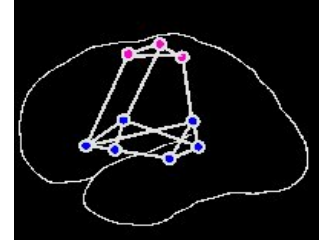




MirrorBot
Biomimetic multimodal learning
in a mirror neuron-based robot
IST-2001-35282



**Stefan Wermter, Frederic Alexandre, Günther Palm,
Friedemann Pulvermüller, Giacomo Rizzolatti/Vittorio Gallese**

University of Sunderland

INRIA at Nancy

University of Ulm

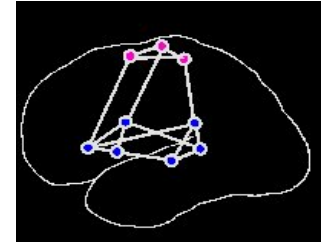
Medical Research Council at Cambridge

University of Parma

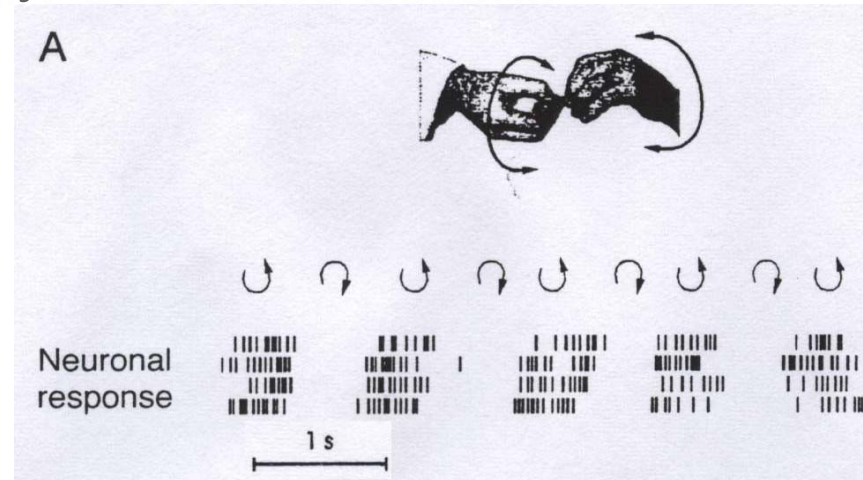


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FET-Open scheme**

Objectives of MirrorBot



- Mirror neurons fire for specific actions, visually observed actions and acoustically described actions

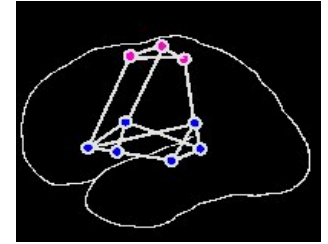


- How can mirror neuron-based associative networks be used for multimodal actions in robots?





Individual goals

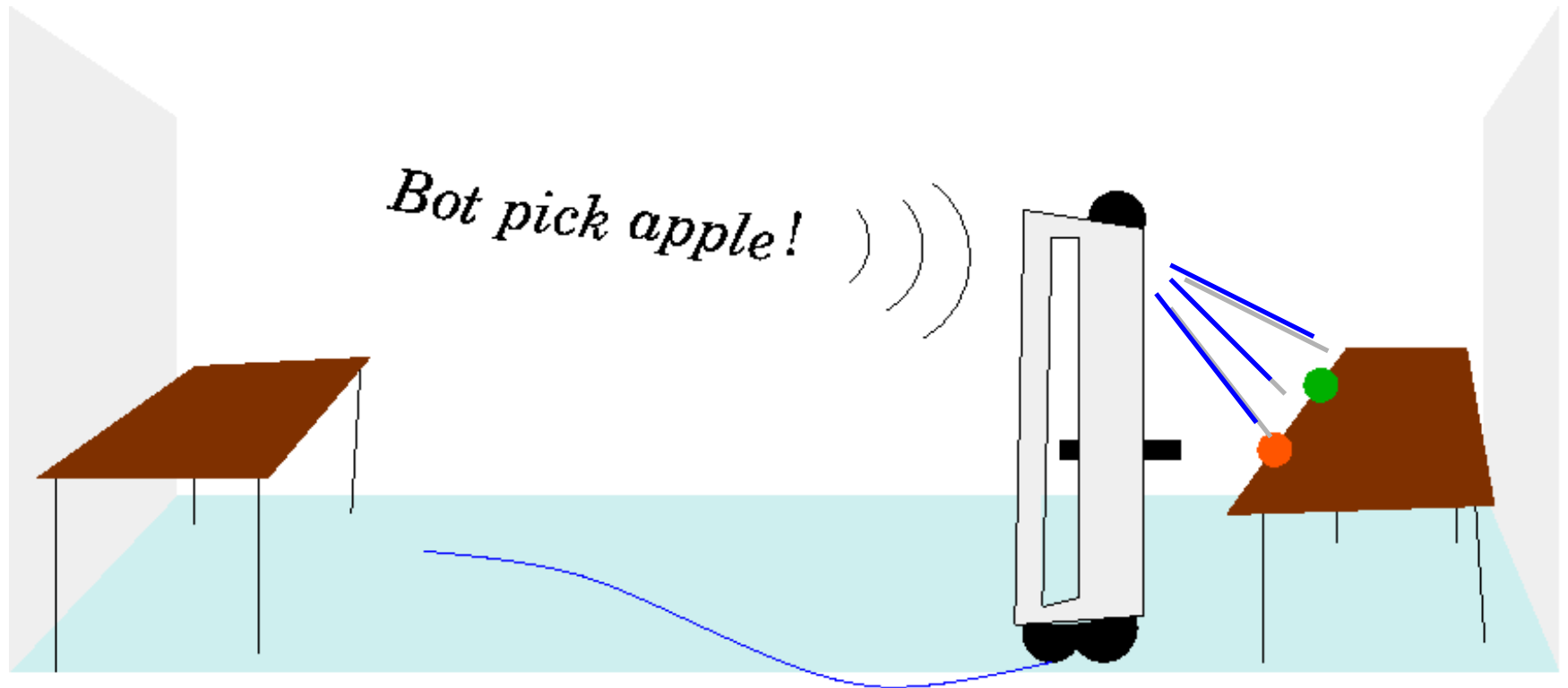
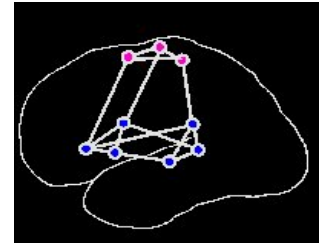


- collect imaging and neural recording data: EEG, MEG, fMRI, TMS
- identify neural architectures for perceptual visual and language data
- develop associative networks for mirror neuron concept
- train and evaluate the MirrorBot robot to perform actions

