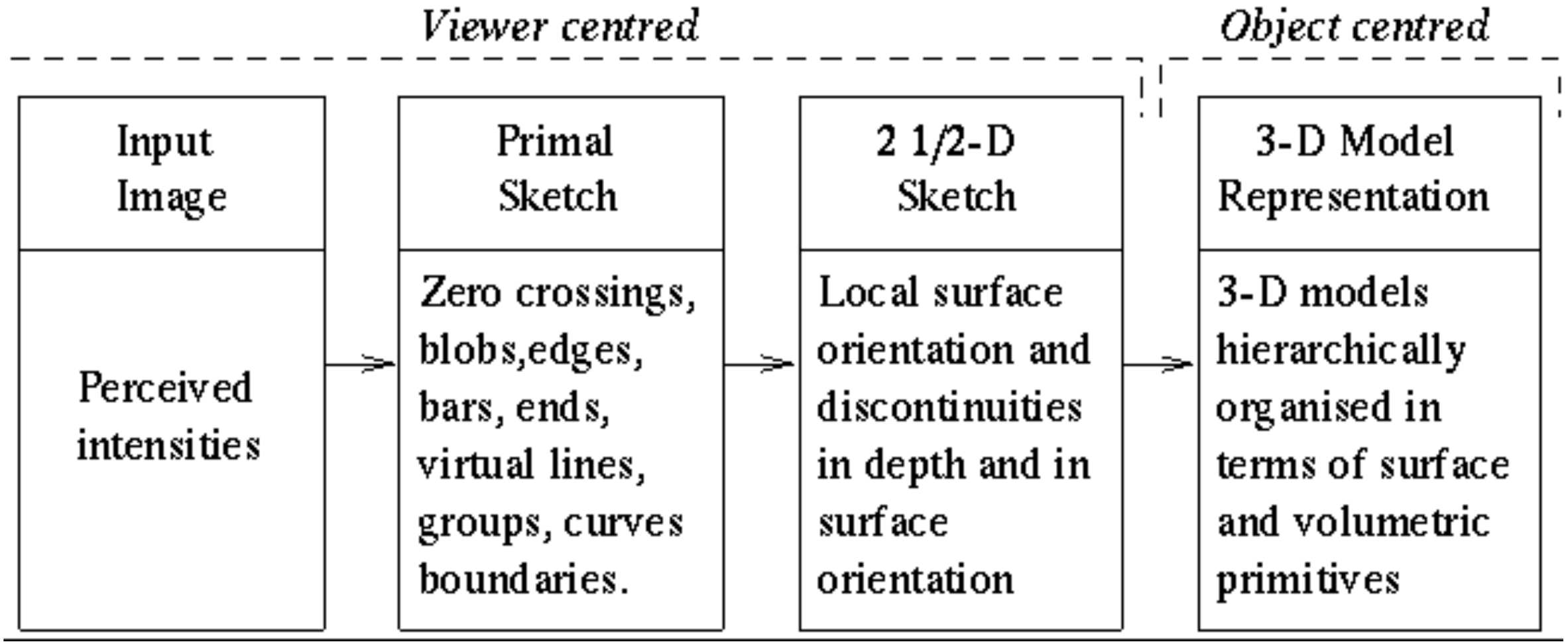
The approach of David Marr



‘AlexNet’
(Krizhevsky, Sutskever & Hinton 2012)

