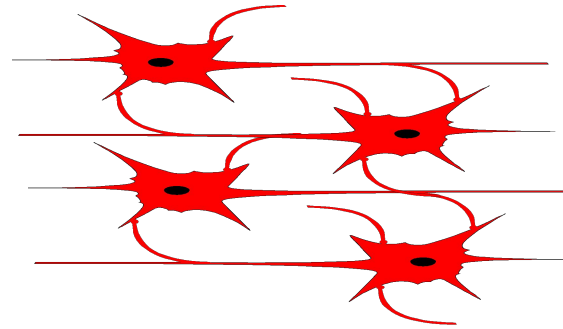


**An Artificial Mind
via**



**Cognitive Modular Neural
Architecture**

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What is Mind?

Human mind is characterized by

Inner imagery,
Inner speech,
Sensations,
Emotions

An artificial mind should also have these
to qualify as a mind of any credibility.

Human Mind

- The human brain processes information with meaning and importance
- There is “an unified experience” the instantaneous sensory information from multiple sensors is bound together and is coupled to the system’s knowledge and emotional state so that a stream of interpretation, meaning and mental responses arises - the flow of inner imagery, inner speech, feelings
- This style of information processing **-cognitive information processing-** is completely different from present day computers

What is Involved in Cognition?

- Meaning and understanding
- Perception and recognition
- Prediction
- Priming
- Attention
- Match/mismatch/novelty detection
- Learning and memory
- Judgement, good/bad
- Pain and pleasure
- Emotions
- Motivation, needs, drives, goals
- Deduction, reasoning, planning
- Language
- Consciousness?**

What is Involved in Consciousness?

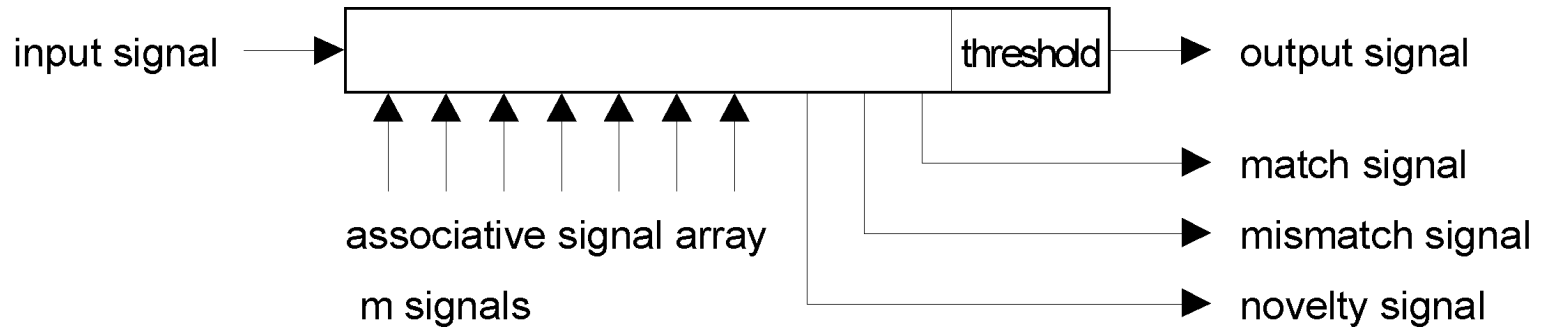
- Awareness of environment
- Awareness of own body
- Awareness of qualia, how it feels
- Introspection of thoughts, emotions and feelings
- Awareness of past, present and expected future
- Awareness of self, one's own existence
- Awareness and ability to report the existence of one's inner imagery and speech as such

Inner Imagery, Inner Speech

- The flow of inner speech, inner imagery is typical to human cognition
- Inner speech and inner imagery are also understood as verbal and visual thinking
- Inner speech, imagery, emotions and sensations are also the contents of our consciousness

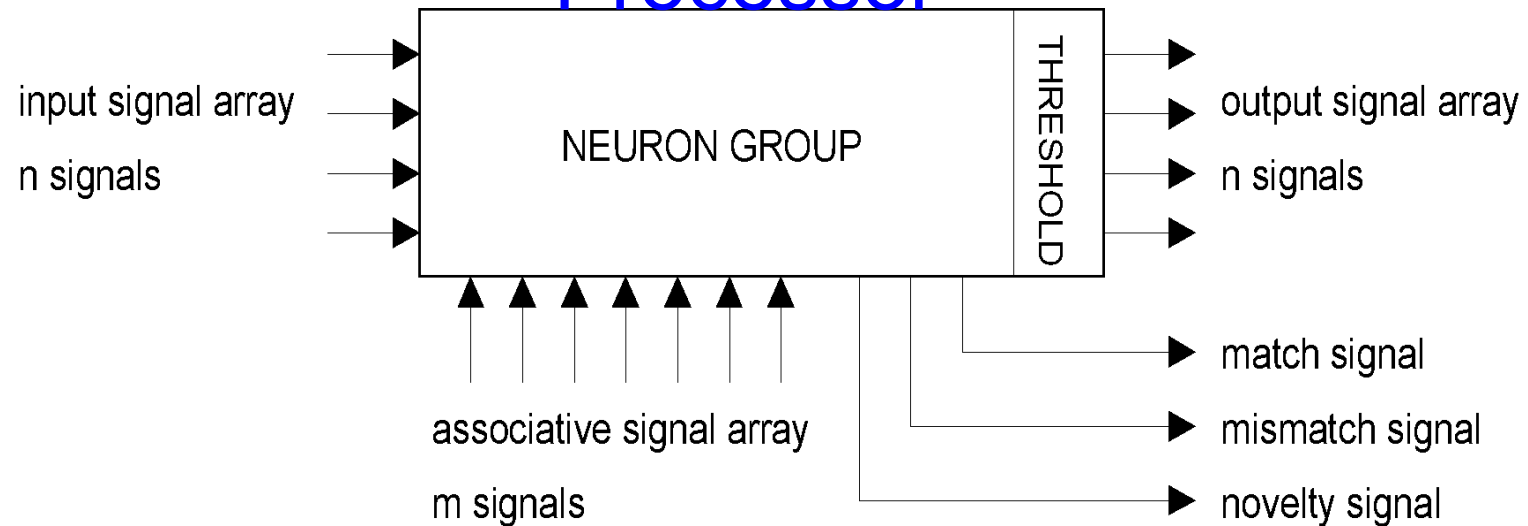
Steps towards Machine Mind

1. Devise suitable information representation method ([distributed signal representation](#))
2. Devise an elementary processing unit for the above ([non-numeric associative neuron](#))
3. Devise system architecture that can support inner imagery etc. and the cognitive processes ([reentrant modular architecture](#))



