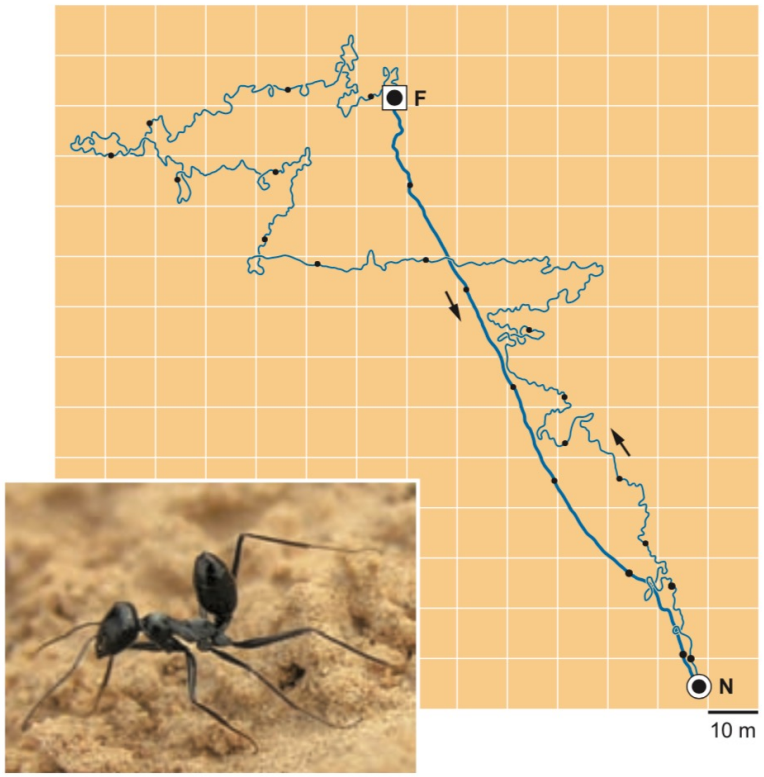
Computation in the brain

Romain Brette

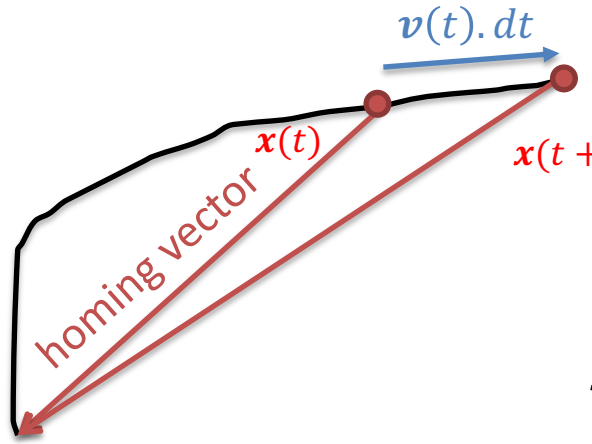
INSTITUT DE LA VISION PARIS

romain.brette@inserm.fr

Neurocomputationalism



Wehner. Desert navigator (2020)



$$\boldsymbol{x} = \int \boldsymbol{v}$$ *computational problem*

$$\boldsymbol{x}(t) \overset{\varphi}{\mapsto} \boldsymbol{x}(t+dt) = \boldsymbol{x}(t) + \boldsymbol{v}(t).dt$$ *algorithm*

