

# The origins of 'thinking'

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# 'Fast and frugal' decision-making

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- To stay alive, animals must respond appropriately *in real time* to opportunities and threats.
- The most efficient and reliable means of producing fitness-enhancing responses will be favoured by natural selection.
- Routinizing decision-making (e.g., 'hard-wiring' stimulus-behaviour links) increases reliability and efficiency (via faster responses, energy-saving, fewer steps to go wrong).



# Principle of Cognitive Economy

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- *To increase the reliability and efficiency of behaviour production, control will tend to be passed to the lowest possible level (e.g., habit formation).*
- One consequence can be that the causes of behaviour become **opaque** to the behaving animal (i.e., unconscious).



# The 'adaptive unconscious'

(Timothy D. Wilson)

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'The mind operates most efficiently by relegating a good deal of high-level, sophisticated thinking to the unconscious...which does an excellent job of sizing up the world, warning people of danger, setting goals, and initiating action.'



# Thus...

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- The brain's job is to **produce behaviour**, not to 'think'.
- In fact, brains have been designed to minimize 'thinking'.



# What is 'thinking'?

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- **Operational:** significant response delay
- **Neuroscientific:** more than a few cognitive steps (synaptic connections) between stimulus and response
- **Functional:** reflection on past/future events – more than 'here-and-now' decision-making



# Comparative cognition

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- A phylogenetic approach to the development of cognition shows that (reflective) thinking is
  - very recent
  - an addition to pre-existing abilities
  - restricted to a very few species (most do fine without it)
  - probably designed to help animals achieve a longer time horizon for planning and controlling behaviour

# 'Evo-logic'

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- An animal's niche determines the **evolutionary tasks** an animal must perform to survive and reproduce (e.g., sexual reproduction, frugivory, respiration of air).
- Behaviour is designed to solve evo-tasks.
- Brain structures that picked behaviours that solved tasks got selected.
- Niches and task repertoires for brains became more complex over human ancestry.
- Hence brains became more complex.

# Types of behavioural end-states

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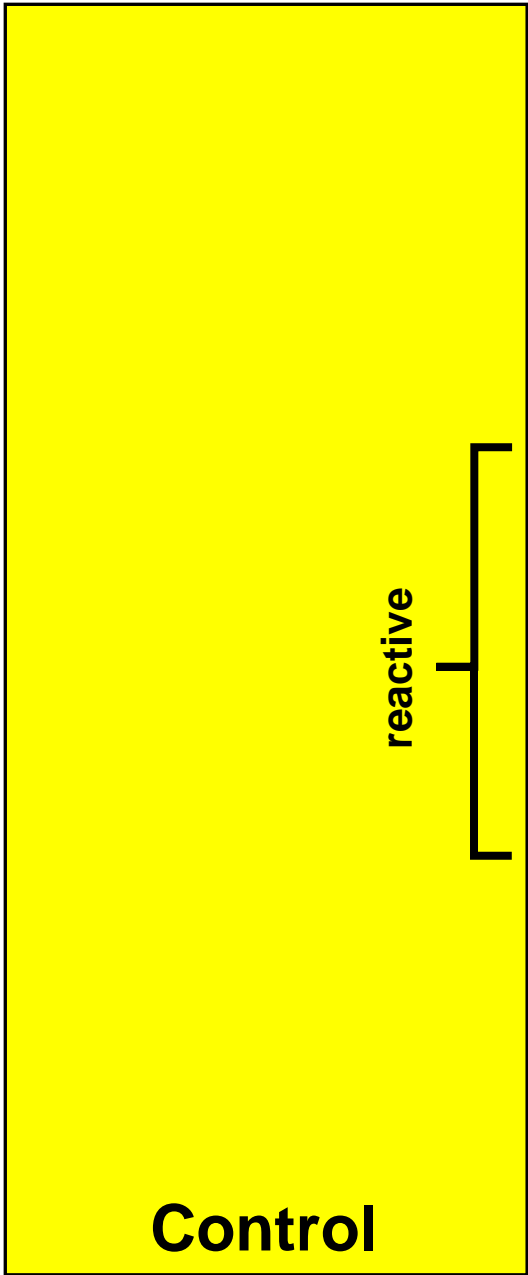
<i>Type</i>	<i>Definition</i>
<b>Primary</b>	A state of the world which provides an animal with immediate benefits associated with survival or reproduction (e.g., consumption, copulation)
<b>Secondary</b>	A state of the world which has tended to be associated with evolutionary benefits during an animal's phylogenetic history, but which is costly (in energetic or risk terms) to achieve (e.g., aggression)



# Stage 1: Non-representation

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- Behaviour is driven by **cues**, or perceived stimuli.



reflexes

A horizontal black arrow pointing to the right, starting from the right side of the "reflexes" box and extending across the middle of the diagram.

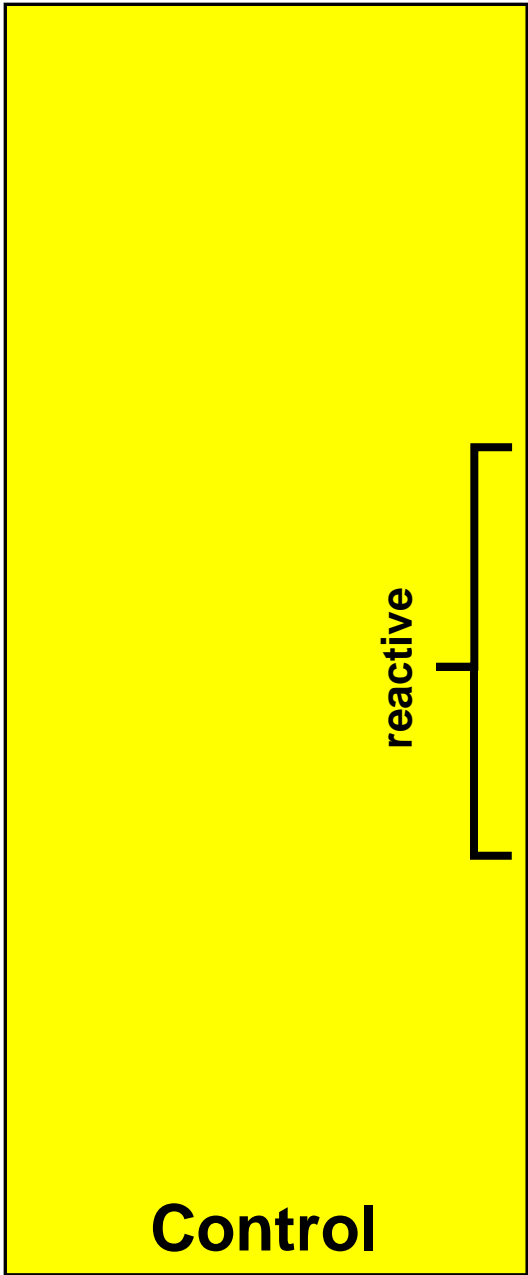
**END-DIRECTED  
BEHAVIOUR**

Metazoan

# Reflexes



<b><i>Definition</i></b>	Stimulus-generated behaviour leading to the attainment of a primary end-state
<b><i>Innovation</i></b>	transfer of functionality to nervous system (multicellularity)
<b><i>Algorithm</i></b>	If sense X, do Y
<b><i>Learning</i></b>	habituation/associative
<b><i>Examples</i></b>	eat, excrete, recoil (whole body convulsions)



**MEANS-ORIENTED  
BEHAVIOUR**

*explore*

(stimulus-  
generation)

reflexes

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BEHAVIOUR**

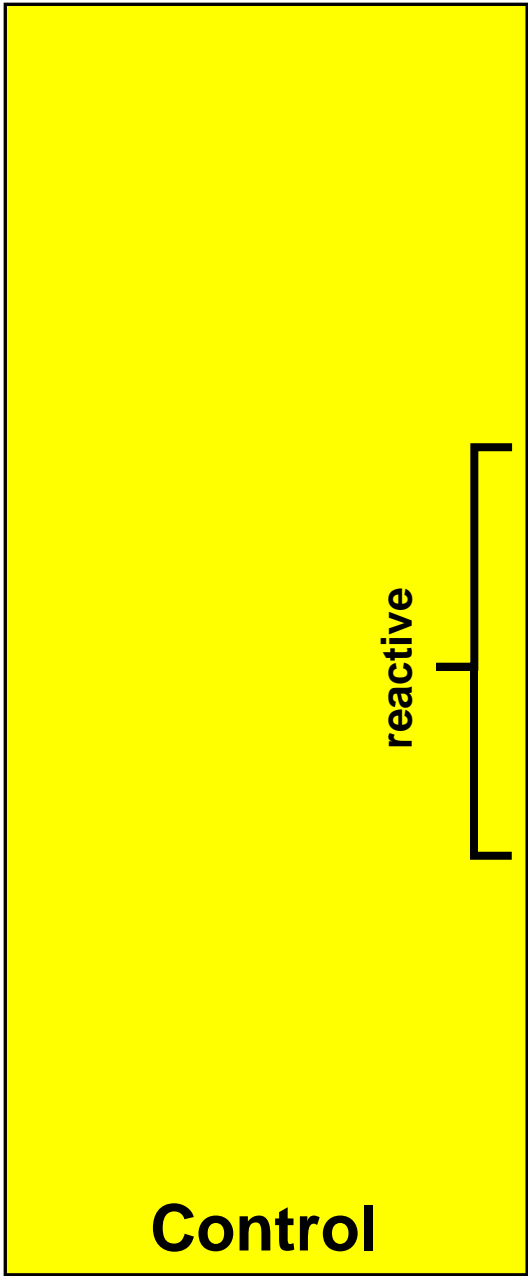
Metazoan



# Explore



<i><b>Definition</b></i>	<b>Undirected search</b>
<i>Innovation</i>	internally-generated (proactive) behaviour
<i>Algorithm</i>	If no significant stimulus, engage in motor behaviour
<i>Learning</i>	habituation, simple associative
<i>Examples</i>	'Brownian motion' (whole body convulsions)