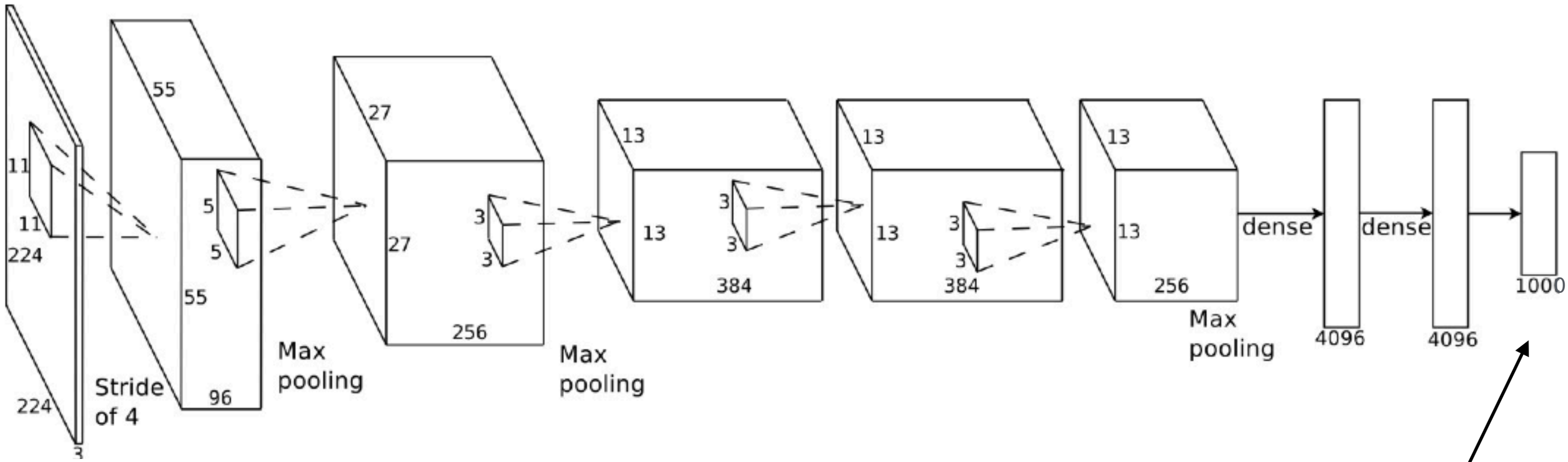
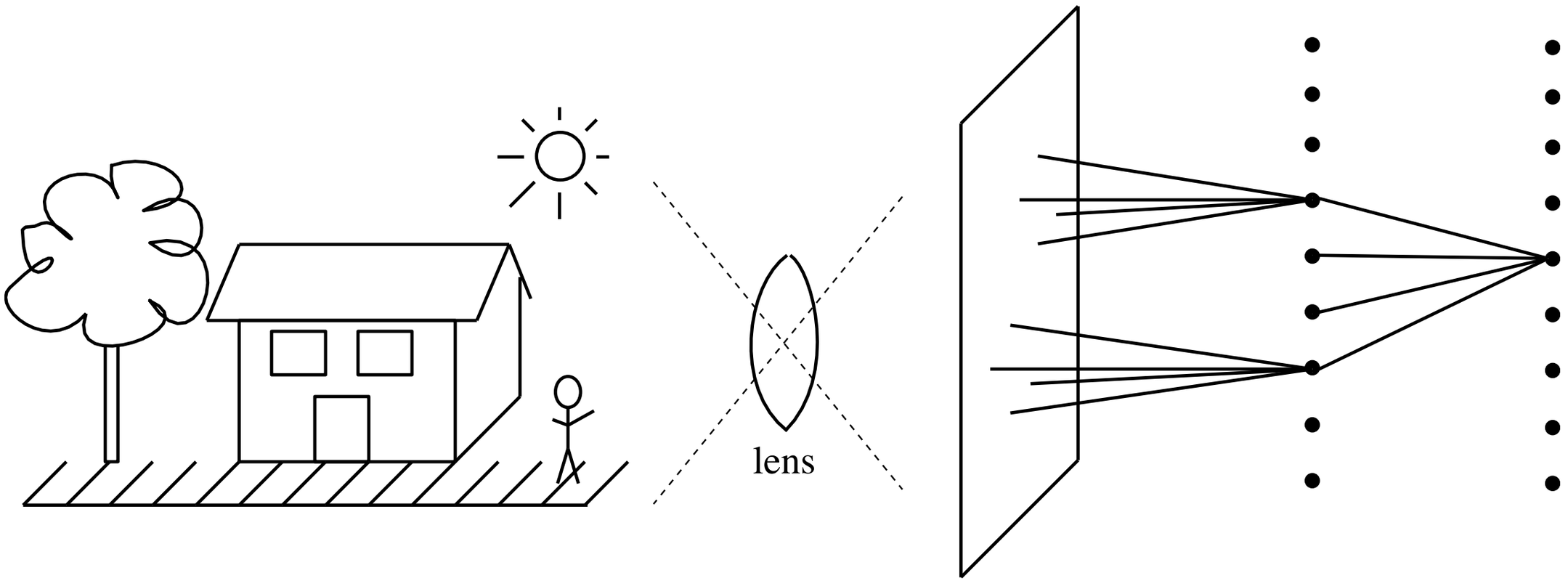
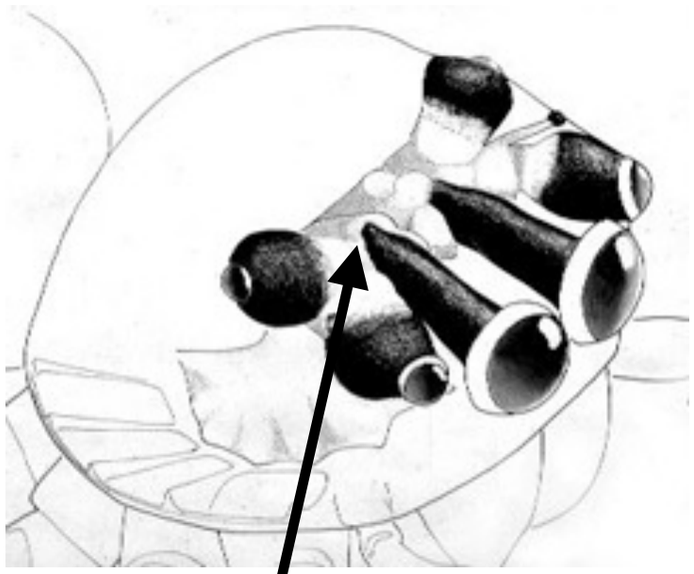


image feature extraction and pooling classification

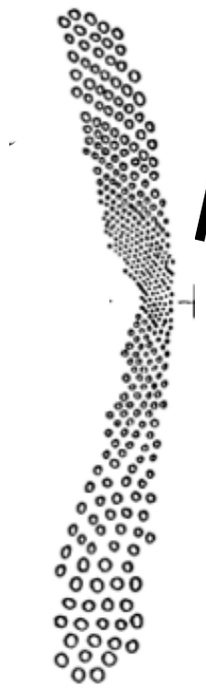
Vision as inference



Active vision in jumping spiders



(Wayne Maddison)



(Bair & Olshausen, 1991)

