

BICS 2004 Tutorial,

Models Consciousness:
The World Scene
(And the Axiomatic Approach)

Igor Aleksander FREng

Imperial College, London

Visiting Research Fellow, U. Sussex

Machine Consciousness Conferences

2001: Cold Spring Harbour

2003: Symposium at ASSC 7, Memphis

2003: ESF Workshop, Birmingham

2003: NoE 'Exystence' Workshop, Turin

2004: Antwerp Parallel with ASSC8

This conference: Session CNS3 10.00 Tuesday ,
Debate 11.20 Tuesday

Machine Consciousness Funding

2004: EPSRC 500K to Owen Holland (Essex)
Investigation of Robot Consciousness

2004: EU Call (FET): Architectures that have
'world- and self- awareness'.

Beware of Words!

... For twenty years I
have mistrusted
consciousness .. It is
the name of a non-
entity and has no right
place among first
principles ..."

William James

*'Does Consciousness
Exist?' 1904*

Consciousness:

Where are the
molecules?

Being conscious:

What are the
mechanisms?

"... Plato, Descartes and Eccles, make no clear distinction between the terms 'consciousness', 'mind' and 'soul'. But in the modern context these terms have different meanings."

*Max Velmans,
'Understanding
Consciousness' 2000*

What do I mean?

Being conscious means that I am experiencing internally an out-there world, self, past, future, intention and fiction.

My Mind is the sum total of my capacity for having such experiences.

Soul is best left to theologians

WHY MACHINES?

*There comes a time when you have to stop
talking and MAKE SOMETHING*

EVEN IF IT IS A MISTAKE!

*The late Tom Kilburn of Manchester
University*

OBJECTIVES FOR MAKING THINGS

To explore 'what it is to be conscious' with
engineering clarity

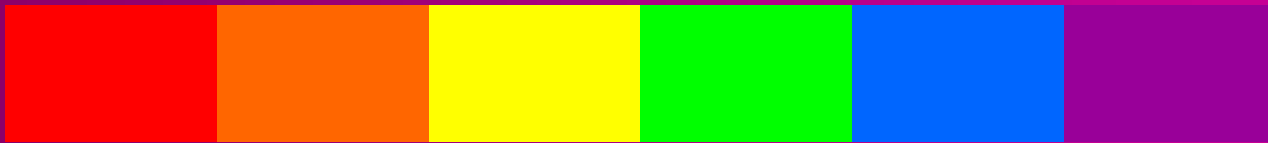
To achieve behaviours in machinery that, in
areas of technological need, approach the
competence achieved by living organisms
by virtue of being conscious.

(e.g. an autonomous exploratory robot on Mars)

THERE IS A SPECTRUM OF WAYS IN
WHICH PEOPLE APPROACH

BEING CONSCIOUS

IN MACHINES



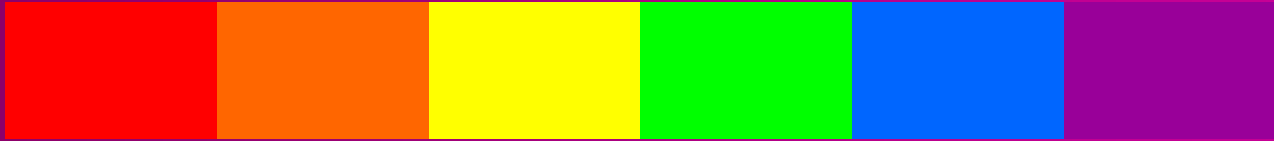
FUNCTIONAL

WHAT IS IT TO BEHAVE
IN A CONSCIOUS WAY?



