating what is where and how to get there, a multimodal ability using all senses to offer information on the spatial environment.

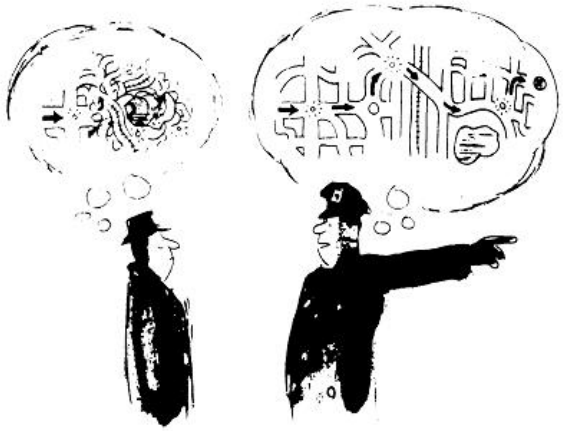

Figure 3. Visualisation through communication

Spatial categorisation is used to establish relations vital for analysing complex visual scenes through coordinate spatial processing (metric decisions, visual search) and categorical spatial processing (global position sense, spatial communication). Postma finishes with the hypothesis whether spatial preposition is hardwired in the brain, which could be solved by research using blind individuals.

Name: **Friedemann Pulvermuller**
Contribution Title: **Embodiment of words, rules, and meaning in minds, brains, and automata**

Pulvermuller's presentation was on research understanding language and thought at the level of brain circuits. He described the theory of brain mechanisms of language; neuronal connections strengthen as a consequence of correlated brain activity and this binds neurons with a role in perception and action into multimodal *discrete distributed neuronal assemblies, DDNA's,* which carry linguistic function. He argues that this could be how the brain models language:

- Lexicon – DDNA's for words, stems?
- Semantics - DDNA's that reflect meaning?

- Syntax – Discrete combinational grammar networks that connect sets of lexical DDNA's.

With the repeated articulation of a word, strongly connected neuron ensemble distributed over persisylvian areas.

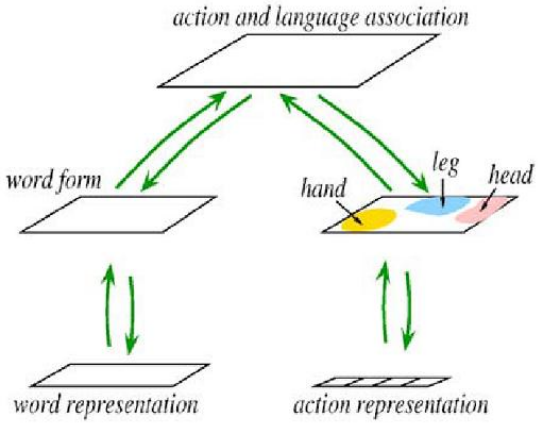

Figure 4. Neural network (robot internal) processing words and their actions.

Conclusions

- Discrete combinatorial neuronal assemblies (DCNAs) are a possible neuronal basis for syntactic-semantic rules
- DCNA emerge as a result of associative learning of substitution patterns in a hetero- and auto-associative network
- "Grammar Organ" properties of neuronal connectivity are required

Name: **Ludwig Huber**
Contribution Title: **The evolution, development and intentional control of imitation**

Huber's presented research investigating imitation, a fundamental aspect of human behaviour, part of the NEST PATHFINDER initiative on "What it means to be human".

The human capacity for imitation provides the foundation for language acquisition, skill learning, socialisation, and enculturation. The dominant North American model claims the imitation is innate; the EDICI project replaces this conception with a model incorporating evolutionary, developmental and cultural inputs to imitation. The EDICI project investigates the widely held, but largely untested, hypothesis that in human adults a crucial role is played by mentalising and perspective taking - mechanisms in the prefrontal cortex that differentiate self from other. It also asks whether humans are unique in their capacity to bring imitative potential under intentional control, and examine how and when in human infancy this capacity emerges.

Huber hypothesized that adults' *communicative-referential cuing* (CRC) is interpreted by human infants as indicating the presence of an infant-directed communicative 'teaching' disposition in which relevant and new cultural information will be

exhibited. Use of CRCs to activate imitative potential, and thereby to enhance both learning and performance of relevant aspects of modelled action, may be uniquely human. It is also thought that domesticated dogs may have sensitivity to CRCs through close contacts with humans.