**MEANS-ORIENTED  
BEHAVIOUR**

*explore*

(stimulus-  
generation)

**reflexes**

**instincts**

secondary  
end-state

**END-DIRECTED  
BEHAVIOUR**



# Instincts



<b><i>Definition</i></b>	Stimulus-generated behaviour leading to the attainment of a secondary end-state
<b><i>Innovation</i></b>	secondary end-state
<b><i>Algorithm</i></b>	If sense X, do Y
<b><i>Learning</i></b>	biologically 'prepared'
<b><i>Examples</i></b>	schooling; migration; bee cell-capping; hygiene

# Evolution of behaviour control

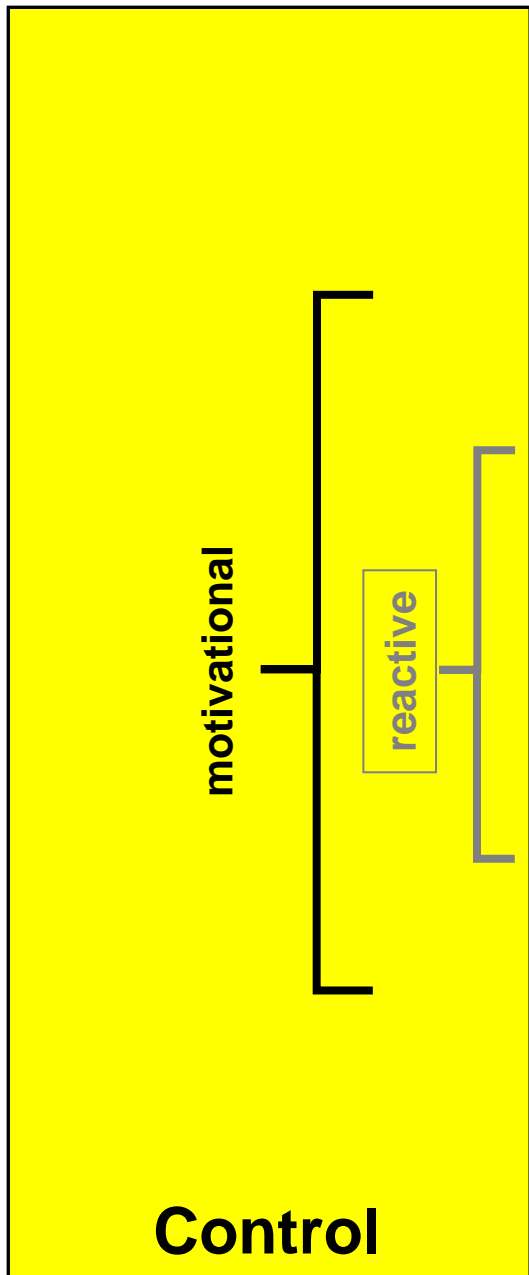
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<i>I</i>	Reactive	reflexes [ <i>explore</i> ]	primary	Metazoans	habituation/ sensitization, simple associative	bidirectional nerve net (undifferentiated but specialized tissue)
		instincts	secondary	Chordates	bio-prepared	centre/ periphery (nerve cord w/ganglion + transverse nerves)
<i>II</i>	Motivated	drives	primary	Vertebrates	associative	mylinated, lobed brain, 3-layer cortex
		emotions	secondary	Mammals	vicarious	neocortex (6-layers), CT-fibers
<i>III</i>	Executive	plans	tertiary (objectives)	Humans	reasoning	expanded neocortex, spindle neurons



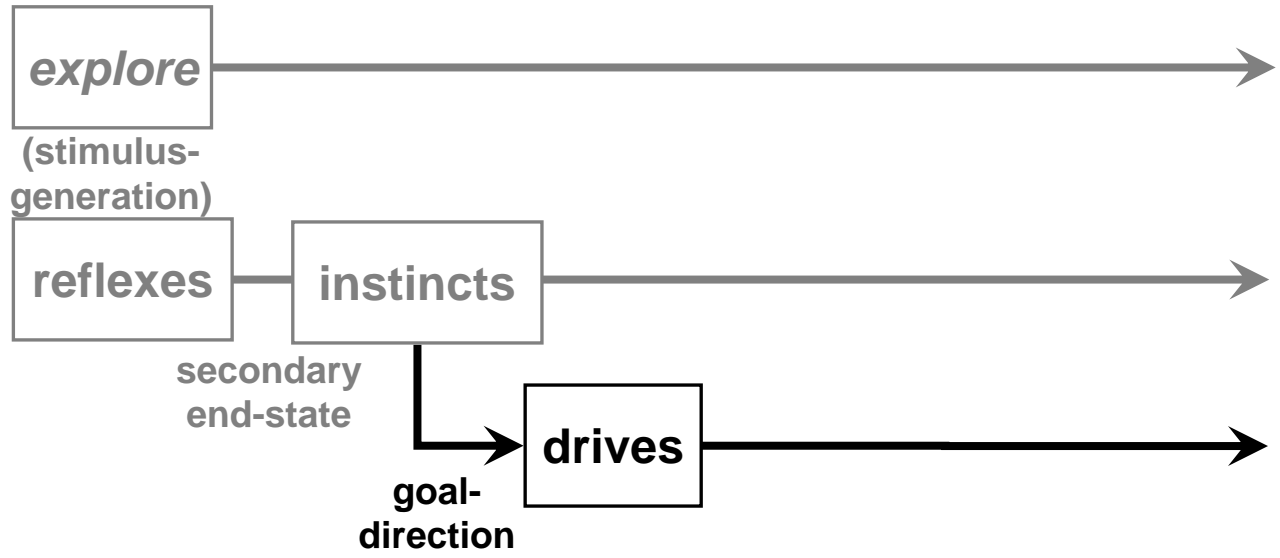
# Stage 2: Representation

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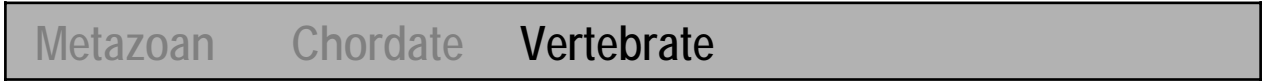
- Behaviour is *goal-directed*.
- ***Goal***: An internal representation of a (desired) end-state.
- ***Reward***: Psychological system (based on dopaminergic feedback) indicating assessed progress toward goal.
- Result: control is extended beyond immediate response.



