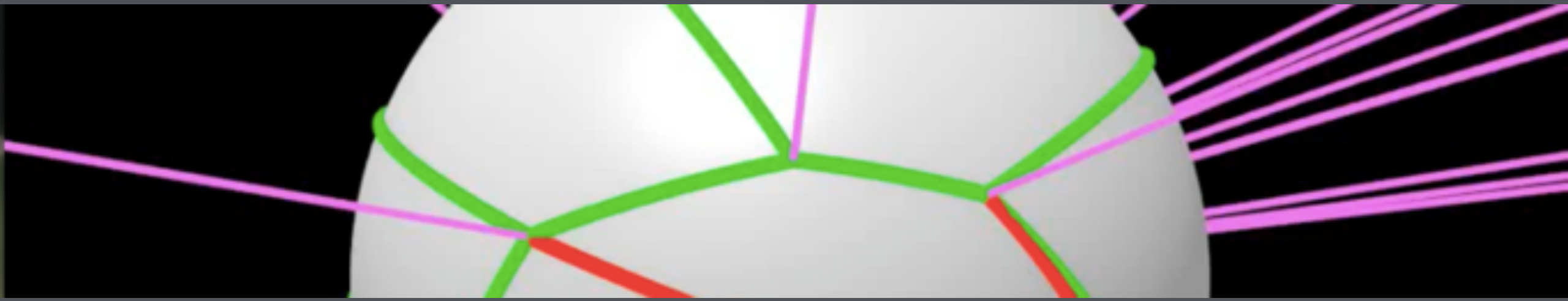
School of Psychology and
Clinical Language Sciences

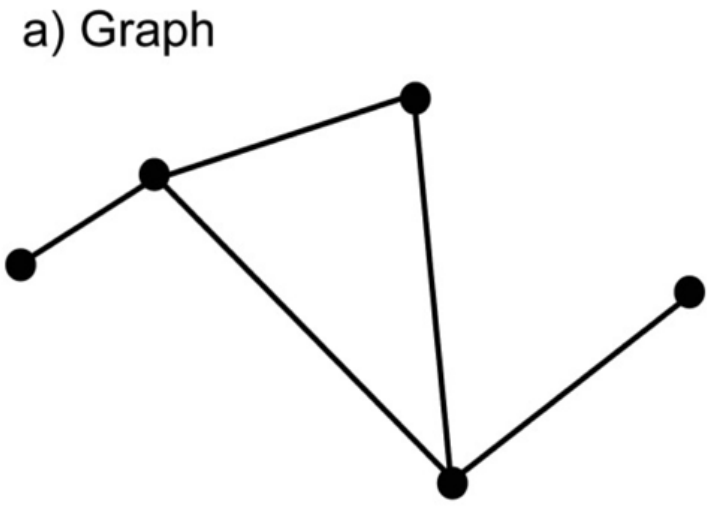
University of Reading

POINTING ERRORS IN NON-METRIC VIRTUAL ENVIRONMENTS



Andrew Glennerster

Hierarchical representation of space



From Chrastil and Warren, 2014

- Siegel and White (1975)

Outline

- A pointing experiment with ‘wormholes’
- Two models of the data assuming:
  - a distorted representation of space (metric)
  - a distorted representation of space *and* independent rotation of regions (non-metric)
- A non-metric model fits the data best

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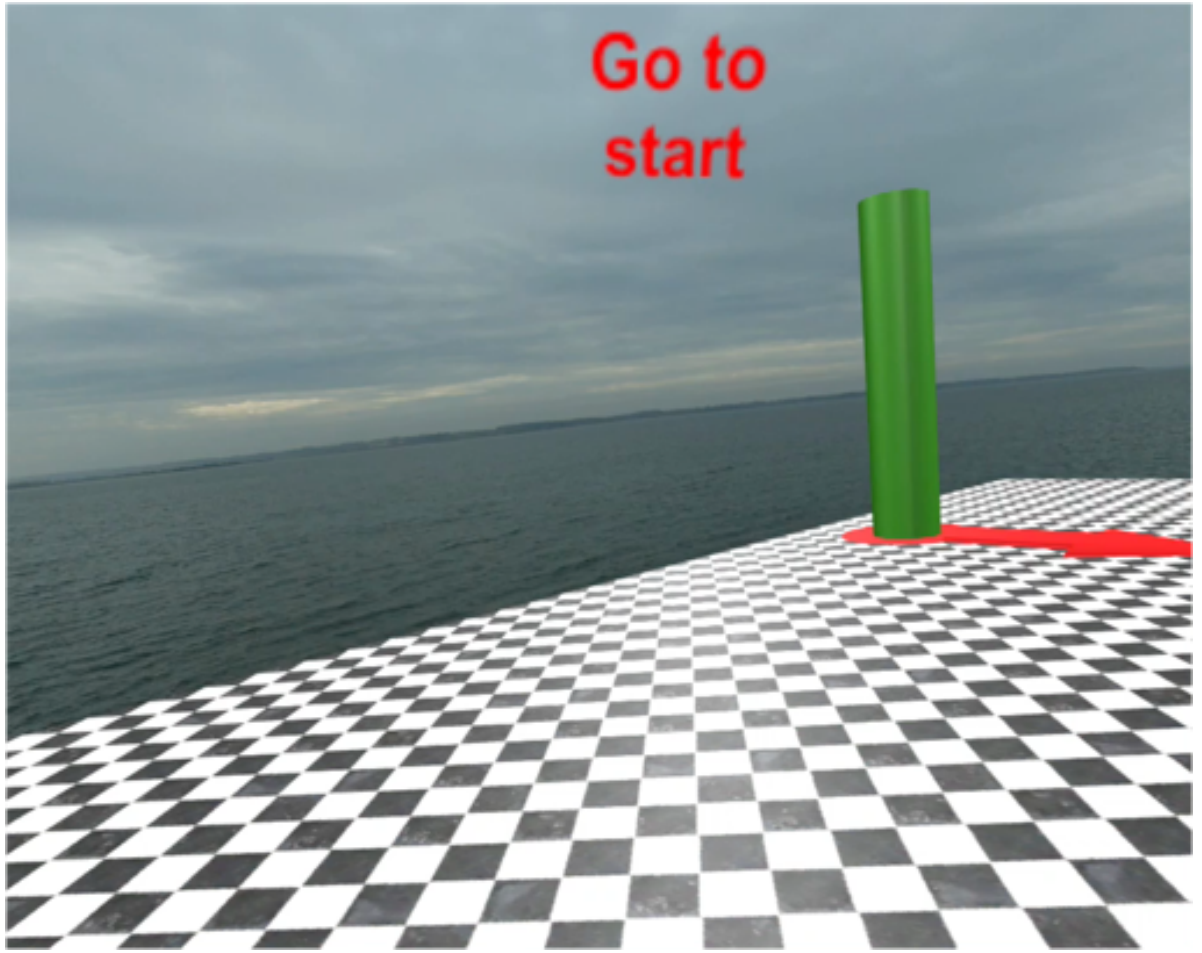
Learning to point to targets in a maze



Tasks:

(i) find targets in specified order and

(ii) point to them…

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Learning to point to targets in a maze

- 14 Vicon cameras
- nVis SX111 HMD
- 3 by 3m space
- Maze is 5 by 5m reduced to 3/5 size about cyclopean point (virtual floor is above real floor)
- Participants hold a tracked pointing device rendered as long pole (‘sword’) during the pointing task
- 8 participants

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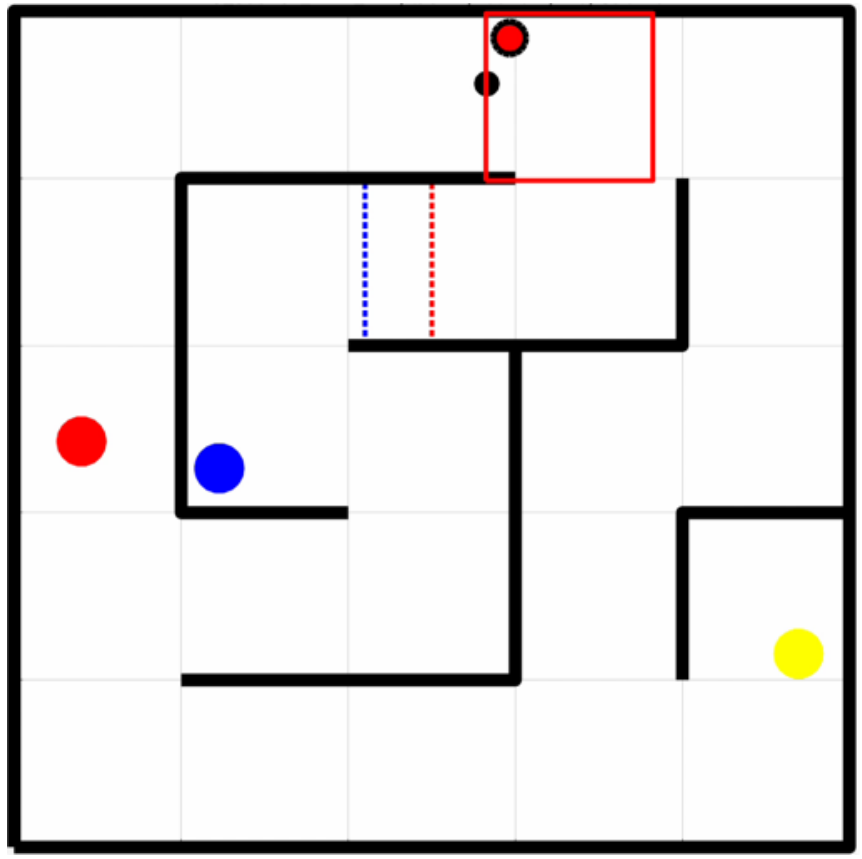
Learning to point to targets in a maze