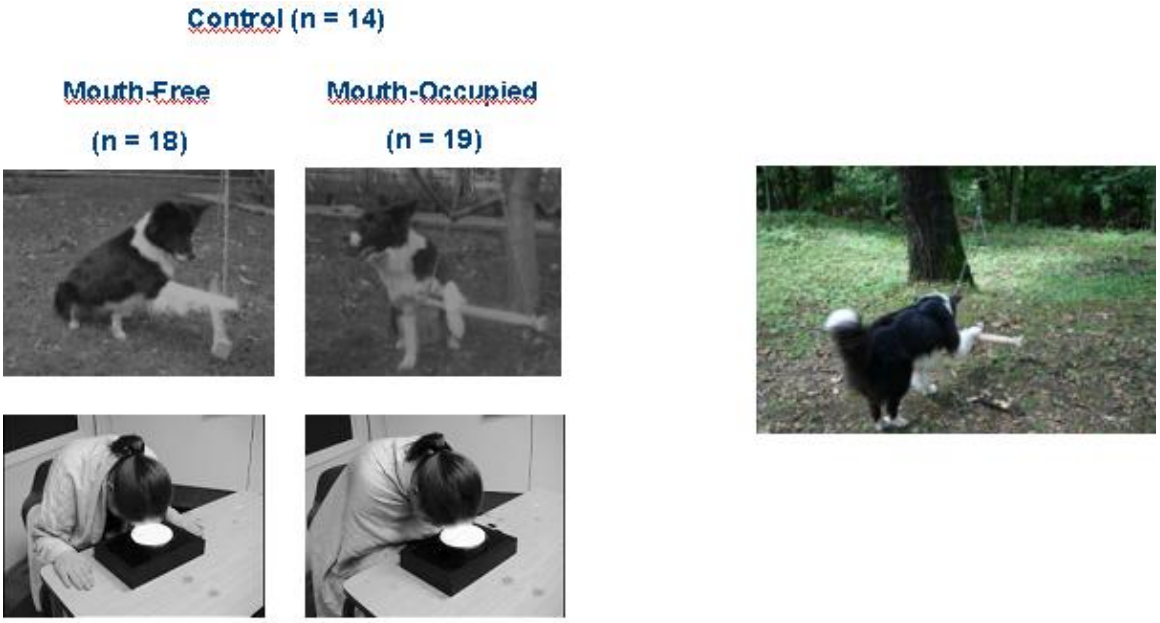

Figure 5. Dogs and infants experiment

Huber showed this in a recent experiment, subjects watched a demonstrator dog pulling a rod with the paw instead of the preferred mouth action. In the first group, using the ‘‘inefficient’’ action was justified by the model’s carrying of a ball in her mouth, whereas in the second group, no constraints could explain the demonstrator’s choice. In the first trial after observation, dogs imitated the non-preferred action only in the second group. Consequently, dogs, like children, demonstrated inferential selective imitation.

Name: **Frederic Alexandre**
Contribution Title: **Coordination, attention, communication**

Alexandre discusses the theory of intelligence with emphasis on:

- The neural substratum for computation
- Multimodal self-organisation liking poles of representation in the cortex
- The situated-ness of cognition

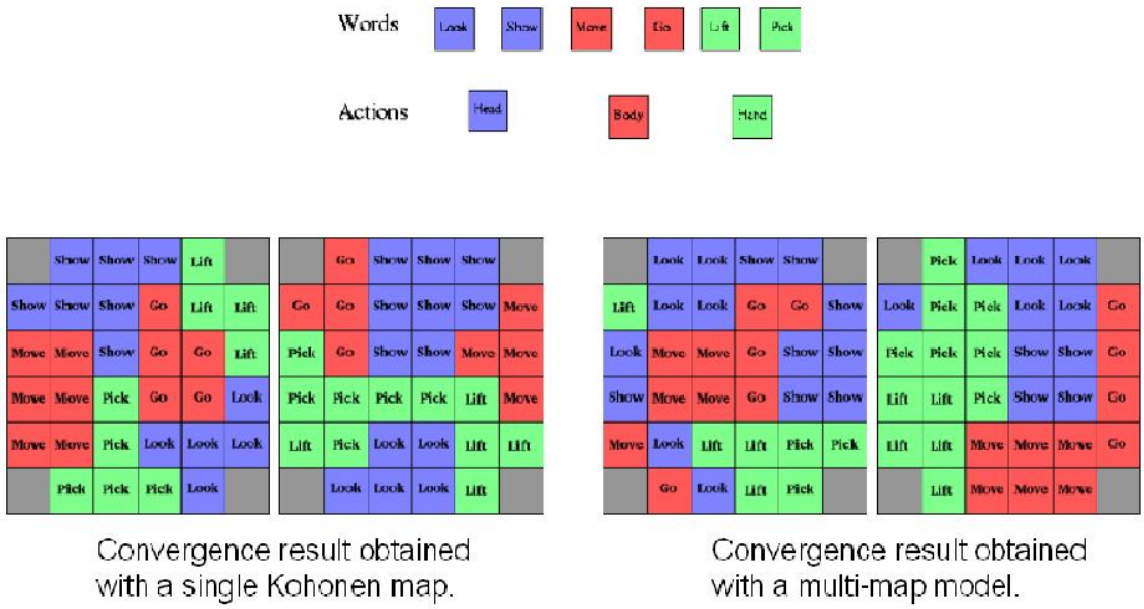

Figure 6. Multimodal self-organisation

After multimodal learning, the perception of objects pre-activates the catalogue of possible actions that can be chosen. Alexandre poses the possible consequences for communication:

- Fixation and attention seen as mechanical and neural deictic devices
- Orientation of body parts gives information about intentionality
- Multimodal association of « objects » with articulated sounds
- Organisation of action also for elaborated communication

Name: **Didem Gökçay**
Contribution Title: **Investigating behavioural problems in text-based communication**

Gökçay's contribution discussed the problems of text based and computer mediated communication. With an ever-increasing population of users of the Internet, it has become a quick and easy means of communication via chat and email. However Gökçay believes users have a misconception in that people can communicate in the same manner as they can in face-to-face scenarios.

Face-to-face Communication

Type of information
Facial expressions
Gestures
Prosody
Pitch/tone of voice
Surrounding environment
Emotional cues/ Visual cues

Tex-based CMC – Email and Chat

Type of information
Text
Emotions :) :(

Because of the information redundancy of solely text communication it is thought that people are free of the constraints of face-to-face communication in that they can write what they wish, not adhering to the everyday rules that are present. For example, individuals are capable of evaluating the real intent or meaning behind a sentence, not only by judging the content in semantics, but also by judging facial expressions, prosody in speech and sensory inputs received from the surrounding environment.

With respect to what it means to communicate, there is much missing when using solely text; communication should incorporate as many human attributes as possible in order to communicate as successfully as possible.

For more information on each of the presentations, each can be found on the internal pages of the NESTCOM website [NESTCOM, internal].

3.5. Publications

It is envisaged that extended paper versions of selected contributions made by workshop attendees shall be published at a later date. During project meeting discussions after the workshop, it was felt the optimum option would be in a special issue e.g. in a journal such as the Neural Networks Journal.

3.6. Other Nest events

Nestcom participated in various conferences and workshops. In particular the NEST Project CONTACT organised a workshop: Is a neural theory of language possible? This event was held in Leece, Italy, June 28-30, 2007. The project aims to build an integrated system for characterising motor processes of speech production endeavouring to identify motor and neural invariants that share a common structure during the development of perception and production for both speech and manipulation. The hope is that in the future, research in the field of cognitive neuroscience will mature and converge to an integrated epistemological perspective, leading to the elaboration of a unified neural theory of language and motor control [CONTACT, home]. Friedemann Pulvermuller, one of the partners on the Nestcom project from MRC, Cambridge presented a talk at the workshop as a NESTCOM representative.

4. Further research into multimodal communication

In this section we shall discuss further research which was mentioned and discussed in the context of Nestcom and its workshop. We shall focus on communication involving interactive artificial agents in two areas, Multimodal Communication and Social Communication.

In order to achieve fully interactive robots, it is necessary to enable them to communicate using a variety of modes simultaneously, in the same way that humans do when they interact with each other. This leads to a more natural means of

programming robots to achieve some goal. McGuire et al [McGuire et al 2002] have developed a robot which can learn to grasp an object using visual and gesture instructions from a human operator in conjunction with verbal commands. It is proposed that visual attention is crucial for successful interaction. Visual attention is biased by linguistic input. Short term visual memory allows the robot to integrate linguistic prompts with salient features extracted from the visual input.

Duffy et al [Duffy et al 2005] describe the importance of imbuing a robot with the ability to interact with humans and other robots socially. Various modes of input are considered to be crucial such as facial expressions and hand gestures. In order to interact with others, it is essential to have a good conceptual model of how the other operates. Using this model enables a robot, for example, to explain and predict what the other is about to do, its reasons for doing it, and how to elicit a desired behaviour from it[Norman, 2001]. Emotions constitute a subset of motivations that provide support for an agent's survival in a complex environment. Both motivations and emotions affect behavioural performance, but motivation can additionally lead to the formulation of concrete goal-achieving behaviour, whereas emotions are concerned with modulating existing behaviours in support of current activity [Fellous & Arbib, 2005].