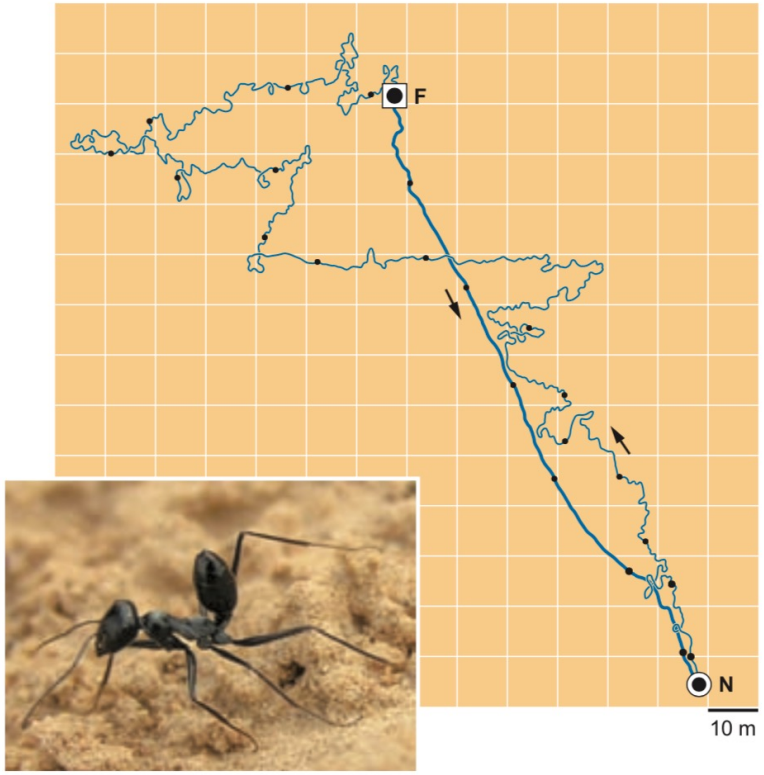
$f \uparrow$ $\quad$ $f \uparrow$ *representation*

$$\boldsymbol{s}(t) \overset{\phi}{\mapsto} \boldsymbol{s}(t+dt)$$ *implementation*

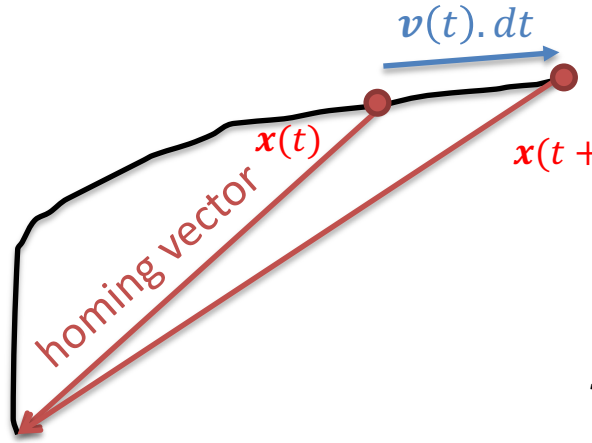
neural states $\quad$ *neural dynamics*

Gallistel (1998), Symbolic Processes in the Brain: The Case of Insect Navigation.

Is all behavior computational?



Wehner. Desert navigator (2020)



$$x = \int v$$

computational problem

$$x(t) \overset{\varphi}{\mapsto} x(t+dt) = x(t) + v(t).dt$$

algorithm

$$s(t) \mapsto s(t+dt)$$

neural states *neural dynamics*

representation ✗

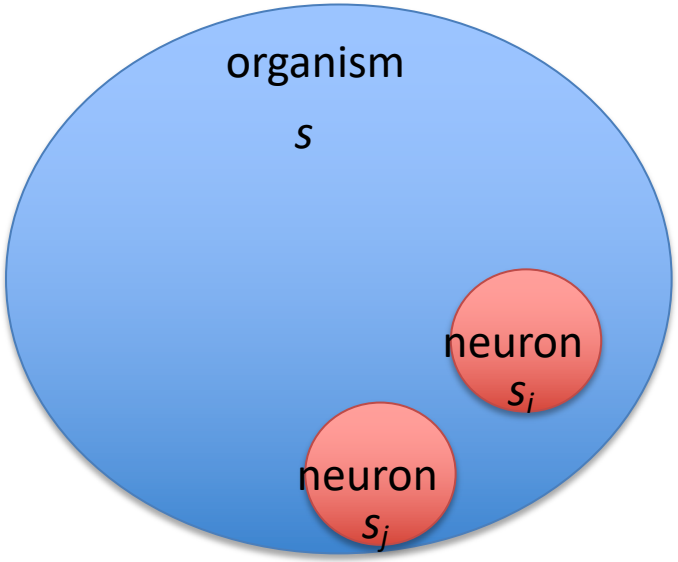
implementation ✗

Gallistel (1998), Symbolic Processes in the Brain: The Case of Insect Navigation.