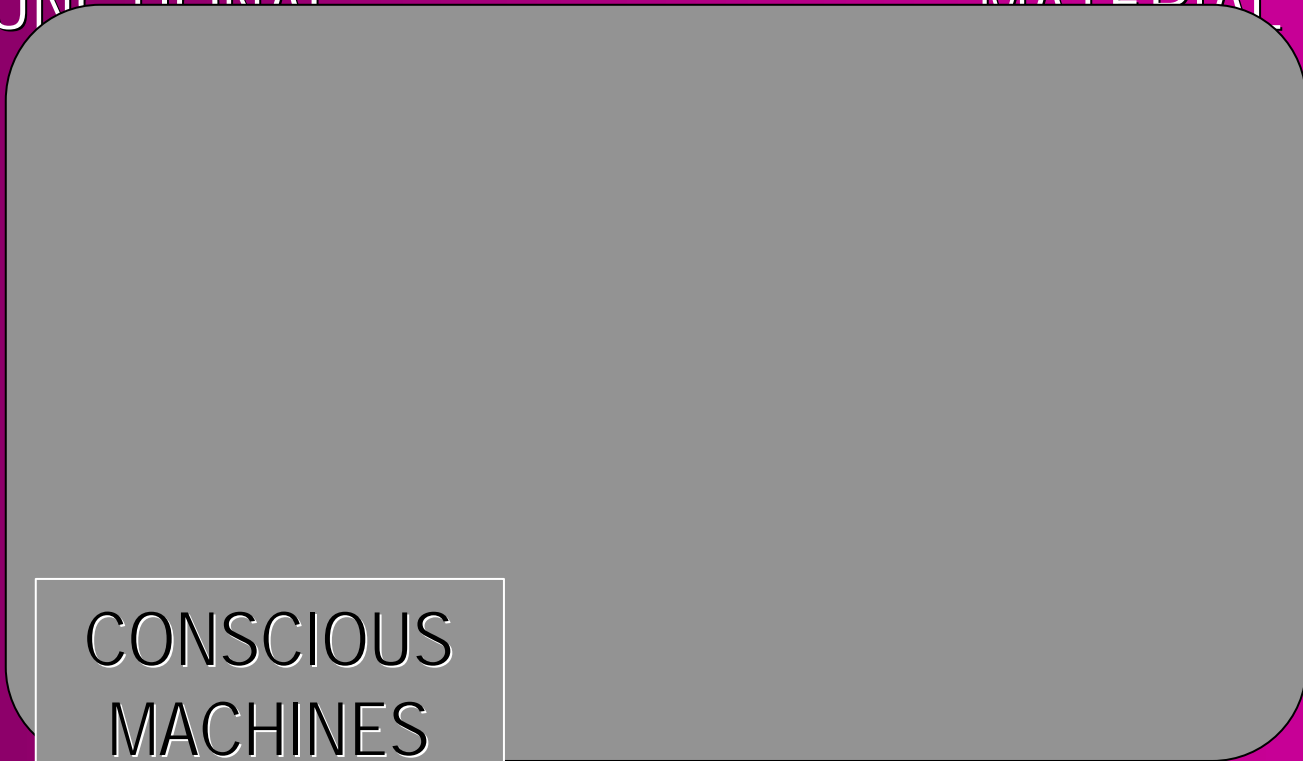
MATERIAL

WHAT ARE THE ESSENTIAL
MECHANISMS FOR BEING
CONSCIOUS?

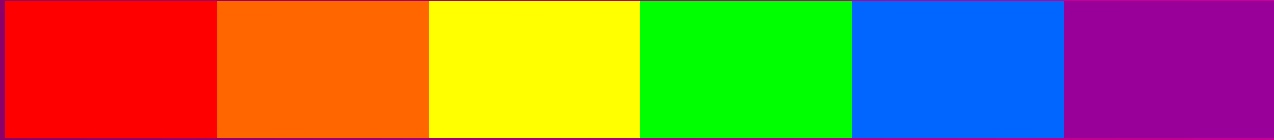


FUNCTIONAL

MATERIAL



CONSCIOUS
MACHINES
PARADIGM



FUNCTIONAL



MATERIAL



Stan Franklin – University of Memphis

The Intelligent Distributed Agent (IDA)

