Neural Dynamics For Embodied Cognition Coordination transforms, grounded cognition

Gregor Schöner
Institute for Neural Computation (INI)
Ruhr-University Bochum

Survey

- Foundations 1: Neural dynamics [GS]
  - Introduction to Cedar/Instabilities in DFT [Stephan Sehring]
- Foundations 2: Dimensions/Binding [GS]
  - Cedar architecture: visual search [Raul Grieben]
- Foundations 3: Toward grounded cognition [GS]
  - Cedar architecture: relational grounding [Daniel Sabinasz]
- Foundations 4: Sequence generation [GS]
  - Cedar architecture sequence generation [Minseok Kang]

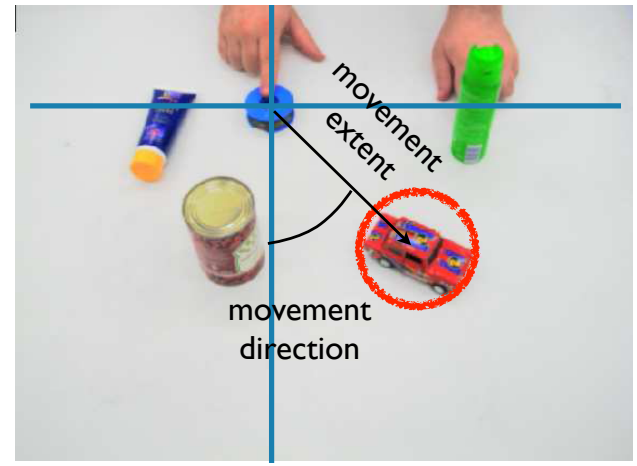
Roadmap

Session 3: Grounded cognition

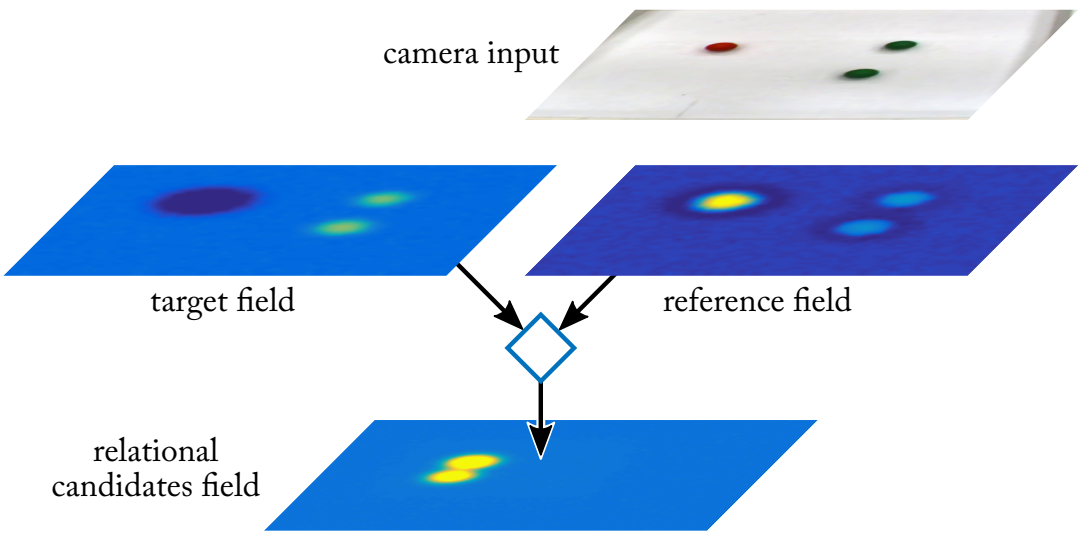
- coordinate transforms
- relational concepts
- grounding
- mental mapping

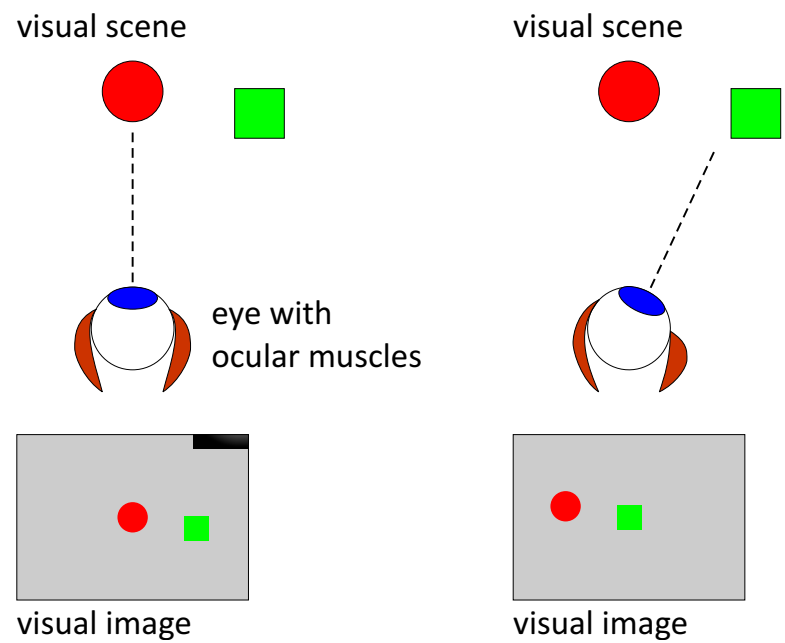
Coordinate transforms

- are central to sensory-motor cognition but also critical to higher cognition!



"where are the green objects relative to the red one"



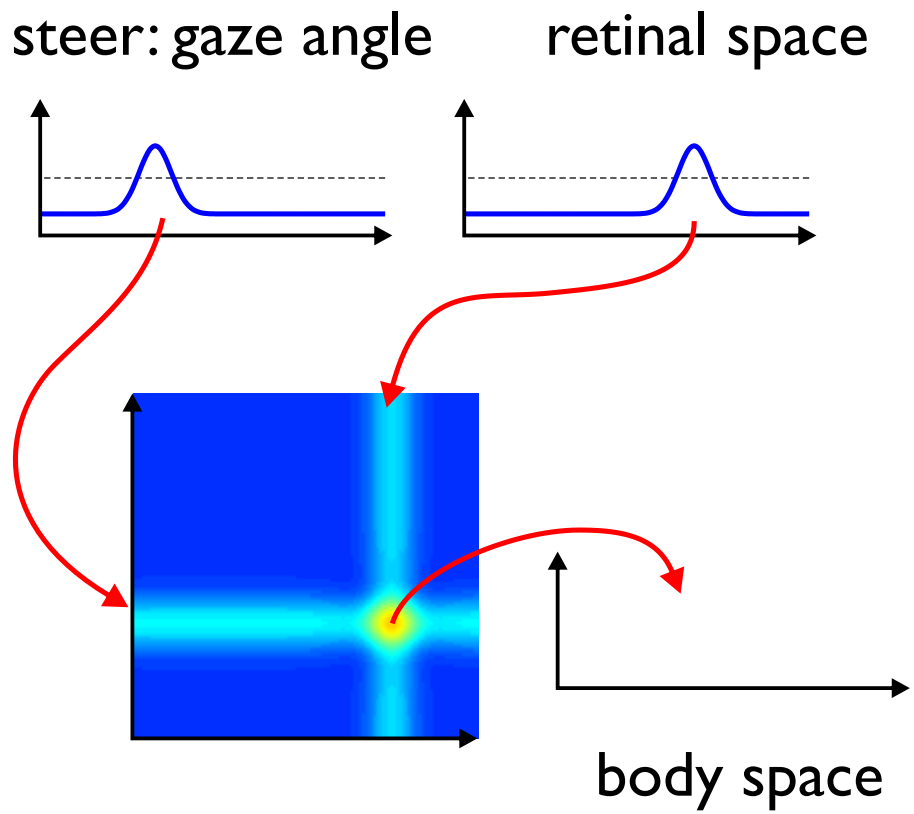


[Richer Doctoral dissertation, 2017]

[Schneegans Ch 7 of *DFT Primer*, 2016]

