An Architecture for Dual Reasoning

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Outline

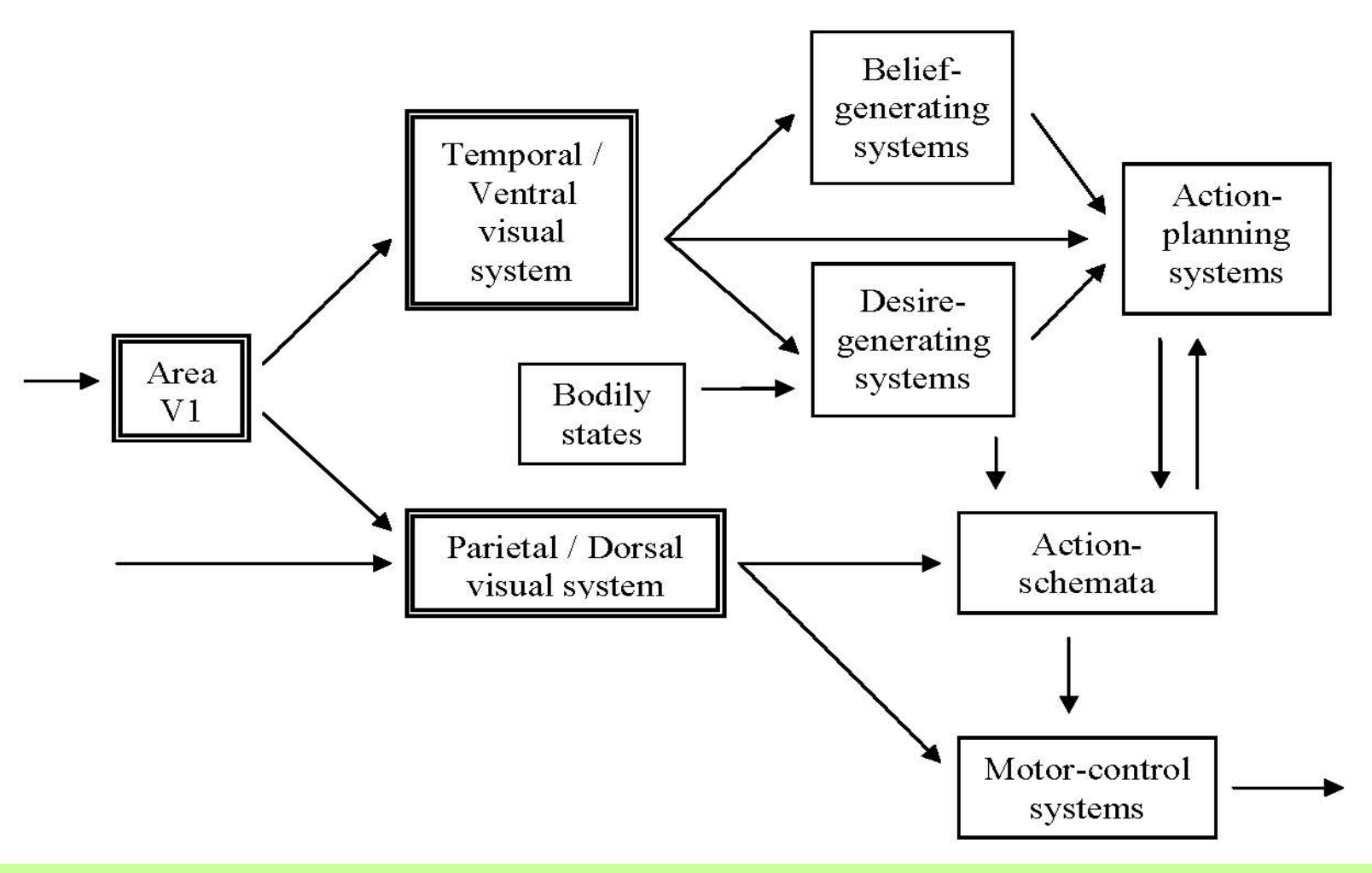
- Properties of the two systems
- The puzzle of System 2 (and solution)
- Mental rehearsal of action schemata
- Global broadcasting of percepts and images
- Soma-sensory monitoring
- The proposed System 2 architecture
- Explanatory advantages
- Predictions

Properties of the two systems

- **System 1**: is fast, parallel, unconscious;
- isn't easily altered; is universal;
- is impervious to verbal instruction;
- is heuristic based.