Life gets harder…

Learning phase (repeat x5):
a) Navigation: go Start-R-G-B-Y
b) Pointing: from Y point to S, R, G, B

Test phase (x3):
a) novel sequences (e.g. G-B-Y-R)
b) Point to all targets

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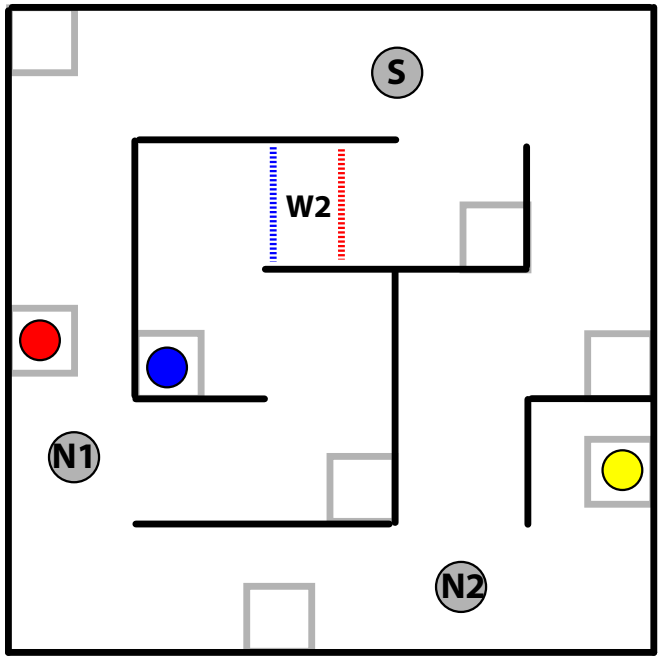
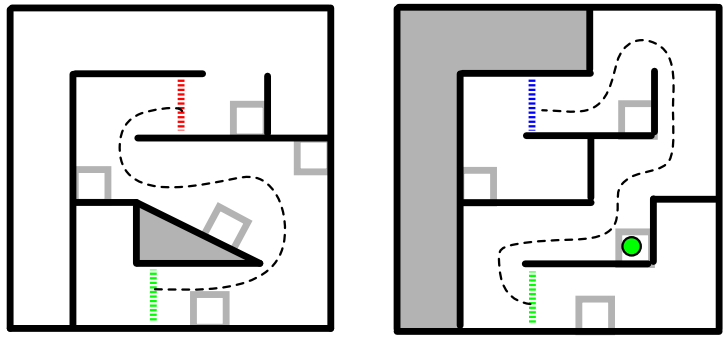
Non-metric scene: 1 wormhole

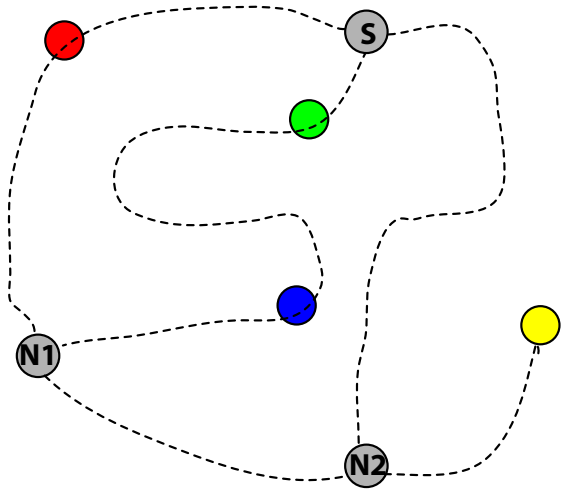


- topological node
- small walls
- w - wormhole

wormhole



topological graph



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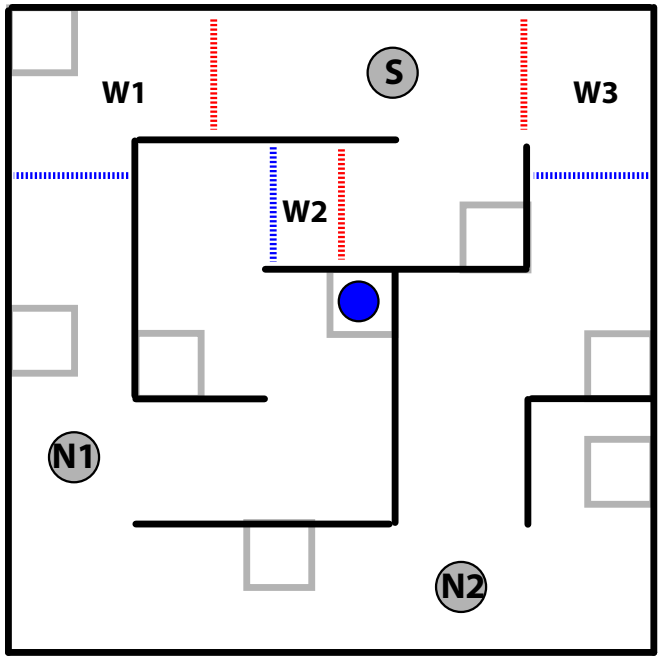
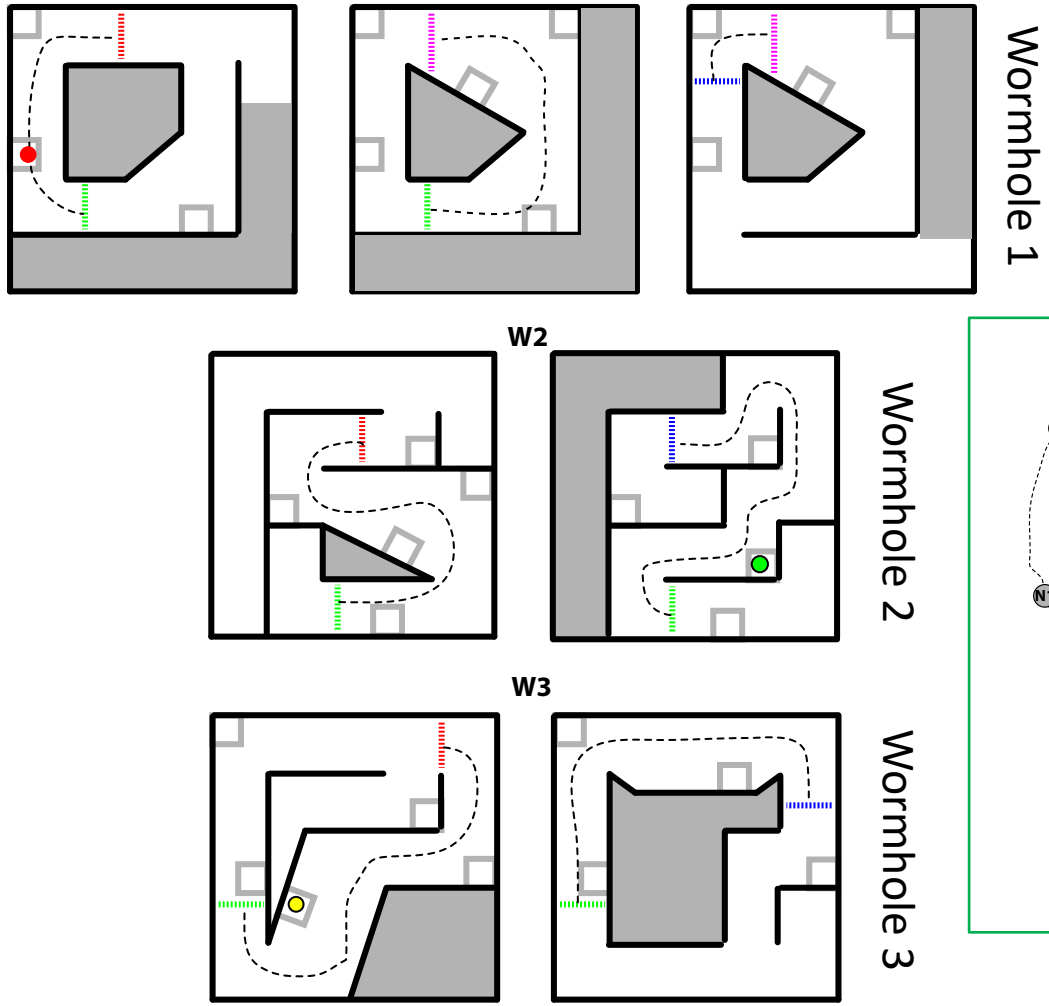
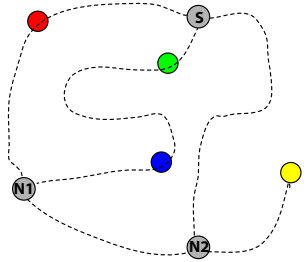
Non-metric scene: 3 wormholes



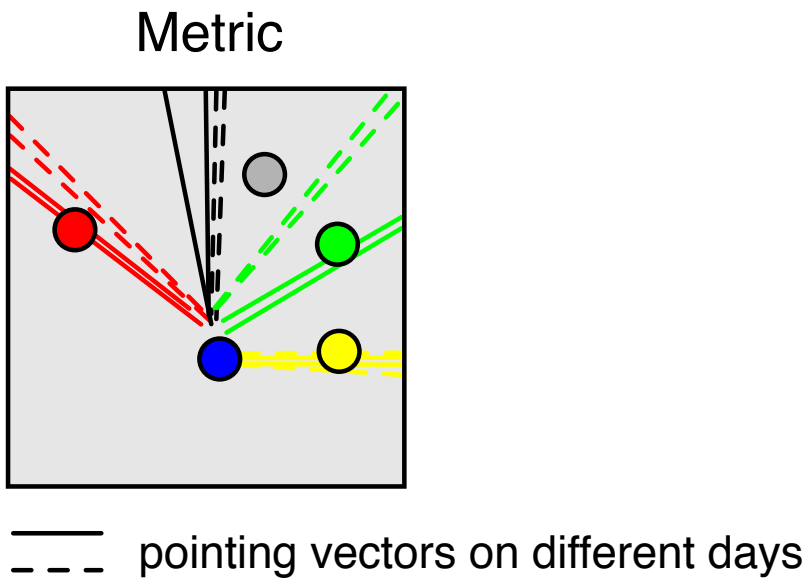
- topological node
- small walls
- wormhole