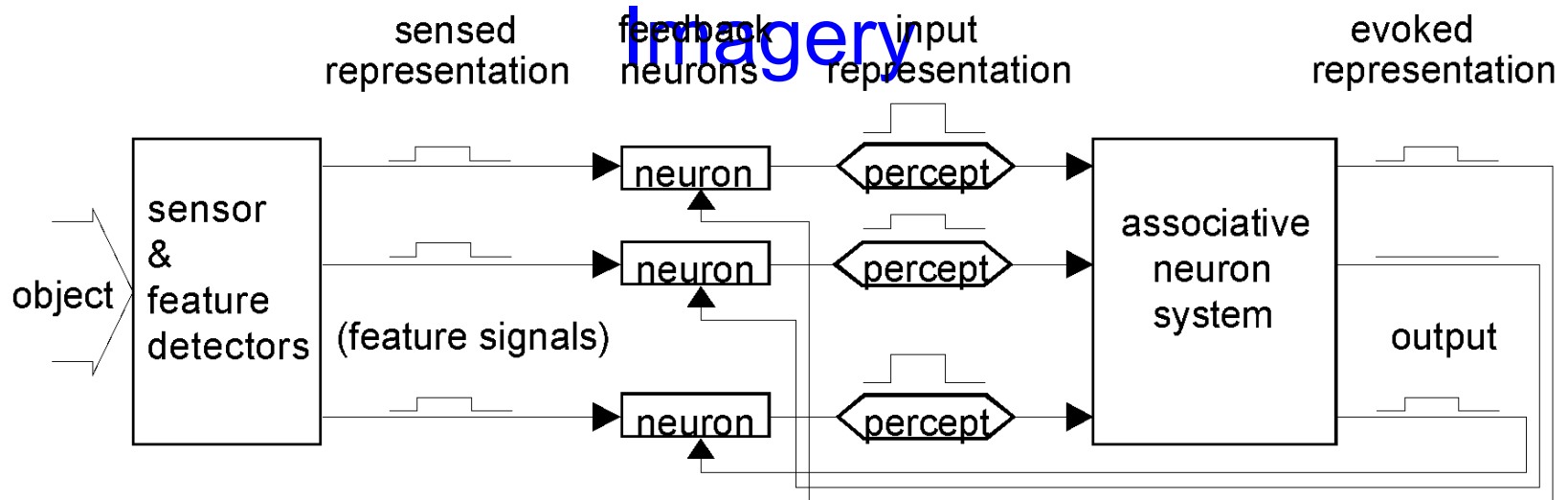
- Preservation of the input signal meaning
- Correlative Hebbian (Associative) learning
- Resolves match/mismatch/novelty states
- Non-numeric

Neuron Group as the Basic Signal Processor



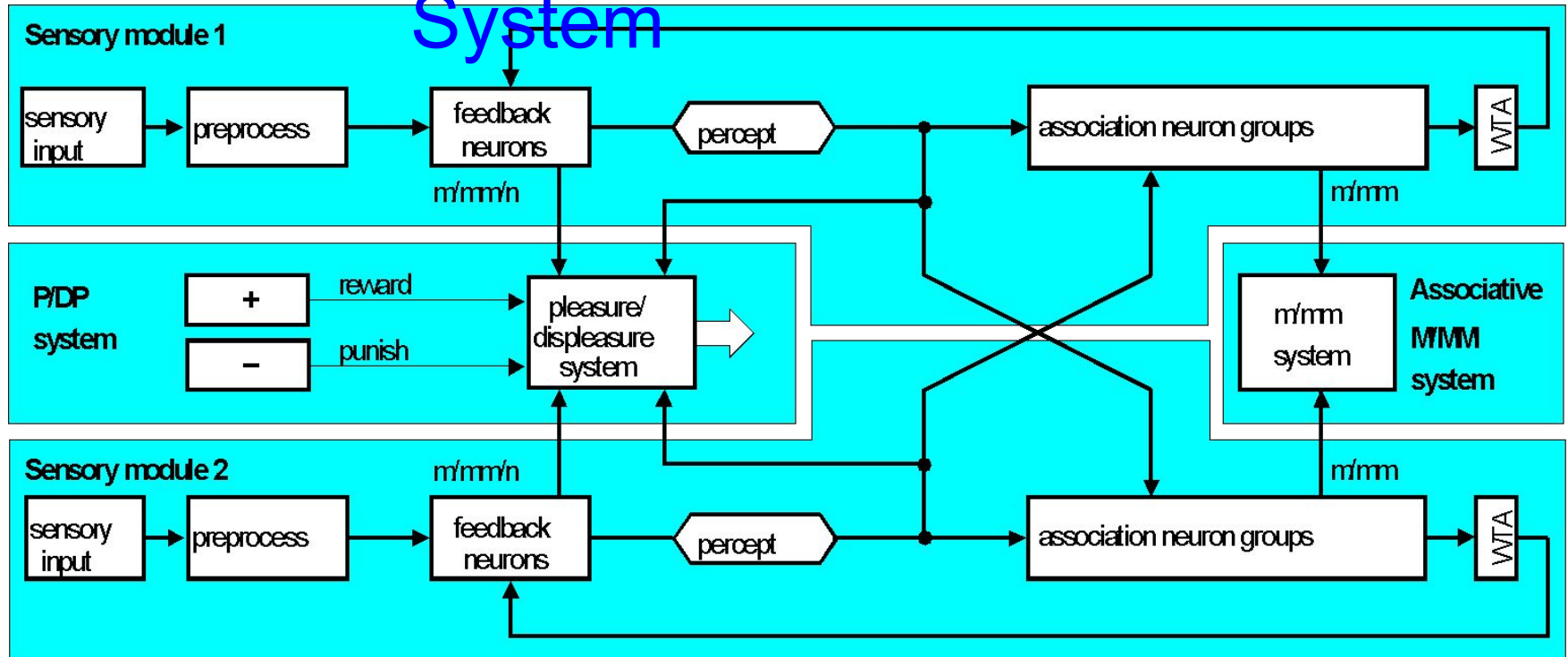
- Association of signal arrays to each other
- Associative evocation of output signal arrays
- Compression or generalization when $n < m$
- Amplification or priming by the associative signal array
- Resolves match/mismatch/novelty between input and evocation