Used to billet US Navy personnel via e-mail

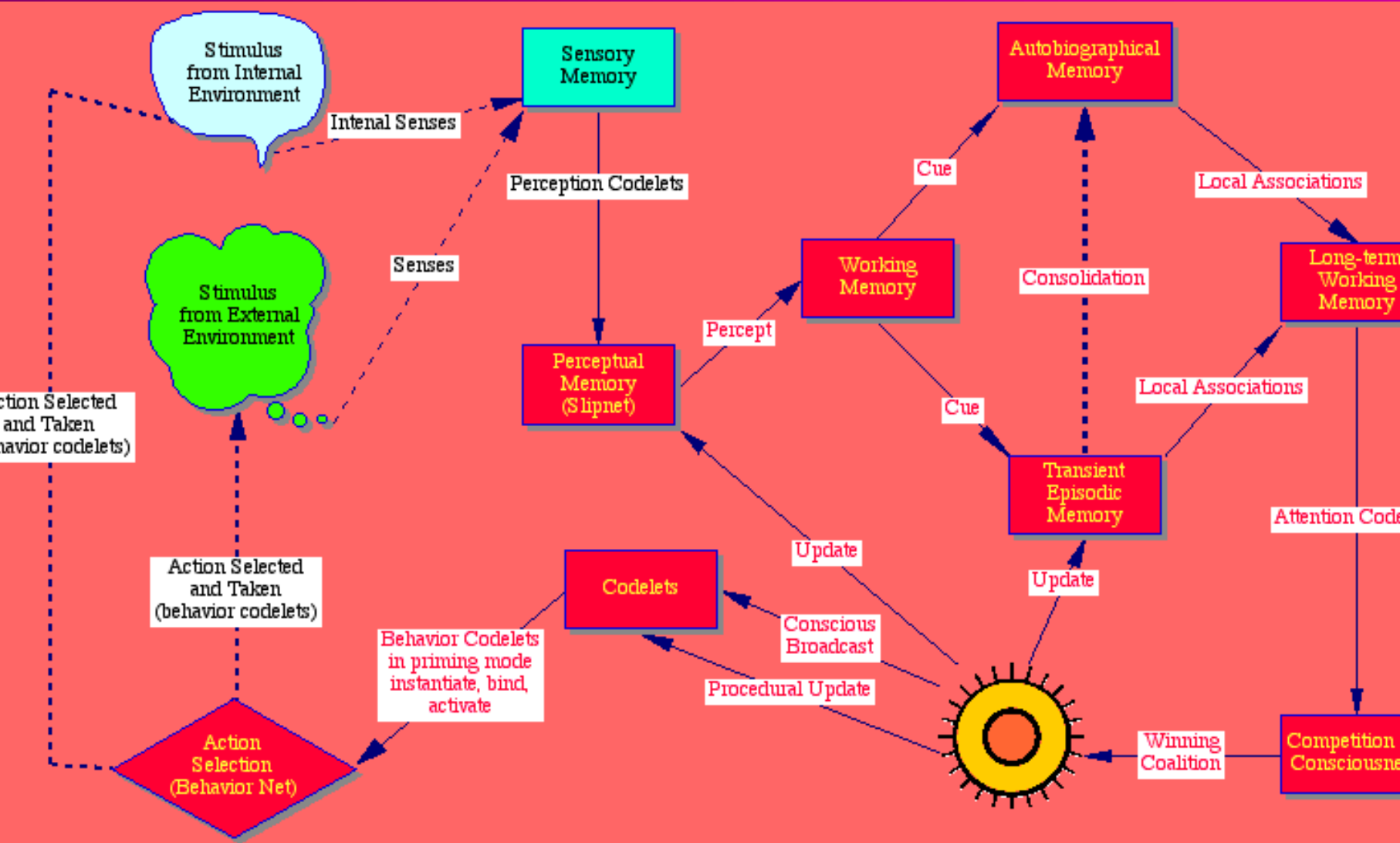
Replaces conscious human billetters

Methodology based on Bernie Baars' Global Workpsace theory.

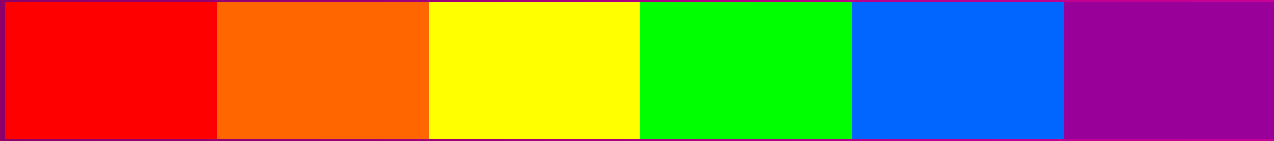
Franklin, S. & Graesser, A. (1999). A Software Agent Model of Consciousness. *Consciousness and Cognition* 8, 285–301.

Baars, B.J. (1997). *In the Theater of Consciousness: The Workspace of the Mind*. Oxford University Press.

The IDA System



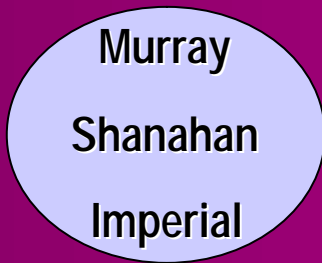
Red indicates feelings or emotions are involved



FUNCTIONAL



MATERIAL



Murray Shanahan – Imperial College, London

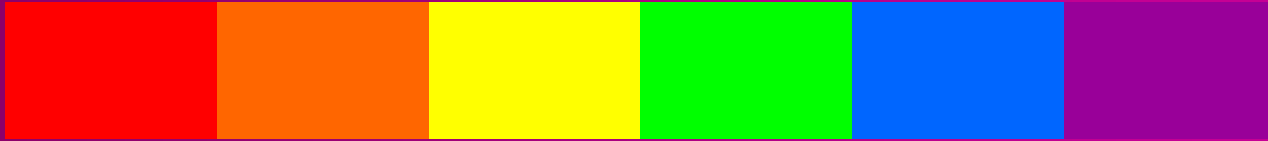
The 'Logic process' of consciousness

1. The frame problem: Uses Baars' global workspace to constrain computation to only that which is relevant

Shanahan, M. & Baars, B. (2004). Applying Global Workspace Theory to the Frame Problem *to be published 2004*.