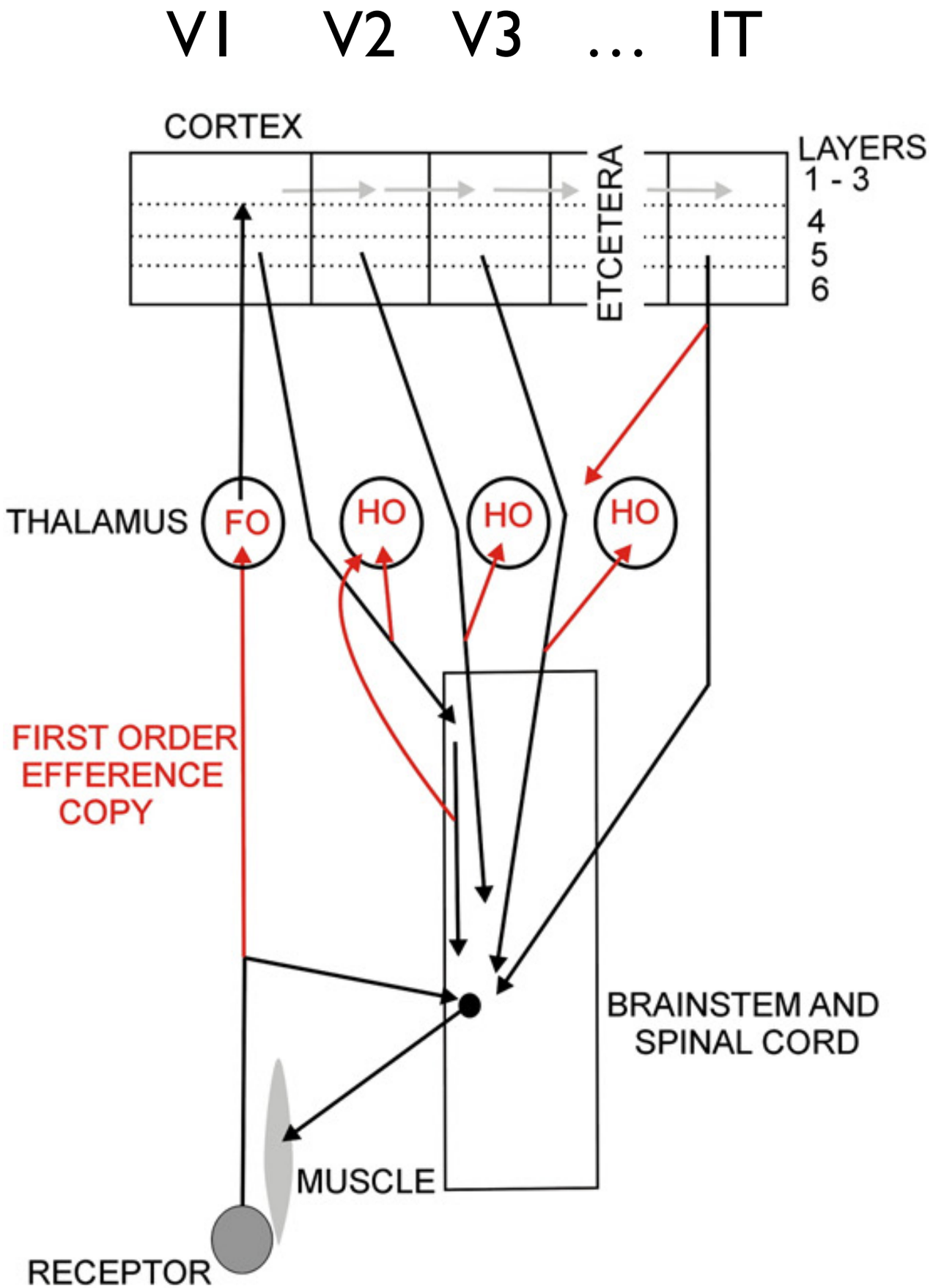
One-day old jumping spider
(filmed in the Bower lab, Caltech 1991)

One-day old jumping spider
(filmed in the Bower lab, Caltech 1991)

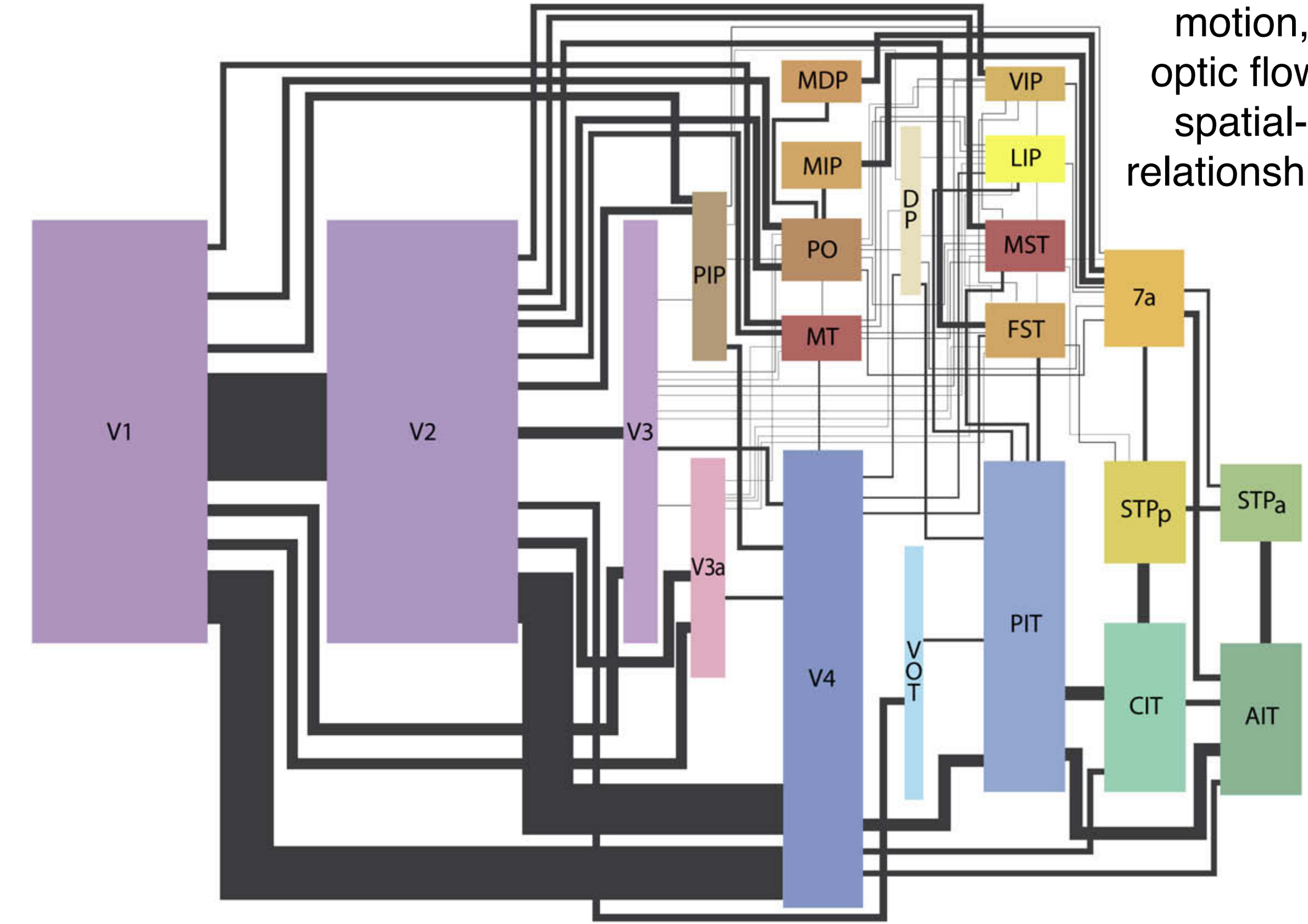
…problem solving behavior, language, expert knowledge and application, and reason, are all pretty simple once the essence of being and reacting are available. That essence is the ability to move around in a dynamic environment, sensing the surroundings to a degree sufficient to achieve the necessary maintenance of life and reproduction. This part of intelligence is where evolution has concentrated its time--it is much harder.