The Reentrant Loop -Key to Inner Imagery



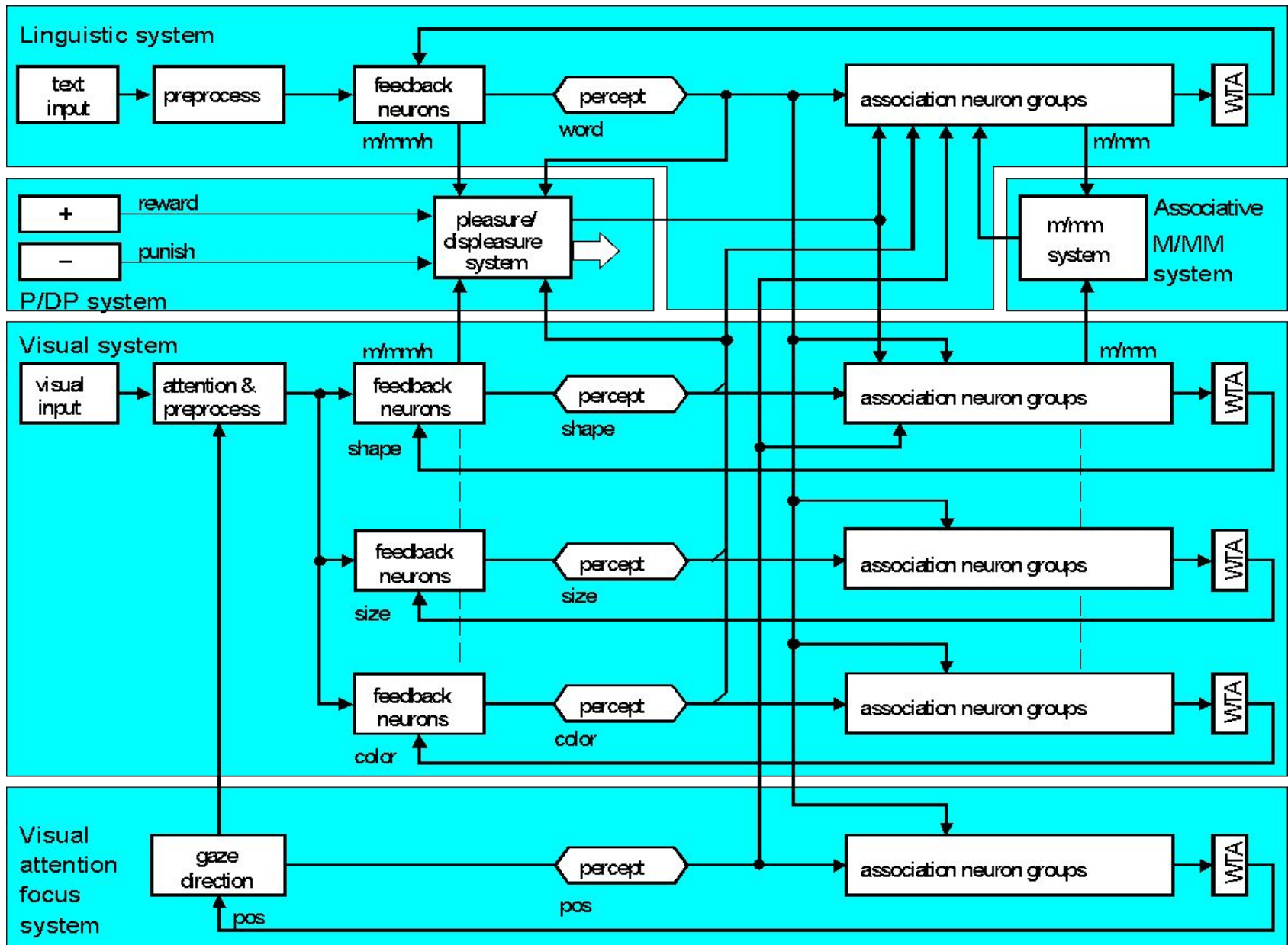
- **Perception** with and without priming
- Reverberating **short term memory**
- Translation of output representations into percepts (inner imagery, inner speech), **Introspection**
- **Grounding of meaning**
- Percept - the “official” output to other modules