2. Rehearsals in internal computational models of sensorimotor space

Shanahan, M. The Imaginative Mind: Rehearsing Trajectories Through an Abstraction of Sensorimotor Space *to be published 2004*



FUNCTIONAL

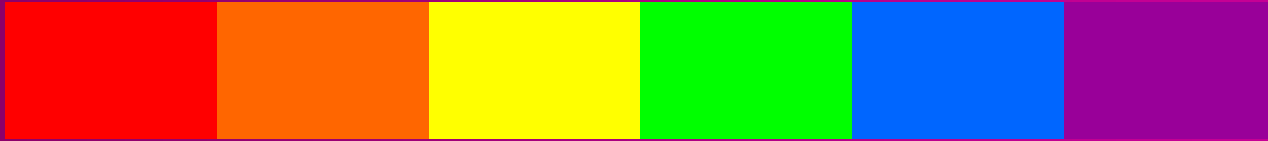


MATERIAL

Clarifying consciousness and computational models of emotions

Sloman, A and Chrisley, R: Virtual machines and consciousness. Jour Conc St, vol 10, no 4-5, 2003 pp133-72

<http://www.cs.bham.ac.uk/~axs/>



FUNCTIONAL



MATERIAL

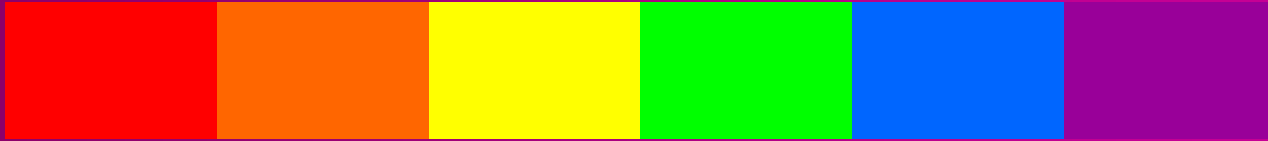
Using control systems theory for large system to model consciousness and to use consciousness for the control of complex plant.

Systems and Consciousness (ASSC7)

Ricardo Sanz, Juan Escasany and Ignacio L´opez

Universidad Polit´ecnica de Madrid,

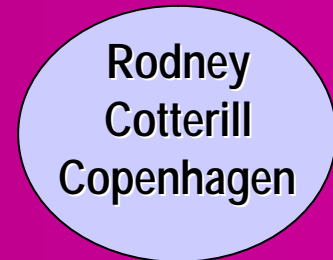
ricardo.sanz@etsii.upm.es



FUNCTIONAL

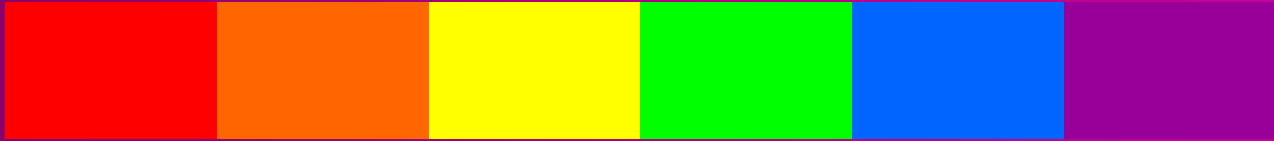


MATERIAL



Cyberchild: An accurate biochemical model of a young baby. Consciousness to do with physico/chemical states

Cotterill, R.M.J. (2003). CyberChild: a simulation test-bed for consciousness studies. *Journal of Consciousness Studies*, 10(4-5), 31-45



FUNCTIONAL



MATERIAL



Phenomenology?

In retrospect ... (where I come from...)

11 years of agonising about the possibility of MC:

From an automata theory/material point of view

1992: The Colin Cherry Memorial lecture

ICANN 92

1996: 'Impossible Minds': 1 postulate 11 corollaries

2000: Depictive theory published

2001: Axioms introduced at Skovde

2003: Axiomatic/Depictive theory published in JCS

Key design principle:

Introspection, shunned
by psychologists

OK for developing
designs.