- **System 2**: is slow, serial, conscious;
- malleable; variable (by culture and individual);
- responsive to verbal instruction;
- influenced by normative belief;
- can involve application of valid rules.

The System 1 architecture (and two visual systems)



The puzzle of System 2

- System 1 is (largely) shared with other animals
- How did a whole new system for reasoning and deciding actions get added?
- Did extra belief-generating, desire-generating, *and* practical-reasoning boxes get added?
- What pressures could have produced such wholesale change?
- (As well as language, mind-reading, etc.)

The puzzle of System 2

- How can reasoning be controlled by beliefs about how one *ought* to reason?
- How can *beliefs* re-write the algorithms by means of which we reason?
- How can reasoning be guided by verbal instruction?
- System 2 needs to be under *intentional control* (Frankish).
- It needs to be an *action-dependent* system.

The puzzle of System 2

- Proposal: System 2 is realized in cycles of operation of System 1.
- Mentally rehearsed action leads to -
- globally broadcast images which -
- generate System 1 inferences and emotional reactions which -
- change the context for the selection of the next action / action-rehearsal.
- Because action-selection in general is under intentional control, so is System 2.

Mental rehearsal of action

- “Efferent copies” of motor commands are created for fine-grained control.
- An emulator system converts the efferent copy into a perceptual representation of the act.
- Matched against the incoming perceptual data.
- And used to create predictions of the likely effects of the act, elaborating the images.
- Which are also matched against incoming data.