The Cognitive System

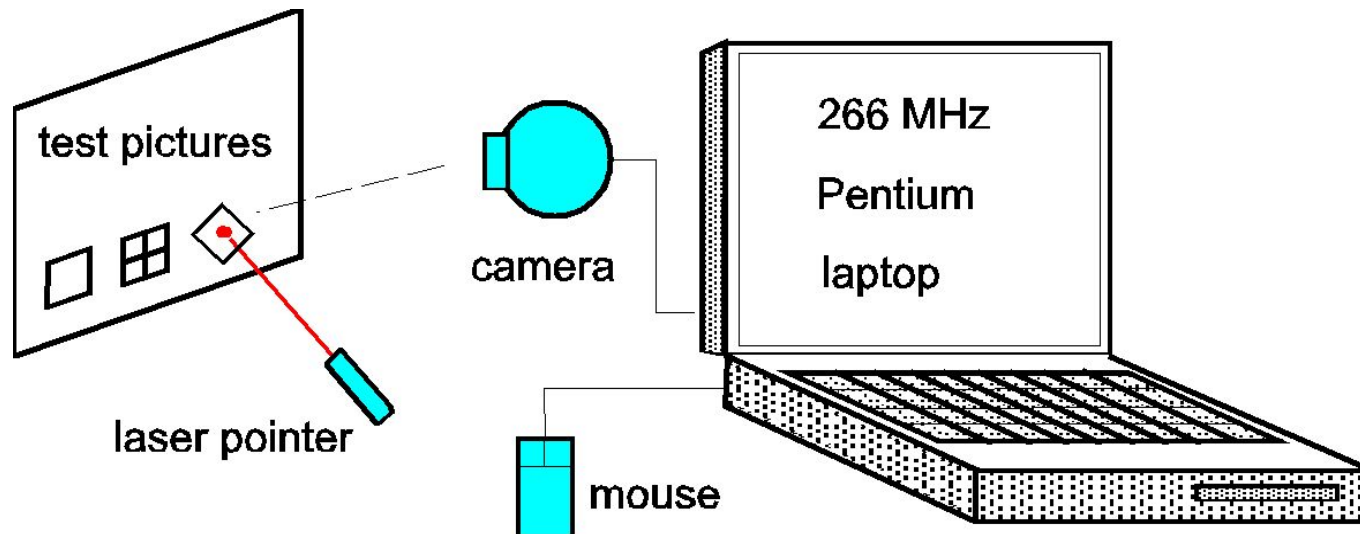


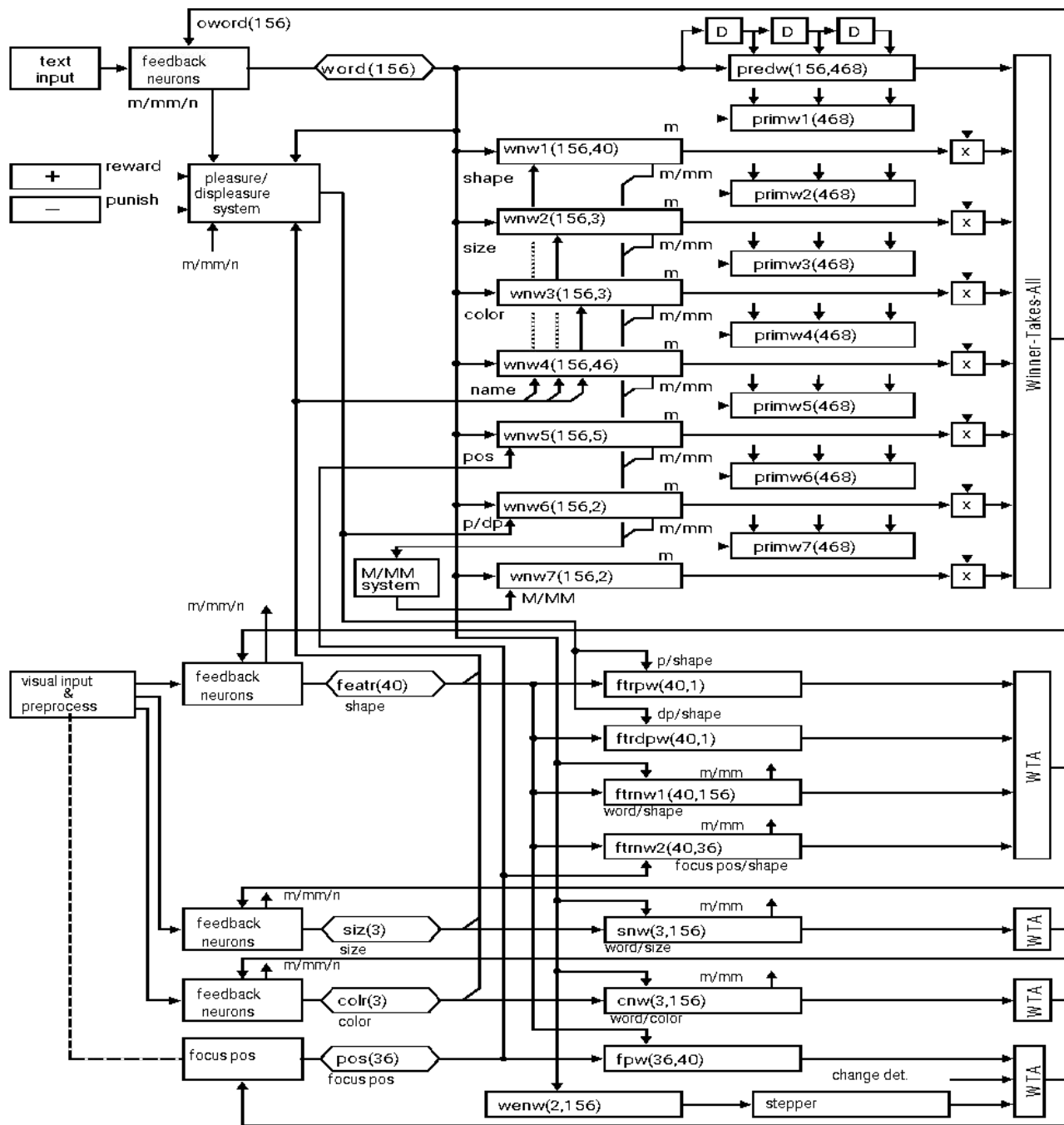
The complete system consists of:

- Multiple associatively cross-connected sensory modules
- Pleasure/displeasure system
- Match/mismatch/novelty detection