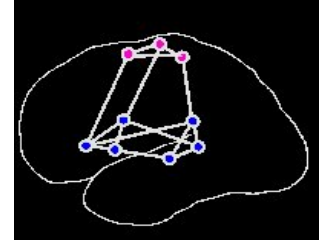


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MirrorBot scenario



MirrorBot scenario



agent ::= SAM **action**
BOT **action**

action ::=
body_action
head_action
hand_action
stop

body_action ::= go
move_body
turn_body

head_action ::= turn_head
show

hand_action ::= pick
put
lift
drop
touch

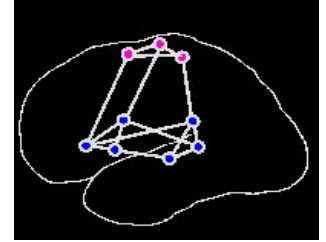
object
x_direction
y_direction
y_direction | z_direction

object

object
object
object
object
object



MirrorBot grammar



x_direction::= forward | backward

y_direction::= left | right

z_direction::= up | down

object::= [colour] natural_object

[colour] artefact_object

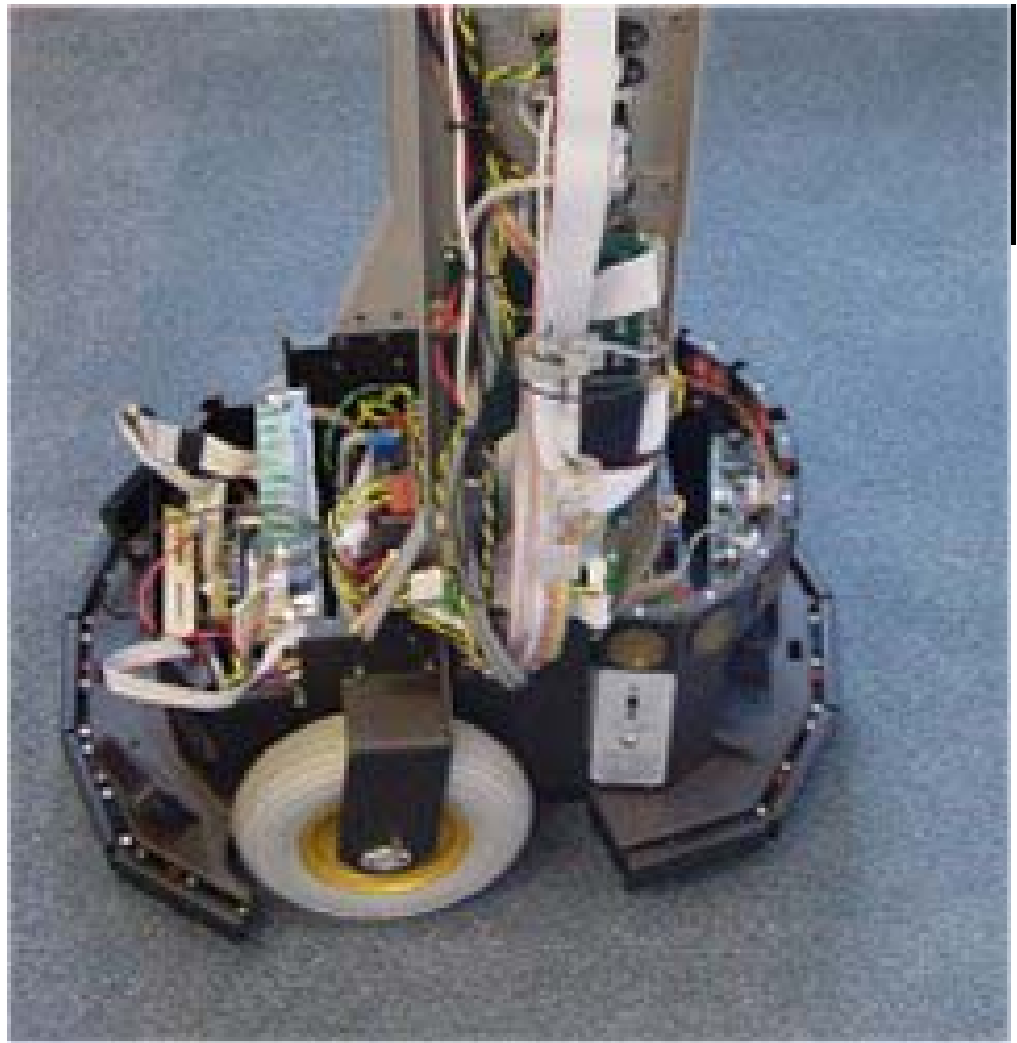
colour ::= brown | blue | black | white

natural_object::= nut | plum | dog | cat

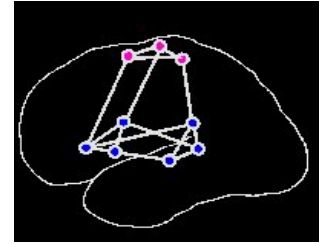
artefact_object::= desk | wall | ball | cup



MirrorBot platform



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Examples of ongoing Work



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F5 Neuron Responses

The response of an audio-visual F5 mirror neuron

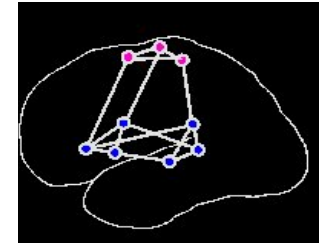
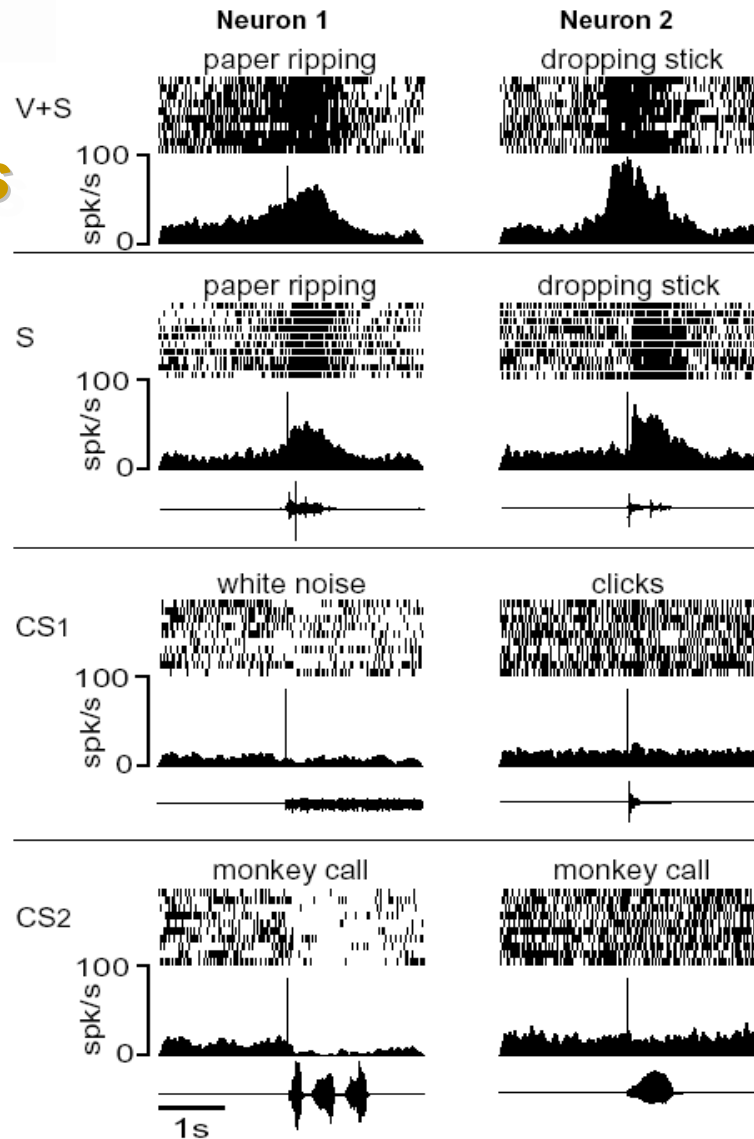
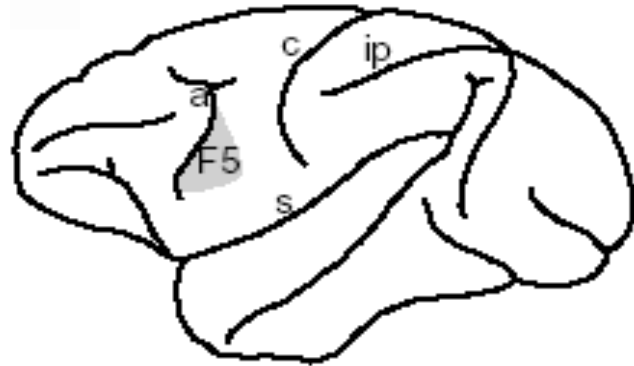
Audio-visual response