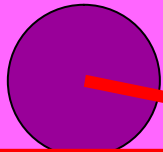
Written as axioms: i.e.
features resulting from
introspection.

What could be special
about mechanisms
that can produce for
them what for *me*
feels that I am
conscious ?

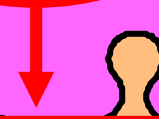
“an inner sensation
of world, self , past,
future, intention and
fiction”

WHAT USE ARE INTROSPECTIVE AXIOMS?

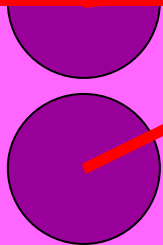
Introspective
axioms



Material
implications



What set of mechanisms could support the inner sensations described by the set of axioms?



Interlocking
Mechanisms

THE AXIOMS

Aleksander & Dunmall: *Axioms and Tests for the Presence of Minimal Consciousness in Agents*, *Journal of Consciousness Studies* June, 2003)

1

PERCEPTION

2

IMAGINATION

3

ATTENTION

4

PLANNING

5

EMOTION

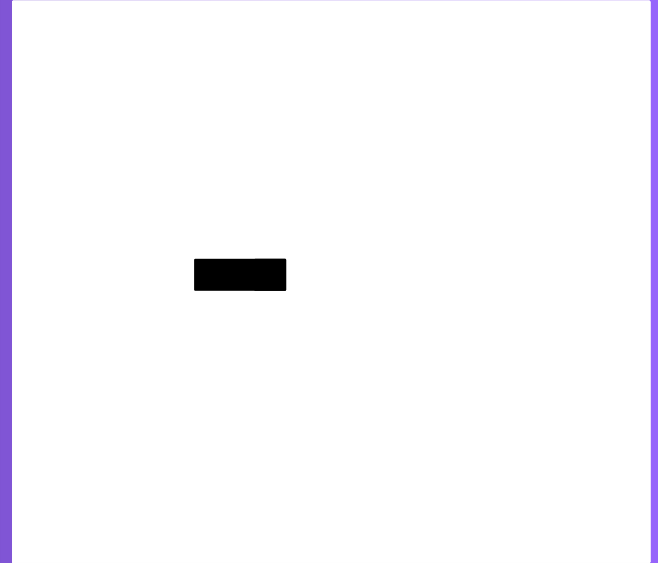
Axiom

1

First Person Phenomenon:

I feel as if *I* am in the middle of an “out there” world.