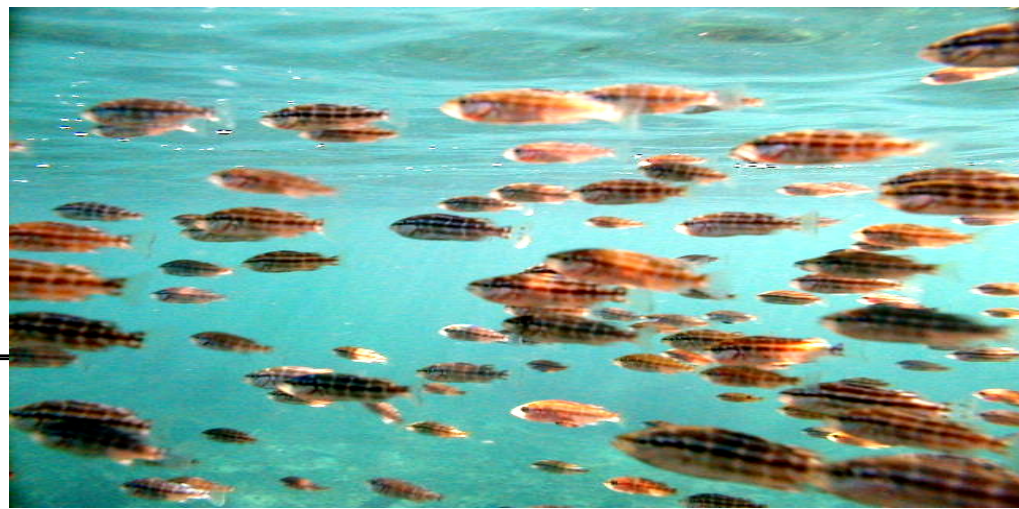
**MEANS-ORIENTED  
BEHAVIOUR**



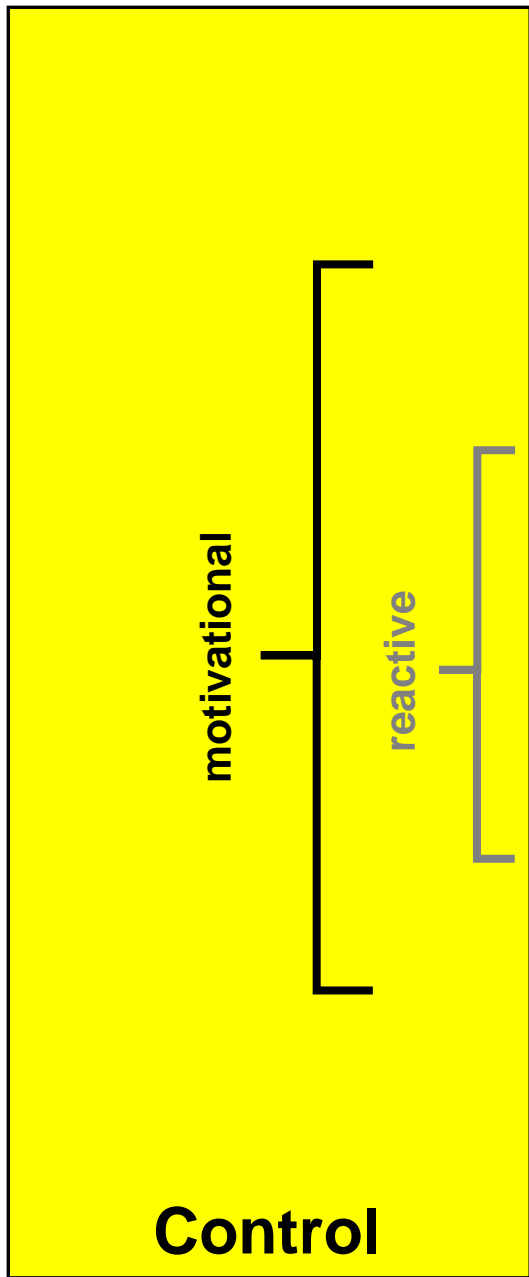
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BEHAVIOUR**



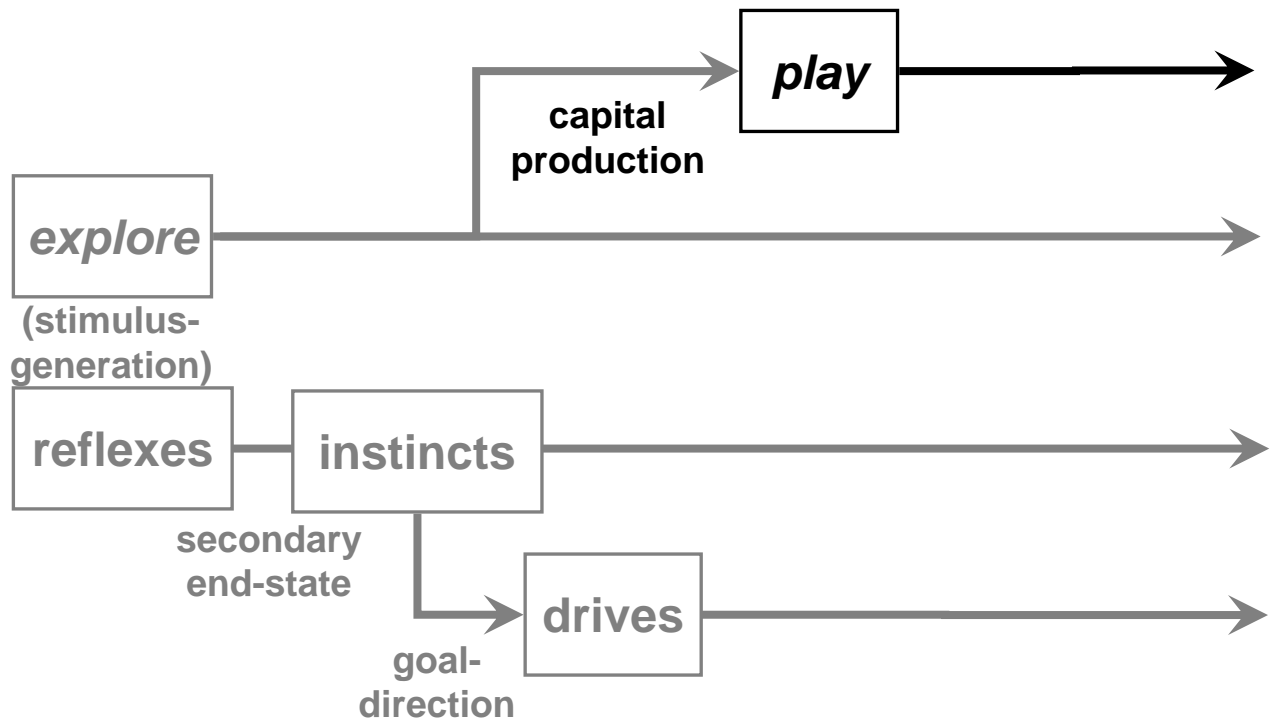
# Drives



<b><i>Definition</i></b>	Goal-directed behaviour leading to the attainment of a primary end-state
<b><i>Innovation</i></b>	arousal; <i>seek</i> + reflex
<b><i>Algorithm</i></b>	If internal resource imbalance, produce response-plan to achieve goal (optimal resource level)
<b><i>Learning</i></b>	associative; reward-based
<b><i>Examples</i></b>	hunger, thirst, sex, habitat selection
<b><i>Features</i></b>	resources typically cross body boundary



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BEHAVIOUR**

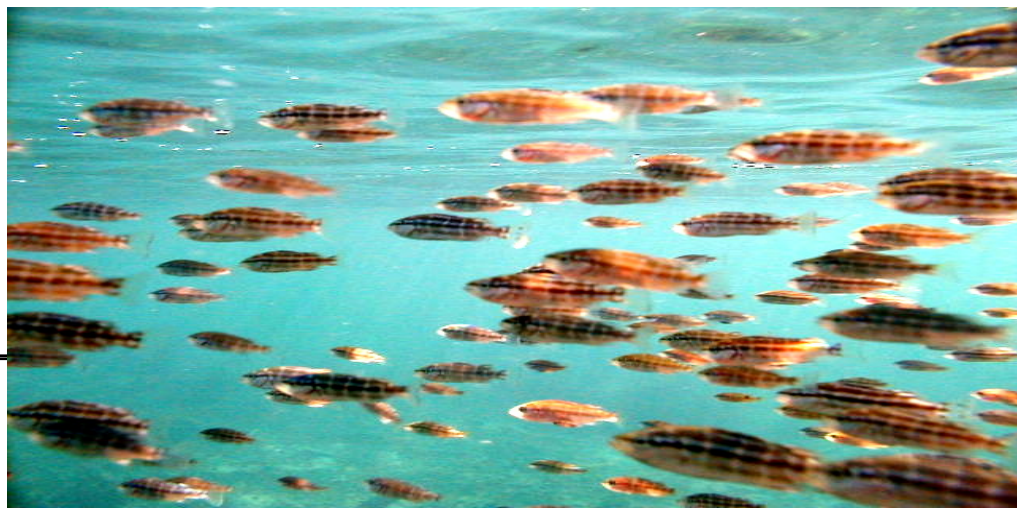


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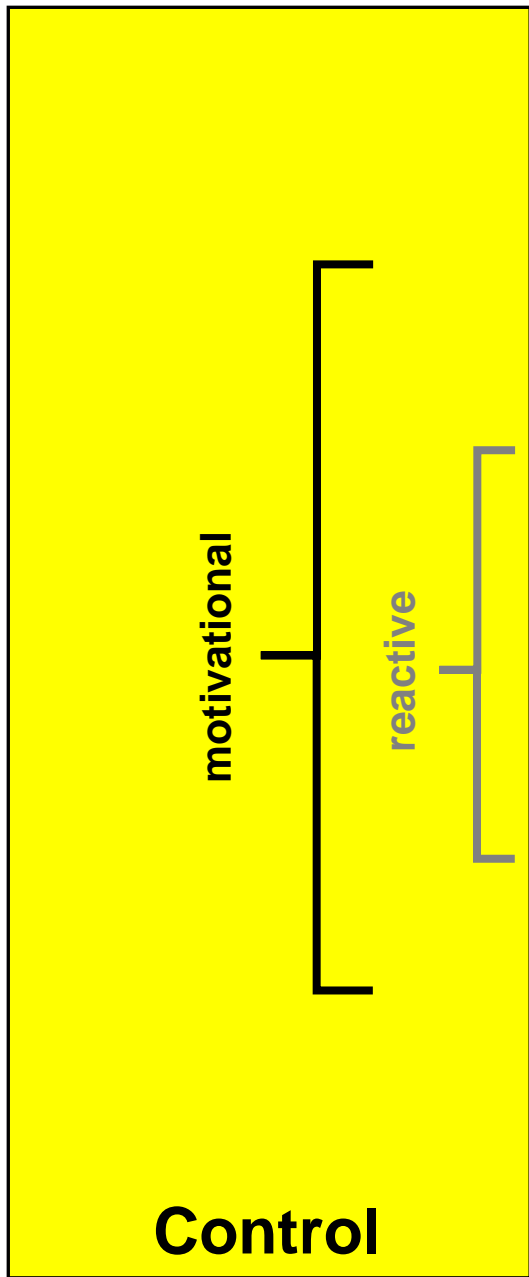