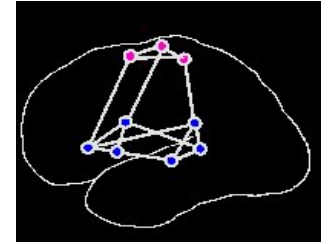
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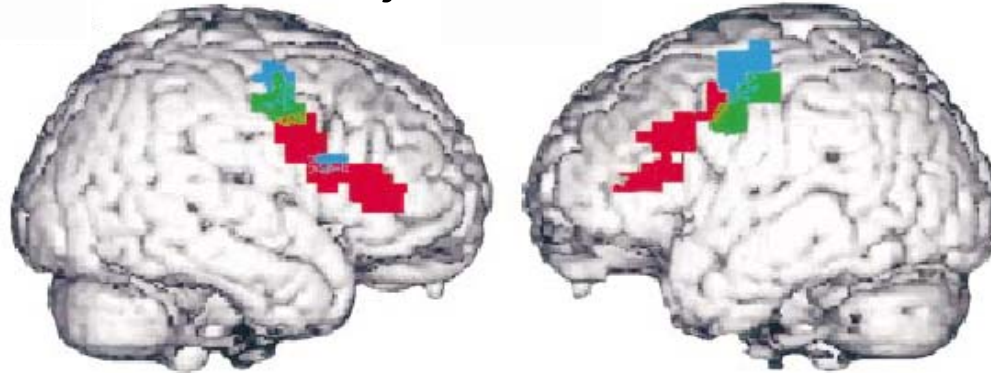
F5 responses



Somatotopy of visual action observation (fMRI)

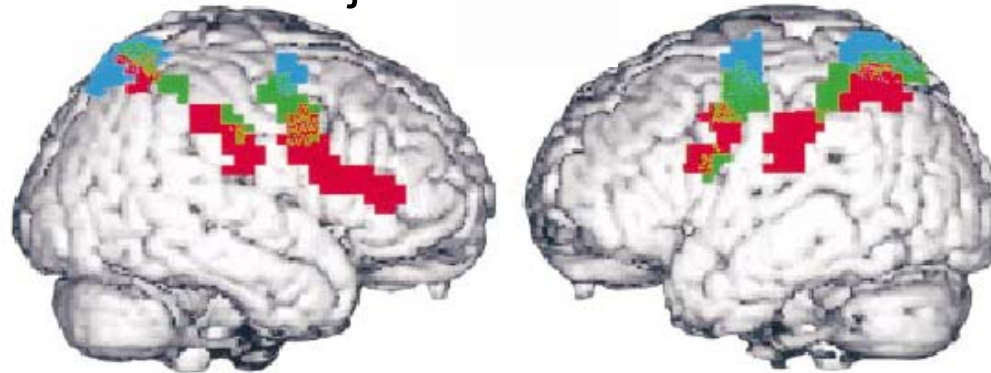


Non-object-related actions



 **Foot Action**

Object-related actions

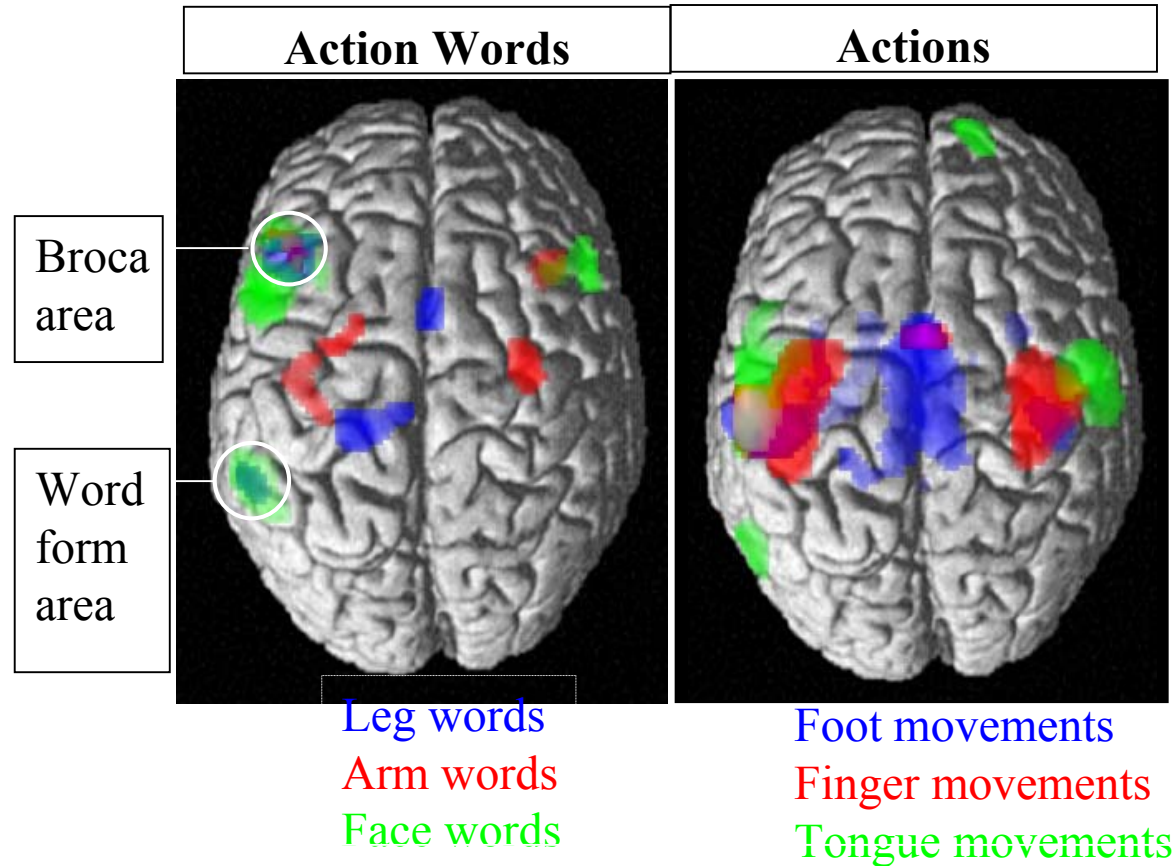
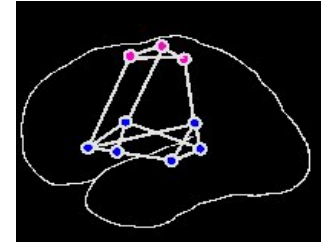