Material
Implications of
Axiom 1



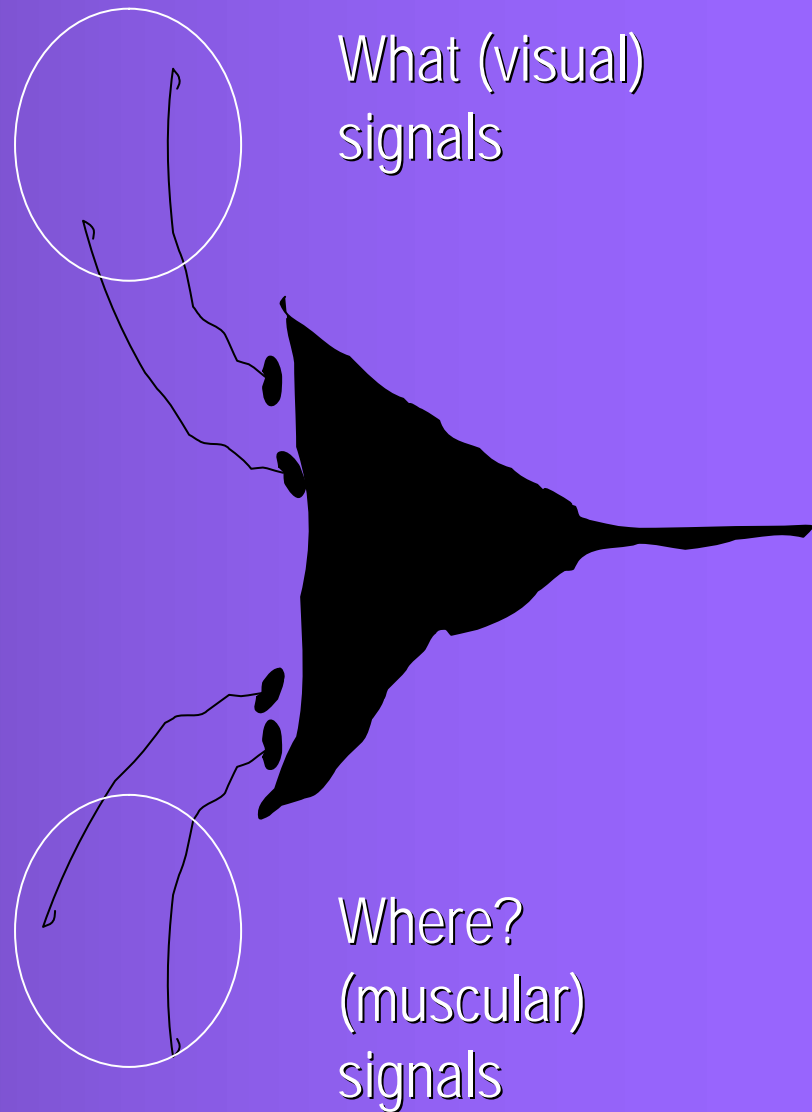
Material
Implications of
Axiom 1

Unique minimal world events have a unique coding (easy with a cellular structure)

Minimal events compose complex events both in the world and the mechanism

OUT THERE ??

The material
implications
of
Out-thereeness



LOCKING

Evidence:

- Galletti and Battaglini, *J Neurosci*, 9, 1112-1125, **1989** > **V3 (Gaze-locked)**
- Galletti et al, *Europ J Neurosci*, 9(2), 410-413, **1997** > **Arm movment in vis sys V6A.**
- Galletti et al, *Exp. Brain Res.* 96 (2): 221-229, **1993** > **Head-indexed in parietal.**
- Bender & Youakim, *J Neurophys*, 85(1), 219-234, **2001** > **Att. Lock V2, V4, 7a.**
- Boussaoud et al, *Exp Brain Res*, 128 (1-2): 170-180, **1999** > **All visuomotor paths.**
- Trotter & Celebrini, *Nature*, 15(5): 398(6724): 239-242, **1999** > **Prestriate V1**
- Trotter et. Al, *J Neurophys*, 76(5), 2872-2885, **1996** > **View dist. Coded in V1**
- Bremmer et al., *Europ J Neurosci*, 10(1), 153-160, **1998** > **V3A, 7a, V6 Post. Pariet**
- Duhamel et.al., *Nature*, 389 (6653): 845-848, **1997** > **Ventral IntraParietal**
- Guo & Li, *Neuroreport*, 8 (6): 1405-1409, **1997** > **All over striate cortex**
- Siegel, *Jour of Comp Neurosci*, 5(4), 365-381, **1998** > **Gaze locking in parietal 7a**
- Gdowski et.al., *Exp. Brain Res.* 135 (4): 511-526, **2000** > **Neck/gaze coding.**
- Desimone, *Proc Nat Acad Sci. USA* (93): 13 494-9, **1996** > **Attention in extrastriate**

Aleksander & Dunmall

Proc R. Soc. London B, Jan 22, 2000

Material
Implications of
Axiom 1

The design that captures

- Composition from minimal events
- Out-thereeness

We shall call

DEPICTIVE

*(Alva Noe:
enacted/sensorimotor)*

Axiom

2

First Person Phenomenon:

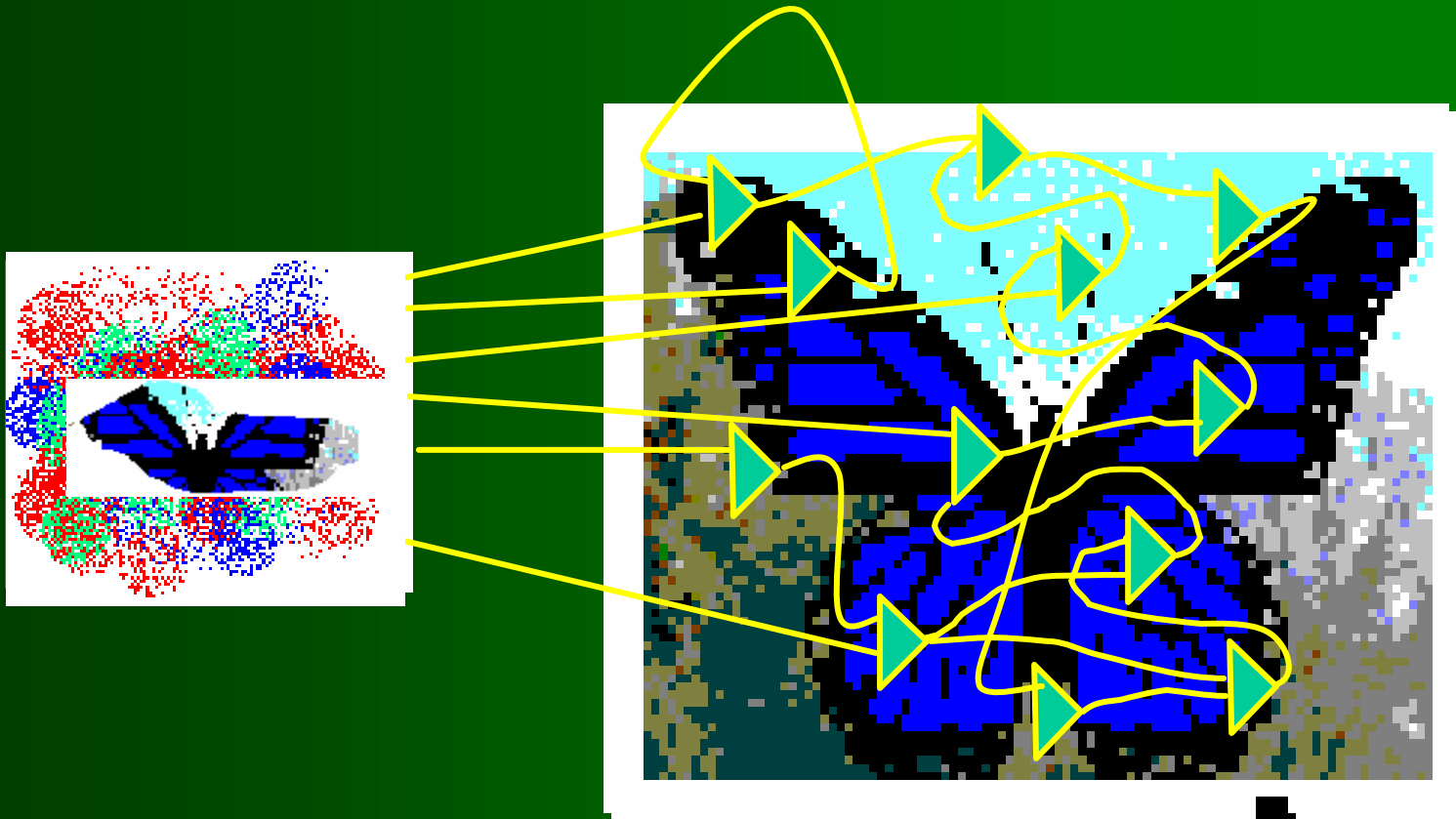
/ can recall 'out there'
worlds and imagine worlds
/ have never experienced.

Material
Implications of
Axiom 2

Depictive neural firing is sustained due to cells forming closed loops or layers 're-entering':

(Major link with complexity phenomena)

Communicating neurons: memory and imagination





Axiom

3

First Person Phenomenon:

I am conscious of only
that to which *I* attend.

Material
Implications of
Axiom 3

External Attention:

Is driven by localization signals for important events in the 'out-there' world and continuity.

Material
Implications of
Axiom 3

Internal Attention:

Is driven by the use of internally driven motor locking signals (inverse to reconstruction)

Or

Informational continuity

Axiom

4

First Person Phenomenon:

/ imagine future events in
the world and determine
my actions to get what /
want.

Material
Implications of
Axiom 4

Depictive states have a chaining property shaped by learning and recalled in imagination. Re - entry is again responsible for this

Axiom

5

First Person Phenomenon:

My emotions affect and are affected by **my** decisions.

Material
Implications of
Axiom 5

Structures continually (and innately?) evaluate perceptual and imagined future events in preparation for action .