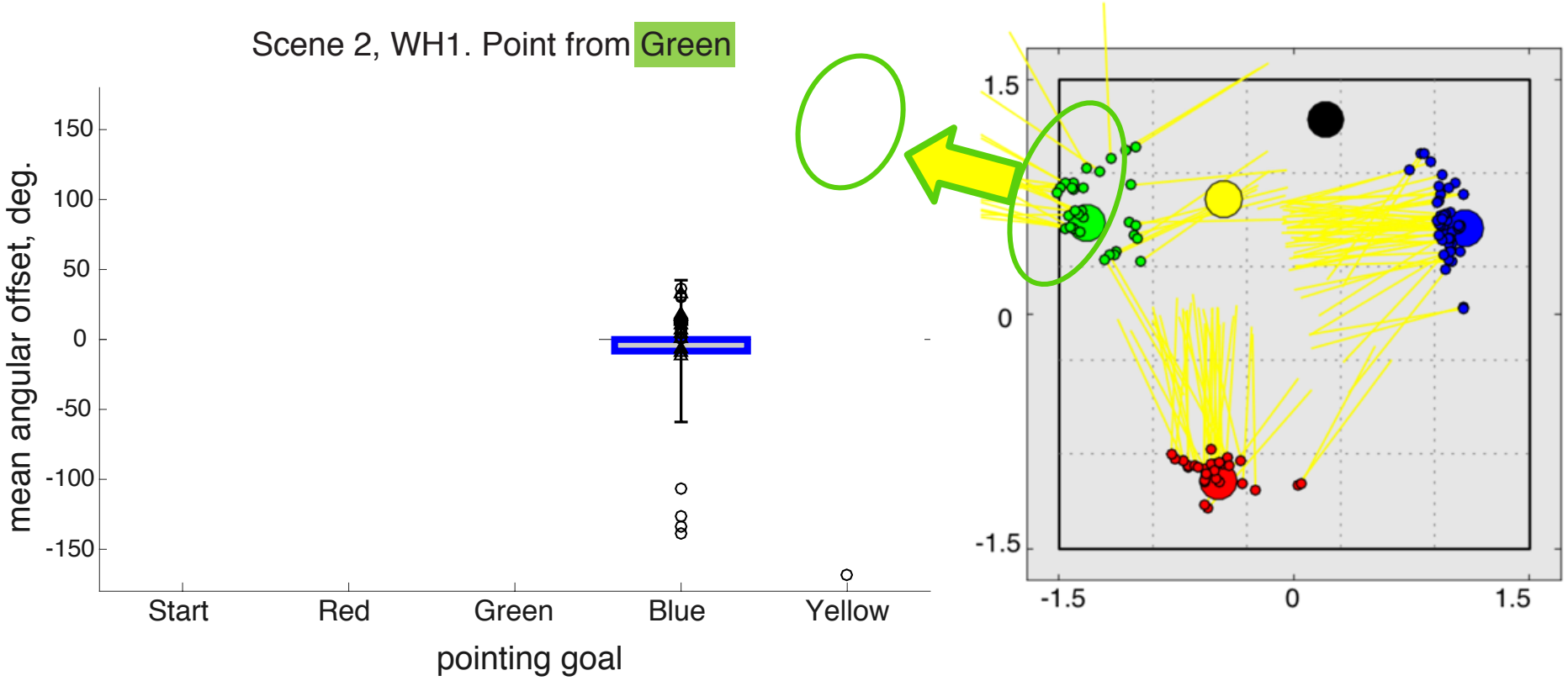


… but same topological structure

Example of pointing

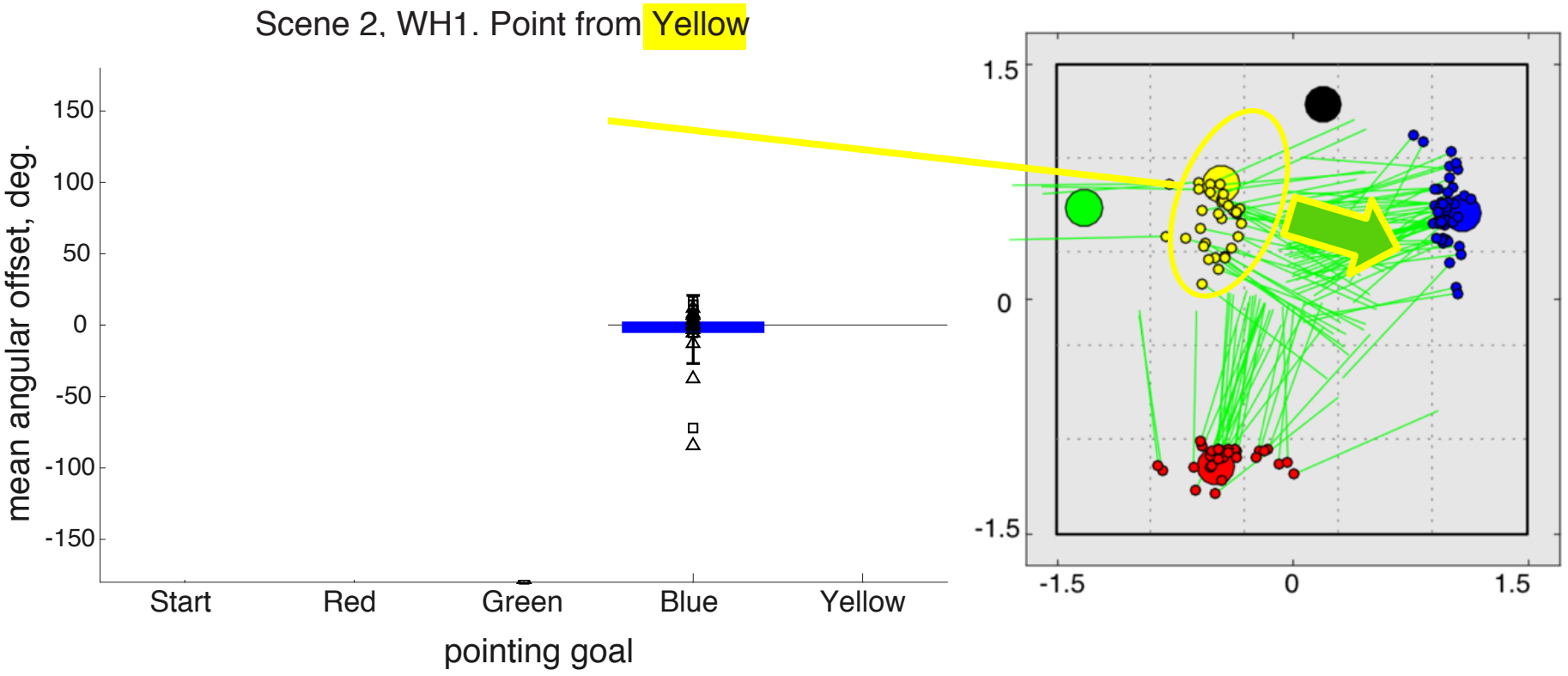


Pointing: a 'metric' task



Pointing to some targets leads to very large, systematic errors.

Pointing: a 'metric' task



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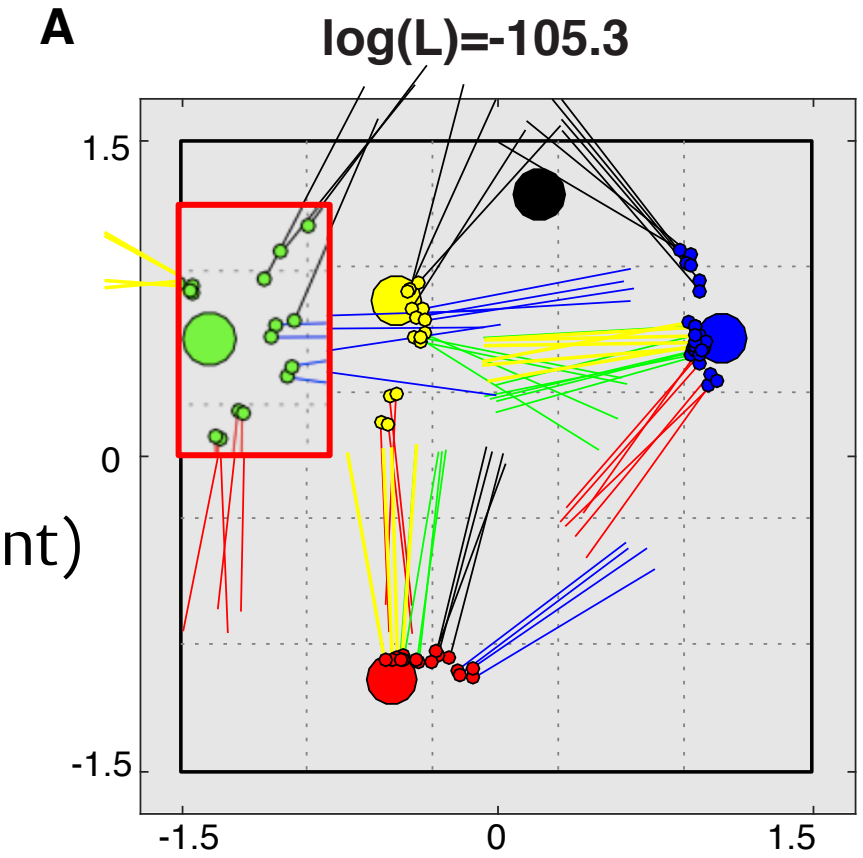
Pointing: a 'metric' task