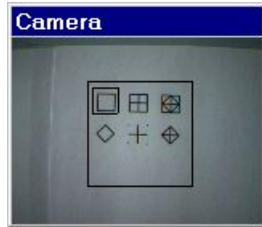
The Simulation System



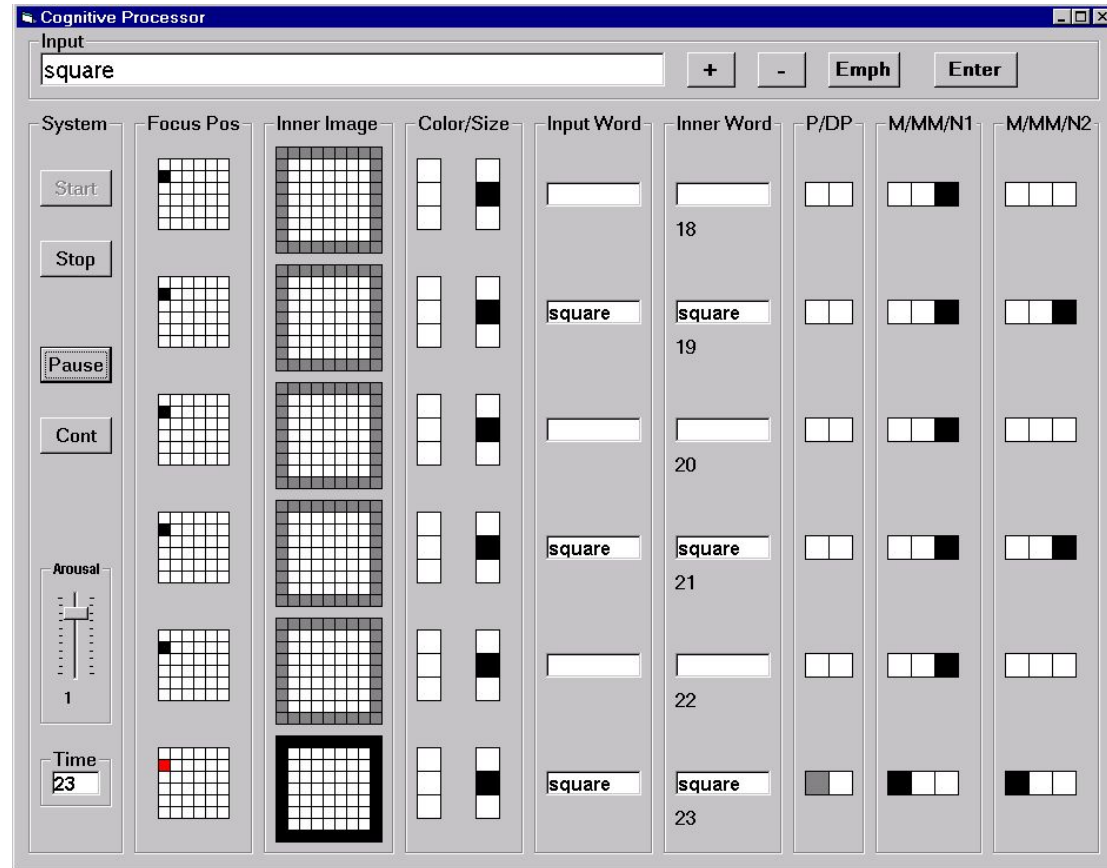


The Simulation System

Naming entities



1. Point the object with a laser pointer
2. Type in a name
3. Push "Emph" and "Enter"

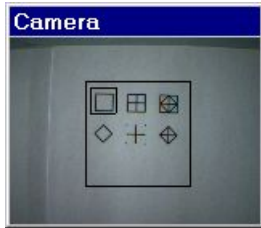


The "Cognitive Processor" window displays a simulation of the naming process. It features a central table with columns for System, Focus Pos, Inner Image, Color/Size, Input Word, Inner Word, P/DP, M/MM/N1, and M/MM/N2. The simulation progresses through time steps 18 to 23. A vertical arrow on the right indicates the direction of time.

System	Focus Pos	Inner Image	Color/Size	Input Word	Inner Word	P/DP	M/MM/N1	M/MM/N2
Start	Grid with black dot at (1,1)	Grid with black dot at (1,1)	Color/Size controls		18			
Stop	Grid with black dot at (1,1)	Grid with black dot at (1,1)	Color/Size controls	square	square			
Pause	Grid with black dot at (1,1)	Grid with black dot at (1,1)	Color/Size controls		19			
Cont	Grid with black dot at (1,1)	Grid with black dot at (1,1)	Color/Size controls	square	square			
Arousal	Grid with black dot at (1,1)	Grid with black dot at (1,1)	Color/Size controls		20			
Time 1	Grid with black dot at (1,1)	Grid with black dot at (1,1)	Color/Size controls	square	square			
Time 23	Grid with red dot at (1,1)	Grid with red dot at (1,1)	Color/Size controls	square	square			

The Simulation System

Teaching categories; category "shape"

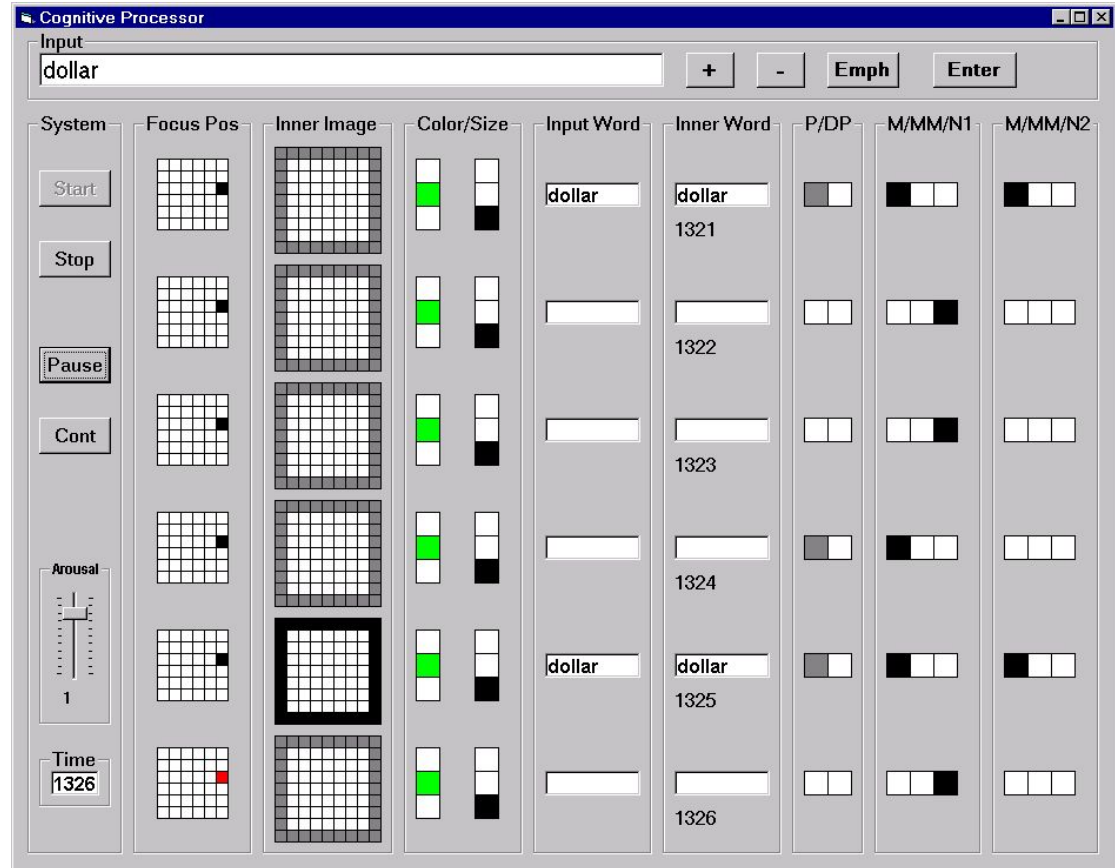
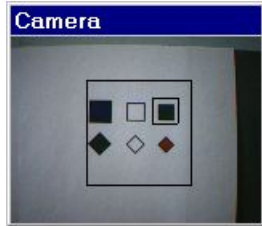


The screenshot shows the "Cognitive Processor" window with the following components:

- Input:** A text field containing "what shape square" and buttons for "+", "-", "Emph", and "Enter".
- System:** A vertical column of control buttons: "Start", "Stop", "Pause", "Cont", "Arousal" (with a vertical slider), and "Time" (displaying "178").
- Focus Pos:** A 5x5 grid with a black square in the top-left cell.
- Inner Image:** A 10x10 grid showing a 5x5 square region highlighted with a thick black border.
- Color/Size:** Two vertical columns of 5 cells each, representing color and size attributes.
- Input Word:** A sequence of text boxes containing "what", "shape", "square", and empty boxes.
- Inner Word:** A sequence of text boxes containing "173", "what", "shape", "square", and empty boxes.
- P/DP:** A sequence of 2-cell grids representing probability or decision parameters.
- M/MM/N1:** A sequence of 3-cell grids representing memory or network states.
- M/MM/N2:** A sequence of 3-cell grids representing memory or network states.