# Play

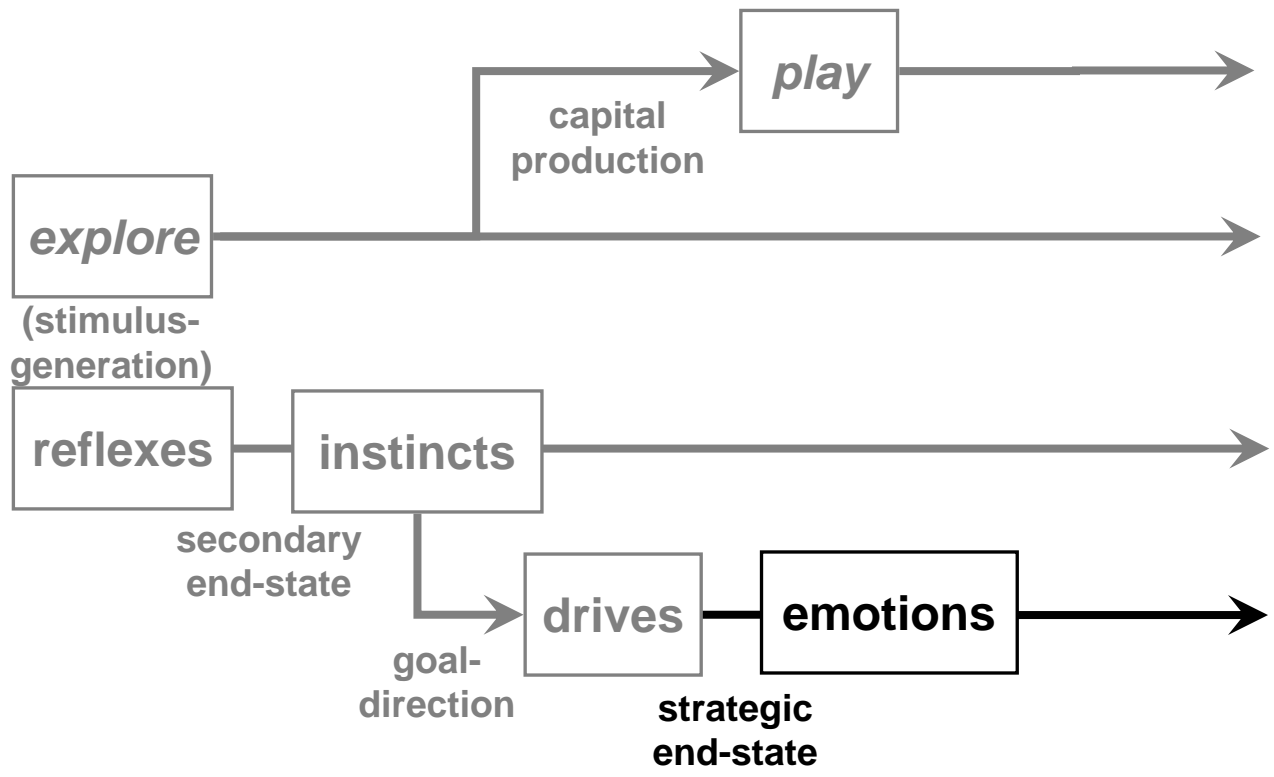
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<b><i>Definition</i></b>	Environmental, social or personal 'capital' production
<b><i>Innovation</i></b>	behaviour in 'pretend' context
<b><i>Algorithm</i></b>	If no internal or external stimulus, and have energy reserves, then initiate 'practice'
<b><i>Learning</i></b>	reflexive (end-in-itself)
<b><i>Examples</i></b>	practice subsistence/social skill, manipulate new objects



**MEANS-ORIENTED  
BEHAVIOUR**



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BEHAVIOUR**



# Emotions



<b><i>Definition</i></b>	Goal-directed behaviour leading to the attainment of a secondary end-state
<b><i>Innovation</i></b>	strategic behaviour
<b><i>Algorithm</i></b>	If perceive socially-dependent fitness gain/loss situation, determine strategy to achieve goal
<b><i>Learning</i></b>	vicarious (social)
<b><i>Examples</i></b>	protection of mate/offspring, maximize status, conform to norms
<b><i>Features</i></b>	dependence on behavioural response of conspecifics

# Emotions as games



- Limited to species which depend on conspecifics to achieve fundamental evolutionary tasks
- Goal-achievement is thus *strategic*
- Emotional interactions therefore modelled as *games*
- Players choose *strategies* (e.g., display anger/submission, aggression)
- Interaction of strategies determines *outcomes*
- Outcomes associated with *payoffs* (perceived as psych rewards)
- In some species, players *appraise* outcome situation to determine if goal achieved; if not, play new strategy (i.e., iterated game-playing)
- Appraisals are associated with *feelings* (e.g., anger, joy, shame, jealousy, envy, elevation)

# Stages of evolution in emotions

STAGE	<i>SOCIALITY TYPE</i>	NOVEL TASKS	STRATEGIES	ASSESSMENT SKILLS
Mammalian (pro-social) 65MYA	<i>mother + offspring</i>	coordinate with male for sex, protect/nurture offspring	mother-love, anger	subjective/hedonic awareness (reward-based)
	<i>nuclear family</i>	initiate/maintain pair-bond, secure paternal investment	pair-bond love	
	<i>harem</i>	share mate	jealousy	
	<i>confederation of families</i>	form coalitions (e.g., group hunting)	nepotism	
Primate (anti-social) 35MYA	<i>social hierarchies</i>	compete for status	dominance/submission	'theory of mind'/ self-concept
Human (pro-social) 6MYA	<i>status-levelling groups</i>	share resources with non-kin	compliance, (third-party) reward/punishment	symbolic thinking/ arbitrary rules (social norms)