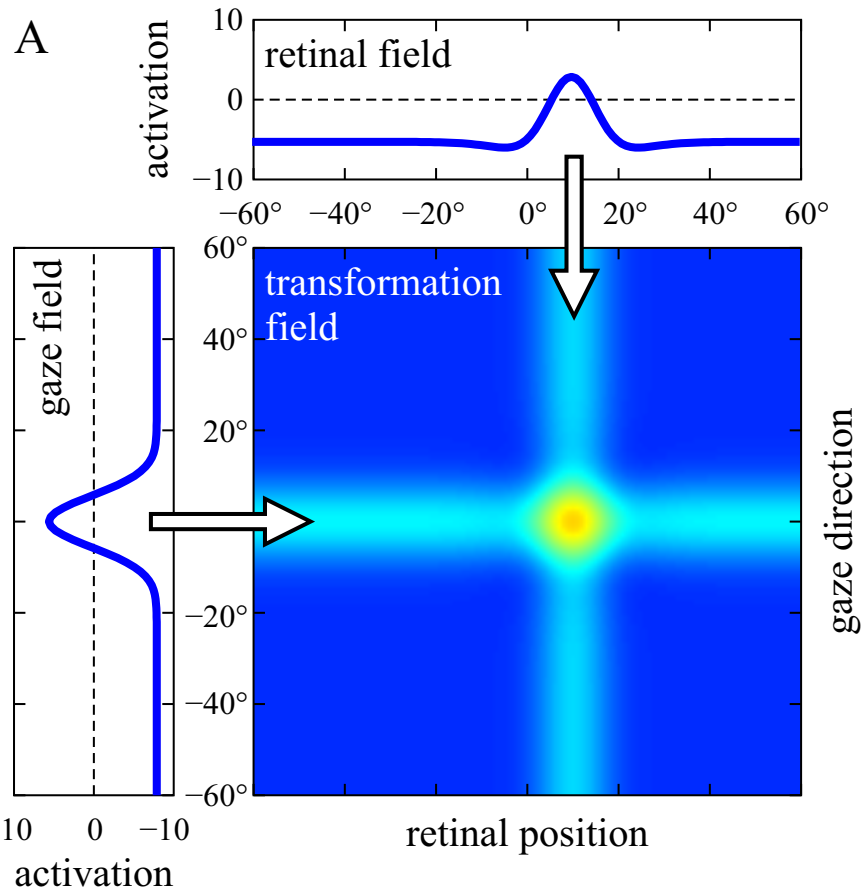
Coordinate transforms involve binding

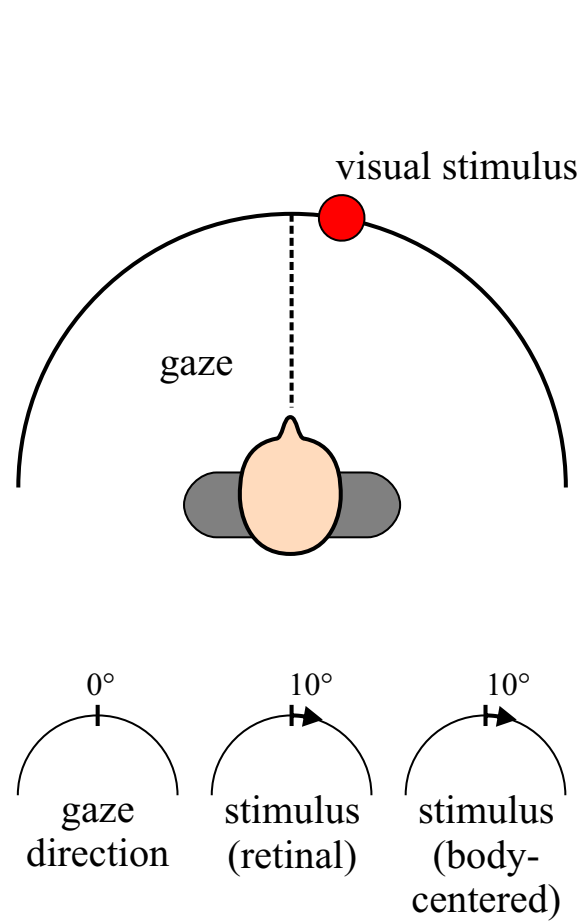
- need a bound neural representation of
  - retinal space
  - gaze angle
- project to body space
- neural evidence: gain field (Andersen/Pouget)



[Schneegans Ch 7 of *DFT Primer*, 2016]

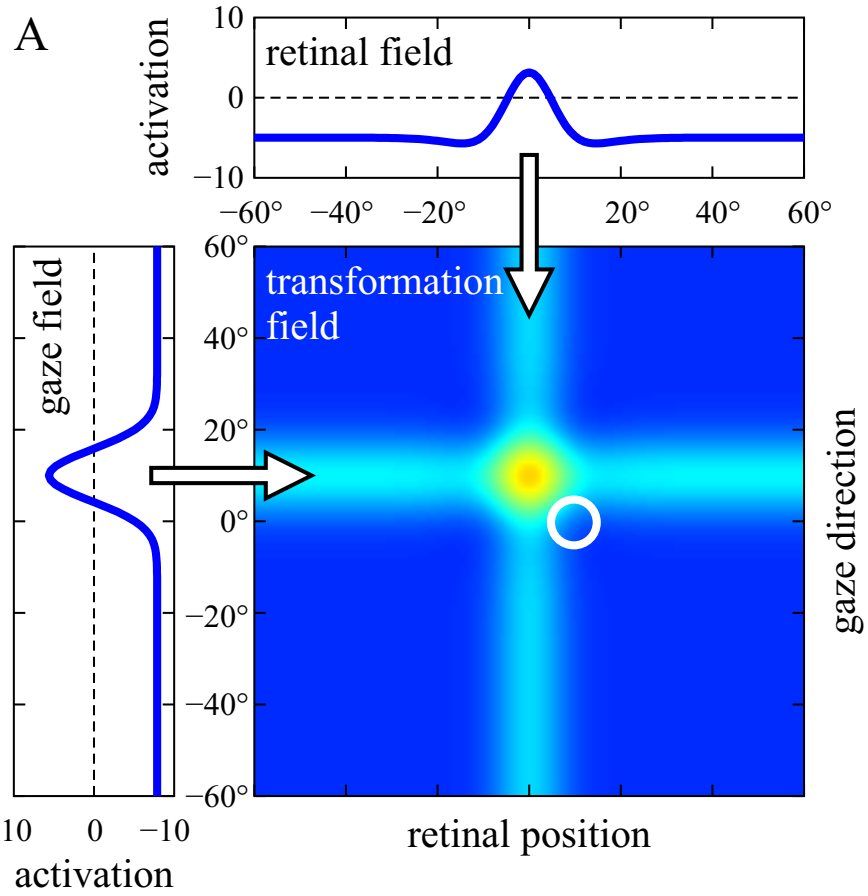
Coordinate transform

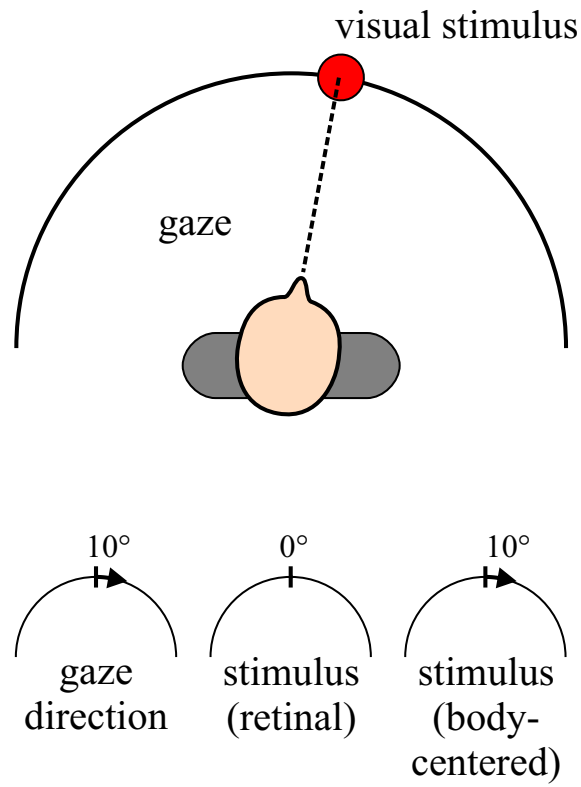




[Schneegans Ch 7 of *DFT Primer*, 2016]

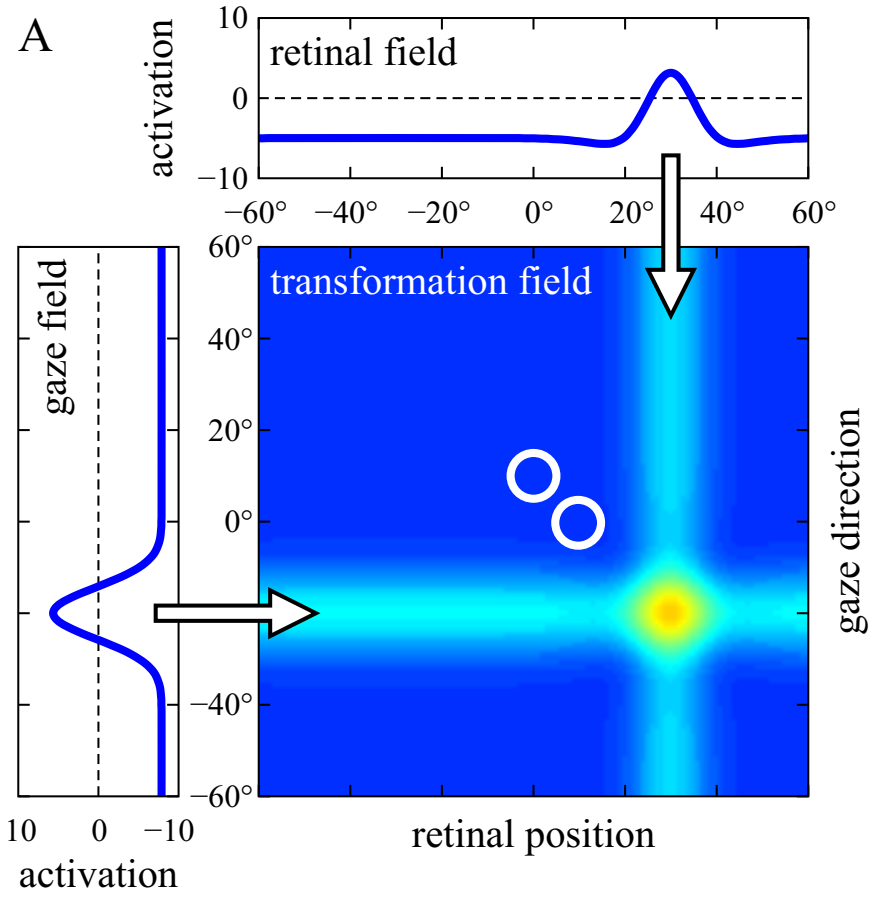
Coordinate transform

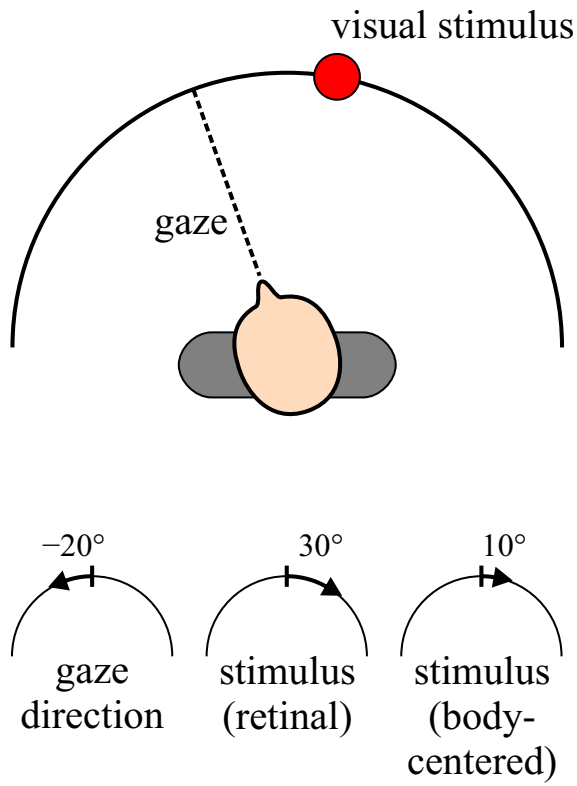




[Schneegans Ch 7 of *DFT Primer*, 2016]