The Simulation

Naming an entity with shape, color and size attributes

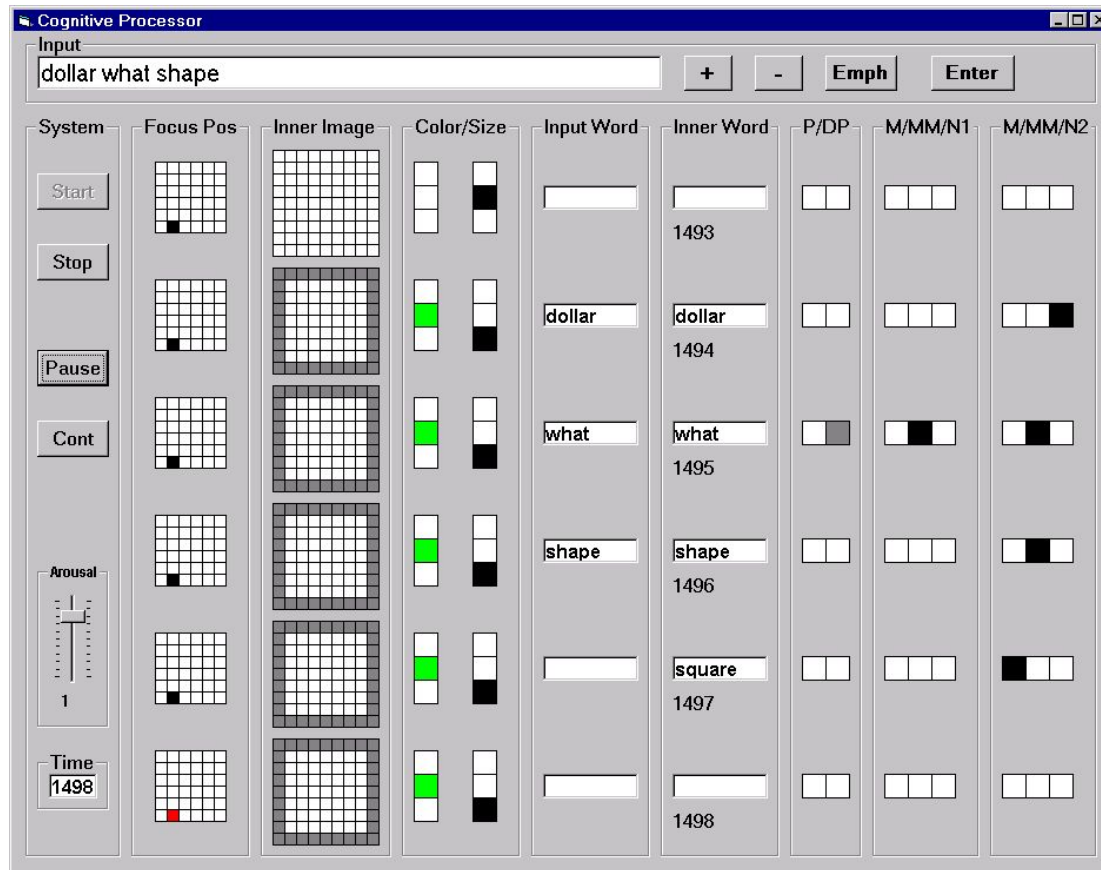


System	Focus Pos	Inner Image	Color/Size	Input Word	Inner Word	P/DP	M/MM/N1	M/MM/N2
Start	5x5 grid	10x10 grid	Green/Black	dollar	dollar 1321	Grey bar	Black/White bar	Black/White bar
Stop	5x5 grid	10x10 grid	Green/Black			White bar	Black/White bar	White bar
Pause	5x5 grid	10x10 grid	Green/Black			White bar	Black/White bar	White bar
Cont	5x5 grid	10x10 grid	Green/Black			White bar	Black/White bar	White bar
Arousal	5x5 grid	10x10 grid	Green/Black			Grey bar	Black/White bar	White bar
Time	5x5 grid	10x10 grid	Green/Black	dollar	dollar 1325	Grey bar	Black/White bar	Black/White bar
1326	5x5 grid	10x10 grid	Green/Black			White bar	Black/White bar	White bar

The Simulation

System

Deduction by evoked inner imagery, answering a question

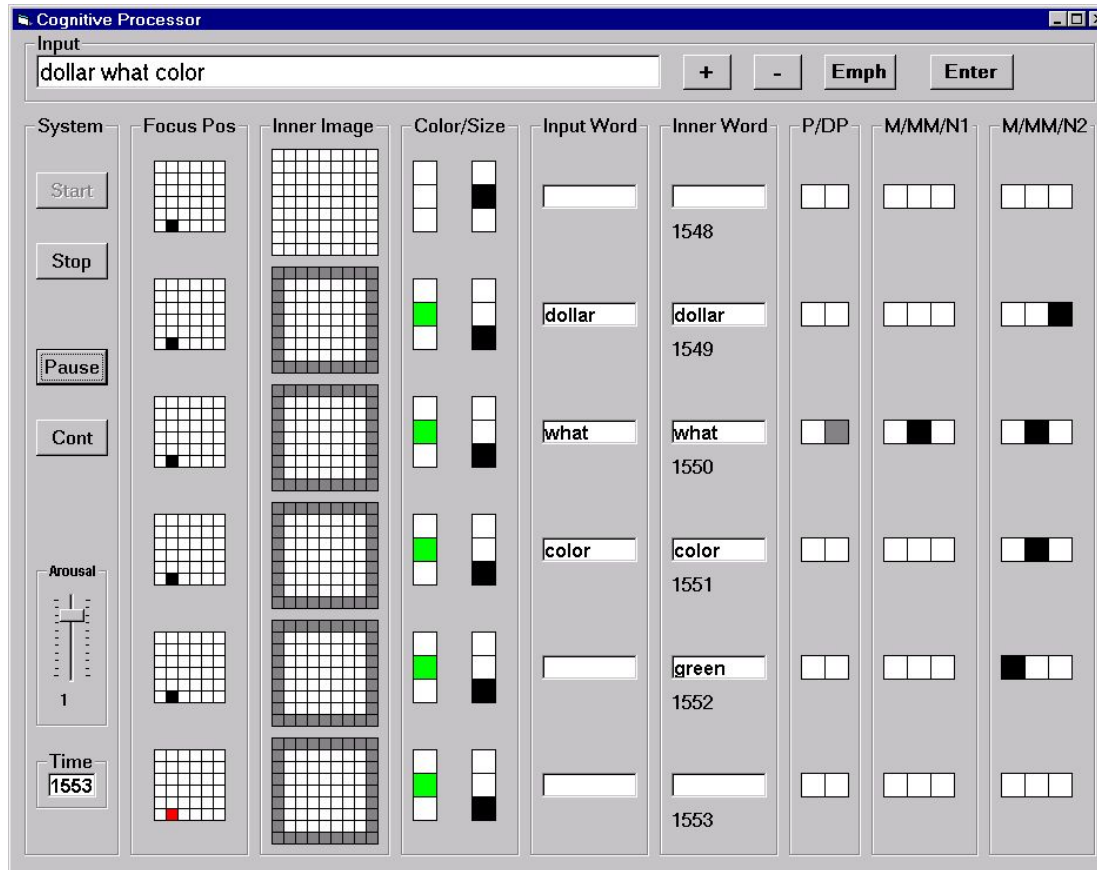


The word "square" has not been explicitly associated to "dollar"!