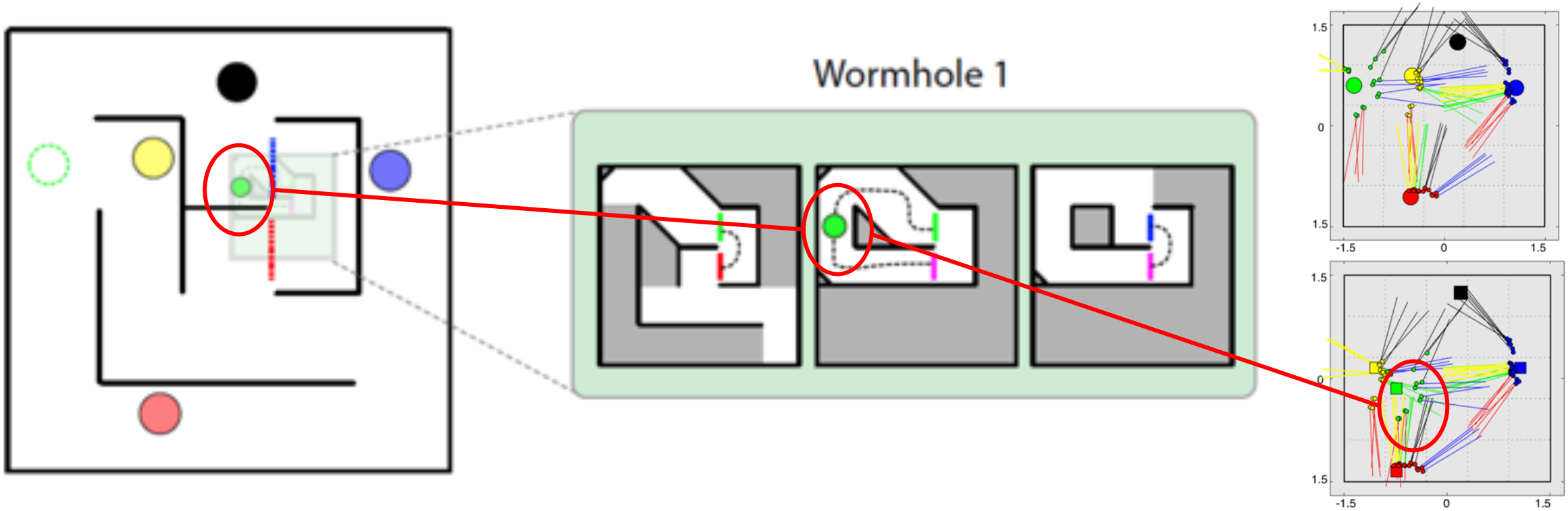


Original (one participant)

Maximum likelihood configuration

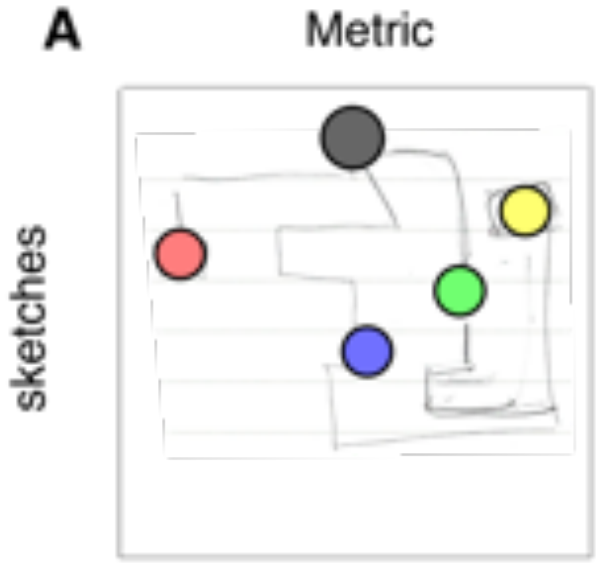
In the most likely configurations, green is to the east of yellow.

Pointing: a ‘metric’ task



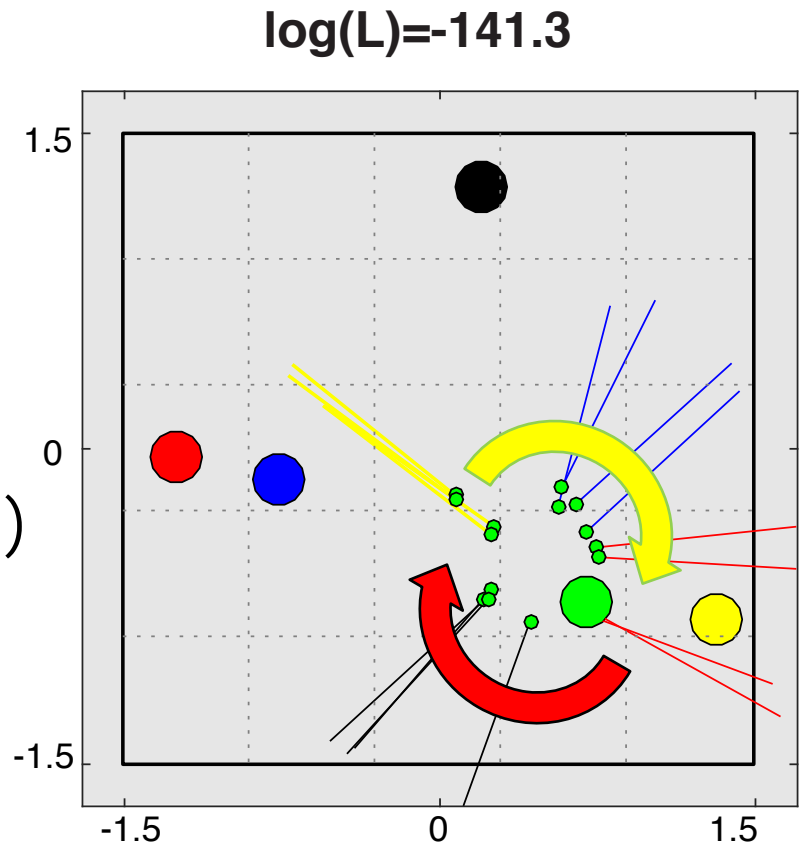
It seems as if participants ‘squash’ the wormhole corridors into a smaller region than they actually occupy .

Sketches



Adding in rotation

Original (one participant)



180° rotation of all pointing directions

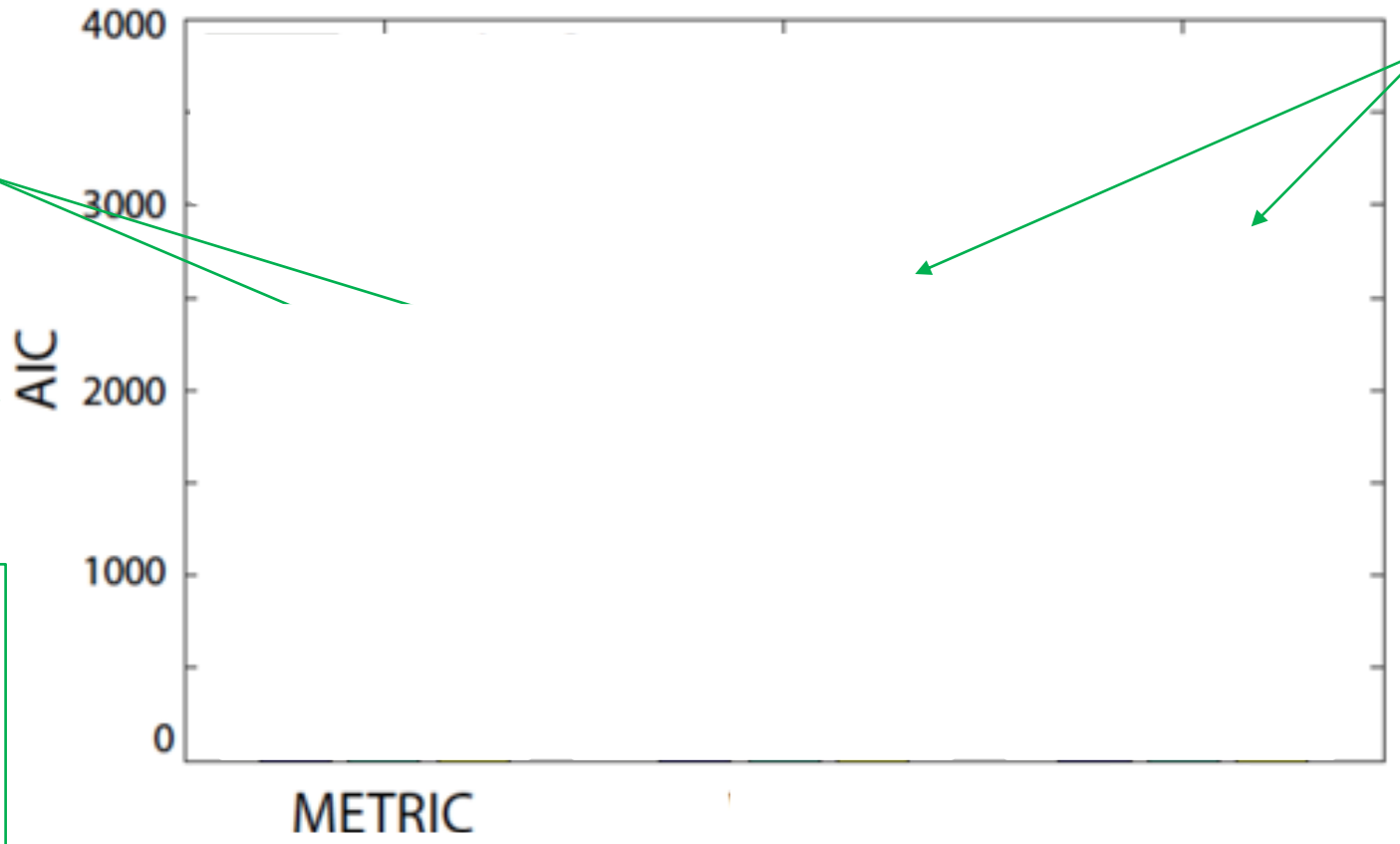
We fit with 0°, 90°, 180°, 270° rotation

This takes into account the possibility that people are disoriented.
But it is not compatible with a single, consistent 3D representation.