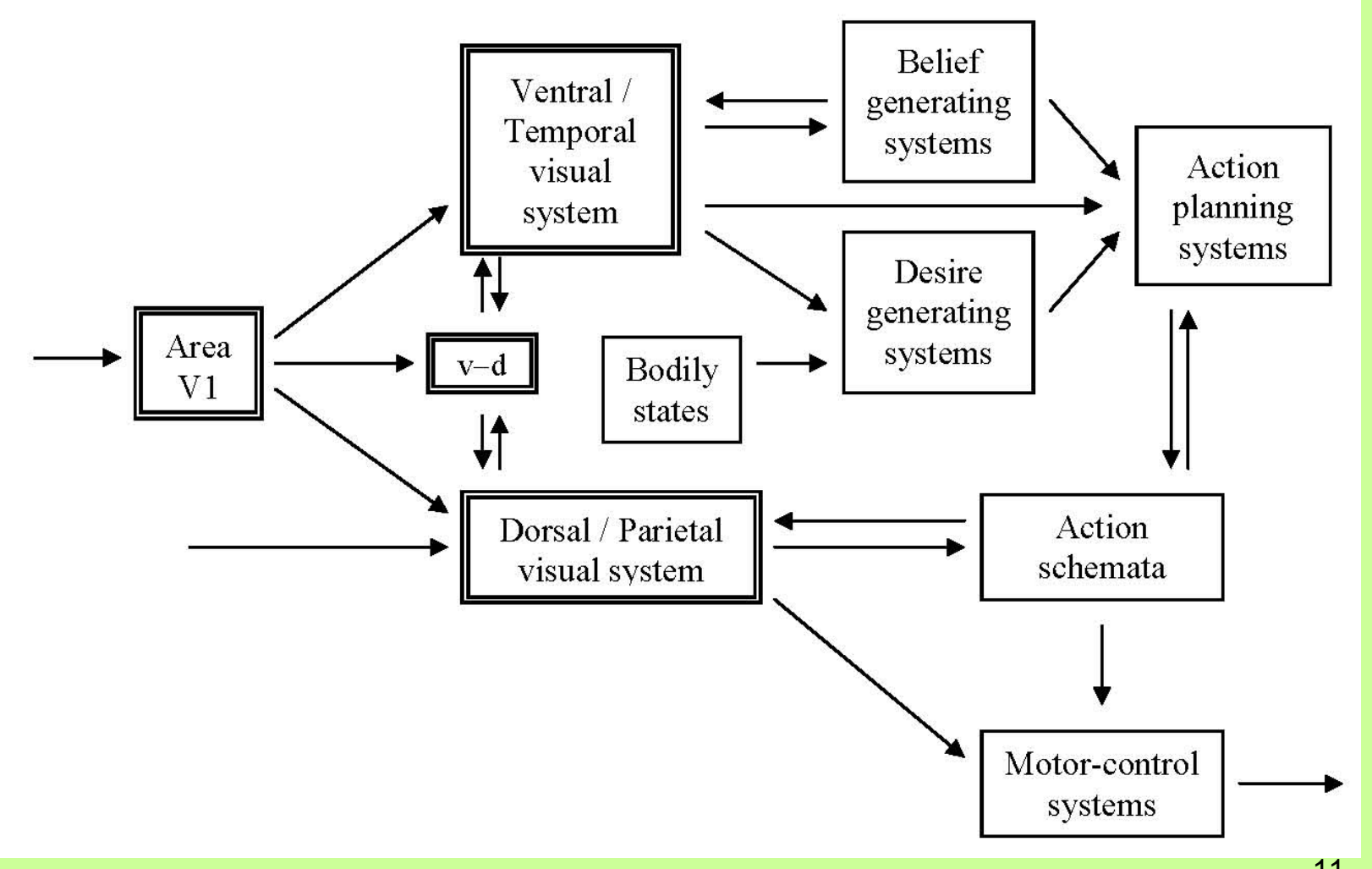
Mental rehearsal of action

- The same system can be used “off line”, with overt action suppressed.
- Used for planning: trying out actions in the imagination.
- Some evidence of use by apes (“insight”).
- Strong evidence of use by *homo ergaster* in sophisticated stone-tool making.
- Also utilized in “inner speech”.

Global broadcasting of percepts

- Conscious percepts are “globally broadcast” to a wide range of consumer systems (Baars).
- Conscious images utilize the same perceptual mechanisms and global broadcast (Kosslyn).
- Images can be created by conceptual systems acting on temporal cortex, e.g. for recognition.
- But movement and transformation of images are the product of motor cortex (Kosslyn).