Neural representations

$\boldsymbol{s}(t) \xrightarrow{f} \boldsymbol{x}(t)$
$\boldsymbol{v}(t)$
shopping list

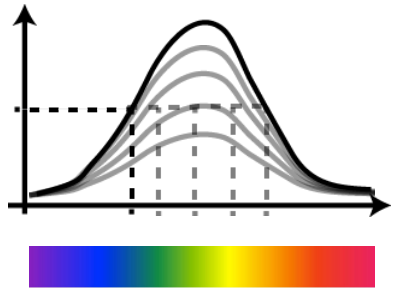
not a symbol!



$s_i(t) \longrightarrow \boldsymbol{x}(t)$

$s_j(t) \longrightarrow \boldsymbol{v}(t)$

Neural code

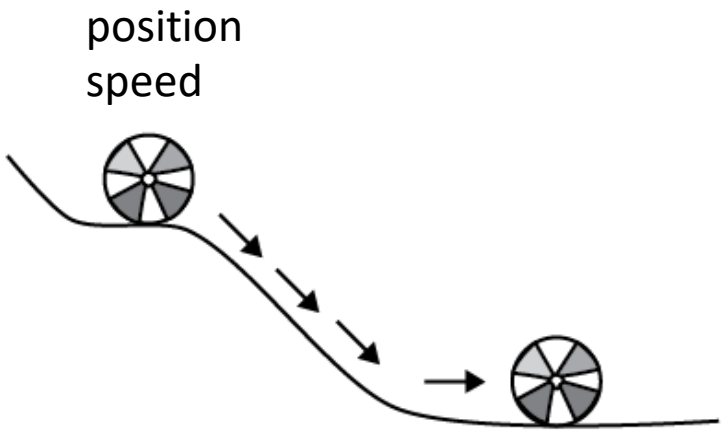


wavelength

Brette (BBS 2019) Is coding a relevant metaphor for the brain?

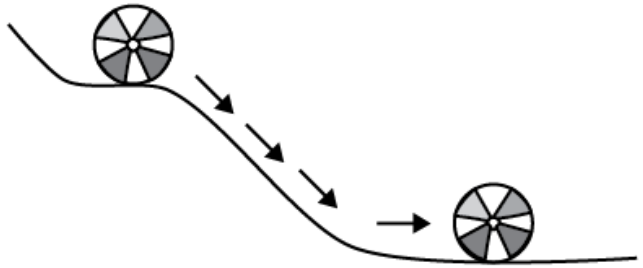
Neural states and physical states

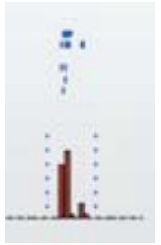
$$s(t) \xrightarrow{f} \vec{x}(t)$$



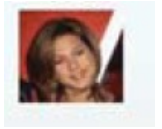
Neural states

$$s(t) \xrightarrow{f} \vec{x}(t)$$



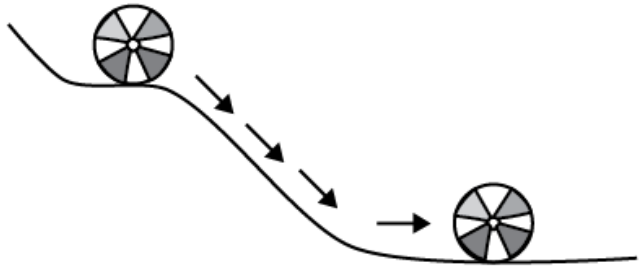


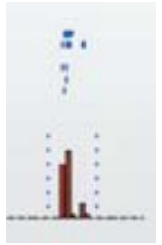
Quiroga et al. (2005)