# Evolution of behaviour control

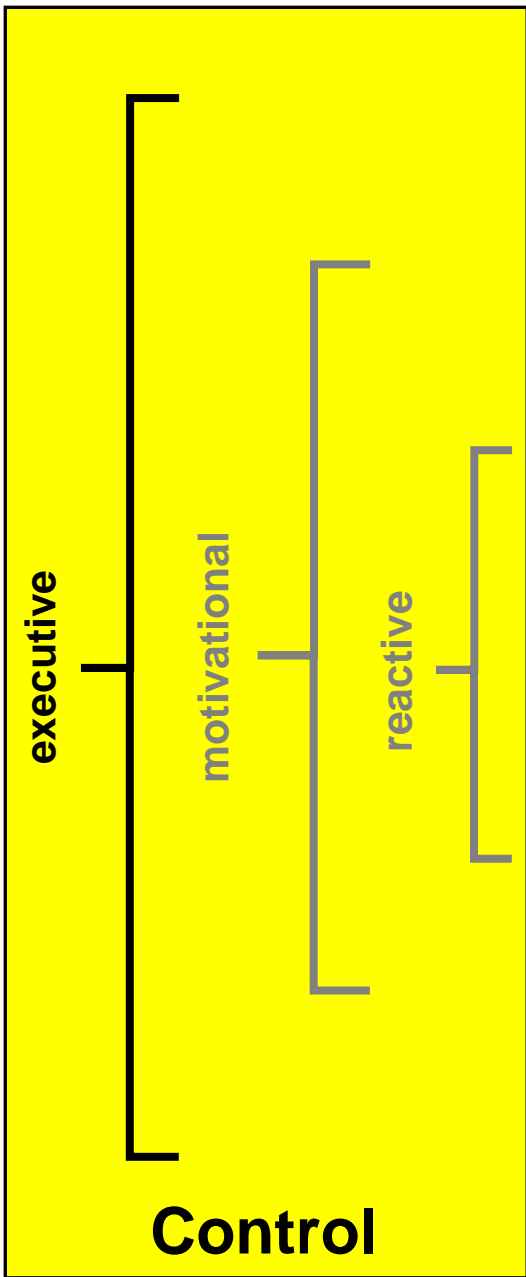
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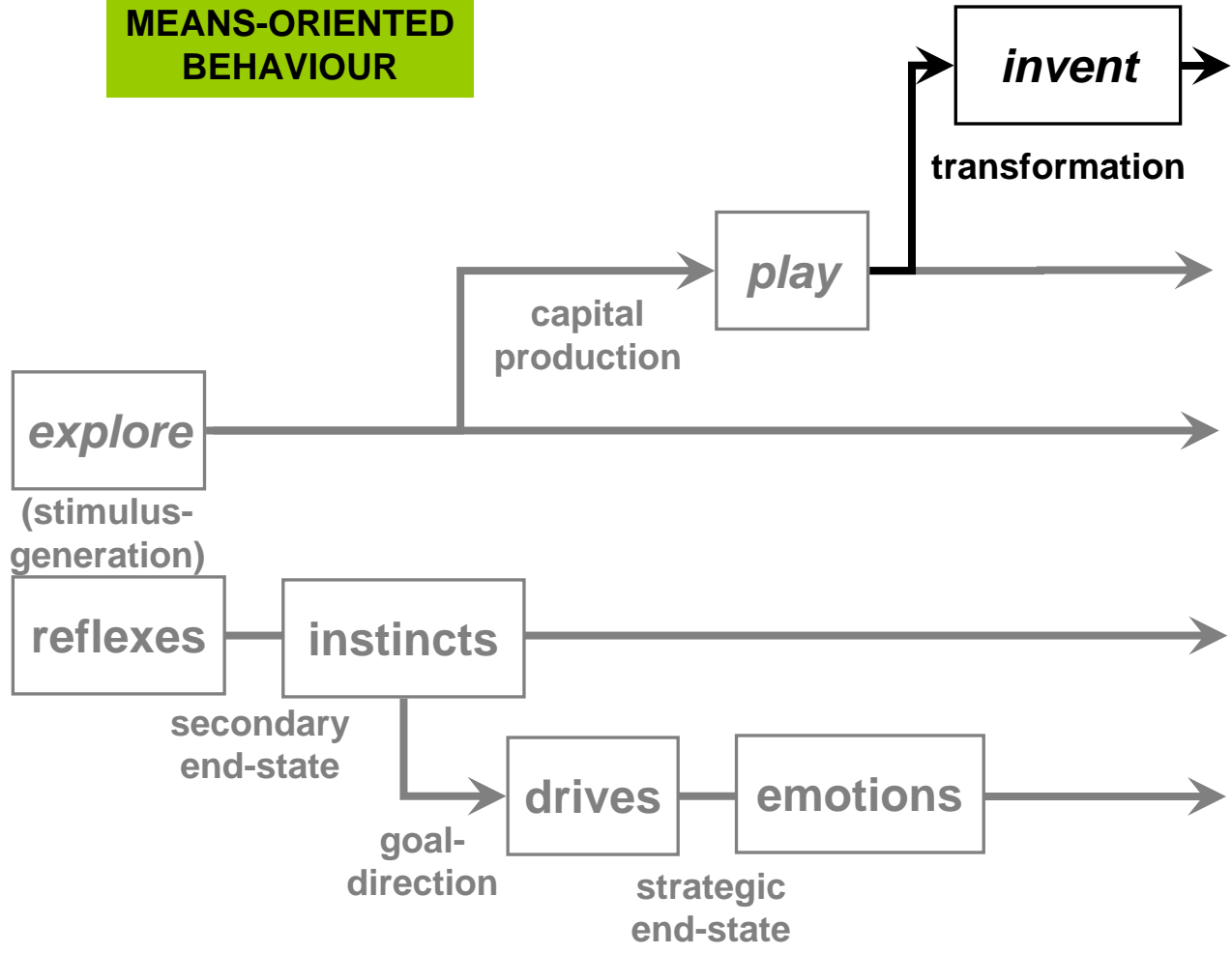
# Stage 3: Meta-representation

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- The ability to represent mental representations hierarchically (e.g., 'theory of mind').
- Linked to feelings (hedonic sensation of reward), symbolic thinking, self-concept, consciousness and language.
- Behaviour directed toward achievement of individually constructed 'objectives' rather than (evolved) goals.
- First observed in Apes (some features only in humans).



**MEANS-ORIENTED BEHAVIOUR**



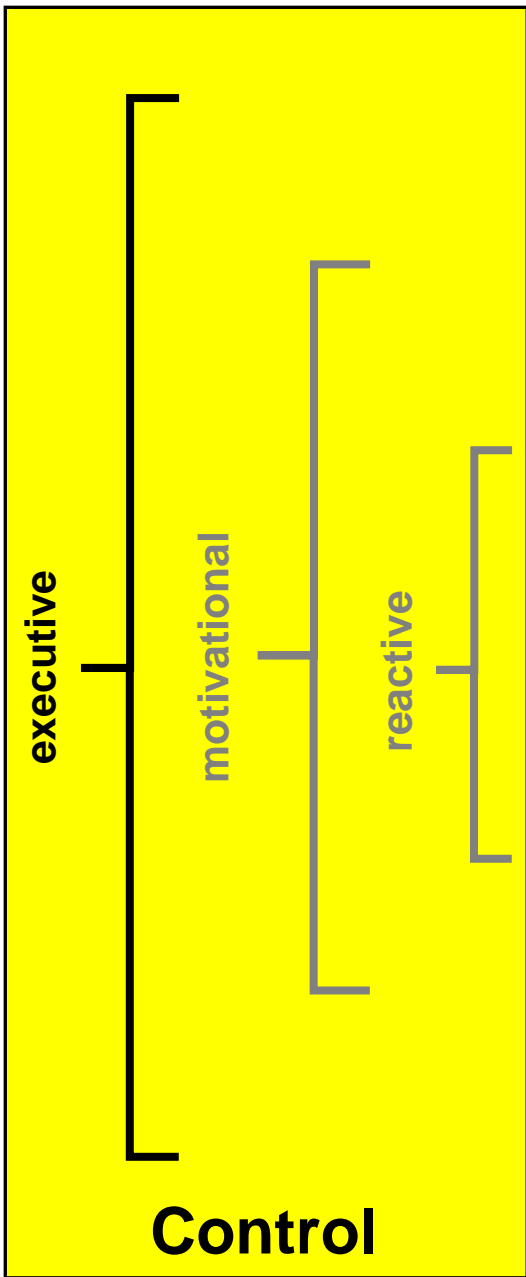
**END-DIRECTED BEHAVIOUR**



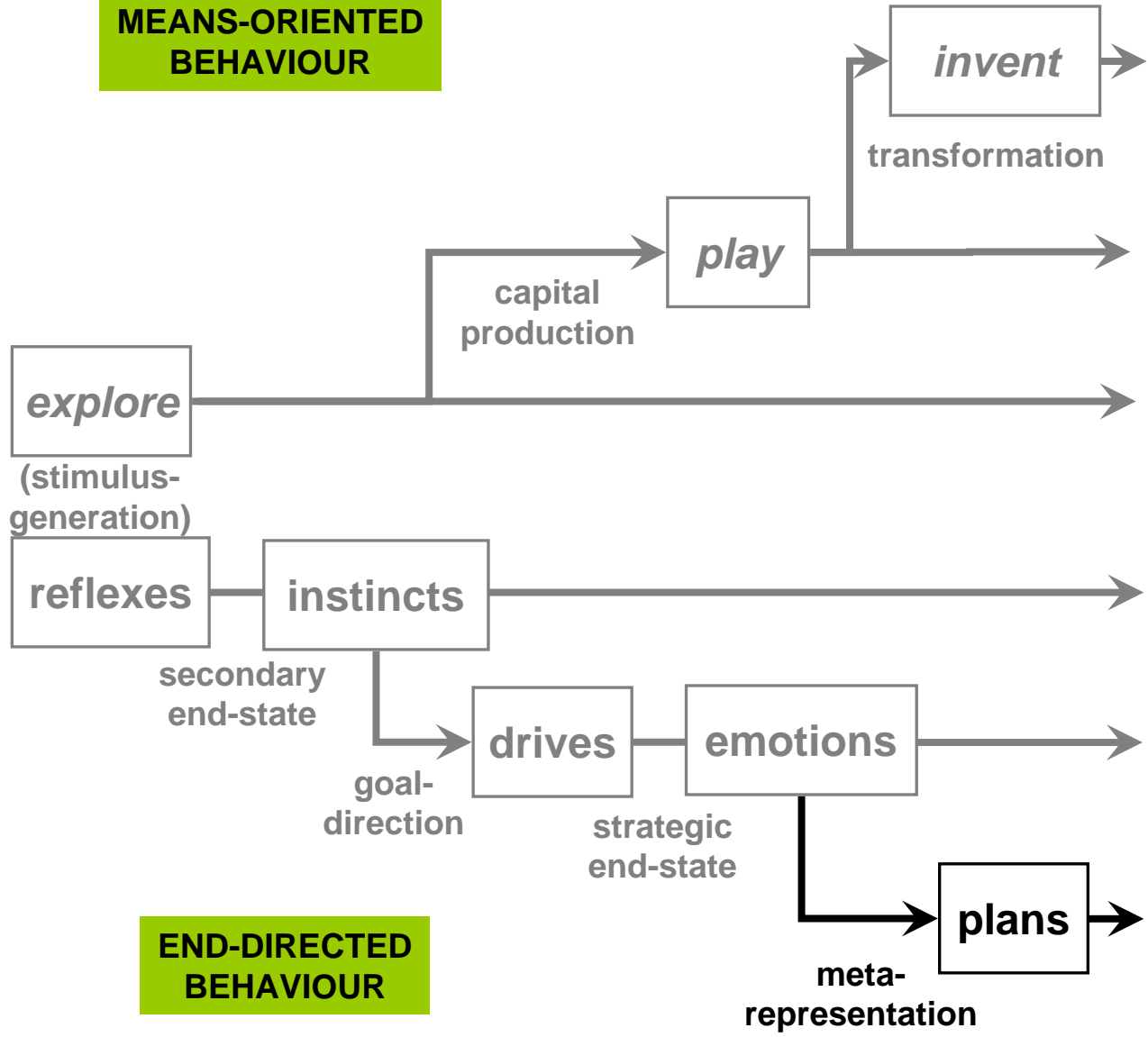
# Invention



<i>Definition</i>	<b>Consciously controlled play</b>
<i>Innovation</i>	mental simulation of behaviour
<i>Algorithm</i>	If no pressing problems, create and manipulate virtual worlds
<i>Learning</i>	exploratory and transformational logic (recombination of representations)
<i>Examples</i>	scientific discovery, creation of art-forms, social 'insights'
<i>Features</i>	symbol manipulation