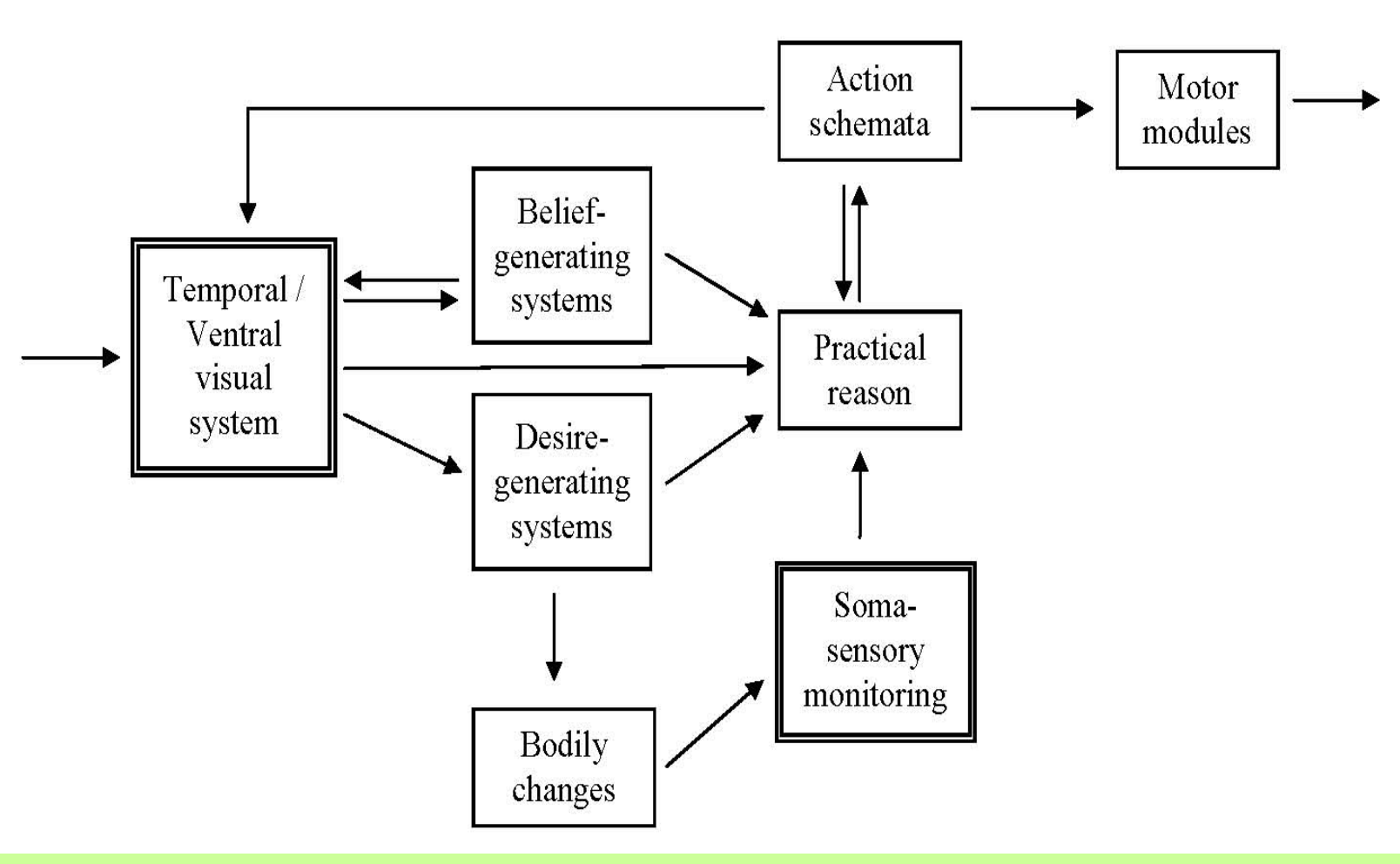
The System 2 architecture



Soma-sensory monitoring

- Broadcast images of action and its effects are also taken as input by motivational systems.
- These respond according to content, producing a suite of physiological responses.
- These are monitored by the subject.
- Motivations to perform the action are adjusted up or down accordingly (Damasio).