 **Hand Action**

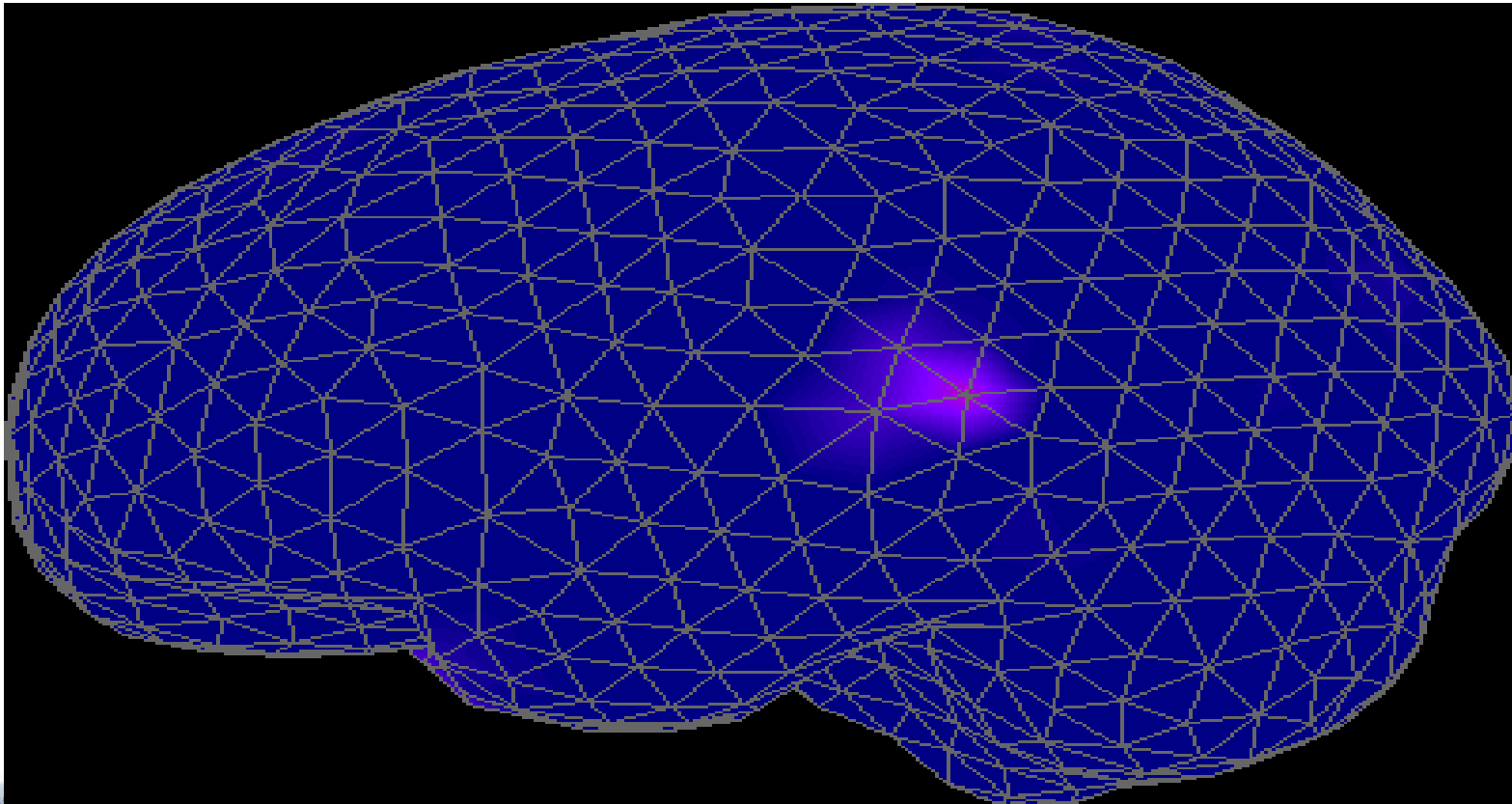
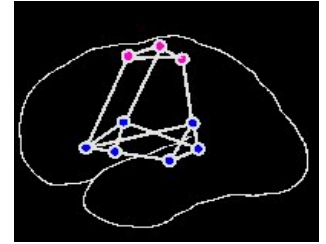
 **Mouth Action**



Somatotopy of actions words and actions (fMRI)

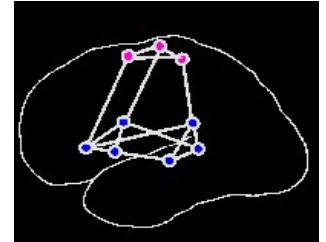


Word-related neuronal ensembles distributed over perisylvian cortex



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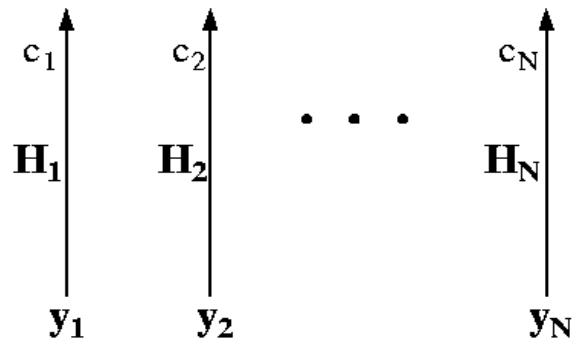
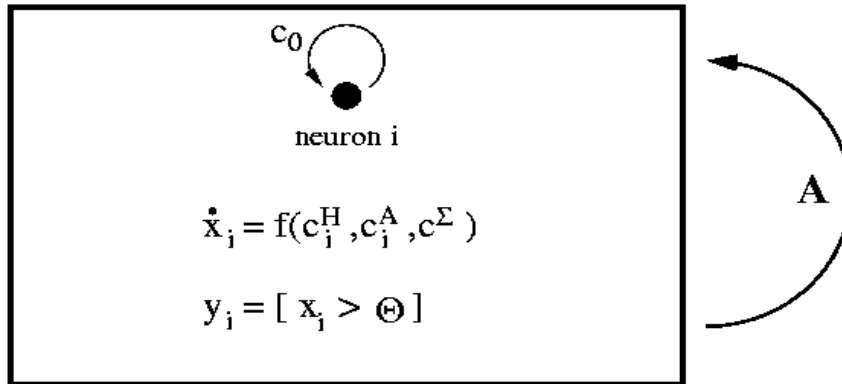
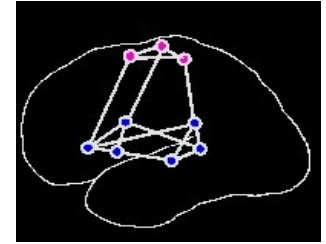
Findings



- Performed actions, visually observed actions and actions described in language are associated with related cortical circuits
- The cortical circuits are topologically organised as areas for mouth, hand and leg areas
- How do we model these findings for language, vision, motor control?



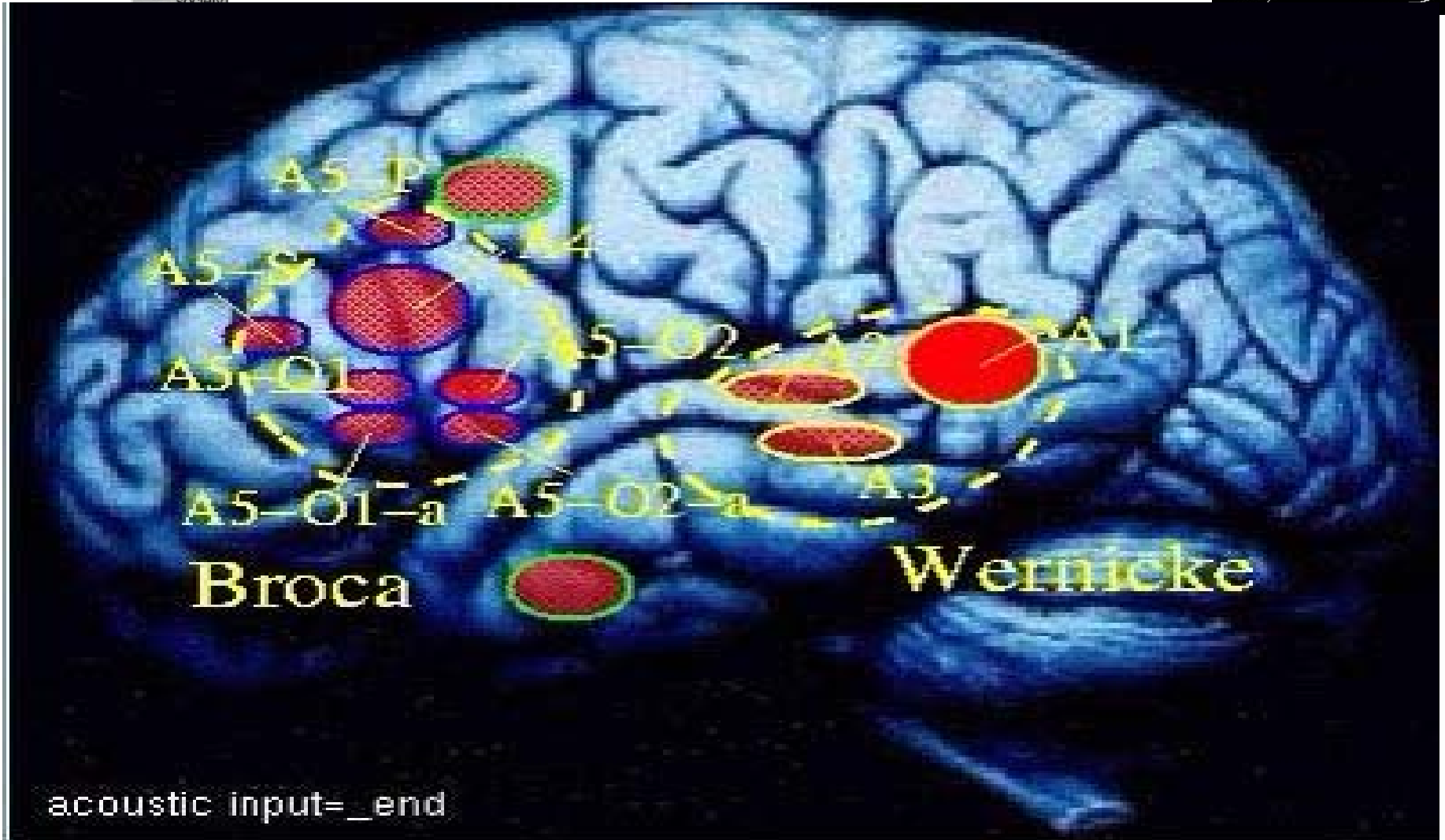
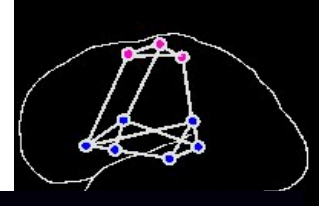
Associative spike counter model for a cortical language area