— Rodney Brooks, "Intelligence without representation," *Artificial Intelligence* (1991)

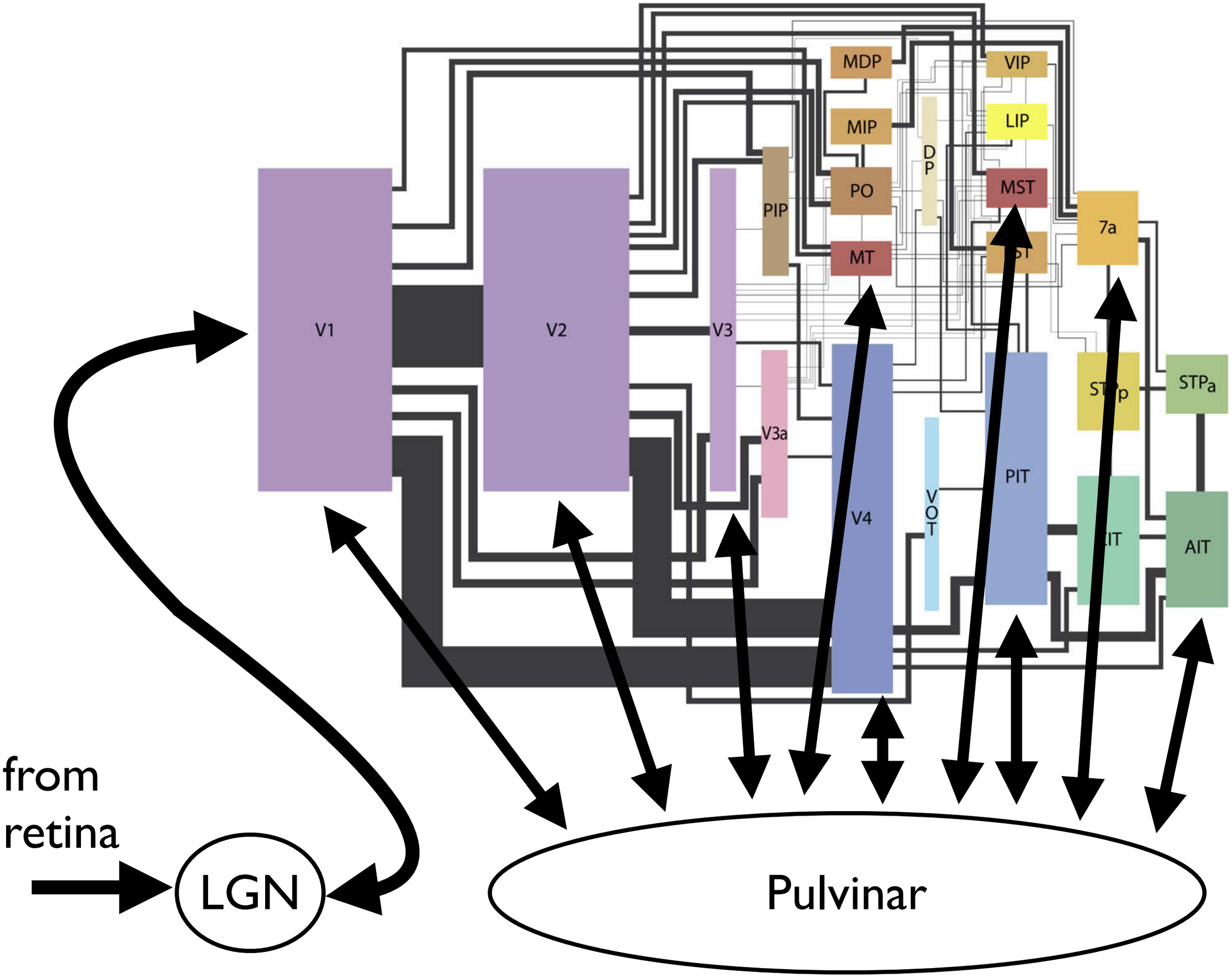
An alternative view
(Guillery & Sherman, 2011)



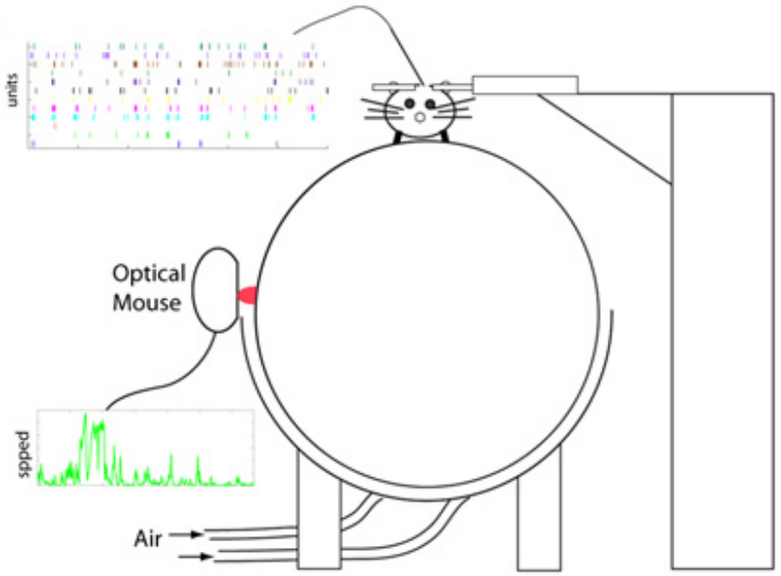
Wallisch & Movshon (2008)