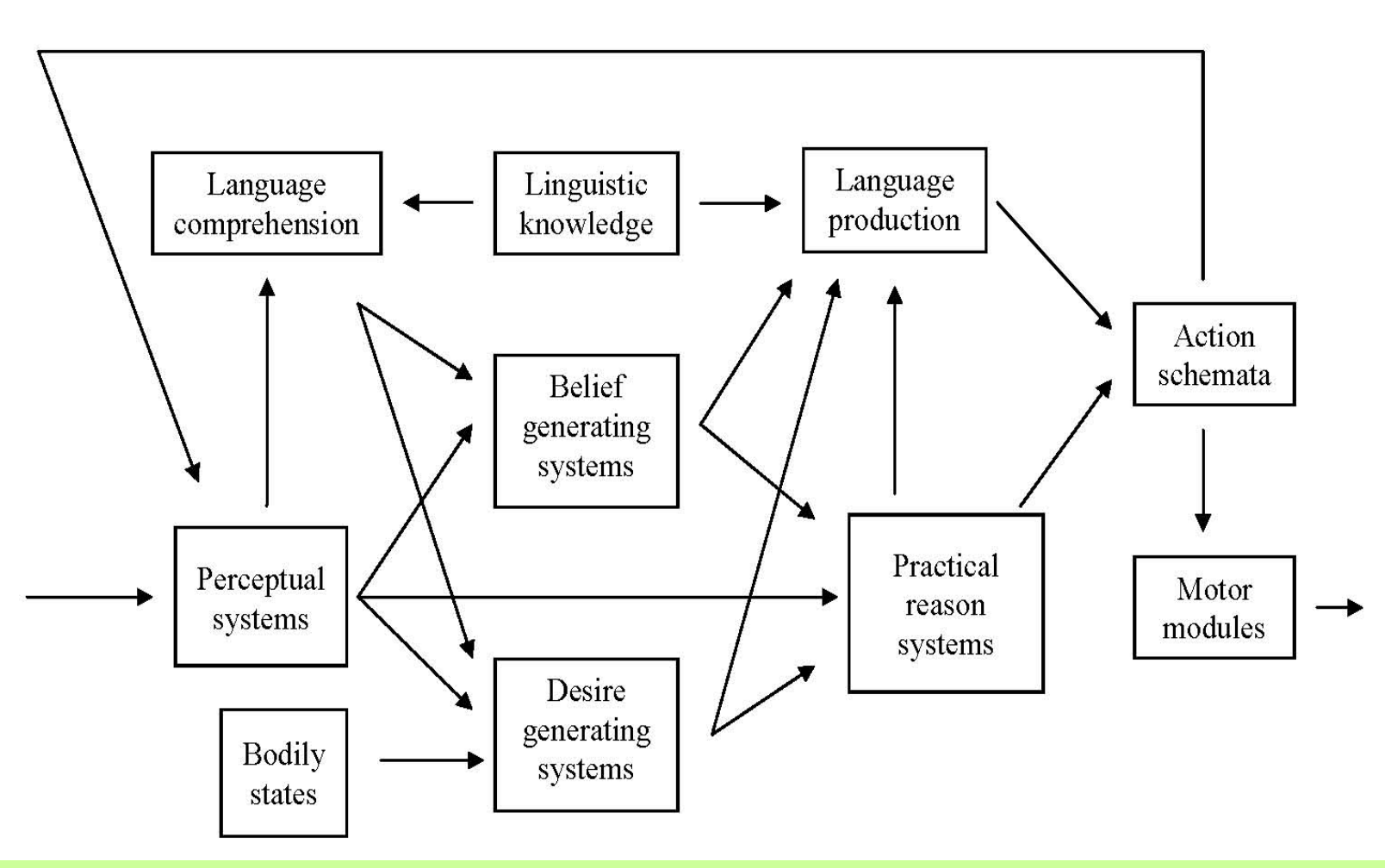
Soma-sensory monitoring



Inner speech

- Mental rehearsal also takes place for *speech* actions.
- Leading to globally broadcast images of speech ("inner speech").
- To which contents are attached by the language comprehension system.
- Which are made available to System 1 systems to draw inferences and generate emotions.

Inner speech



Explanatory advantages

- *Cycles* of System 1 activity explains why System 2 is slow and serial.
- Global broadcasting explains why (some aspects of) System 2 are conscious.
- All the systems involved in mental rehearsal are present in animals (except speech).
- Variable dispositions to engage in mental rehearsal (partly) explain individual variation in System 2.

Explanatory advantages

- Since System 2 is action-based, it can be influenced in any of the ways that action can:
- imitation
- verbal instruction
- beliefs about what one *ought* to do.
- Consistent with the accuracy of "think aloud" protocols for System 2 tasks.

Predictions

- Patients with Huntington's disease should be weaker than controls at System 2 tasks, but not at System 1 tasks.
- Freezing motor and premotor cortex should have the same effect.
- Interference with mental rehearsal (e.g. by shadowing speech) should have the same effect.

Conclusion

- System 2 is realized in cycles of System 1.
- Utilizing pre-existing mechanisms.
- For which we have independent warrant.
- The plausibility of this account further supports the reality of the System 1 / System 2 distinction.