- spiking variant of binary Willshaw associative memory
- requires sparse binary patterns
- binary memory matrices:
A auto-associative
 H_i hetero-associative
- sequence processing by delayed feedback (in H)

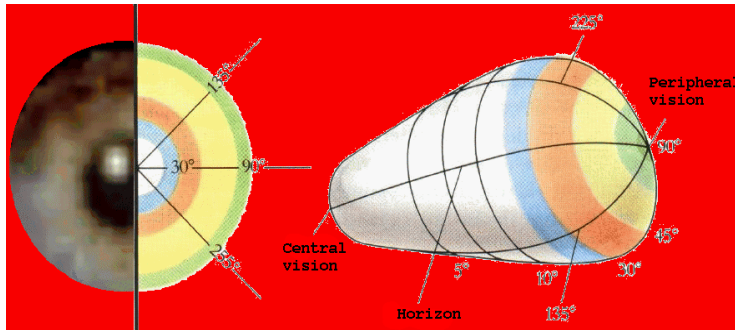
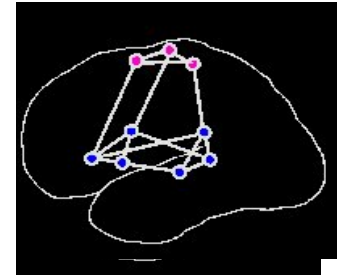


Language areas of MirrorBot: Bot show red apple



acoustic input=_end

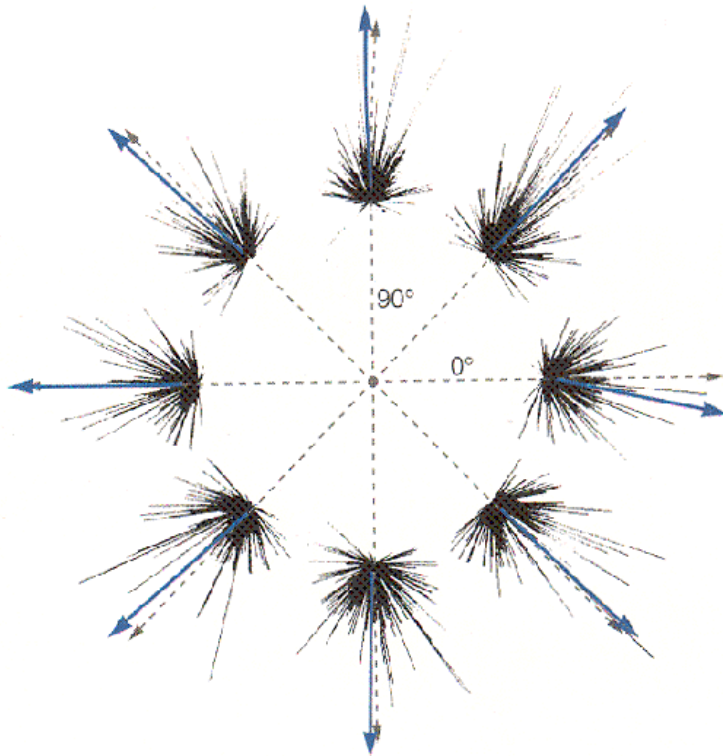
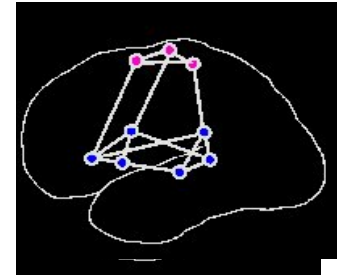
Visual encoding



- Non-uniform distribution on the retina
- Visual neural filters
- Overlapping receptive fields



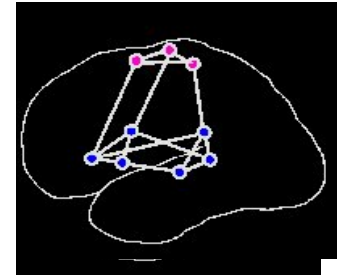
Motor encoding



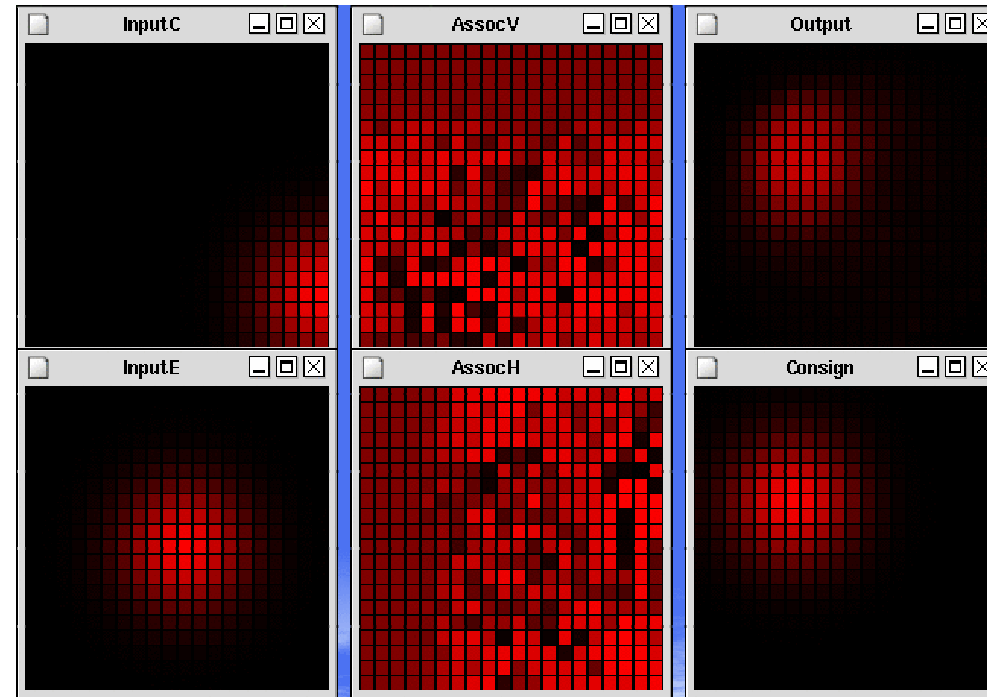
- Maximal activities when movement in preferred direction of neuron
- In M1, topographic organization: neighboring neurons have similar preferred directions
- Neural maps realise population encoding for motor commands