The Simulation

System

Deduction by evoked inner imagery, answering a question



The word "green" has not been explicitly associated to "dollar"!

The Simulation System

Deduction by evoked inner imagery, contradiction detection

The screenshot shows a software window titled "Cognitive Processor" with a text input field containing "is candy green". Below the input field are control buttons: "+", "-", "Emph", and "Enter". The main interface is divided into several columns: "System", "Focus Pos", "Inner Image", "Color/Size", "Input Word", "Inner Word", "P/DP", "M/MM/N1", and "M/MM/N2".

The "System" column contains buttons for "Start", "Stop", "Pause", and "Cont", along with an "Arousal" scale and a "Time" display showing "653".

The "Focus Pos" column shows a 5x5 grid with a small black square indicating the current focus position, which moves from the bottom-left to the bottom-right cell across the rows.

The "Inner Image" column shows a 5x5 grid that evolves from a single black square to a complex grayscale pattern.

The "Color/Size" column shows two vertical columns of three squares each, with the top square in the left column turning red.

The "Input Word" column shows the words "is", "candy", "green", and "no" being processed sequentially.

The "Inner Word" column shows the words "648", "649", "is", "candy", "green", and "no" corresponding to the input words.

The "P/DP", "M/MM/N1", and "M/MM/N2" columns show various patterns of black squares, likely representing internal state or memory representations.

The Simulation

Deduction by evoked inner imagery, affirmation detection

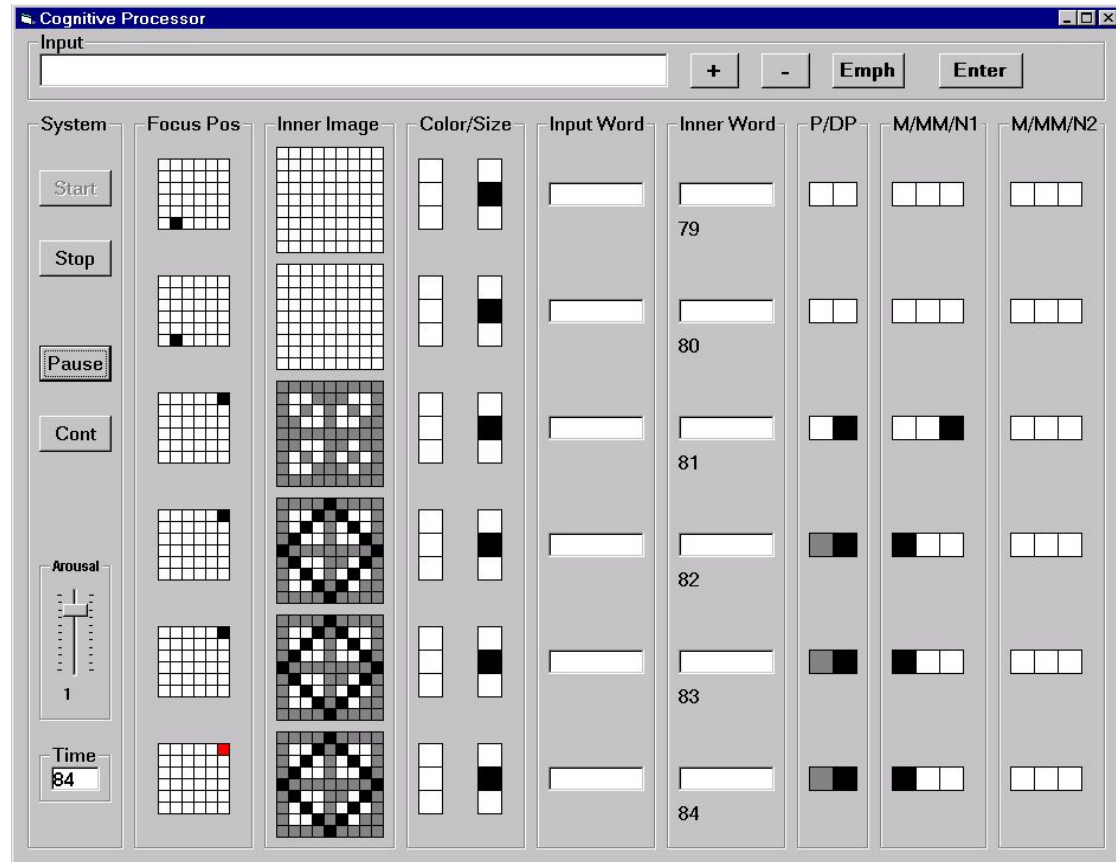
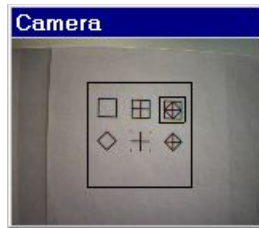
The screenshot shows a software window titled "Cognitive Processor" with a control panel on the left and a data table on the right. The control panel includes buttons for "Start", "Stop", "Pause", and "Cont", an "Arousal" meter set to 1, and a "Time" display showing 672. The data table tracks the simulation's state across six time steps (667-672).