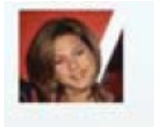
Neural states

$$s(t) \xrightarrow{f} \vec{x}(t)$$





Quiroga et al. (2005)



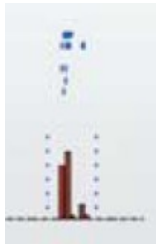
$$\boldsymbol{x}(t) \xmapsto{\varphi} \boldsymbol{x}(t+dt) = \boldsymbol{x}(t) + \boldsymbol{v}(t).dt$$

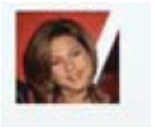
$$\begin{array}{ccc} \uparrow f & & \uparrow f \\ \boldsymbol{s}(t) & \xmapsto{\Phi} & \boldsymbol{s}(t+dt) \end{array}$$

neural states — *neural dynamics*

Neural states

Quiroga et al. (2005)



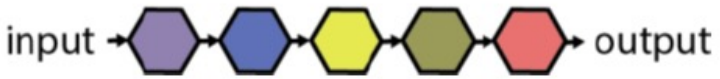


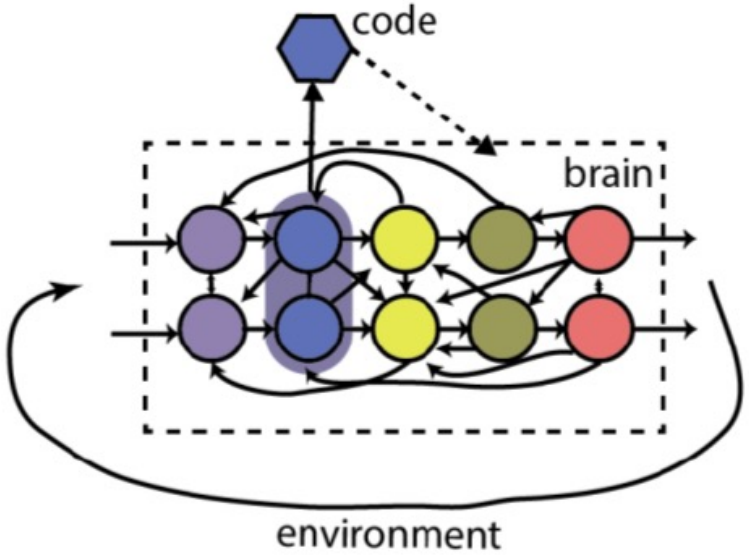
$$\boldsymbol{x}(t) \overset{\varphi}{\mapsto} \boldsymbol{x}(t+dt) = \boldsymbol{x}(t) + \boldsymbol{v}(t).dt$$

$$f \updownarrow \qquad f \updownarrow$$

$$\boldsymbol{s}_n(t) \overset{\phi}{\mapsto} \boldsymbol{s}_{n+1}(t+dt)$$

neural states *neural dynamics*



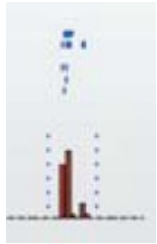


Standing on the shoulders of strawmen

Thompson & Piccinini (2018) Neural Representations Observed.
Shagrir (2006) Why we view the brain as a computer.

$$\begin{array}{ccc} \boldsymbol{x}(t) & \overset{\varphi}{\mapsto} & \boldsymbol{x}(t+dt) = \boldsymbol{x}(t) + \boldsymbol{v}(t).\,dt \\ f\uparrow & & f\uparrow \\ \boldsymbol{s}(t) & \overset{\phi}{\mapsto} & \boldsymbol{s}(t+dt) \end{array}$$

neural states *neural dynamics*



Brette R (2013). Subjective physics
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Brette R (2019). Is coding a relevant metaphor for the brain?
Brette R (2022). Brains as Computers: Metaphor, Analogy, Theory or Fact?