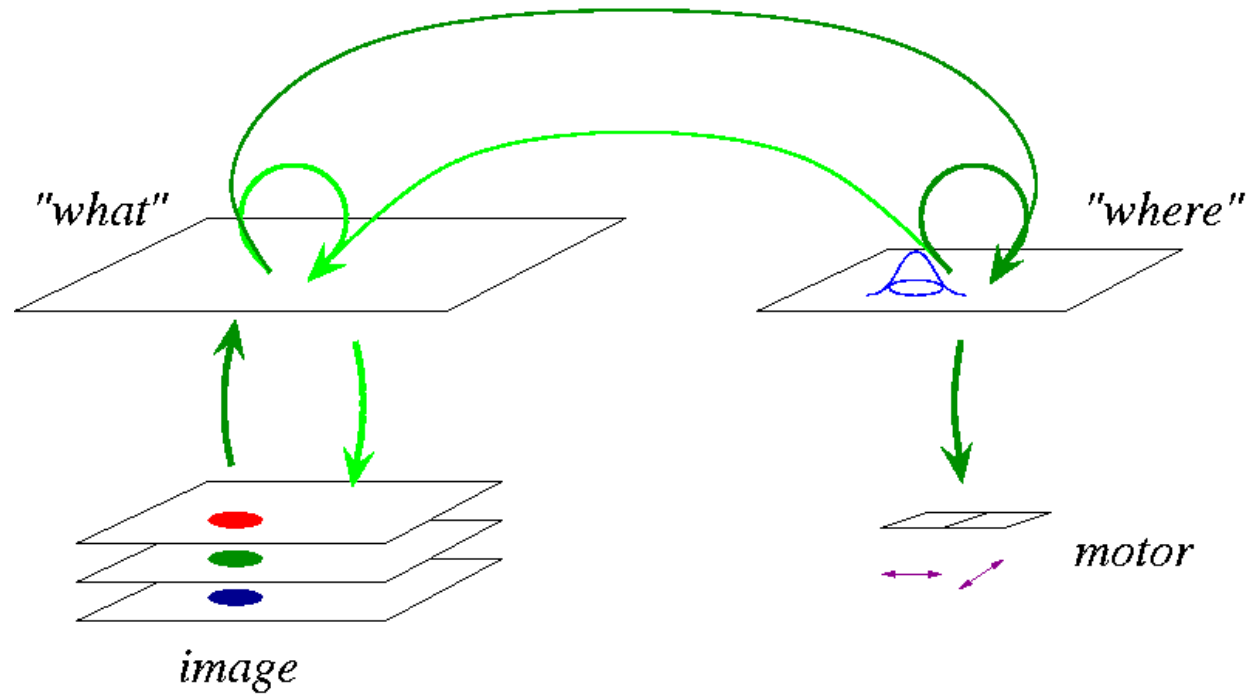
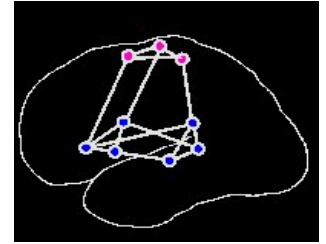
Associative model for sensor motor representation



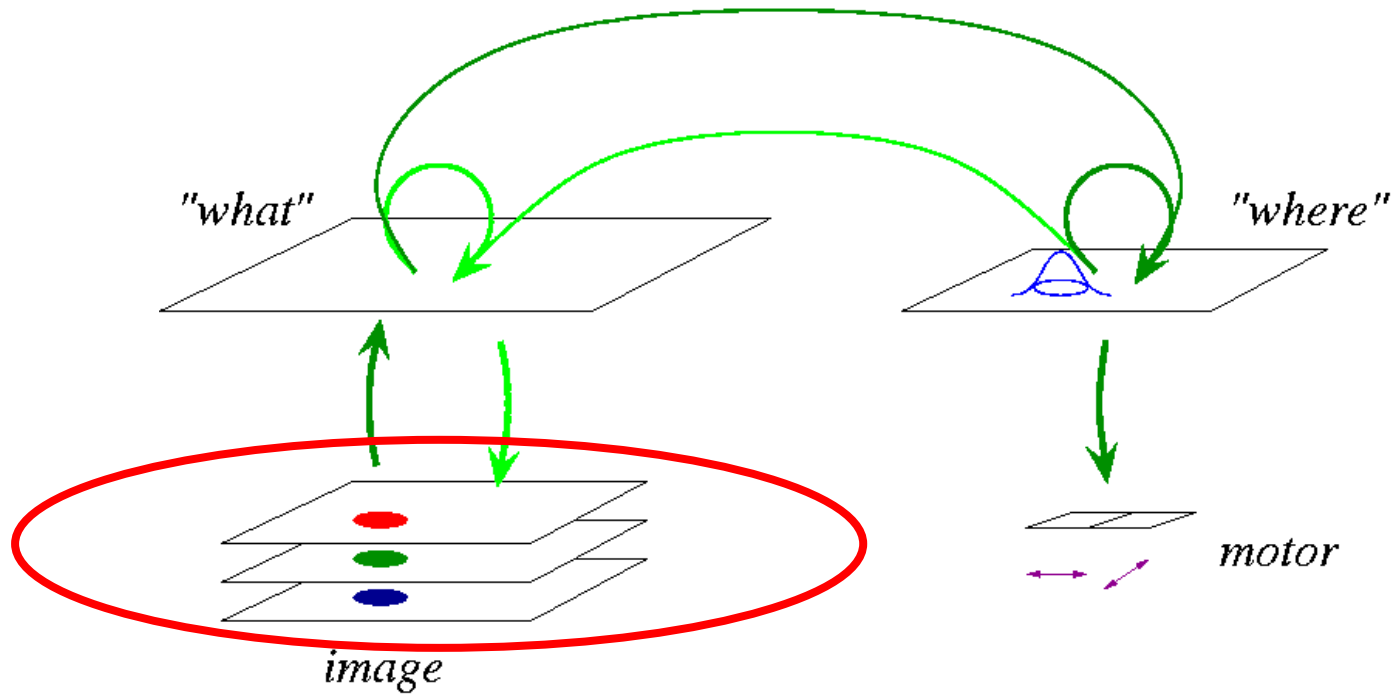
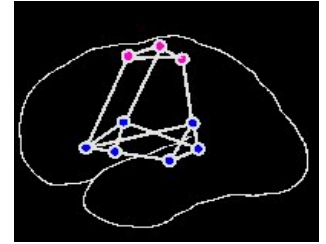
- control of saccadic eye movements towards a target