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# Planning (‘thinking’)

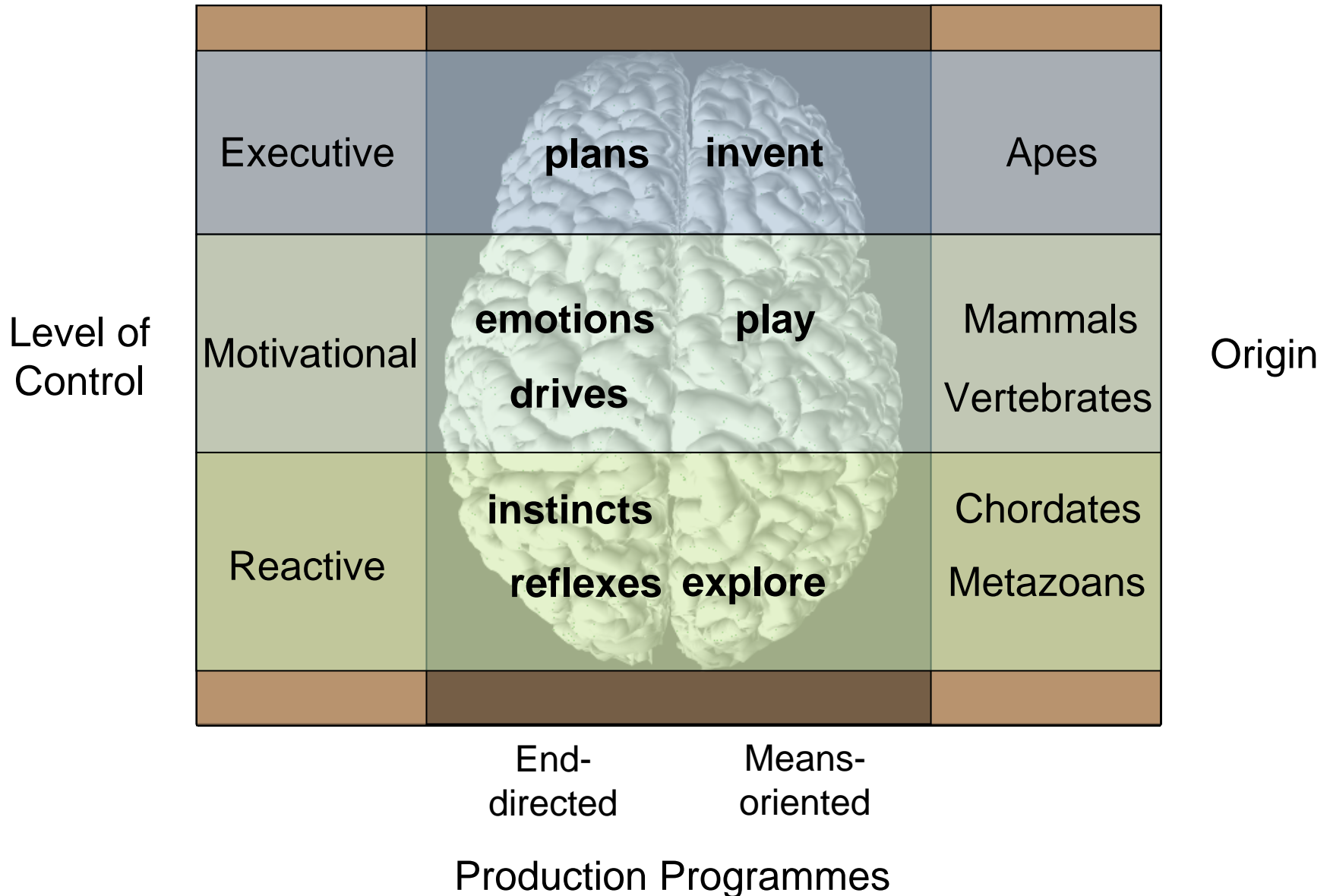


<b><i>Definition</i></b>	Behaviour designed to achieve <i>objectives</i> , based on meta-representations
<b><i>Innovation</i></b>	ordered goal-achievement sequences
<b><i>Algorithm</i></b>	If multiple goals can only be achieved in sequence, construct plan
<b><i>Learning</i></b>	reasoning (deductive/inductive)
<b><i>Examples</i></b>	going to the shop, becoming a professor
<b><i>Features</i></b>	ability to suppress current goal-orientation in favour of long-term objectives

# Evolution of behaviour control

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# Behaviour Production in the Brain



Task Category	Primary end-state	Reflex (stimulus-generated)	Drive (goal-directed)	Secondary end-state	Instinct (stimulus-generated)	Emotion (goal-directed)
SOMATIC	resource levels managed	<i>consume/ suckle, excrete, sweat</i>	<i>hunger/ predation, thirst</i>	access to resources secured	<i>territorial display, migration, panic-cry</i>	<i>competition, affiliation/ coalition</i>
	body envelope maintained intact	<i>startle, withdrawal</i>	<i>habitat choice (pressure, temperature, pH)</i>	dangers (environments, other animals) avoided	<i>flight/freeze, fight</i>	<i>social fear [racial prejudice]</i>
	parasites removed	<i>emesis, scratch</i>	<i>self-medication</i>	disease agents avoided	<i>pathogen avoidance/ habitat removal [hygiene]</i>	<i>social-moral exclusion [shunning/ disgust]</i>
REPRO-DUCTIVE	offspring produced	<i>fission, ejaculation, contraction</i>	<i>mate search, lust</i>	sexual relationship secured/maintained	<i>ritualized courtship, grooming</i>	<i>pair-bond love, jealousy</i>
	offspring nurtured	<i>lactate</i>	<i>offspring food quest</i>	kin environment secured/maintained	<i>shelter-building, offspring defence</i>	<i>parental-love [resource investment]</i>



# Conclusions

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- Behaviour production in humans is a hierarchically controlled process.
- Reflective 'thinking' is a very recent (and perhaps weakly controlled) form of goal-directed behaviour production.
- Few species can afford the luxury of thinking – neither the expensive tissue, nor the delay in response.

'Nothing makes sense except  
in the light of evolution'

(Theodozius Dobzhansky)