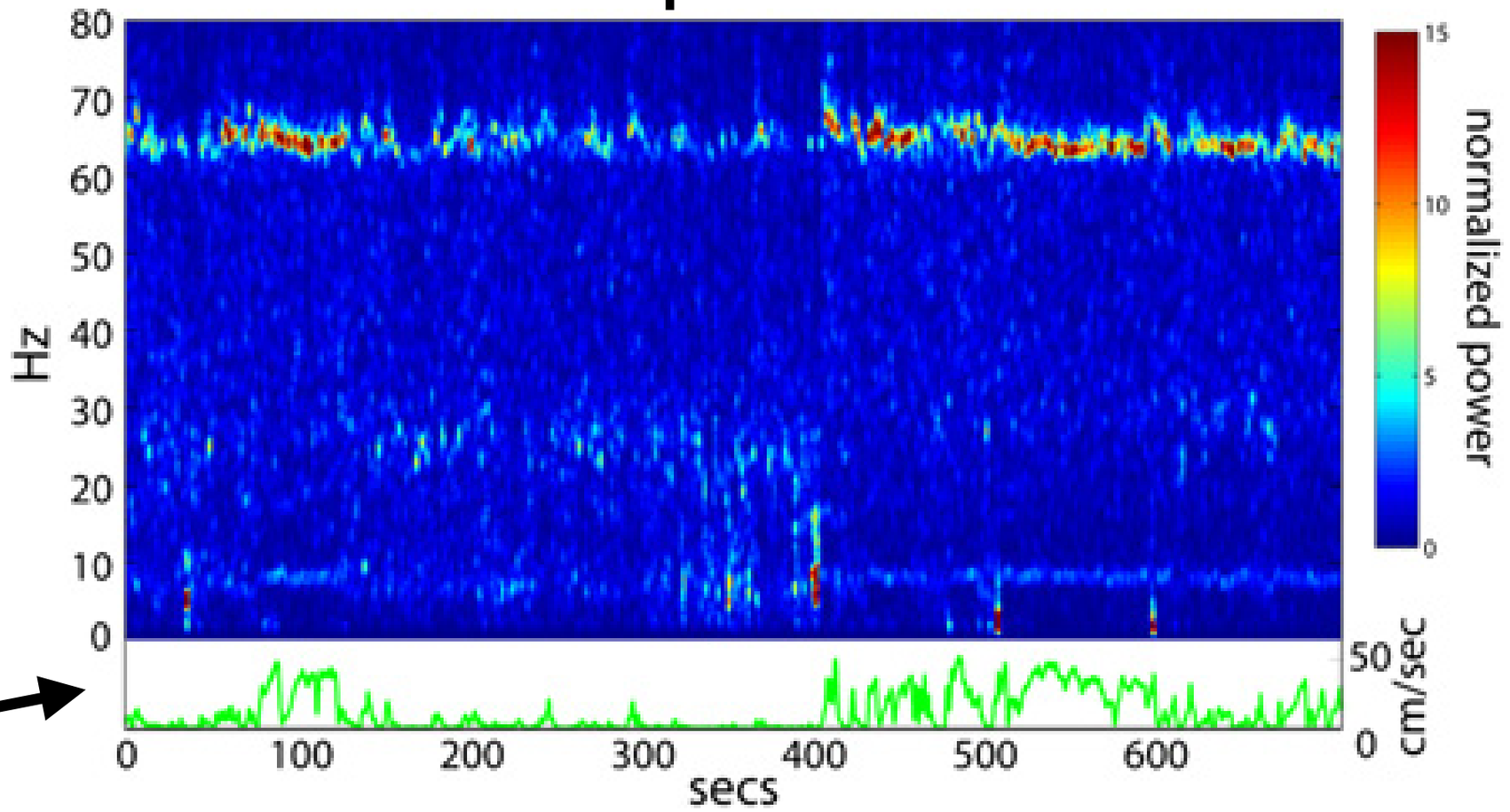
lines, edges surface boundaries ? objects faces


V1
V2
V3
V3a
PIP
MDP
MIP
PO
MT
DP
VIP
LIP
MST
7a
V4
VOT
PIT
AIT
STPa
from
retina
LGN
Pulvinar

Activity in V1 more than doubles during locomotion



animal's speed →



(Neil & Stryker, 2010)

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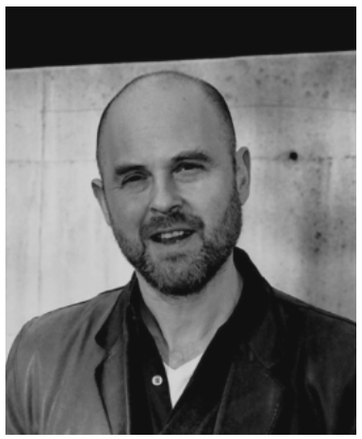
A sensorimotor account of vision and visual consciousness



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visual experience does not arise because an internal representation of the world is activated in some brain area.