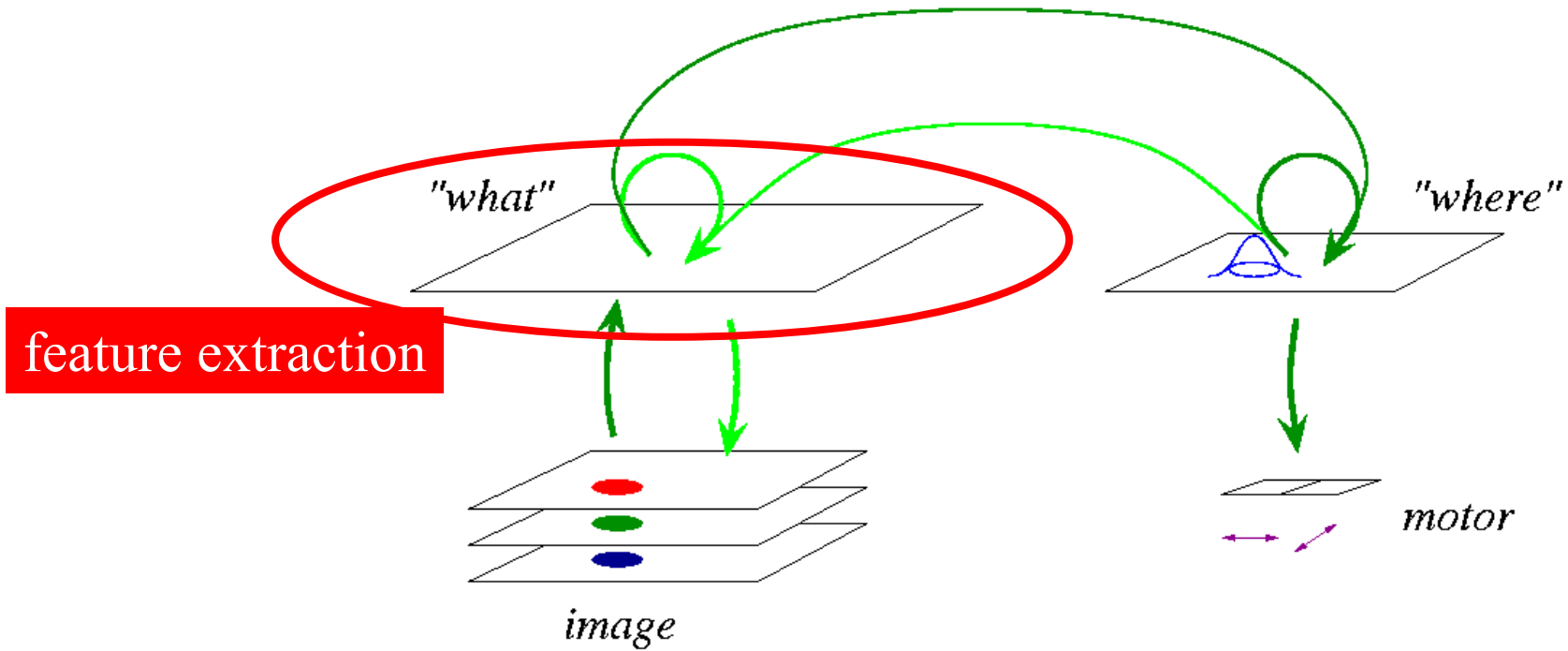
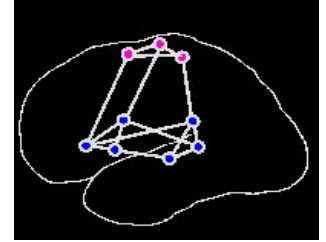
Associative network for "Bot show orange"



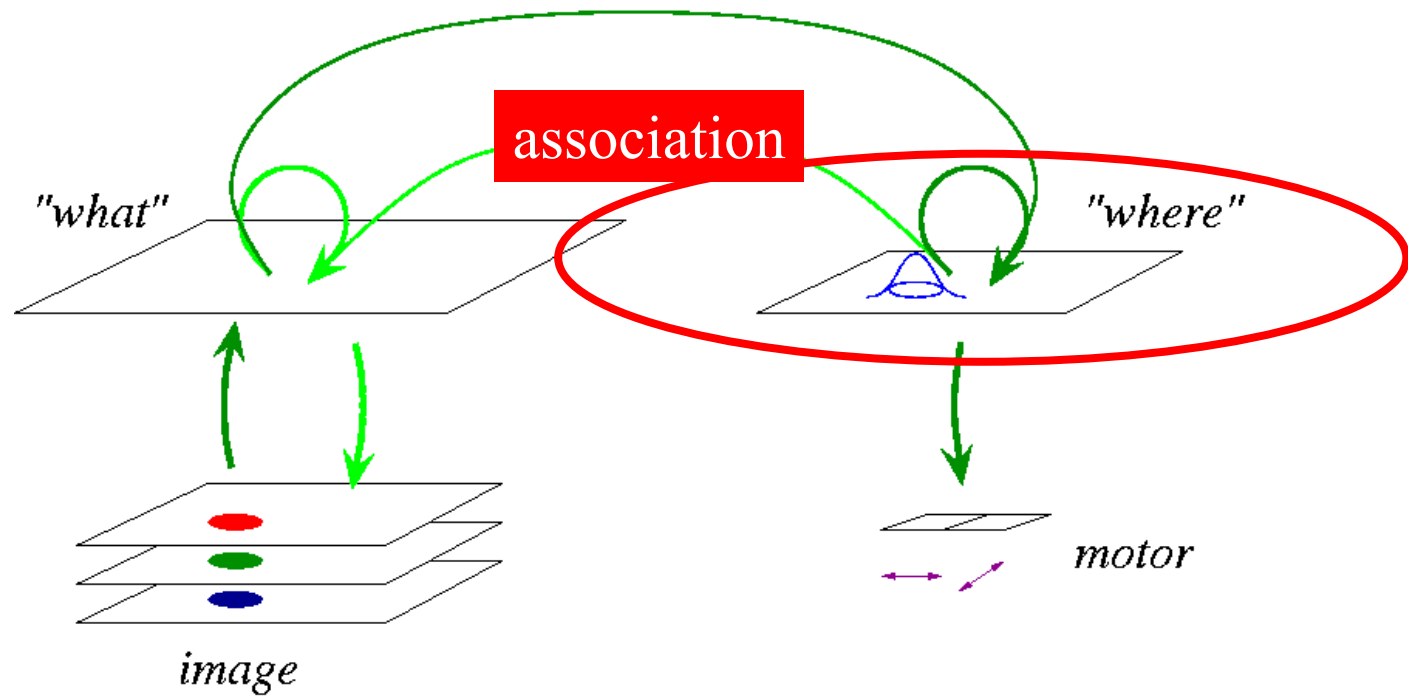
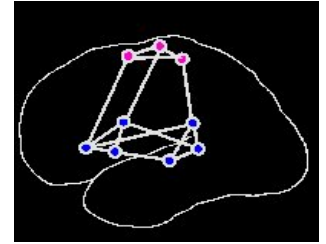
Associative network for "Bot show orange"



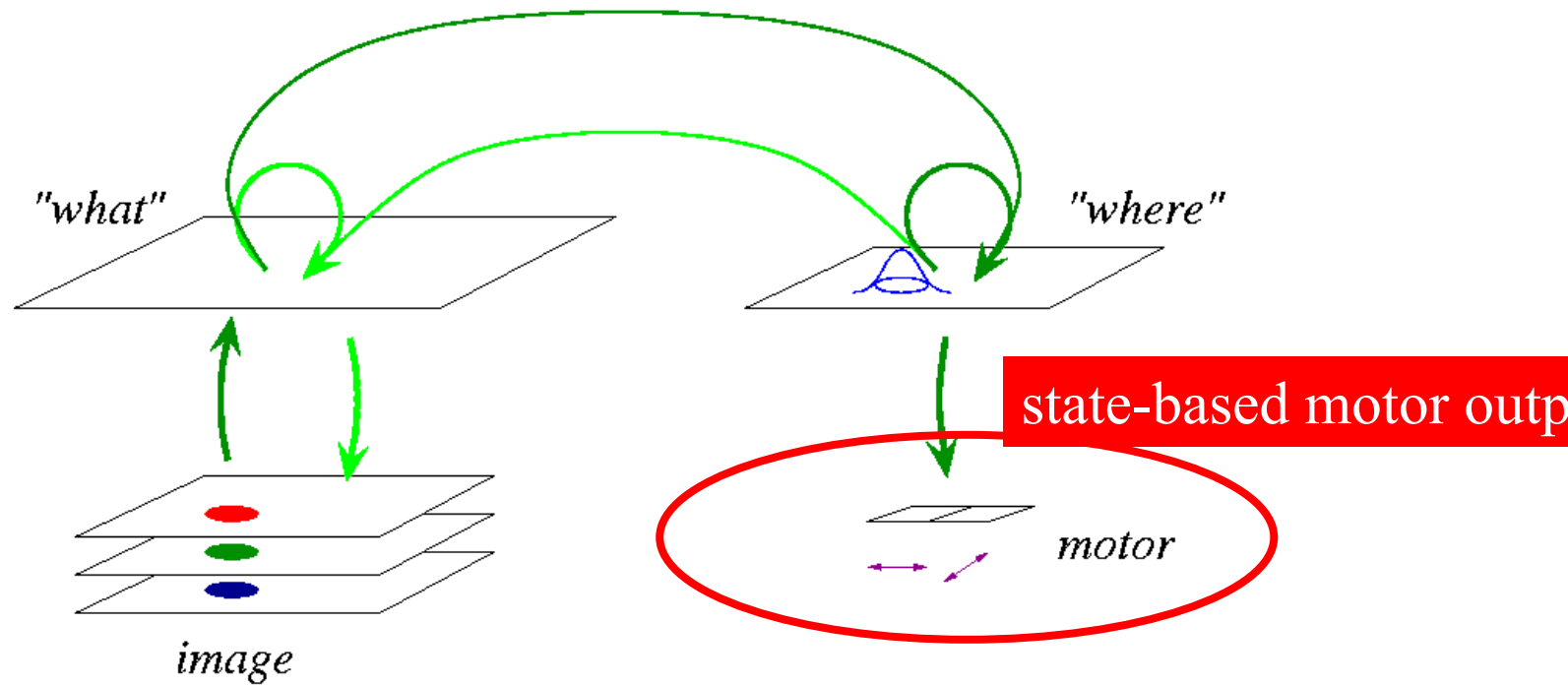
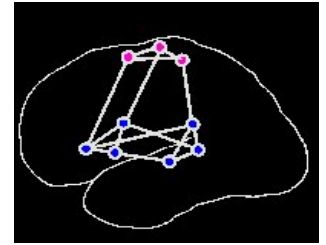
Associative network for “Bot show orange”