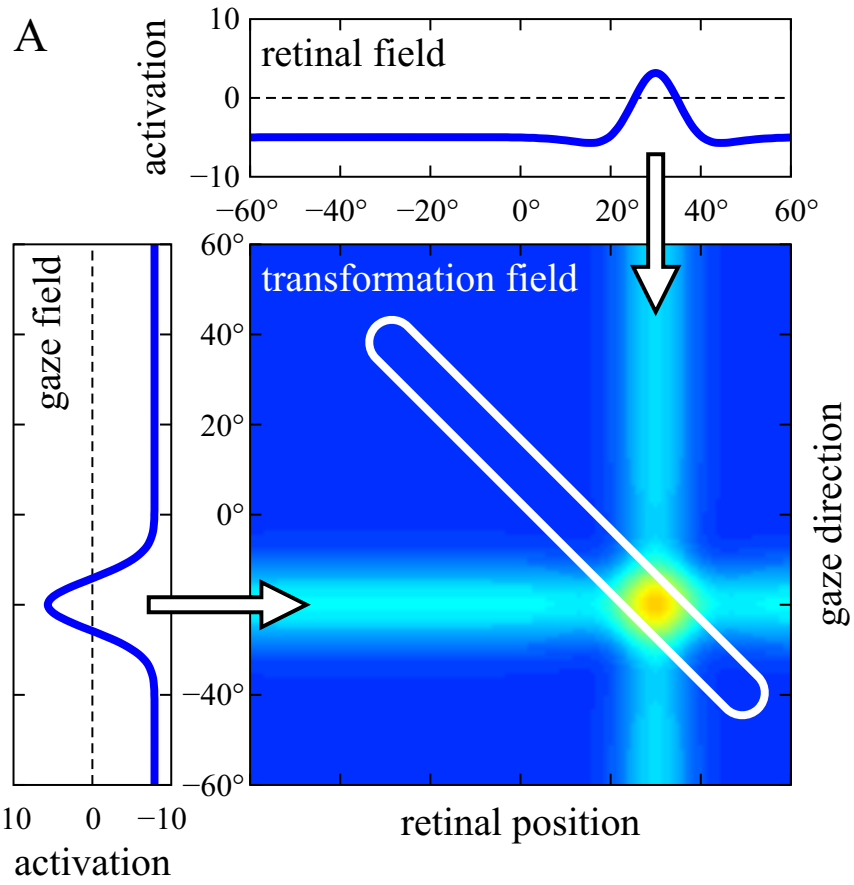
Coordinate transform

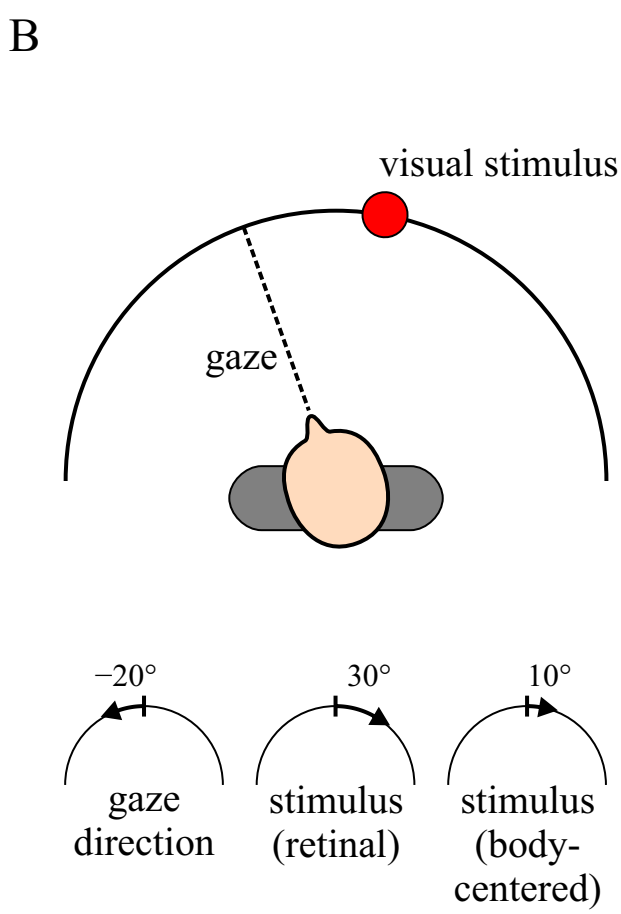




[Schneegans Ch 7 of *DFT Primer*, 2016]

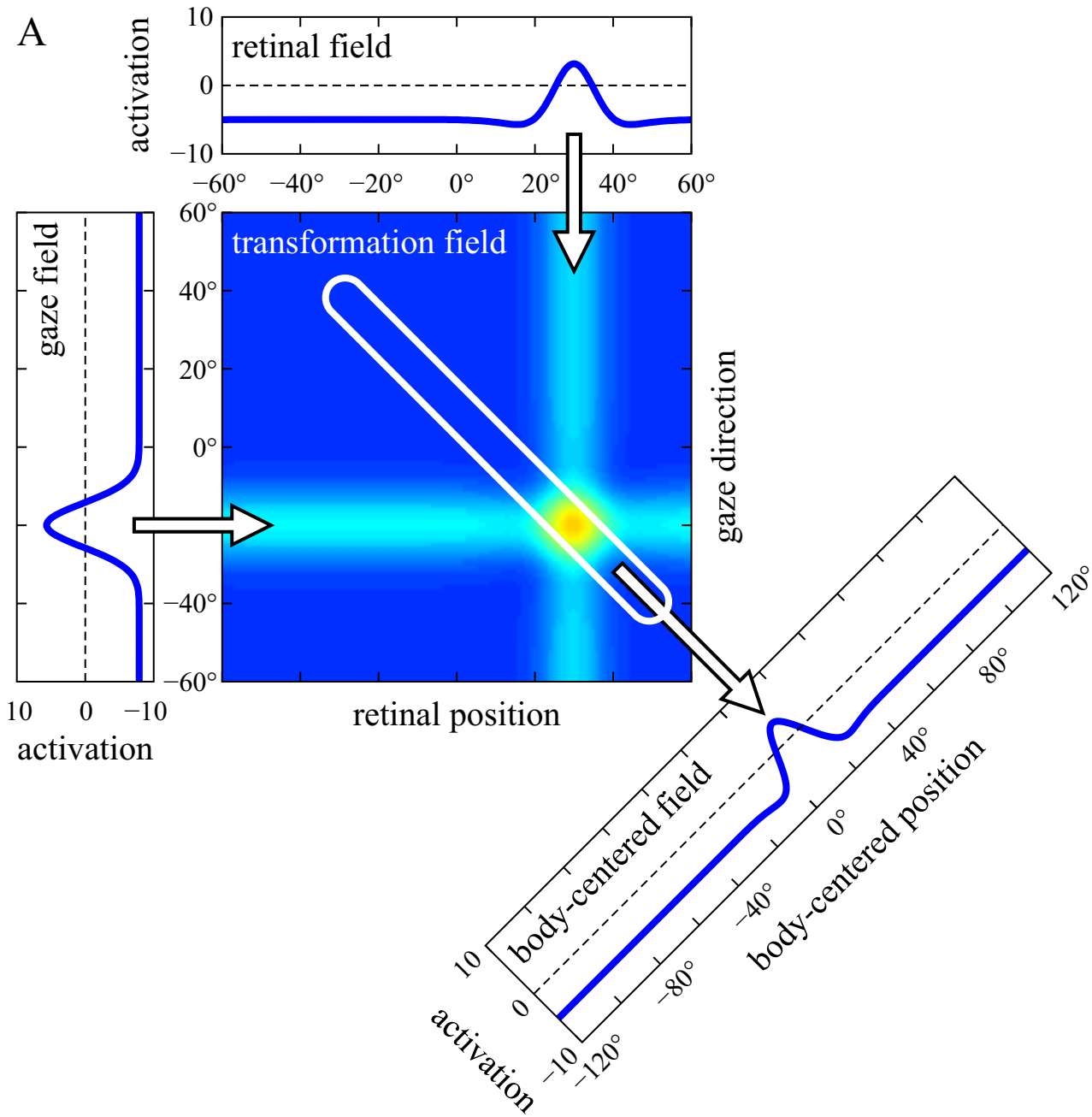
Coordinate transform

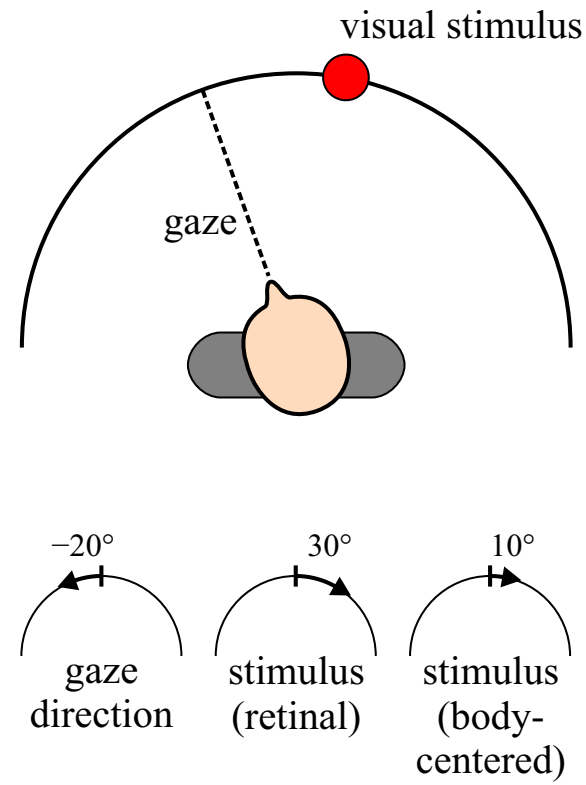




[Schneegans Ch 7 of *DFT Primer*, 2016]