…

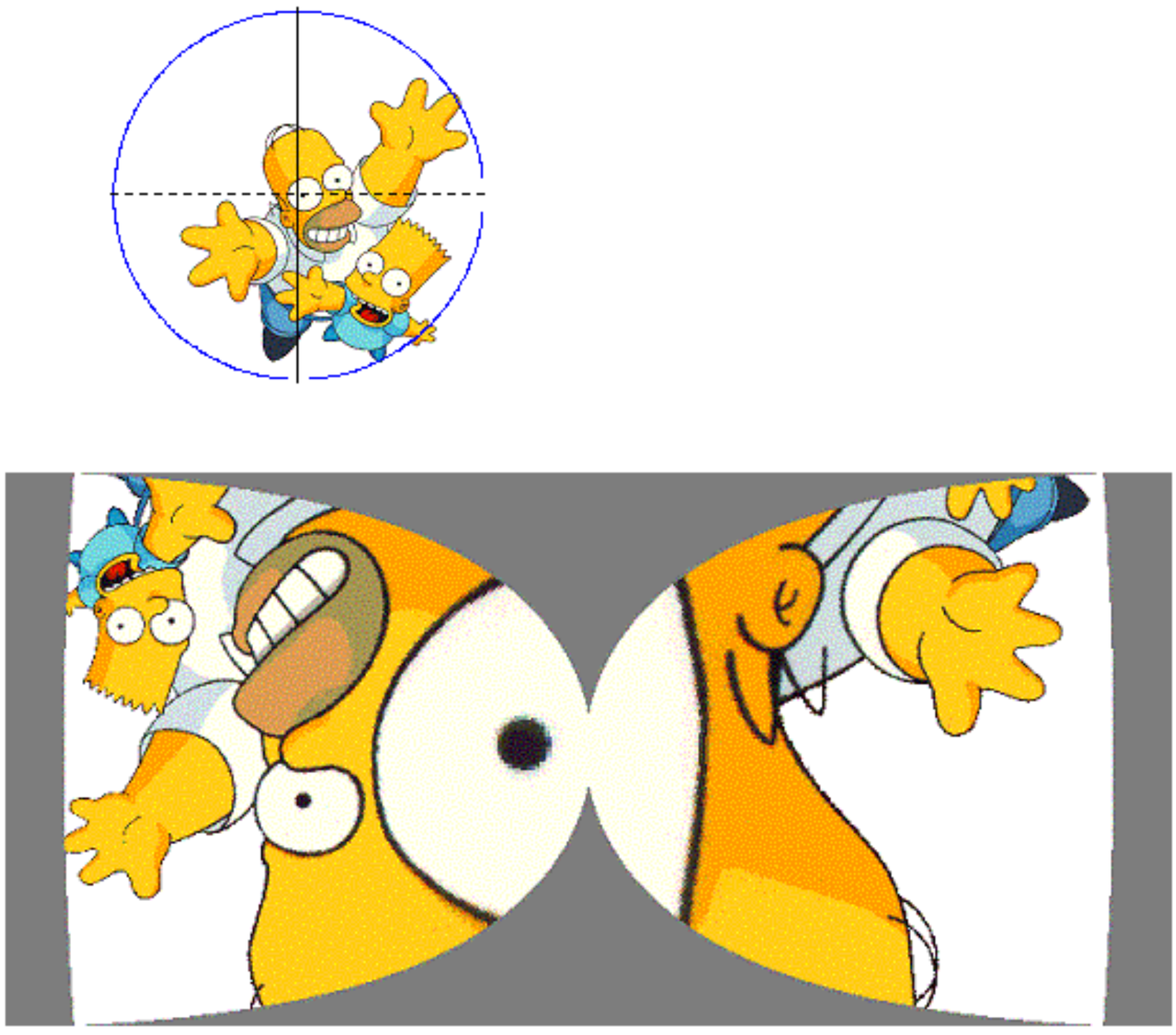
Indeed, there is no "re"-presentation of the world inside the brain:

…

The experience of seeing occurs when the outside world is being probed according to the visual mode.

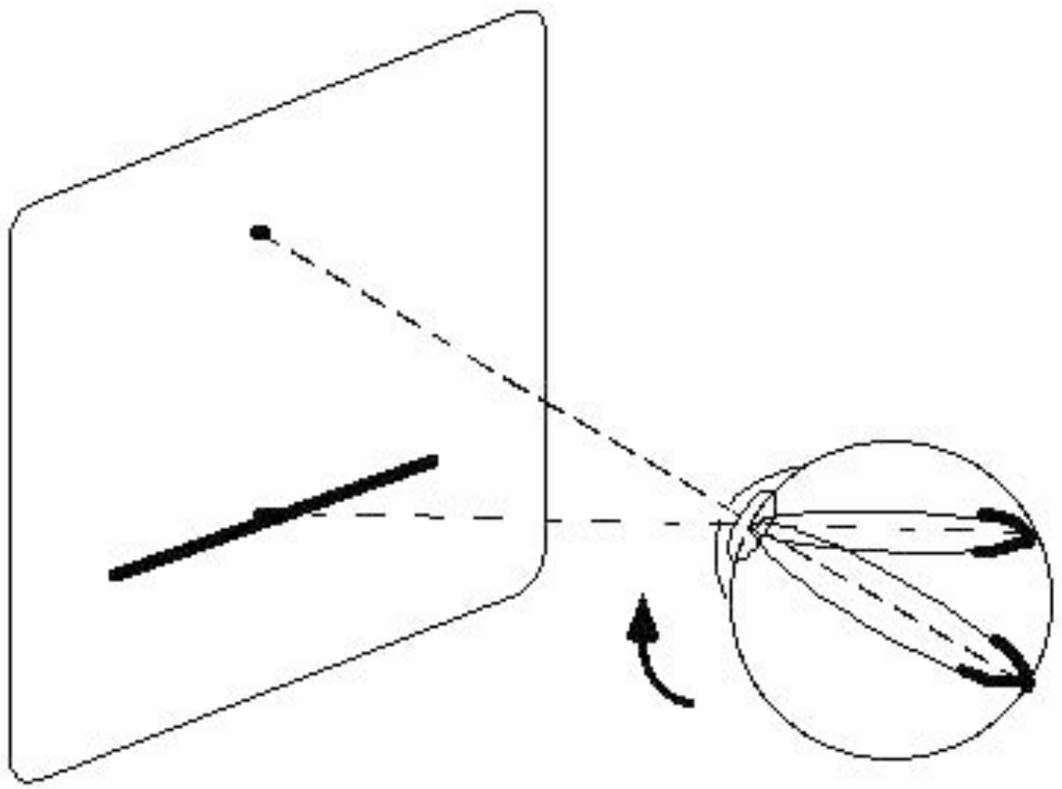
- O'Regan & Noë (2001)