Model comparison

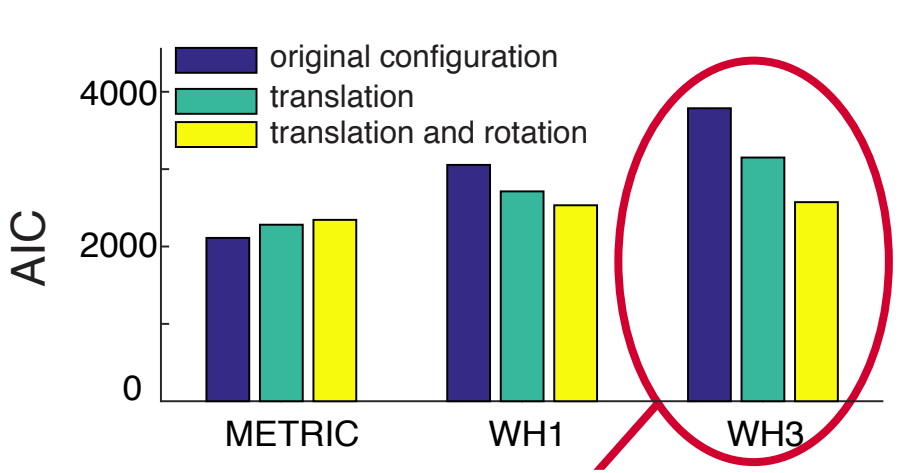
In the METRIC condition, optimised translation and rotation are not better models than the original configuration (when penalized for the extra parameters in the models)

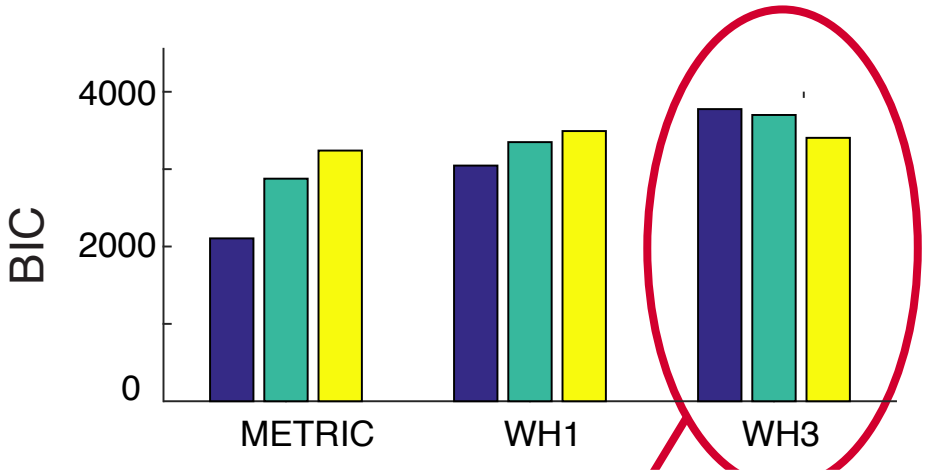
Akaike information criterion, a measure of likelihood (low is more likely)



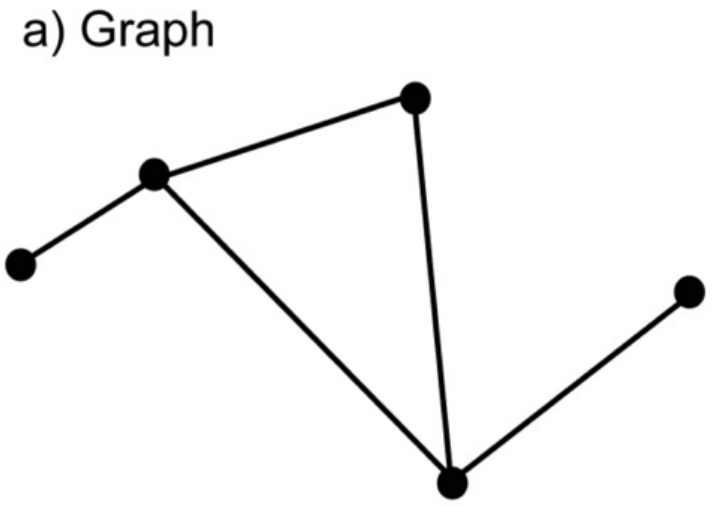
In the WORMHOLE conditions, the best model is one that optimizes the location of the targets (i.e. a distorted world) *and* optimizes the rotation of the observer independently at each pointing zone

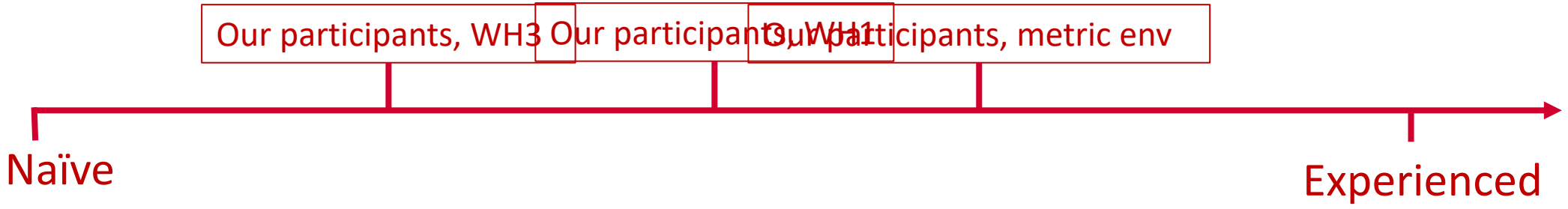
This is not a consistent, metric, 3D representation


original configuration
translation
translation and rotation
AIC
4000
2000
0
METRIC
WH1
WH3


BIC
4000
2000
0
METRIC
WH1
WH3

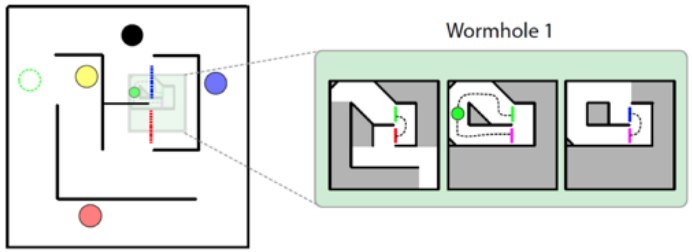
Learning to point to targets in a maze



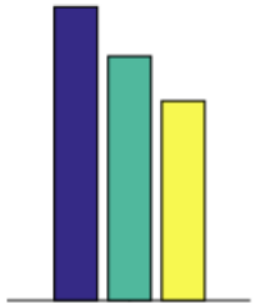


Summary

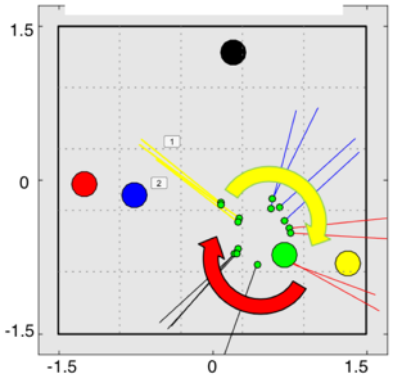
- A pointing experiment with ‘wormholes’



- Two models of the data assuming:
  - a distorted representation of space (metric)
  - a distorted representation of space *and* independent rotation of regions (non-metric)