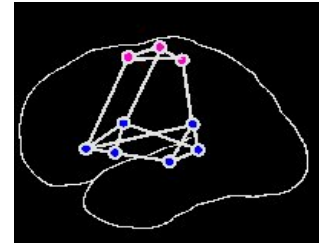
Associative network for "Bot show orange"



Associative network for "Bot show orange"



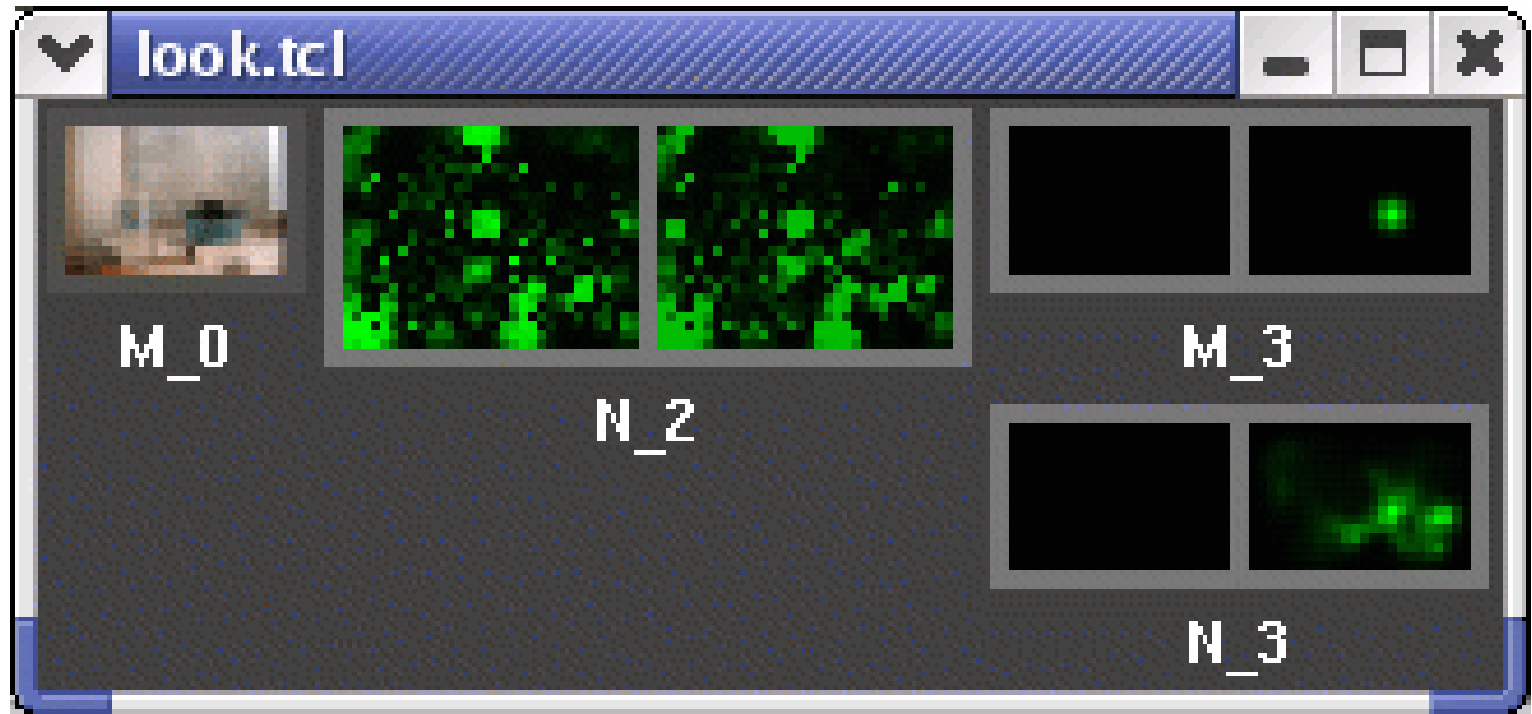
Network activations



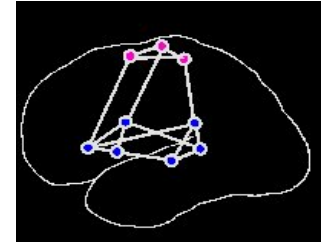
Image

“what”

“where”



Docking



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MirrorBot website

MirrorBot - Microsoft Internet Explorer provided by VNU New Media - www.vnunet.com

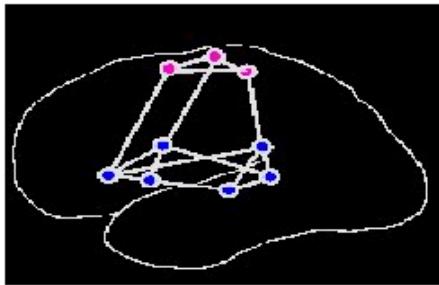
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Address <http://www.his.sunderland.ac.uk/mirrorbot/> Go Links >>

MirrorBot

Biomimetic multimodal learning in a mirror neuron-based robot

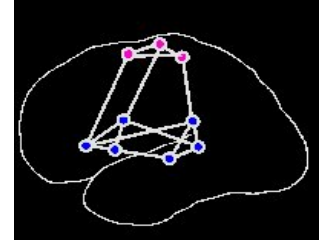
| | | | |
|-------------------------------------|--|----------------------------------|------------------------------|
| Project Description | Contact | Partners | Location |
| Research Groups |  | HIS Site | |
| Positions | | Associations | |
| MirrorBot Internal | | Associated Staff | |
| Events | Related EU Projects | Journals | Publications |

Done Local intranet

■ www.his.sunderland.ac.uk/mirrorbot/



Conclusions

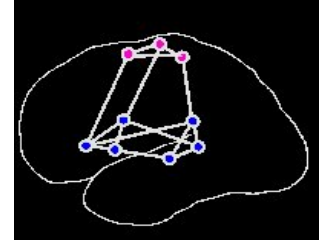


- Experiments on action-oriented cortical organisation
- Computational models for language, vision, action on robot
- Aim towards mirror neuron-based association of multiple modalities in neural models





European MirrorBot Workshop



- A multidisciplinary approach for the study of frontal cortex
- 20 October 2003, Convention Centre, Nancy, France
- www.his.sunderland.ac.uk/mirrorbot/



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