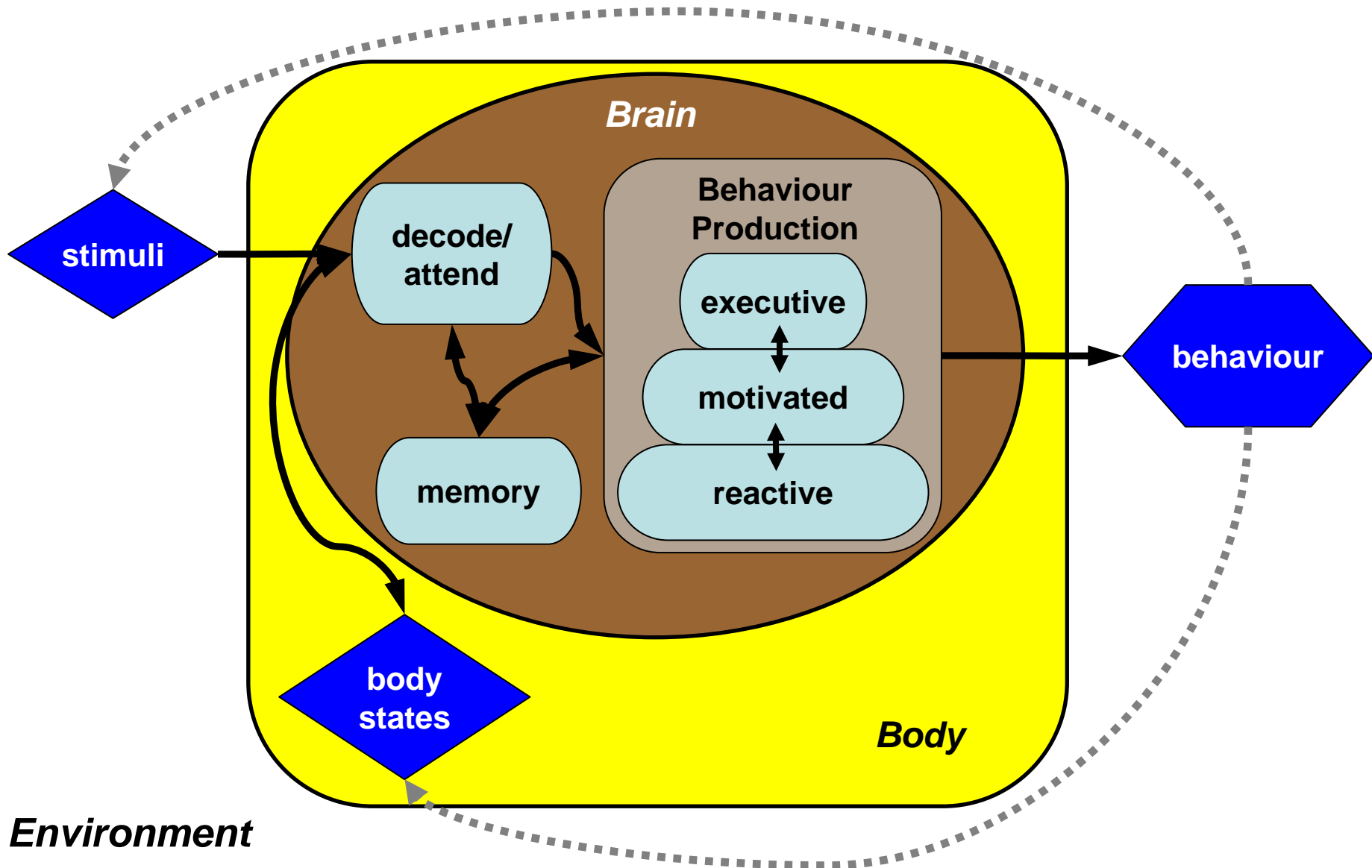
-- including thinking.

# Types of end-directed behaviour production programmes

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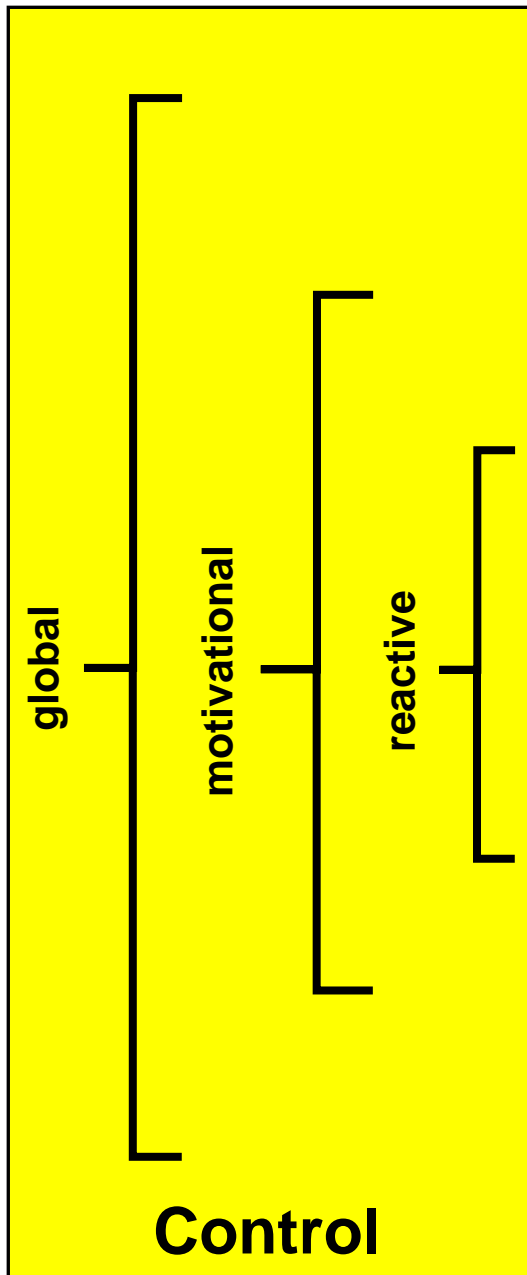
<i>End-state type/ Control type</i>	<i>Stimulus- generated (reactive)</i>	<i>Goal-directed (motivated)</i>
<i>Primary</i>	reflex	drive
<i>Secondary</i>	instinct	emotion

# 'Evo-logical' Model of Behaviour Causation

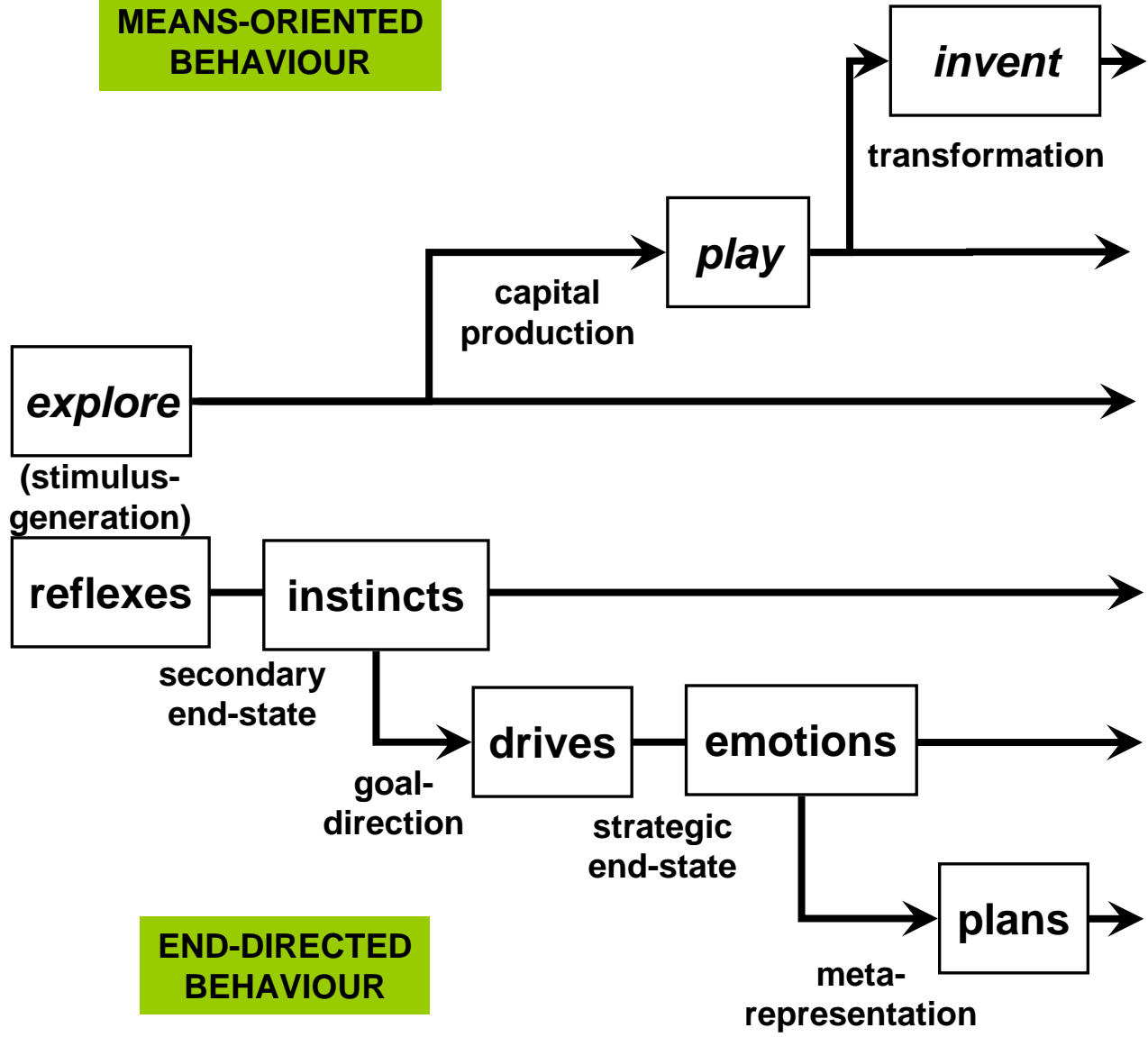


# Evolution of behaviour control

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# The scrambled sentence test

(Bargh et al., 1996)

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- Make grammatical 4-word sentences from each of the following sets of 5 words:
  - him was worried she always
  - from are Florida oranges temperature
  - ball the throw toss silently
  - shoes give replace old the
  - he observes occasionally people watches
  - be will sweat lonely they
  - us bingo sing play let
  - sunlight makes temperature wrinkle raisins



# Afterwards...

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- Subjects walked away from the venue of the test more slowly than they had walked into it.
- Why?