- A non-metric model fits the data best



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Thanks…

Alex Muryy

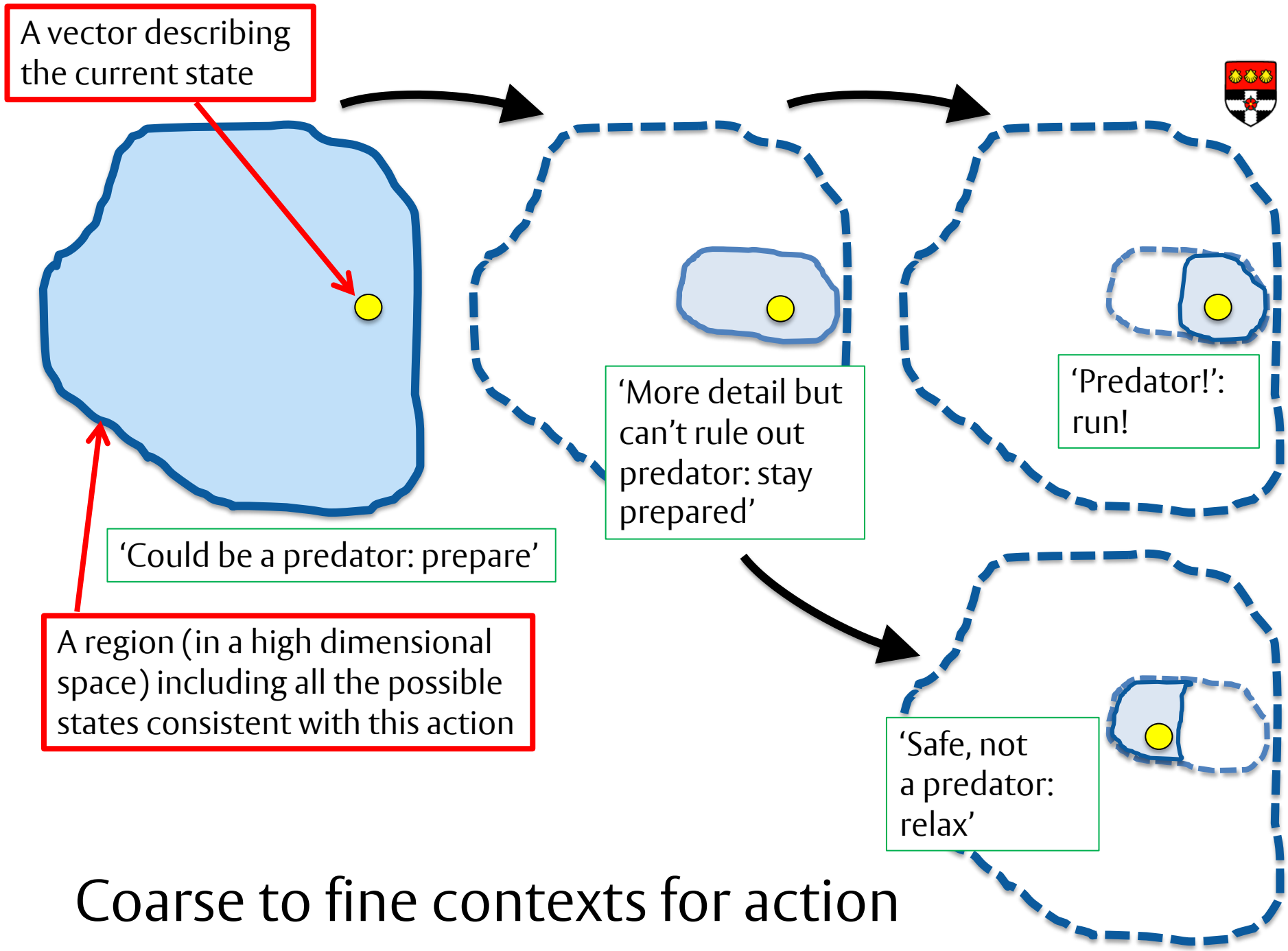
Luise Gootjes-Dreesbach

Peter Scarfe

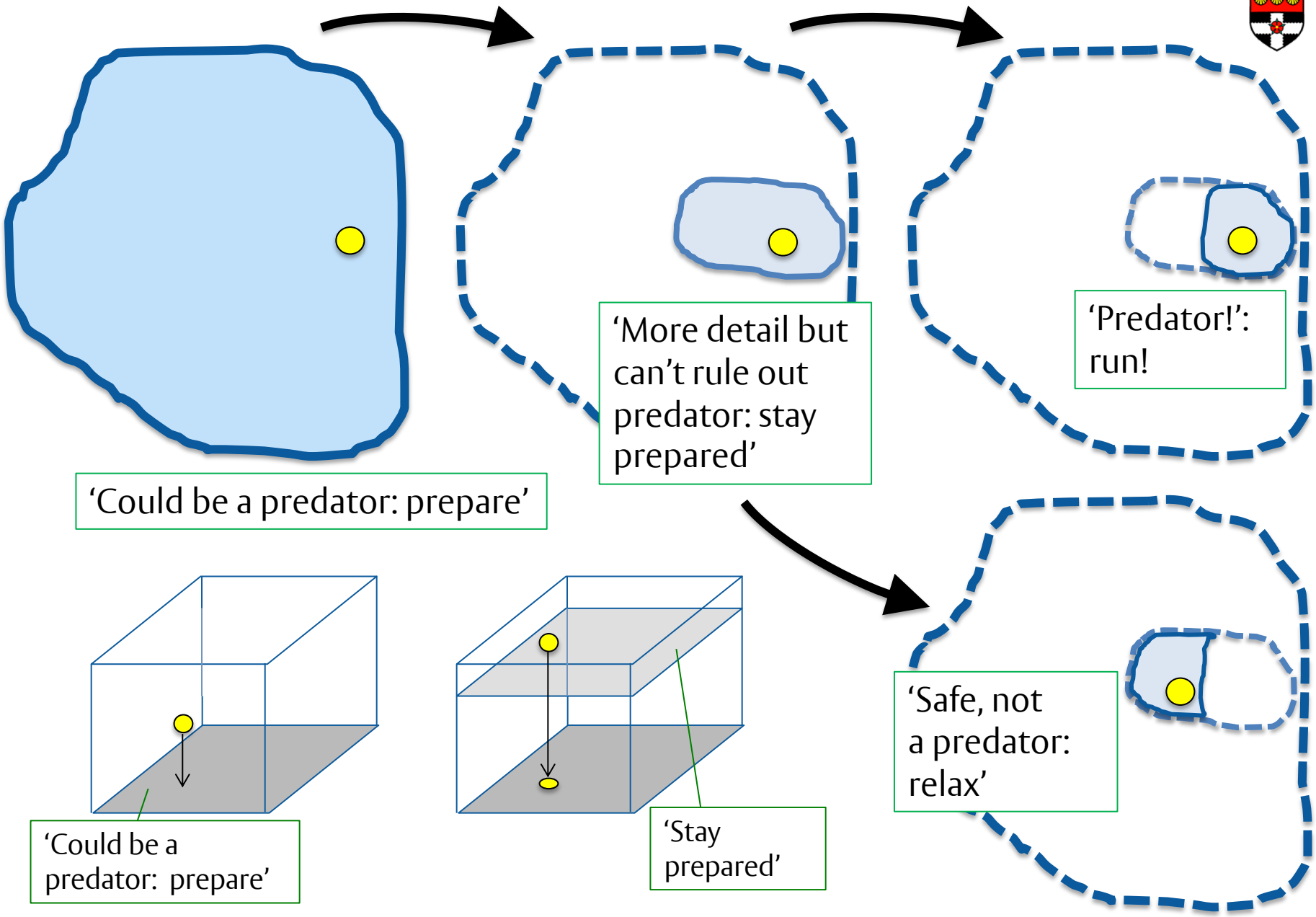
Microsoft Research

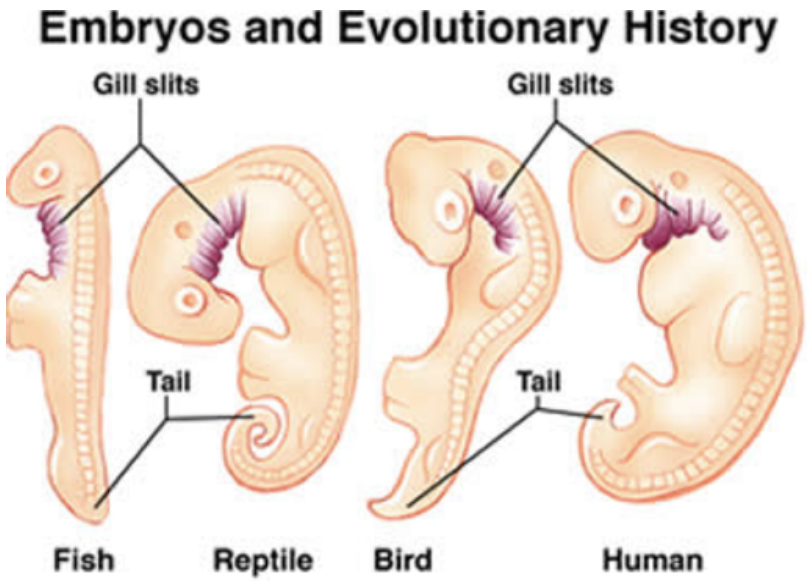
EPSRC

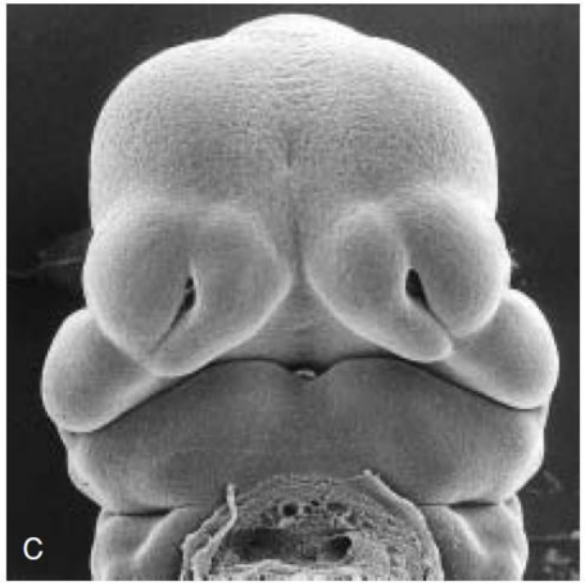
[dstl]