Coordinate transform

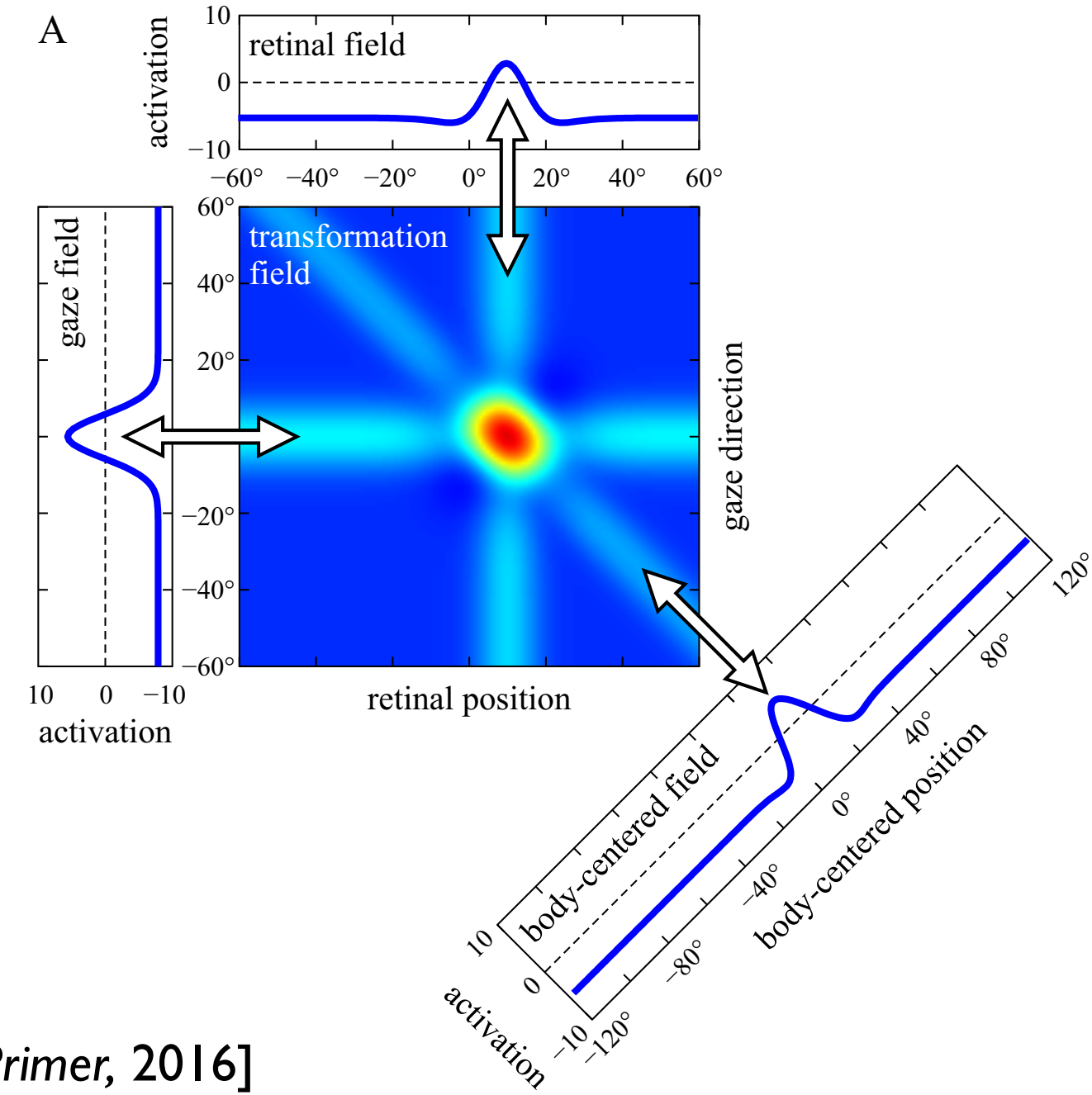




[Schneegans Ch 7 of *DFT Primer*, 2016]

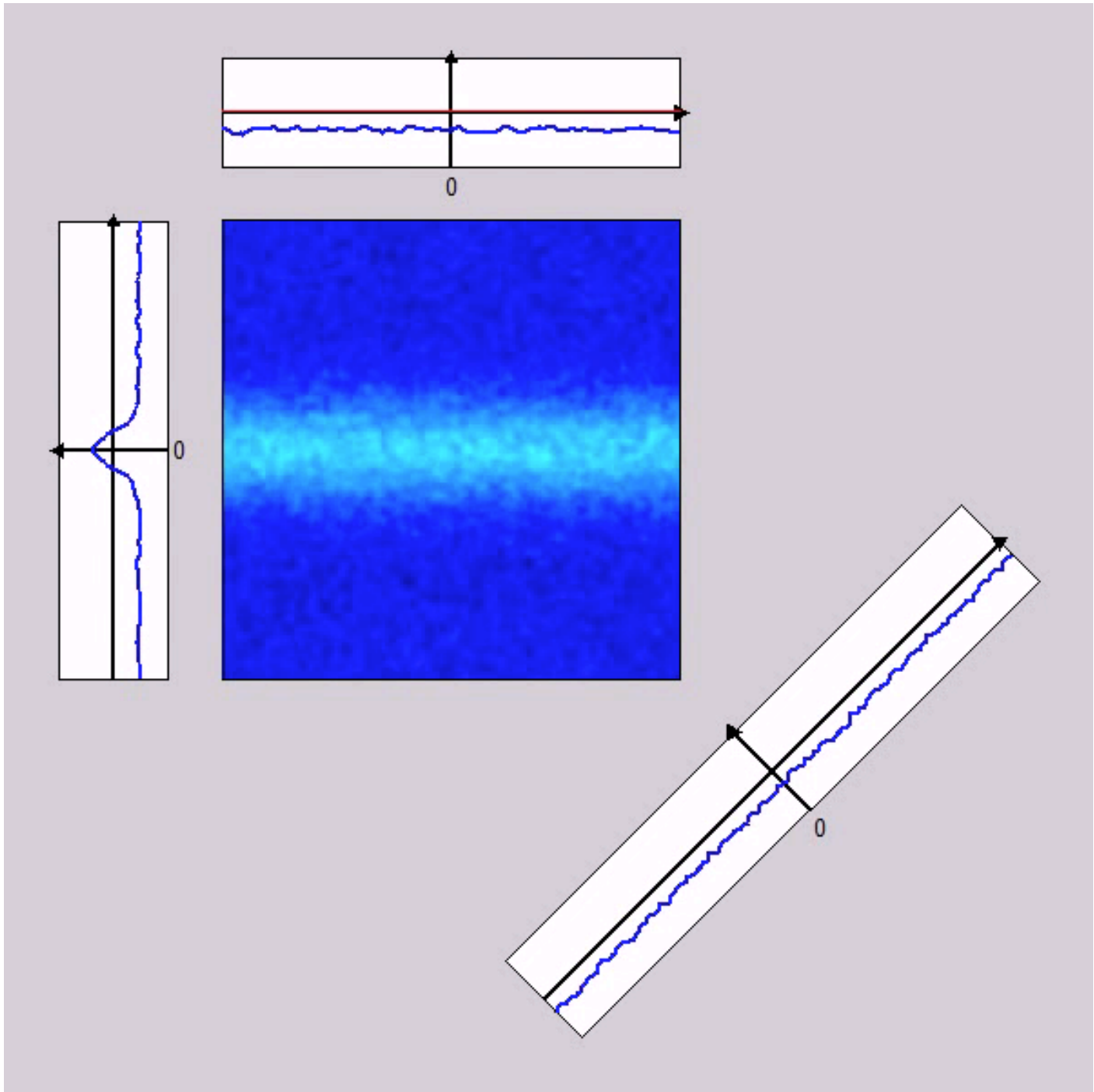
Retina => body space

- bi-directional coupling
- => predict retinal coordinates



[Schneegans Ch 7 of *DFT Primer*, 2016]

Spatial remapping during saccades



[Schneegans, Schöner *Biological Cybernetics* 2012]