# The test (con't)

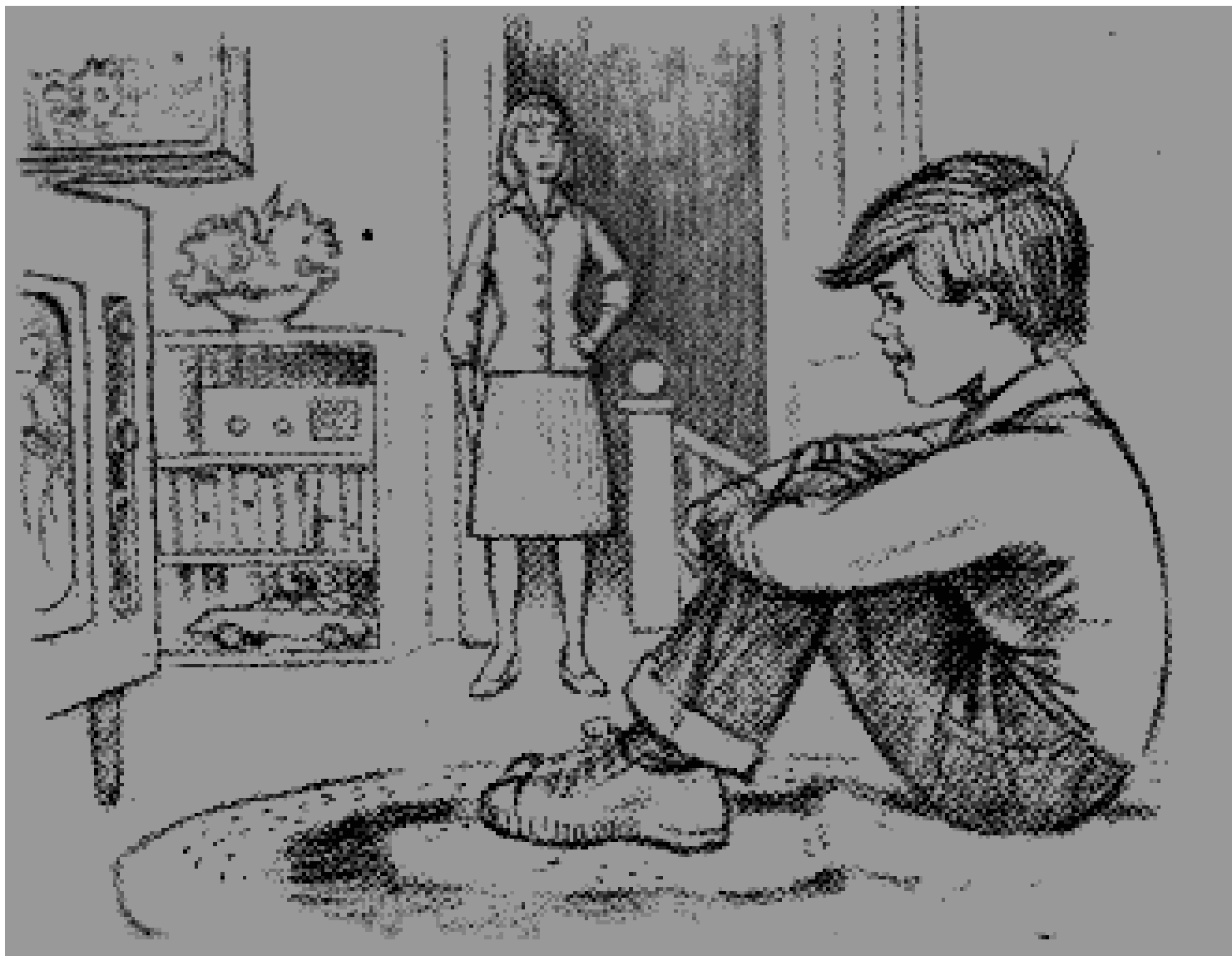
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- The sentences contained implicit cues of age:
  - him was worried she always
  - from are Florida oranges temperature
  - ball the throw toss silently
  - shoes give replace old the
  - he observes occasionally people watches
  - be will sweat lonely they
  - us bingo sing play let
  - sunlight makes temperature wrinkle raisins

# Explanation:

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- 'Priming of a stereotype'
- Other examples:
  - Subjects primed with scrambled sentences including 'rudeness'-related words were more likely to interrupt a later conversation than those primed with 'polite' words.
  - Subjects primed with a 'professor' concept were able to answer more Trivial Pursuit game questions correctly than those primed with 'football hooligan'. (Dijksterhuis and van Knippenberg, 1998)
- Bargh calls this 'automaticity': control of behaviour by external stimuli of which one is not aware. These stimuli unobtrusively trigger mental representations that bias behaviour.



Goofus pretends not to hear when spoken to.



# 'Thin-slice' judgements

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- People make (often accurate) discriminations based on highly limited information:
  - first impressions and 'speed dating'
  - art fakes
  - tennis serves



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<b>Emotion</b>	<i>Goal-directed behaviour designed to attain a secondary end-state</i>
<b>Strategy</b>	The goal orientation toward an interactant adopted by one party to a social game
<b>Interaction</b>	A single event or game-play in which players enact particular strategies
<b>Episode</b>	A series of social interactions in which an animal attempts to satisfy a goal
<b>Appraisal</b>	The assignment of a task category to a situation
<b>Feeling</b>	A (conscious) mental representation of an affective state



# Opaque judgements

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- People use subconscious criteria for important decisions.
- E.g., 'speed dating': people decide within minutes (or even seconds) whether or not they will consider someone as a potential mate. When asked to sit and think of an ideal partner, there is little relationship between characteristics of ideal and actual choice in speed dating context. (Iyengar and Fisman)
- People cannot report what criteria they use in practice, nor are they necessarily aware of the discrepancy between ideal and actual choice.



# Conclusions

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- Parsimonious model of behavioural causes
- Provides evolutionary model of the history of innovation in behavioural control consistent with animal phylogeny, comparative animal behaviour, and affective neuroscience
- Shows that 'thinking' is only the most recent form of behaviour production



# Principle of Evolved Function

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- *Understanding complex structures begins with a determination of what job that structure has been designed (by a history of natural selection) to do.*

PHYLO TRANSITION	BODY PLAN	EVOLUTIONARY TASKS	MOVEMENT ADVANT	NERVOUS SYSTEM	INFO MGT ABILITIES	LEARNING TYPES	AFFECTIVE RESPONSES
Protist (bacteria) 2BYA	unicellular	[all basic reproductive and survival tasks]	directional control (taxis)	sensory recognition	sensation	'habituation, sensitization' [non-associative learning]	approach, avoid
Metazoan (hydra) 900MYA	radial symmetry, multi-cellularity, tissues	help kin, seek resources, avoid threats	large-scale movement	nerve net (undifferentiated but specialized tissue)	perception, memory (short- and long-term)	classical conditioning	explore, fear
Chordate (flatworm) 700MYA	bilateral symmetry, organs (muscles), one-way digestive system, sexual reproduction	attract mate [reproduction], reject internal threats	directional focus, en-cephalization for fast reaction	centre/ periphery (nerve cord w/ganglion + transverse nerves)	reward	operant conditioning	lust, disgust
Vertebrate (bony fish) 440MYA	differentiated segmentation, bones, skull, appendages	compete for resources, coordinate with others	variety of movement types	mylinated, lobed brain, 3-layer cortex	attention, action selection, arousal	vicarious conditioning	anger, attachment/panic
Mammal (rat) 250MYA	homeothermy, placenta, mammary glands	nurture offspring, secure paternal investment, cooperate with others/act collectively	faster reactions (higher metabolism)	neocortex (6-layers), CT-fibers	feelings, event (cross-modal) memory? 'affective touch'	(complex) mental representation	mother-love, pairbond-love, affiliation
Primate (monkey) 65MYA	hands, stereoscopic vision	maximize social status, guard mate	precise control of movement	expanded neocortex	planning	imitation (fast social learning), top-down control, modulation	pride/humiliation, jealousy, gratitude contempt/ embarrassment
Human	language, culture	cooperate with all	precise control of movement	Broca's area, 16	TCM	imitation	love, health



# Behaviour as adaptation

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- The fundamental adaptation of animals is **movement**.
- **Behaviour** is movement which impacts on the environment. Behaviour can provide evolutionary benefits (e.g., food, mating opportunities) as well as dangers (e.g., contact with predators, hostile physical conditions).
- Brains evolved in animals to produce and control behavioural **responses** to changing circumstances.



# What is 'evo-logic'?

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- Humans are designed to do the things that helped their ancestors survive and reproduce.
- Behaviour is thus the result of evolutionary 'logic'.
- It does not conform to abstract ideals (e.g., rationality).



# Examples of evo-logic

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- Eat sweet and fatty foods though you know this leads to obesity
- Engage in non-reproductive sex
- Play rugby
- Wear jewellery, ties
- Buy designer labels
- Spend the day on a computer game
- Collect trinkets
- Spend now instead of saving for a pension
- Hate flying while knowing it's safer than driving
- Listen to music
- Copy others' behaviour without evaluation



# Brains and behavior

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- Behaviour has a long history.
- Brains evolved to control behaviour.
- Brain structures that picked the right behaviour got selected.
- Tasks for brains became more complex over human ancestry.
- Hence brains became more complex.