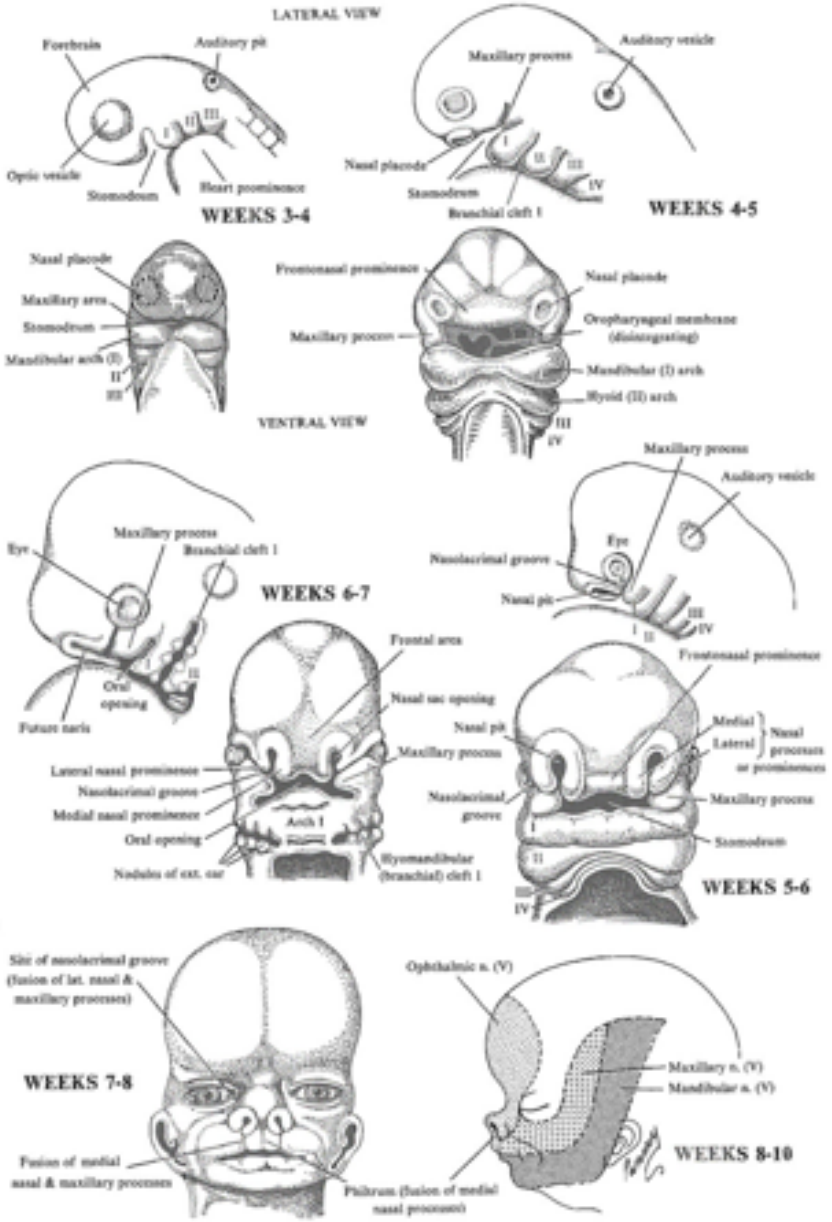


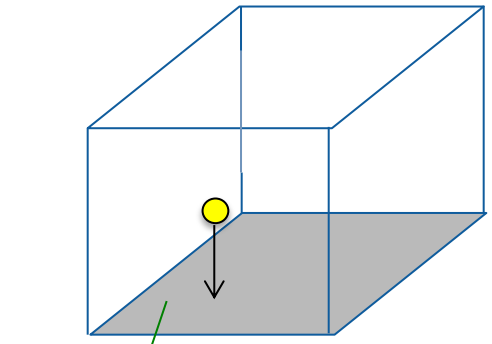
Coarse to fine contexts for action


'Could be a predator: prepare'
'More detail but can't rule out predator: stay prepared'
'Predator!': run!
'Safe, not a predator: relax'
'Could be a predator: prepare'
'Stay prepared'

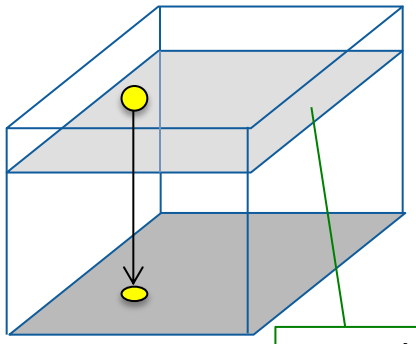




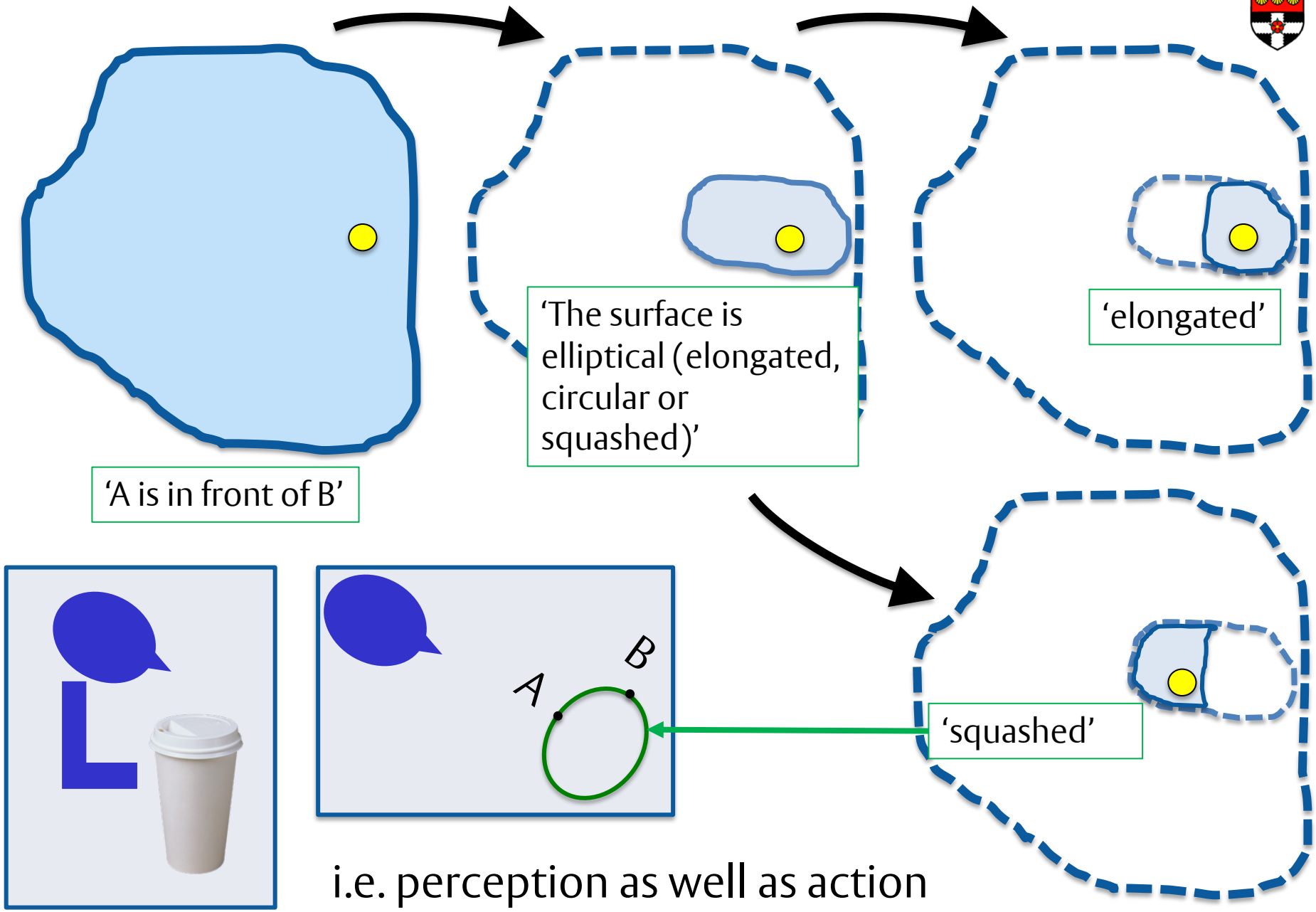




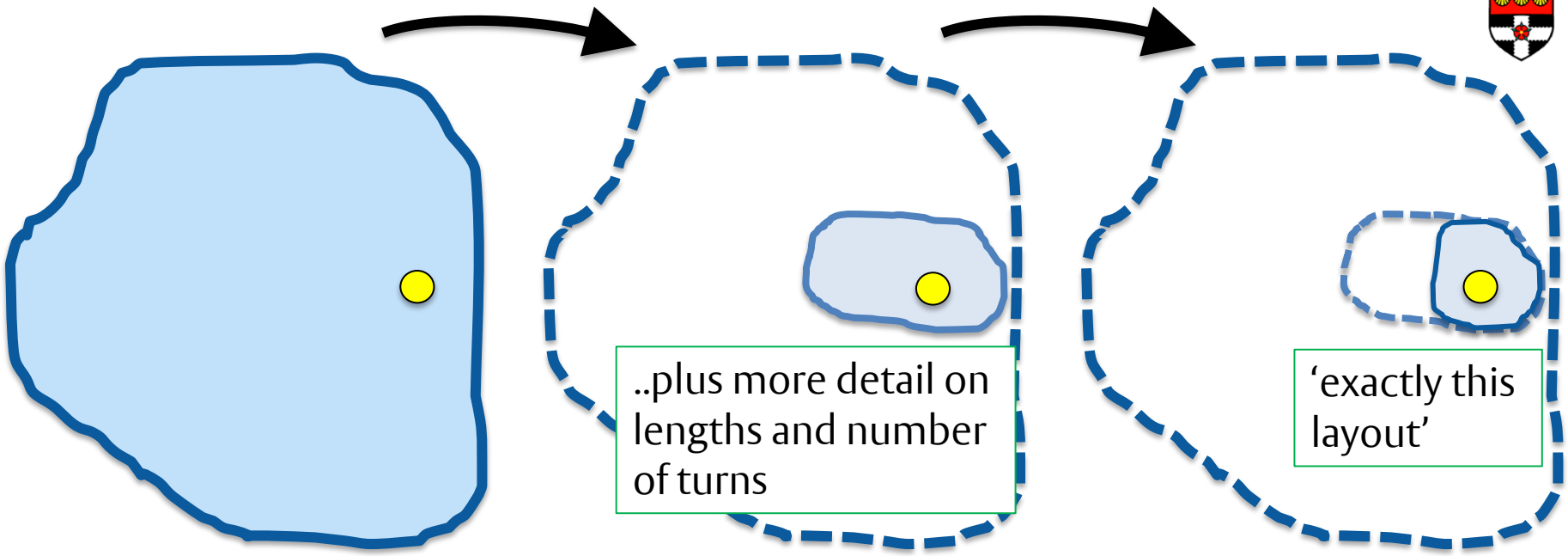
‘Make proto-gills’