Roadmap

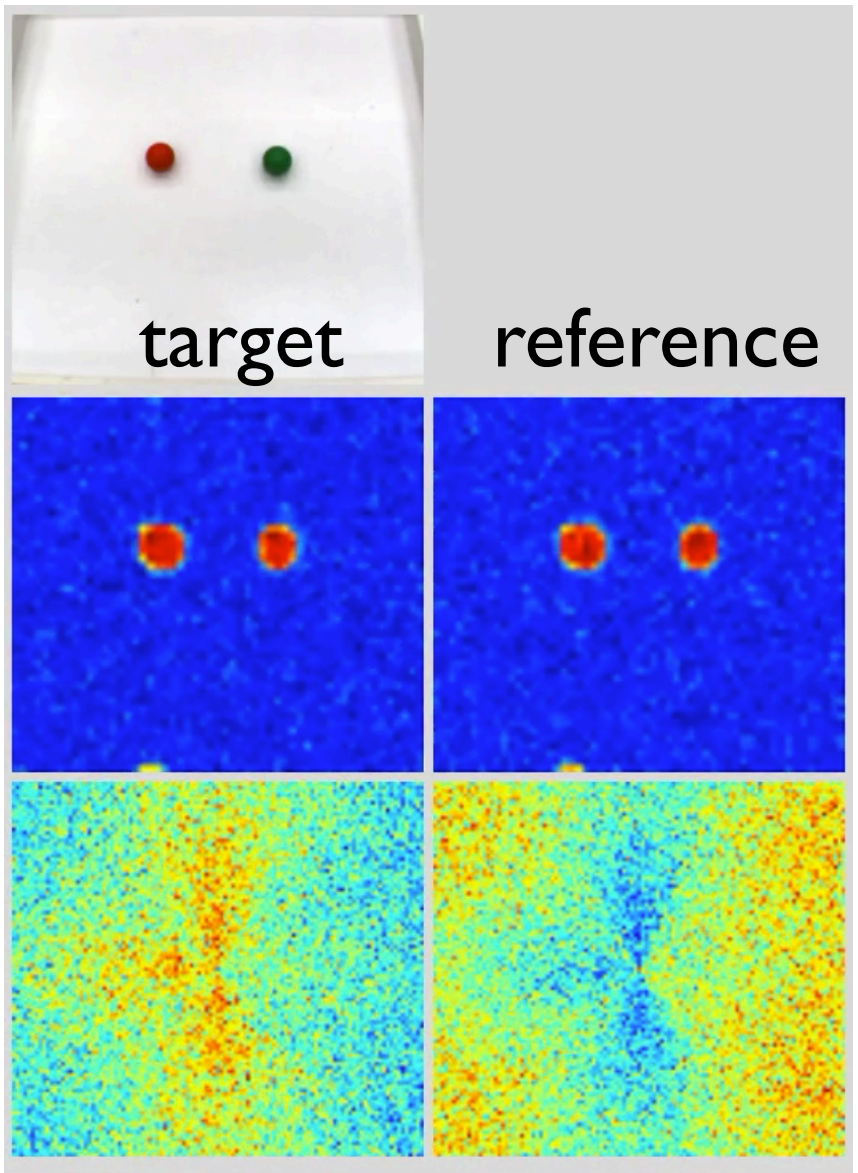
Session 3: Grounded cognition

- coordinate transforms
- relational concepts
- grounding
- mental mapping

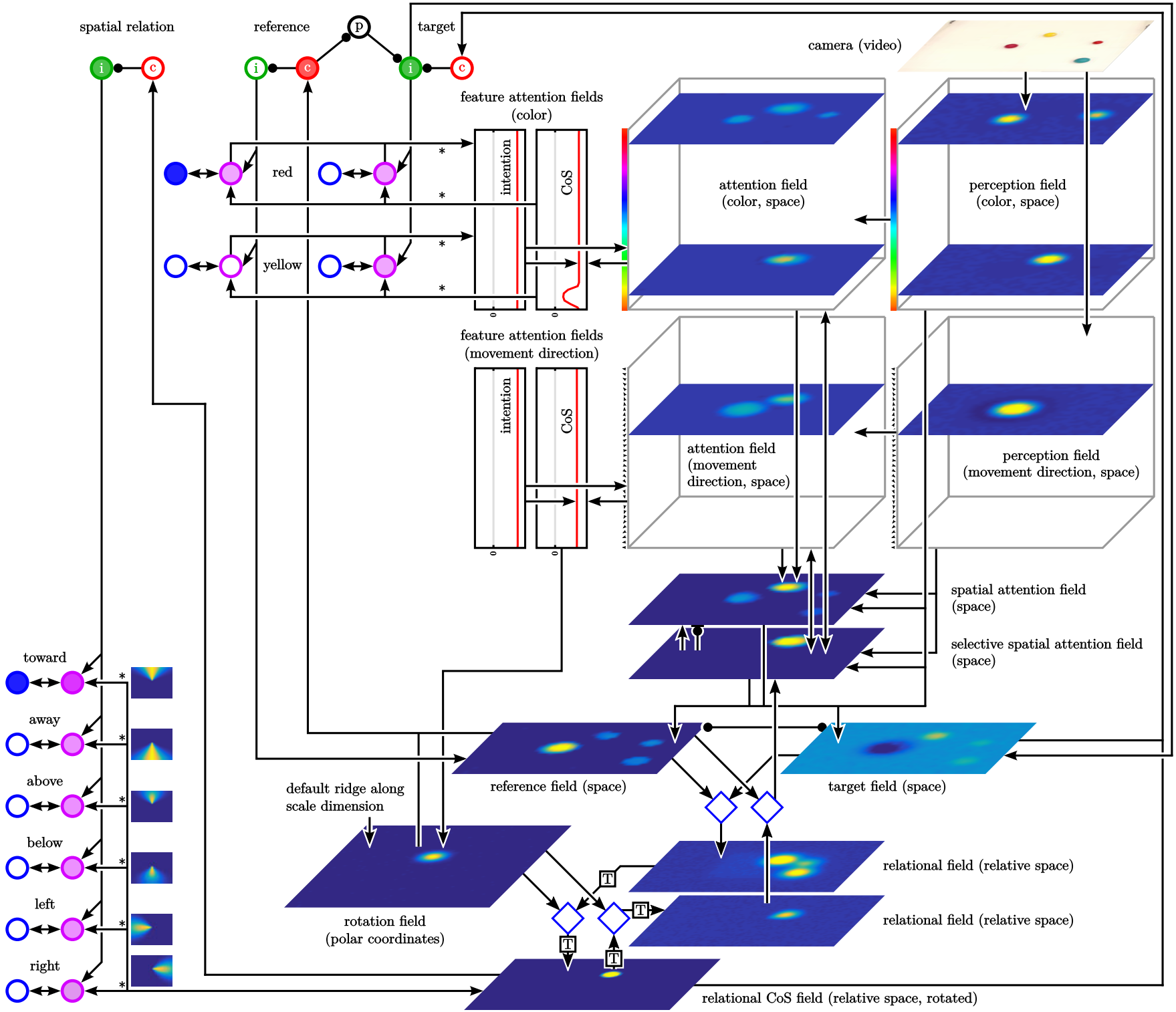
Concepts, relational thinking

- grounding: bringing the target object of a relational phrase into the attentional foreground

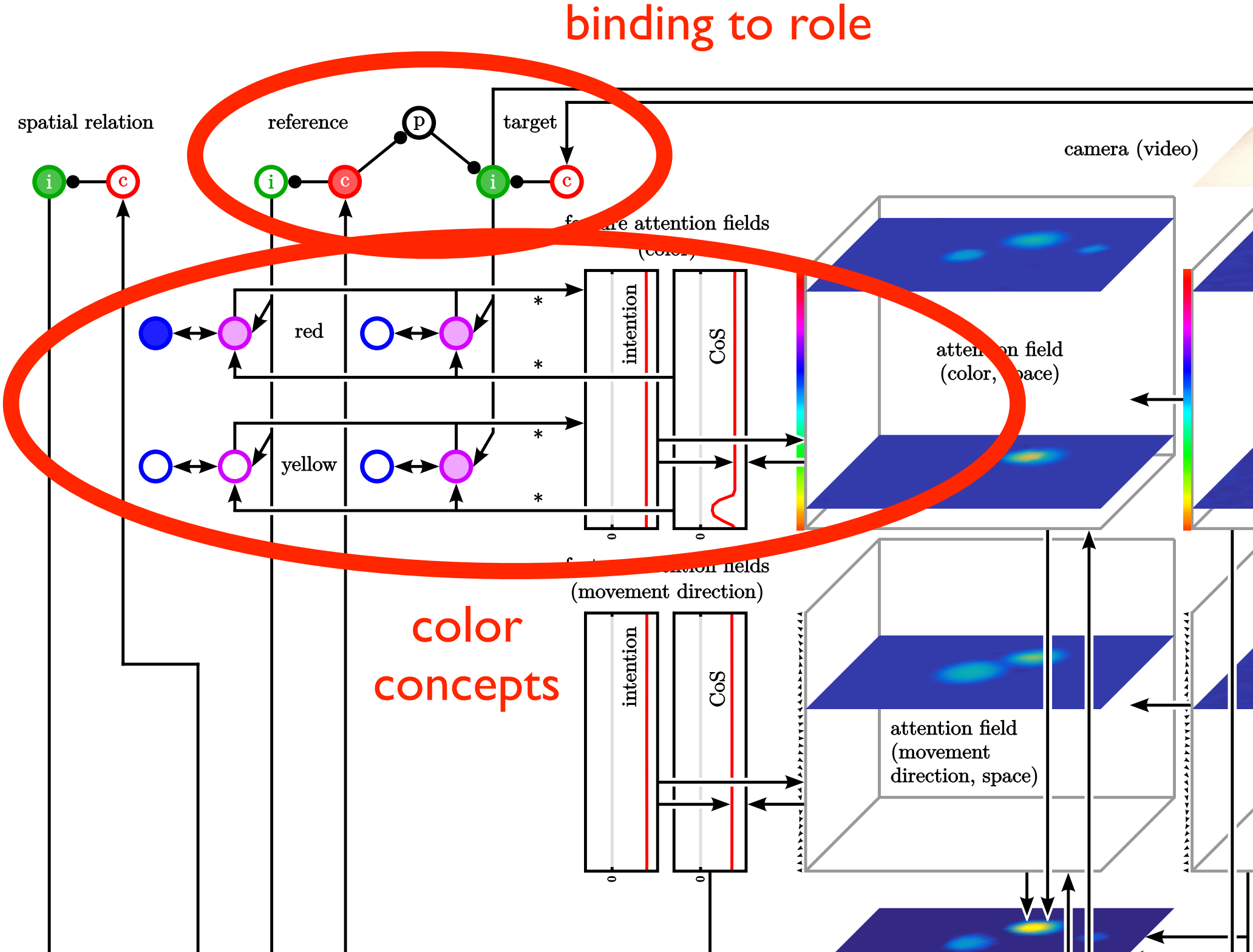
"red to the left of green"



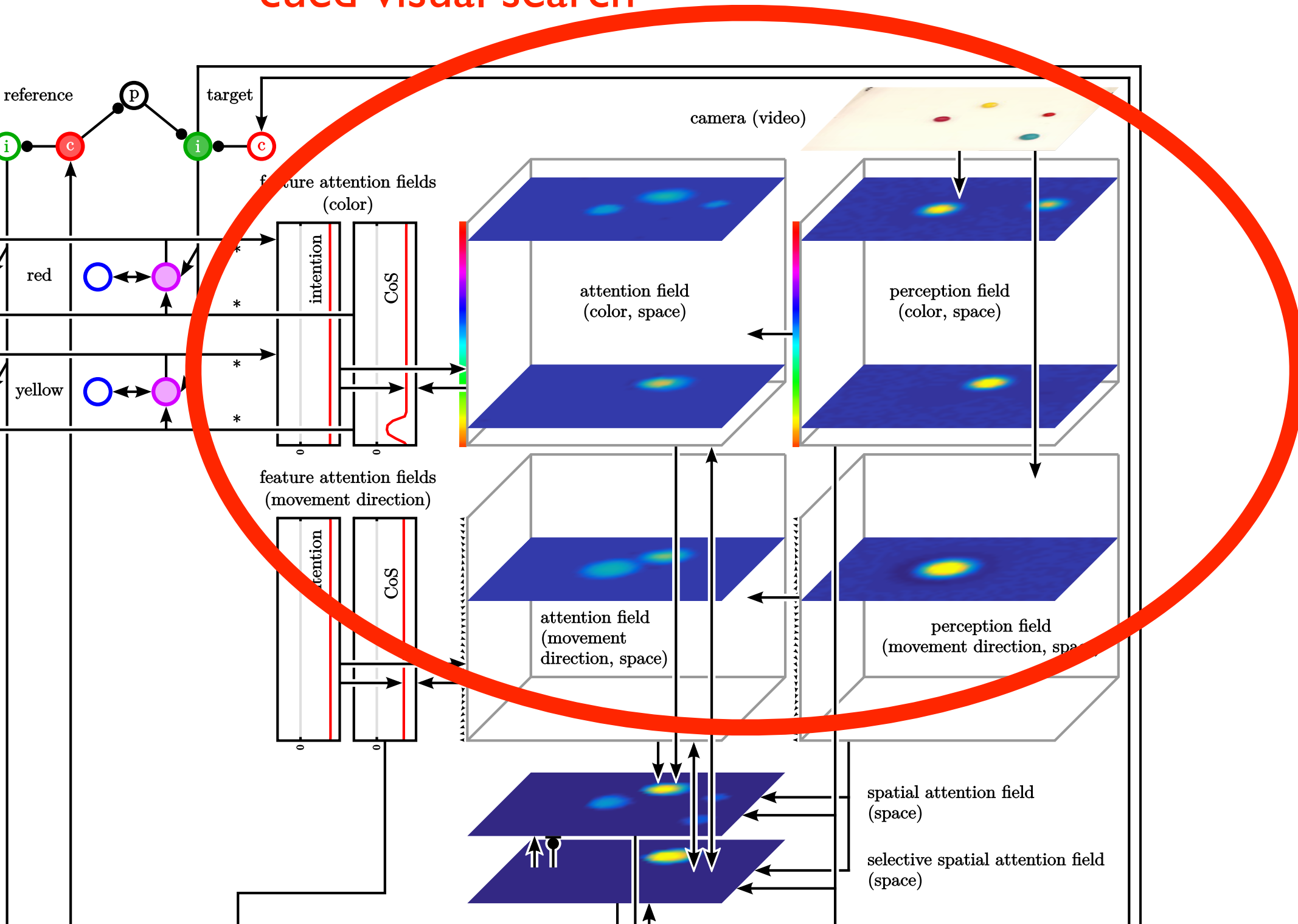
[Lipinski, Sandamirskaya, Schöner 2009 … Richter, Lins, Schöner, *Topics* 2017]