V1 representation during eye movement

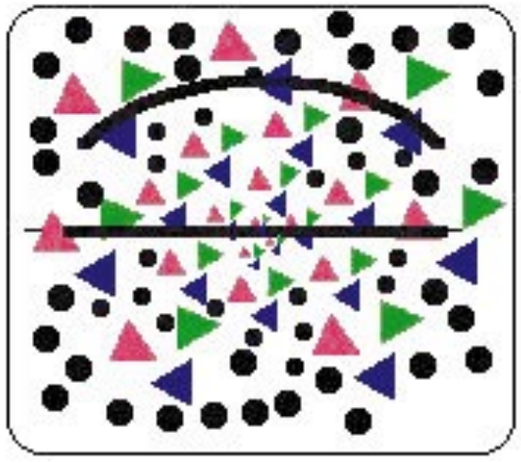


courtesy of Arash Fazl

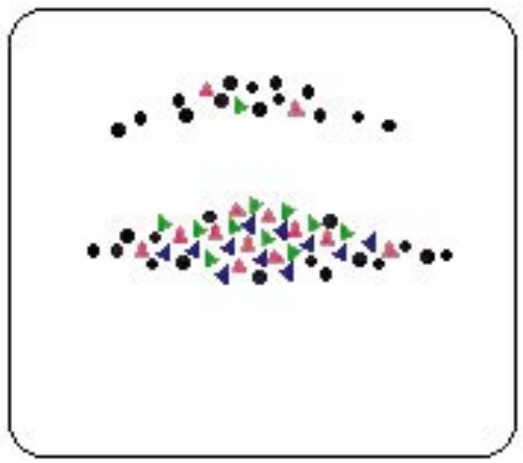
SCENE



RETINAL STIMULATION



CORTICAL REPRESENTATION



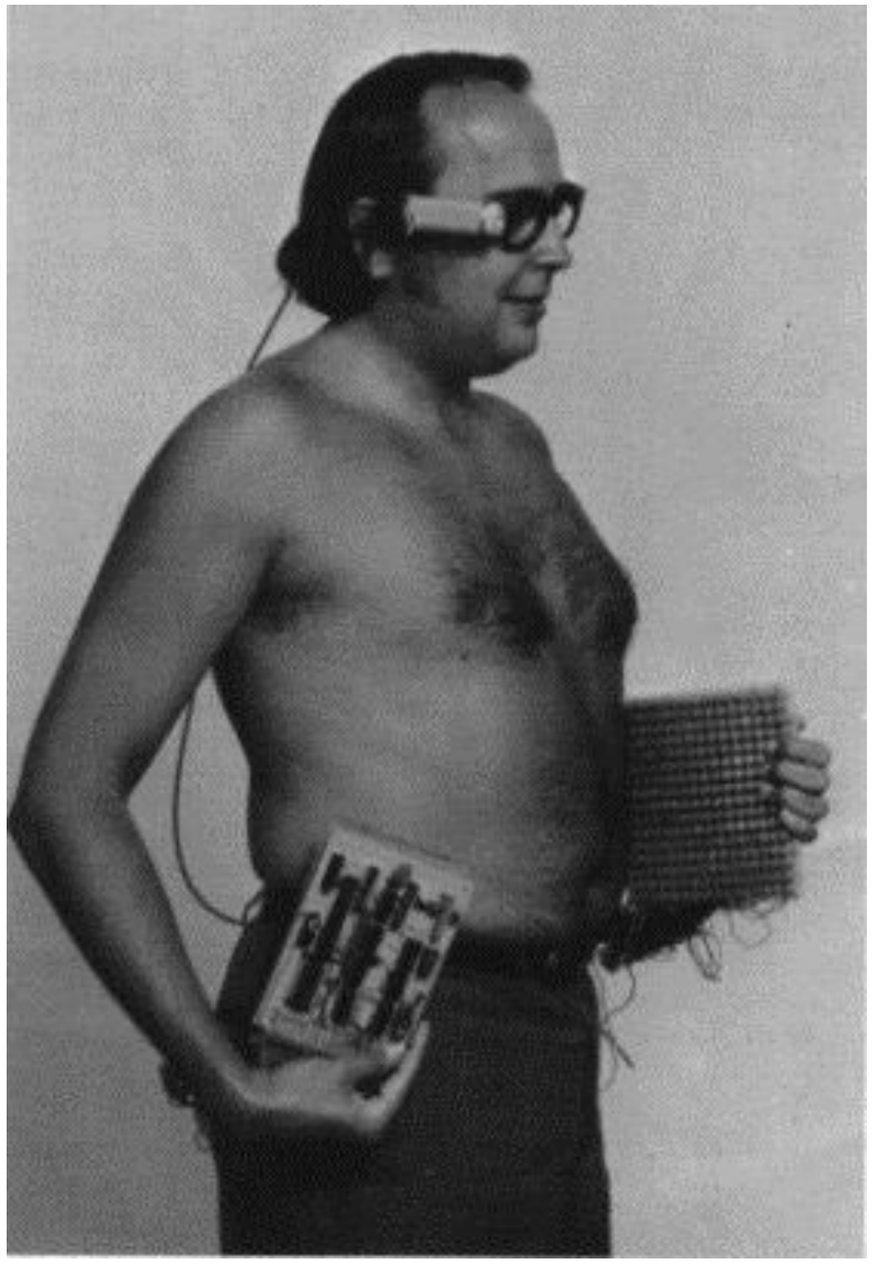


Figure 7. A blind subject with a "Tactile Visual Substitution system" (TVSS). A TV camera (mounted on spectacle frames) sends signals through electronic circuitry (displayed in right hand) to an array of small vibrators (left hand) which is strapped against the subject's skin. The pattern of tactile sitmulation corresponds roughly to a greatly enlarged visual image. (Photograph courtesy of P. Bach-y-Rita). From Morgan (1977).