‘Turn them into a face’



i.e. perception as well as action

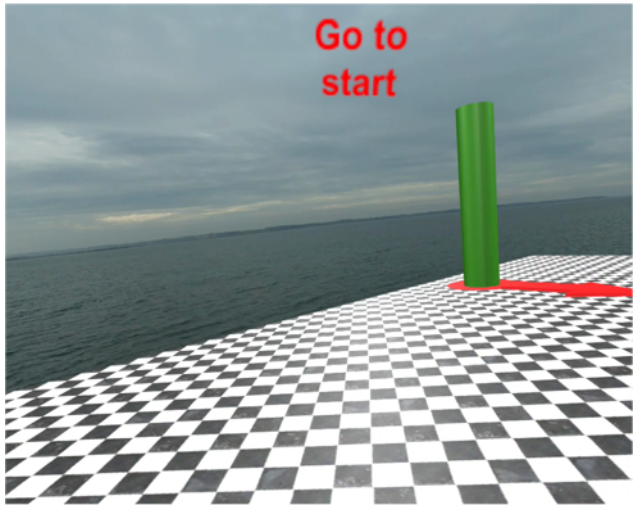


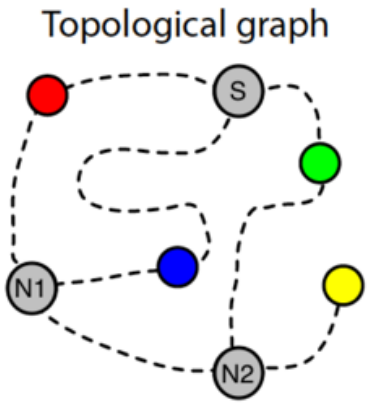
Topological layout

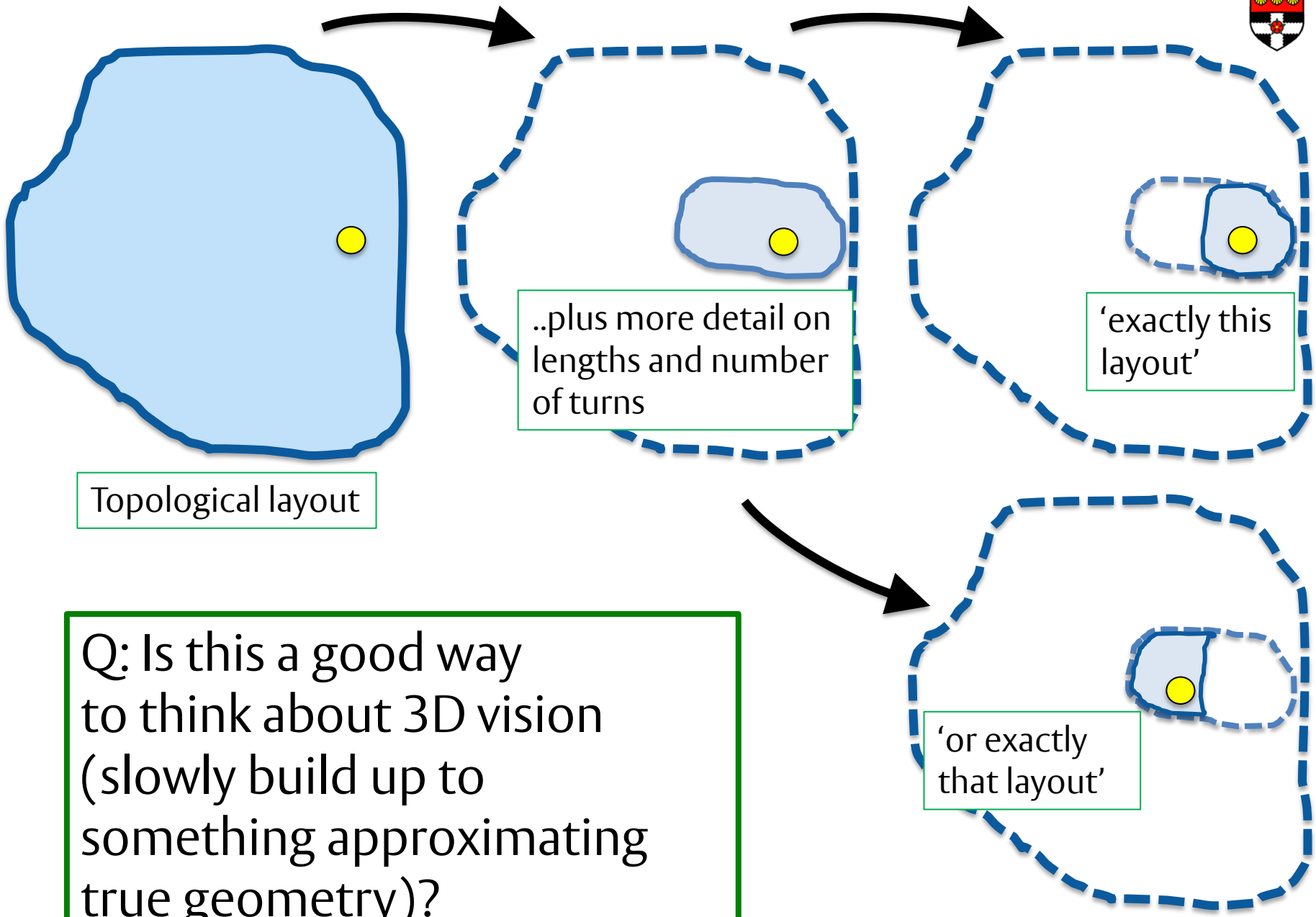
..plus more detail on lengths and number of turns

'exactly this layout'

'or exactly that layout'





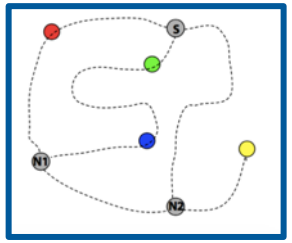


Q: Is this a good way to think about 3D vision (slowly build up to something approximating true geometry)?

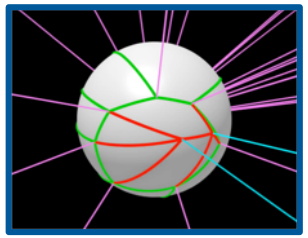
Outline

- Updating visual direction
  - some evidence and a ‘model’

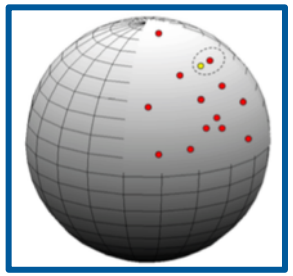
- Navigating through wormholes
  - a 3D model is not the best explanation
  - coarse to fine learning of space



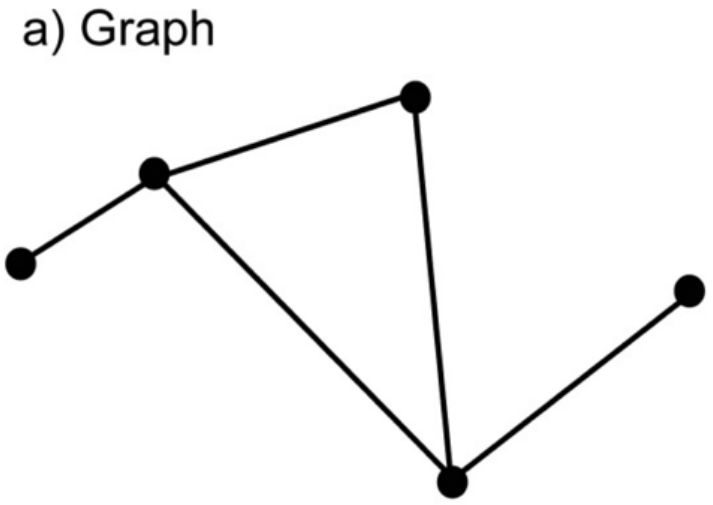
- A sphere of visual directions
  - information about viewing distance
  - A 2½ -D sketch



- A sphere of sensory+motivational states
  - a gradual increase in dimensionality
  - ‘compositionality’



Hierarchical representation of space



From Chrastil and Warren, 2014

- Siegel and White (1975)
- E.g. queried/discussed by:
  - Ishakawa and Montello (2006)
  - Weisberg and Newcombe (2018)
  - Marchette et al (2011)
- Boone, Gong, Hegarty (2018)