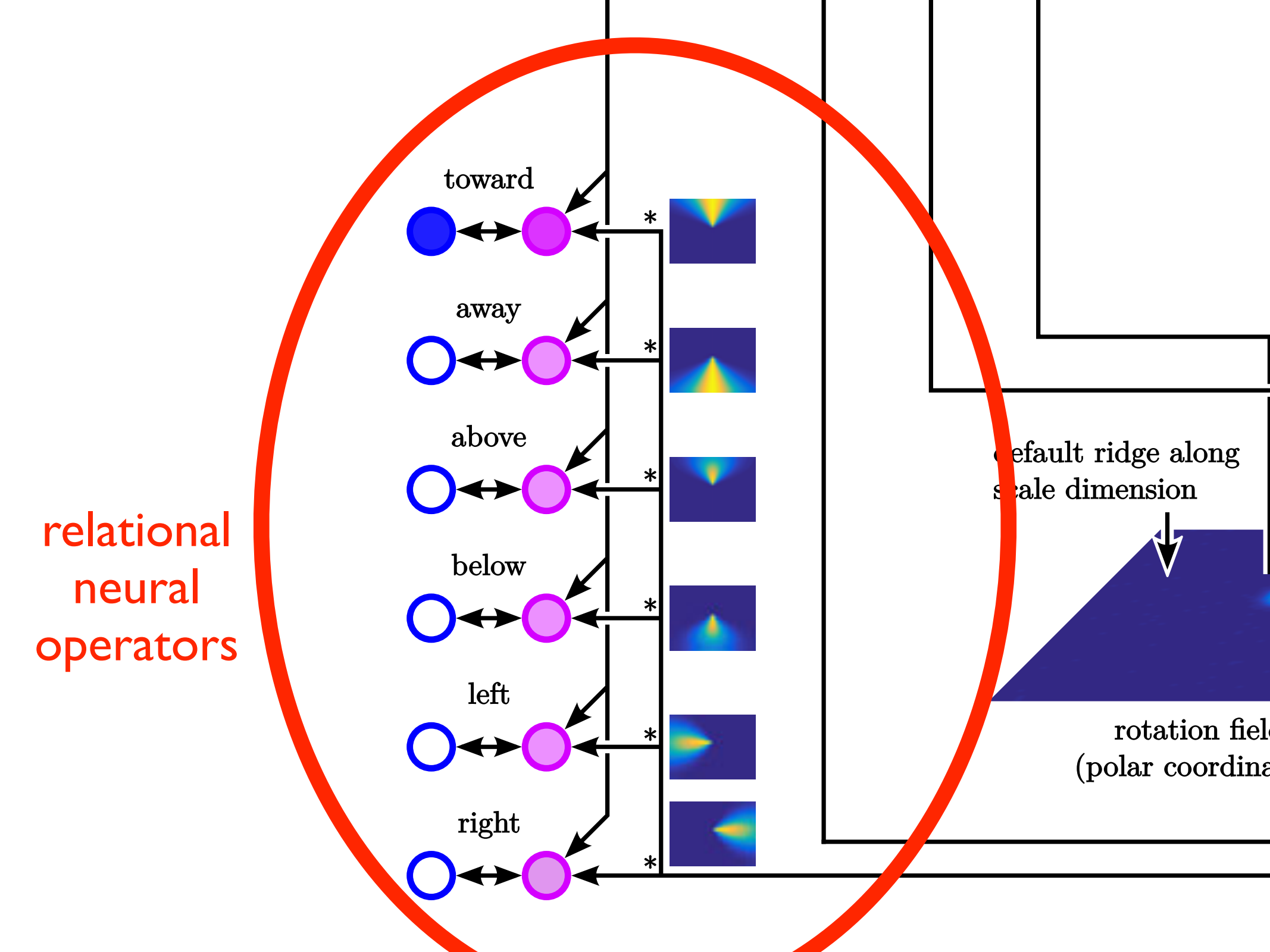


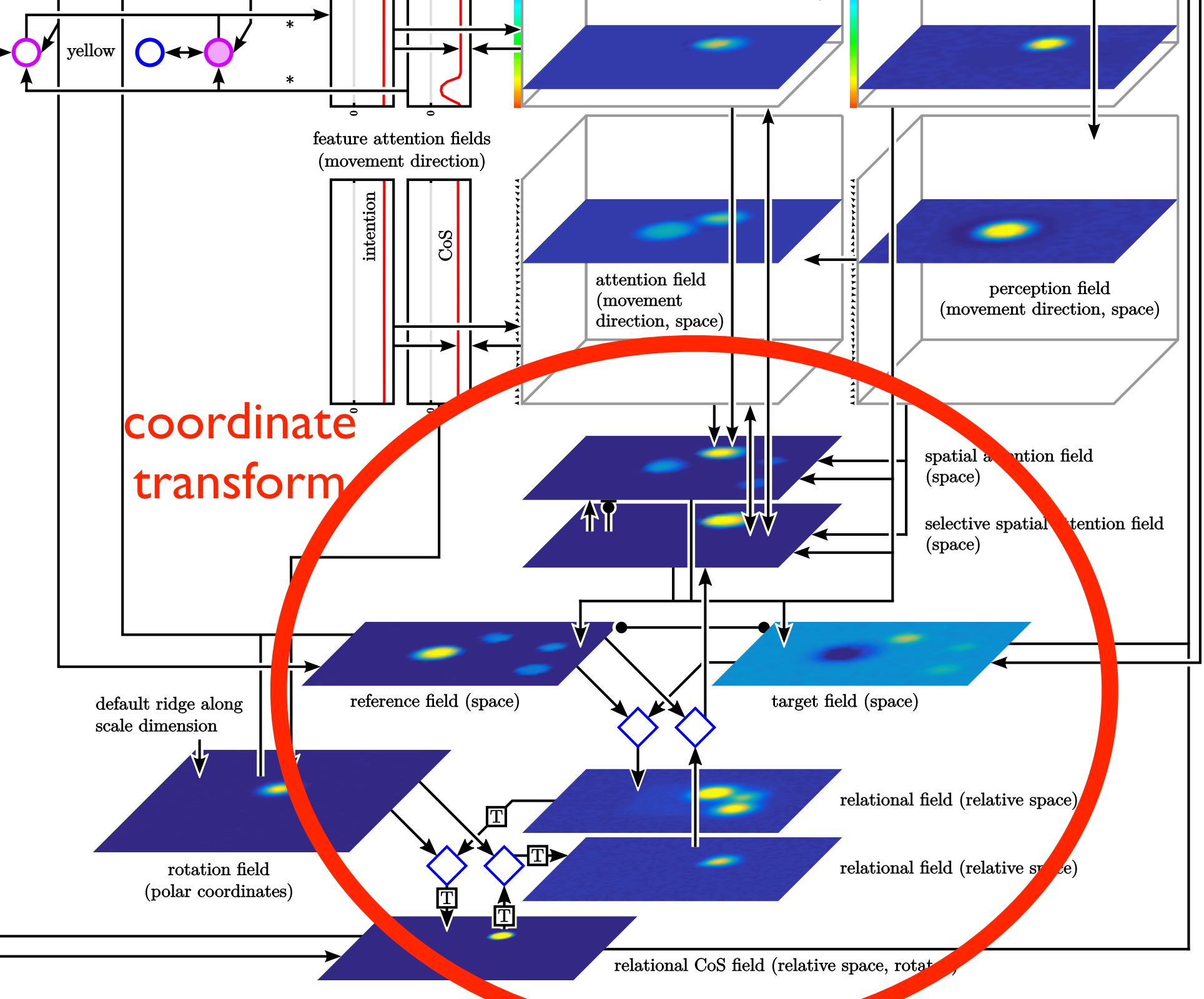
[Richter, Lins, Schöner, ToPiC (2017)]


binding to role
spatial relation
reference
target
camera (video)
red
yellow
intention
CoS
color concepts
(movement direction)
attention field (movement direction, space)