To function and survive in a complex and unpredictable environment, animals and humans are faced with applying their resources to realise multiple goals in an intelligent and flexible manner where communication, cooperation or competition with others is involved [Gould, 1982]. Two conceptually distinct and complementary information-processing systems, cognition and emotion, evolved under such social and environmental pressures to promote health and optimal functioning of the creature [Lzard & Ackerman 2000]. Cognition is responsible for interpreting and making sense of the environment and the emotive system is responsible for evaluating and judging events to assess their overall value with respect to the creature (positive/negative). Fellous & Arbib [Fellous & Arbib, 2005] argue that robots could certainly interact socially with humans in the absence of emotions and feelings although to a limited extent. Fellous & Arbib believe that it is important to have a minimal set of criteria that robots would need to meet in order to qualify as having emotions and feelings. This would be achieved by taking account of how emotions, feelings, and social behaviour are generated within humans and other animals.

An interesting point is made by Fellous & Arbib [Fellous & Arbib, 2005] in that often the distinction between the emotional reaction and the feeling of the emotion is overlooked, as is how to construct a robot that really does have emotions, not merely the beliefs attributed through human reinforcements (rewards and punishments).

Prendinger and Ishizuka [Prendinger and Ishizuka 2001] discuss the importance of situation in social communication. A mental model is proposed which contains components representing world knowledge and high order representations of mental concepts such as emotions, personality, standards, attitudes and goals. This builds on the work of Allen [Allen 99] who encapsulates such concepts as '*control* states'. This is an example of situated cognition where the environment plays a major part in biasing cognitive function and has a major influence on behaviour.

Finally Adolphs [Adolphs 01] discusses the neurobiology of social cognition in animals, and gives an overview of the neural structures involved in social cognition, how they have evolved and how they develop. The role of communication and emotion in the development of social cognition is described as significant.

Appendix A – Initial Meeting Attendees and Agenda

Meeting Agenda

- Introductions
    - Nestcom overview (Sunderland) – 30 minutes
    - Nestcom Goals (Cam) – 30 minutes
    - Nestcom Goals (Parma) – 30 minutes
- Scientific Discussions – 60 minutes
    - Work packages
    - Nest projects incorporated in study
    - Report content and structure
    - Road map structure
    - RoadMap and Future Proposals
    - Future Emerging Technology
        - Possible proposals?
- Organisation and Management of workshop – 60 minutes
    - Workshops
    - First workshop, when, where, who to invite
    - Deliverable dates
    - Management Meetings
    - Dissemination approaches
    - Website
- 12:30 - Lunch

Attendees of Project Meetings

University of Parma

- Professor Gallese

MRC, Cambridge

- Professor Pulvermueller
- Dr. Boulenger
- Dr. Garagnani
- Dr. Hauk

University of Sunderland

- Professor Wermter
- Dr. Erwin
- Dr. Panchev
- Dr. Knowles
- Dr. Elshaw
- Mr. Page

Appendix B – Workshop Attendees and Program Committee List

Workshop Attendees

- Dr M. Knowles
- Dr C. Panchev
- Mr M. Page
- Prof. F. Pulvermuller
- Prof. S. Wermter

- Dr. F. Alexandre*
- Dr. O. Hauk*
- Prof. L. Huber*
- Prof. G. Orban*
- Prof. G. Palm*
- Prof. A. Postma*

- Giovanni Buccino
- Didem Gokcay

*Also on the workshop program committee

Workshop Program Committee

- Prof. J. Austin
- Dr. V. Boulenger
- Dr. G. Bugmann
- Prof. A. Cangelosi
- Dr. M. Casey
- Dr. H. Erwin
- Dr. M. Garagnani
- Dr. J. C. Gómez
- Dr. D. Mareschal
- Prof. J. Mehler
- Prof. B. MacWhinney
- Dr. B. Platt
- Dr. U. Sauerland
- Dr. J. Steele
- Prof. B. Stein
- Prof. J. Taylor
- Dr. T. Wennekers

Appendix C – Second NESTCOM Meeting

Attendees

University of Parma
- Giovanni Buccino

MRC, Cambridge
- Professor Pulvermueller
- Dr. Hauk

University of Sunderland
- Professor Wermter
- Dr. Knowles
- Mr. Page

Appendix D - International NESTCOM Workshop Programme

International Workshop on "What it means to communicate"
Programme
Introduction - Stefan Wermter
Panel Presentations - Session I
Giovanni Buccino - Modulation of the motor system during language processing
Günther Palm - A computational learning perspective
Albert Postma - The neurocognition of spatial categorization and spatial language processing
Coffee Break
Panel Presentations - Session II
Friedemann Pulvermuller - Embodiment of words, rules, and meaning in minds, brains, and automata
Ludwig Huber -The evolution, development and intentional control of imitation
Frederic Alexandre - Coordination, attention, communication
Didem Gökçay - Investigating behavioural problems in text-based communication
General Discussion and Conclusions

Appendix E References

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