LETTER **Communicated by Anthony Bell**

Is There Something Out There? Inferring Space from Sensorimotor Dependencies

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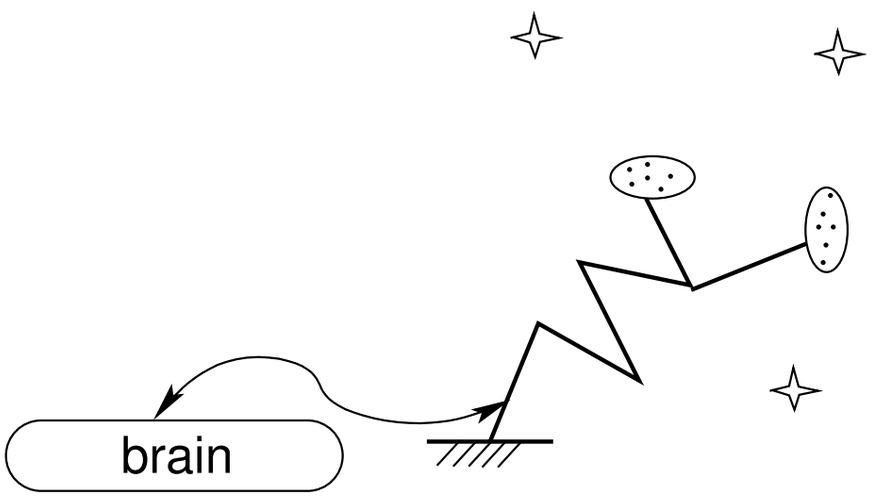

$$S = \psi(M, E).$$

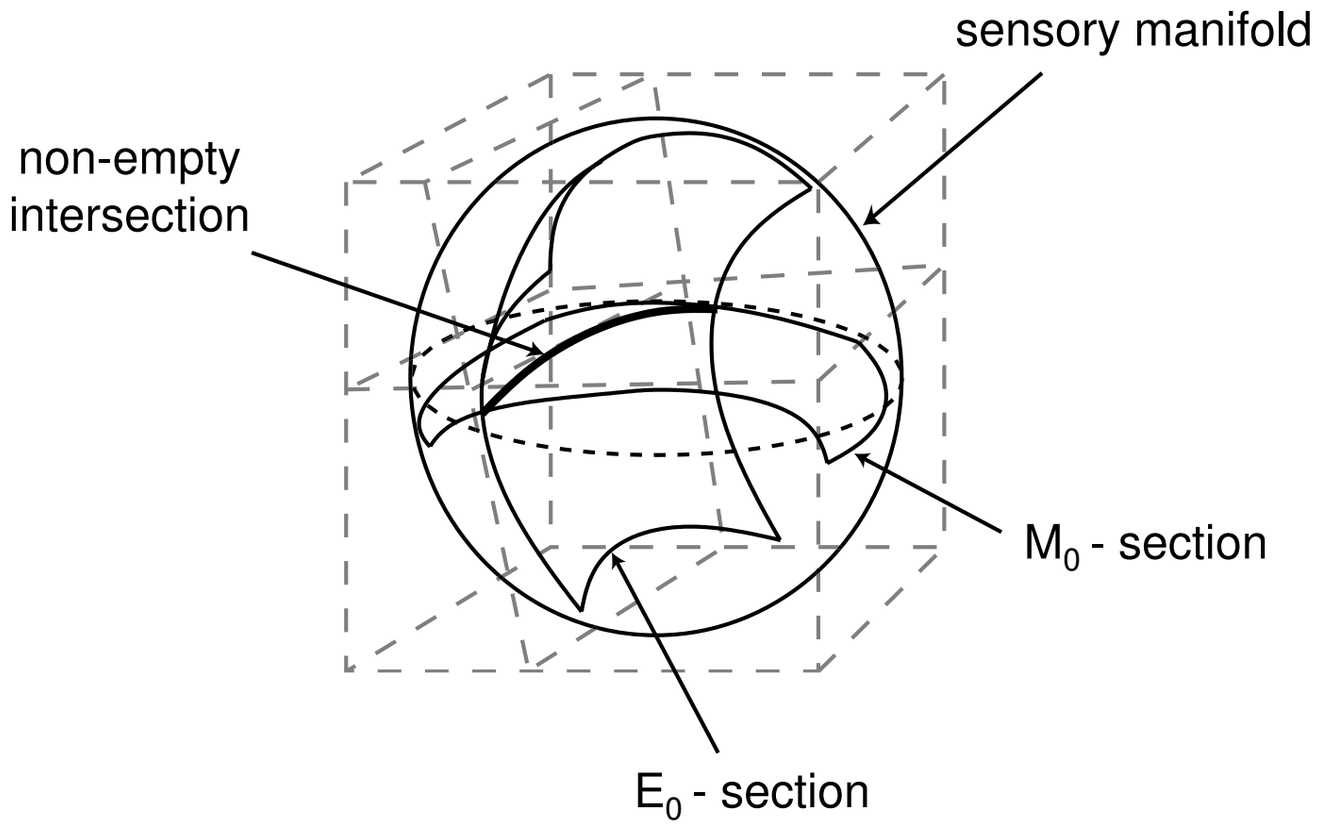

Figure 2: The sensory manifold in the neighborhood of S_0, the E_0 and M_0-sections (see text). These two manifolds are transverse, and their intersection is the manifold of the sensory inputs accessible through either motion of the exteroceptive body or motion of the environment.

$$dS = \frac{\partial \psi}{\partial M}|_{(M_0,E_0)} \cdot dM + \frac{\partial \psi}{\partial E}|_{(M_0,E_0)} \cdot dE$$

$$\{dS\} = \{dS\}_{dM=0} + \{dS\}_{dE=0}$$

Learned degrees of freedom

Characteristics	Organism 1	Organism 2	Organism 3
Dimensions of motor commands	40	100	100
Dimensions of exteroceptive inputs	40	80	80
Number of eyes	2	4	4
Diaphragms	None	Reflex	Controlled
Number of lights	3	5	5
Light luminance	Fixed	Variable	Variable
Dimensions found for body (p)	12	24	28
Dimensions found for environment (e)	9	20	20
Dimensions found for both (b)	15	38	41
Deduced dimension of rigid group (d)	6	6	7