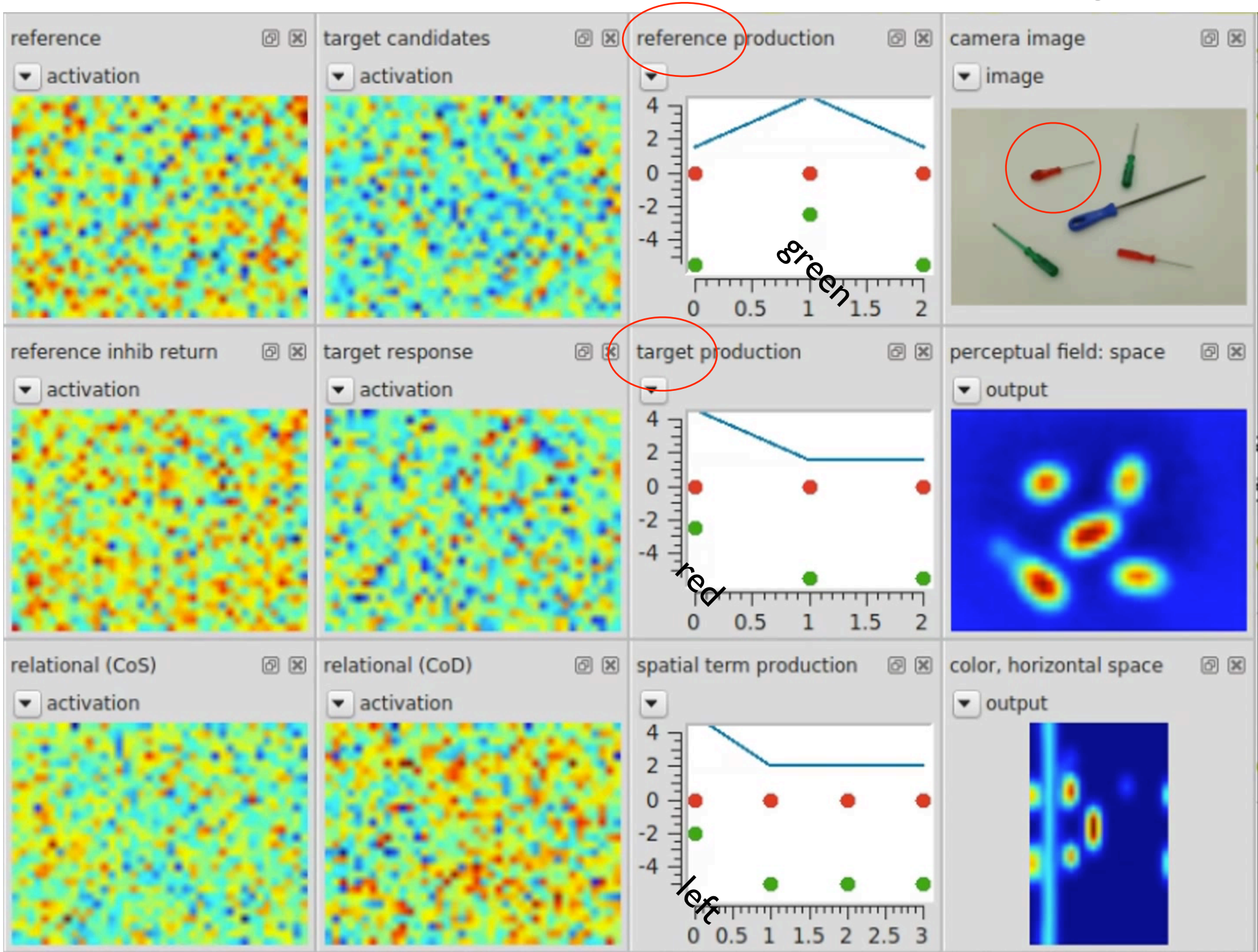
cued visual search




relational
neural
operators
toward
away
above
below
left
right
*
*
*
*
*
*
efault ridge along
cale dimension
rotation fiel
(polar coordina


yellow
feature attention fields
(movement direction)
intention
CoS
attention field
(movement
direction, space)
perception field
(movement direction, space)
coordinate
transform
spatial attention field
(space)
selective spatial attention field
(space)
reference field (space)
target field (space)
default ridge along
scale dimension
rotation field
(polar coordinates)
relational field (relative space)
relational field (relative space)
T
relational CoS field (relative space, rotat

“red to the left of green”