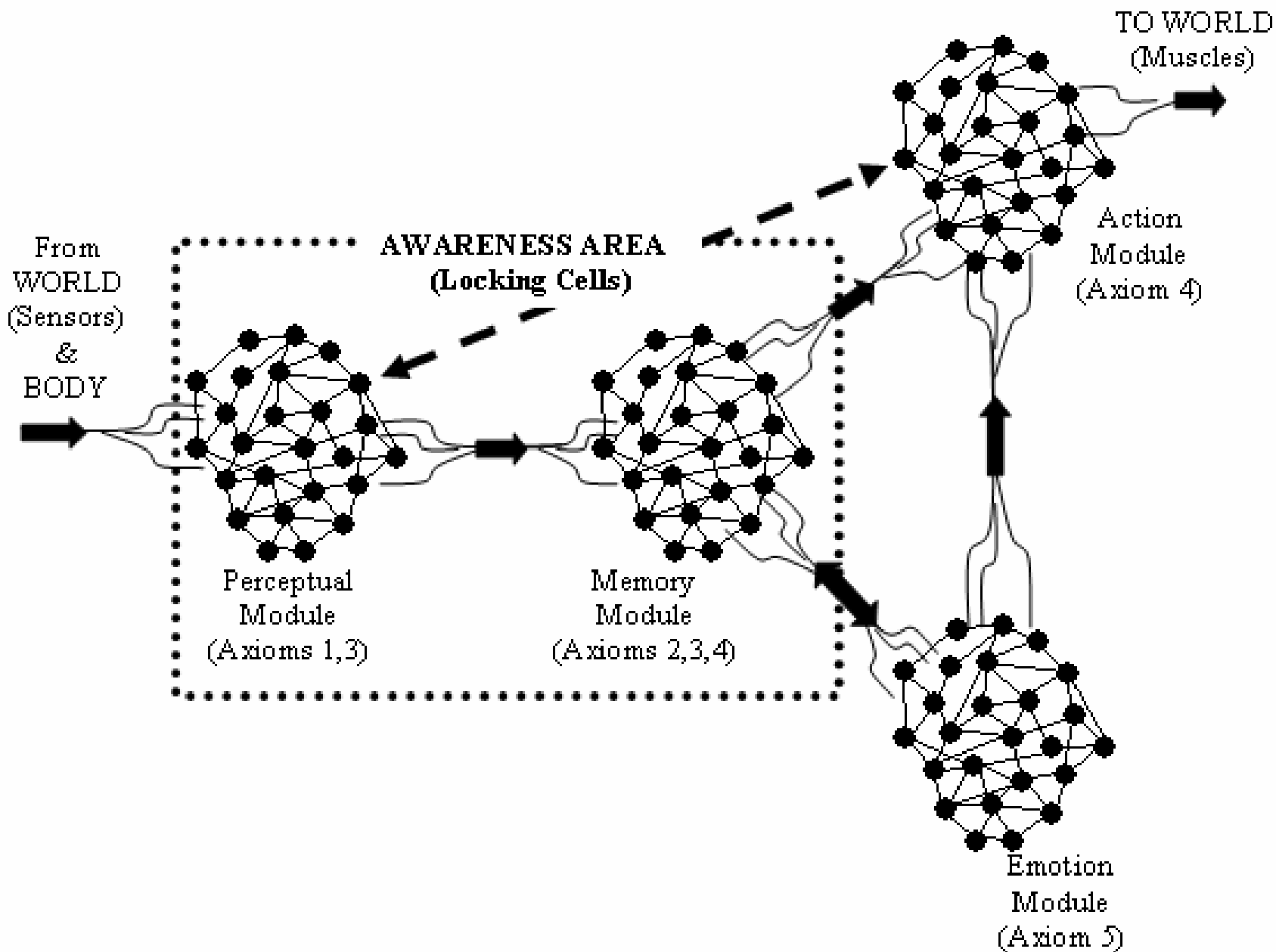
Emotions have a global effect on depictive structures

A vital corollary
resulting from the
Axioms

SELF

The Emergence of *SELF*

Combinations of
sensory, imaginal
attentional and affective
depictions lead to
descriptions starting
with the word /



Some past work from a MC standpoint

- 1998: Imagining Colour & Shape (Ax 1,2)
- 1999: Saccadic Face Perception and Recognition (Ax 1,2,3)
- 2000: Theory of depiction (Ax 1,2)
- 2001: Planning and Stacking Action (Ax 1,2,3,4)
- 2002: Mobile Robot (Ax 1,2,3,4)
- 2003: Visual Deficits in Parkinson's disease (Ax 1,2,3)





The first three
axioms at work
in a
Virtual Machine

The architecture is
heavily influenced by
how the brain is
structured

Nov



611

1)

f

.

t

ants

4)

What next?

Depictive attack on natural
language (Rao, Lineker)

Depictive models of
emotions (Lahnstein,
Dunmall)

Depictive plan selection
(Rabinder Lee – Oct 03)

What does
this tell us?

That we have a
long way to go!
BUT

IMPORTANT

What does
this tell us?

Axiomatic theory,

(Note echoes of Chalmers' structural coherence).

Suggests what is needed for an object to be conscious (i.e. design principles of structure that can cohere with sensation).

NOTE

What does
this tell us?

The five axioms
seems a *necessary*
set...

... a *sufficient* set may
be very large and
investigator
dependent!

"What is it like to be a bat?"

Thomas Nagel

Philo Rev 1974

While agreeing that this first person question cannot be answered.....

... A related question *can* be answered....

"What must the bat's brain do so that the bat can know what it's like to be a bat?"

Contact

i.aleksander@imperial.ac.uk

Look out for

The World in My Mind, My Mind in the World:
*Key Mechanisms for Consciousness in Humans, Animals
and Machines*