Concepts, relational thinking

- => hands on exercise

Roadmap

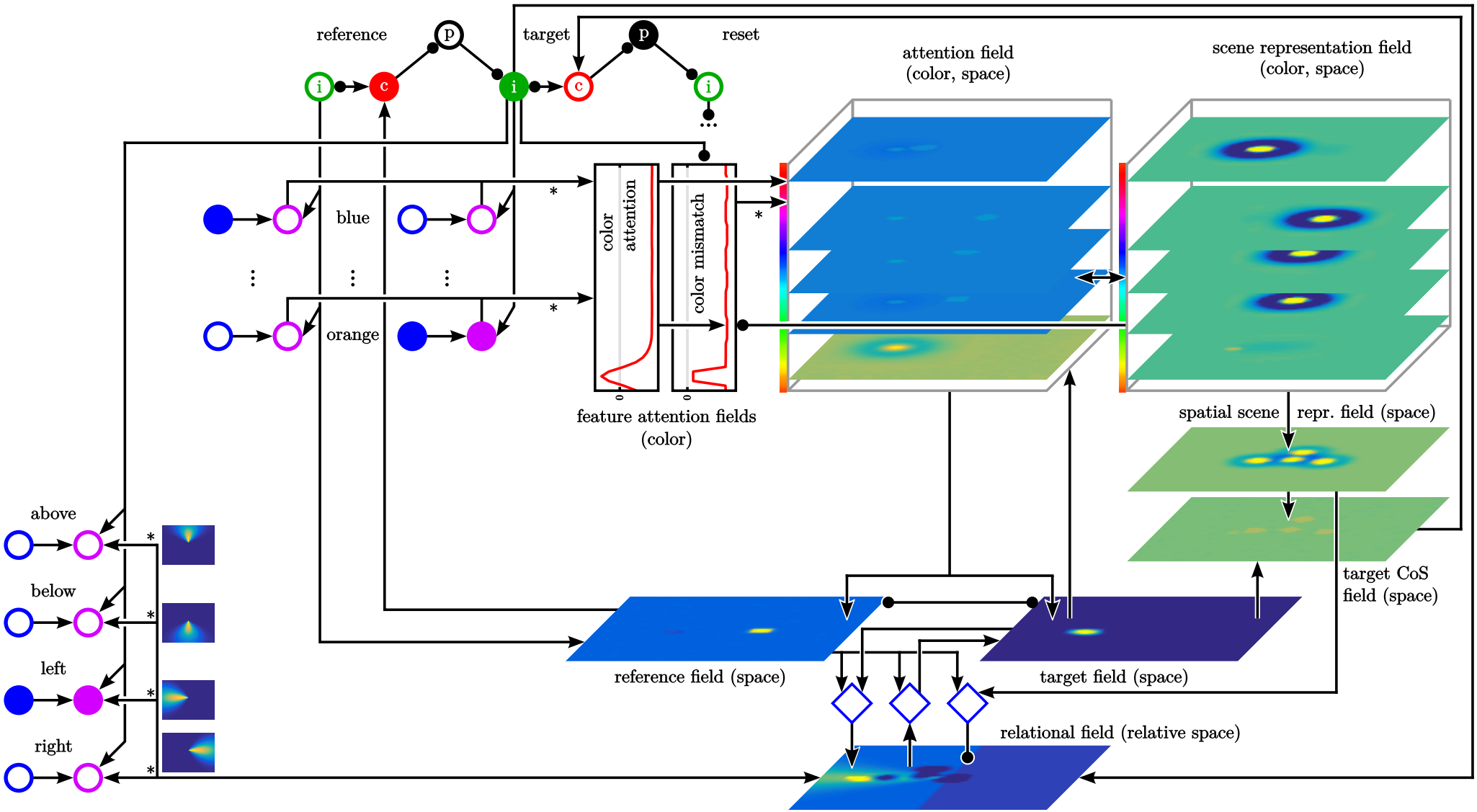
Session 3: Grounded cognition

- coordinate transforms
- relational concepts
- grounding
- mental mapping

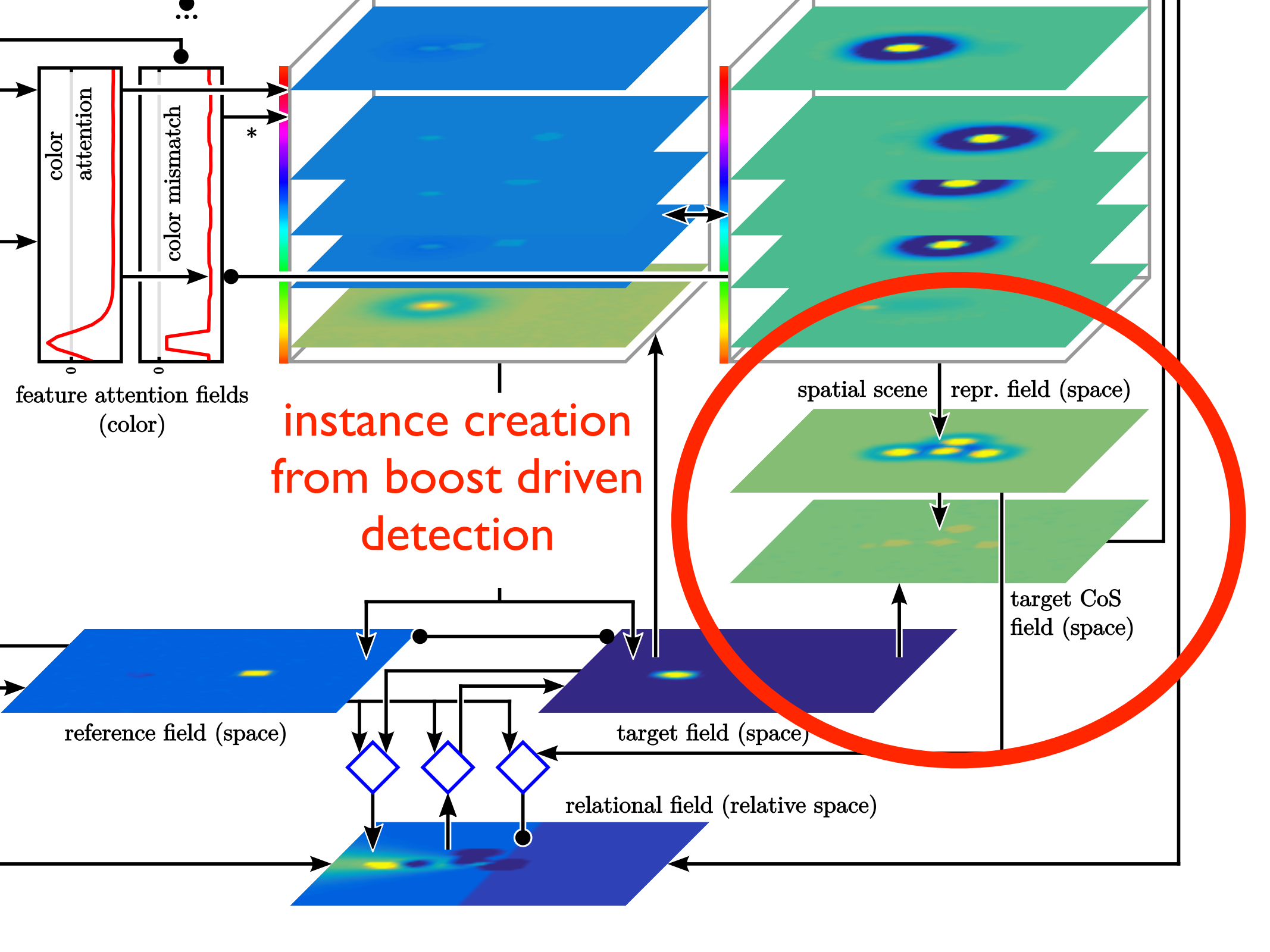
Mental mapping and inference

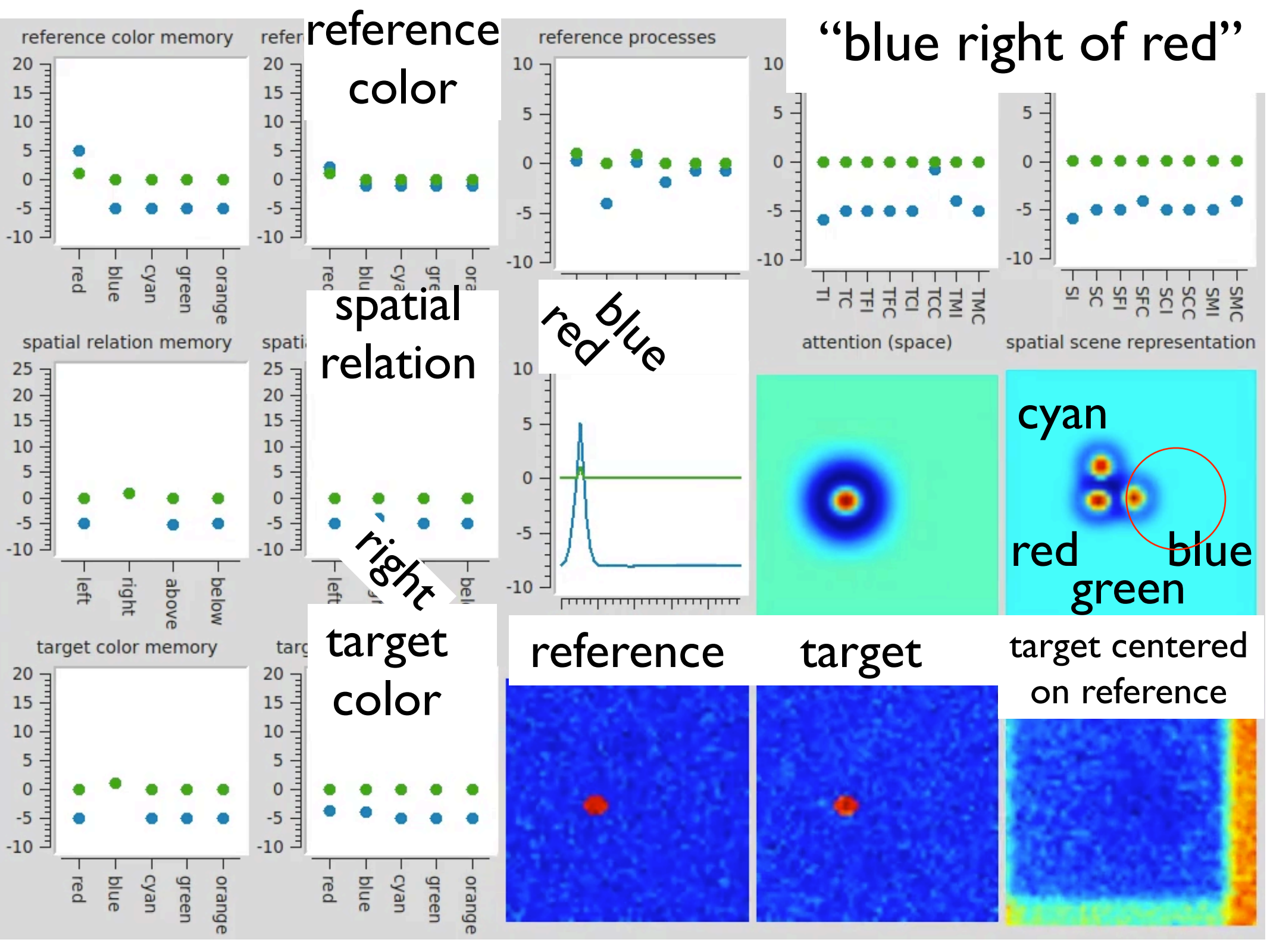
- propositions
  - "There is a cyan object above a green object."
  - "There is a red object to the left of the green object."
  - "There is a blue object to the right of the red object."
  - "There is an orange object to the left of the blue object."
- inference
  - "Where is the blue object relative to the red object?"

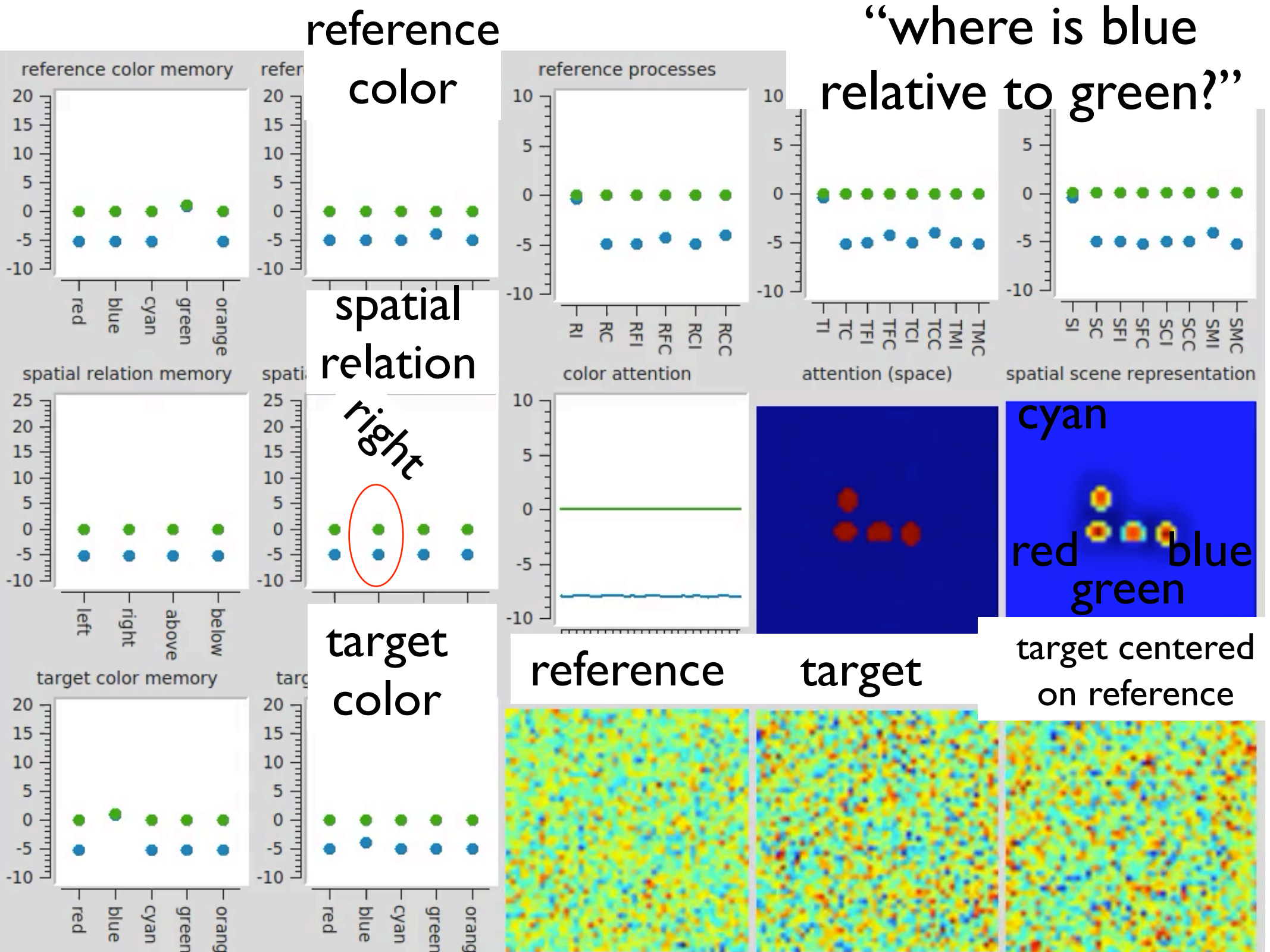
[Ragni, Knauff, *Psych Rev* 2013]



[Kounatidou, Richter, Schöner, CogSci 2018]


color attention
color mismatch
*
0
0
feature attention fields (color)
instance creation from boost driven detection
spatial scene
repr. field (space)
target CoS field (space)
reference field (space)
target field (space)
relational field (relative space)


reference color memory
red
blue
cyan
green
orange
reference color
reference processes
"blue right of red"
TI
TC
TFI
TFC
TCI
TCC
TMI
TMC
attention (space)
SI
SC
SFI
SFC
SCI
SCC
SMI
SMC
spatial scene representation
spatial relation memory
left
right
above
below
spatial relation
blue
red
right
cyan
red
blue
green
target color memory
target color
reference
target
target centered on reference


reference color
"where is blue relative to green?"
reference color memory
reference processes
red
blue
cyan
green
orange
RI
RC
RFI
RFC
RCI
RCC
TI
TC
TFI
TFC
TCI
TCC
TMI
TMC
SI
SC
SFI
SFC
SCI
SCC
SMI
SMC
spatial relation
spatial relation memory
color attention
attention (space)
spatial scene representation
right
left
above
below
cyan
red
blue
green
target color
target color memory
reference
target
target centered on reference

Roadmap

Session 3: Grounded cognition

- coordinate transforms
- relational concepts
- grounding
- mental mapping