System	Focus Pos	Inner Image	Color/Size	Input Word	Inner Word	P/DP	M/MM/N1	M/MM/N2
Start	[Grid]	[Grid]	[Color/Size]			[P/DP]	[M/MM/N1]	[M/MM/N2]
Stop	[Grid]	[Grid]	[Color/Size]			[P/DP]	[M/MM/N1]	[M/MM/N2]
Pause	[Grid]	[Grid]	[Color/Size]			[P/DP]	[M/MM/N1]	[M/MM/N2]
Cont	[Grid]	[Grid]	[Color/Size]	is	is	[P/DP]	[M/MM/N1]	[M/MM/N2]
	[Grid]	[Image]	[Color/Size]	candy	candy	[P/DP]	[M/MM/N1]	[M/MM/N2]
	[Grid]	[Image]	[Color/Size]	red	red	[P/DP]	[M/MM/N1]	[M/MM/N2]
	[Grid]	[Image]	[Color/Size]		yes	[P/DP]	[M/MM/N1]	[M/MM/N2]

The Simulation

System

Emotional significance;
detection of an emotionally significant entity from noise

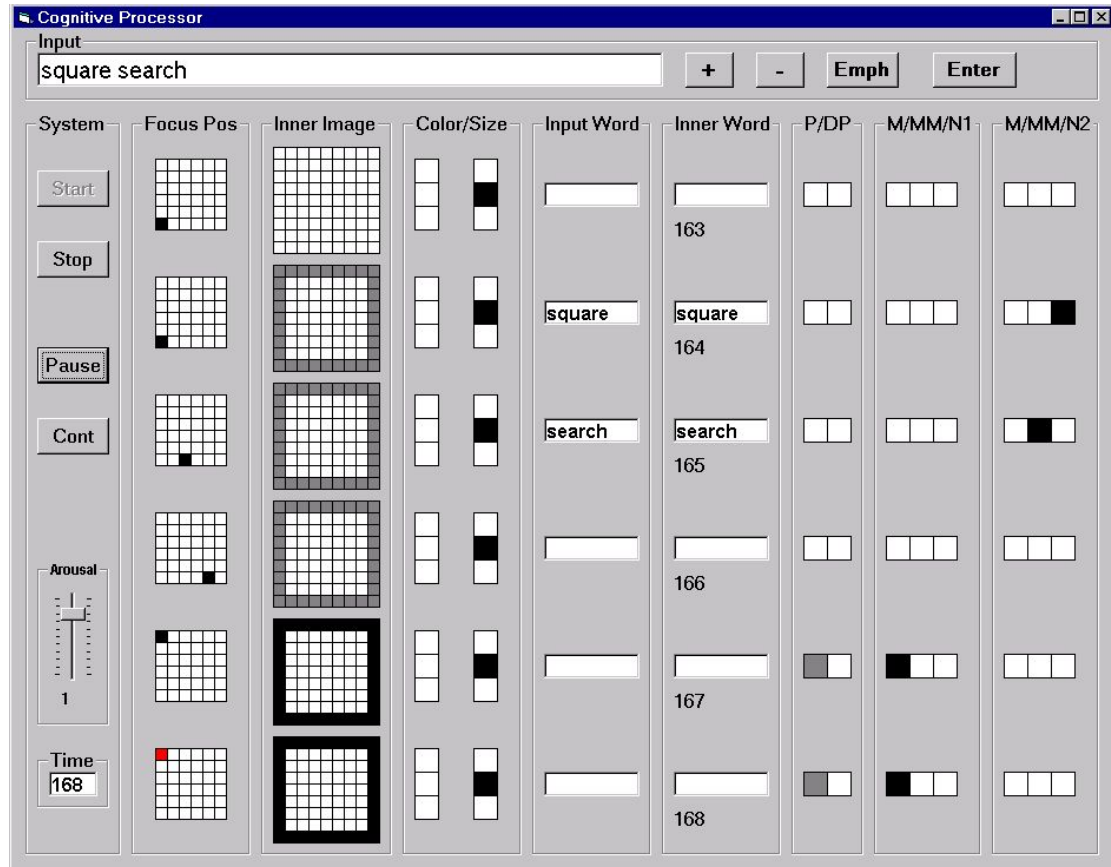
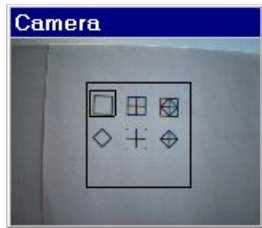


A window titled "Cognitive Processor" showing simulation data. It includes an "Input" field with buttons "+", "-", "Emph", and "Enter". Below are columns for "System", "Focus Pos", "Inner Image", "Color/Size", "Input Word", "Inner Word", "P/DP", "M/MM/N1", and "M/MM/N2". The "System" column has buttons "Start", "Stop", "Pause", and "Cont". The "Focus Pos" column shows 5x5 grids with a black square indicating focus. The "Inner Image" column shows 10x10 grids with patterns of black and white squares. The "Color/Size" column shows two vertical bars with black squares. The "Input Word" column has empty text boxes. The "Inner Word" column shows numbers 79, 80, 81, 82, 83, and 84. The "P/DP" column shows two vertical bars with black squares. The "M/MM/N1" and "M/MM/N2" columns show 3x3 grids with black squares.

System	Focus Pos	Inner Image	Color/Size	Input Word	Inner Word	P/DP	M/MM/N1	M/MM/N2
Start	Grid with black square at (1,1)	10x10 grid	Two vertical bars, black square at (1,1)		79	Two vertical bars	3x3 grid	3x3 grid
Stop	Grid with black square at (1,1)	10x10 grid	Two vertical bars, black square at (1,1)		80	Two vertical bars	3x3 grid	3x3 grid
Pause	Grid with black square at (1,1)	10x10 grid with noise	Two vertical bars, black square at (1,1)		81	Two vertical bars, black square at (1,1)	3x3 grid with black squares	3x3 grid
Cont	Grid with black square at (1,1)	10x10 grid with noise	Two vertical bars, black square at (1,1)		82	Two vertical bars, black square at (1,1)	3x3 grid with black squares	3x3 grid
Arousal	Grid with black square at (1,1)	10x10 grid with noise	Two vertical bars, black square at (1,1)		83	Two vertical bars, black square at (1,1)	3x3 grid with black squares	3x3 grid
Time	Grid with black square at (1,1)	10x10 grid with noise	Two vertical bars, black square at (1,1)		84	Two vertical bars, black square at (1,1)	3x3 grid with black squares	3x3 grid

The Simulation

Visual search of a system entity; the search is completed when a sensed object matches the inner image of the object to be searched. **No pattern matching is done however!**



The screenshot shows the "Cognitive Processor" interface. At the top, there is an "Input" field containing the text "square search" and buttons for "+", "-", "Emph", and "Enter". Below this is a table with columns: System, Focus Pos, Inner Image, Color/Size, Input Word, Inner Word, P/DP, M/MM/N1, and M/MM/N2. The table shows a sequence of operations from time 163 to 168. The "Inner Image" column shows a 5x5 grid with a highlighted square. The "Input Word" and "Inner Word" columns show the words "square" and "search" being processed. The "P/DP", "M/MM/N1", and "M/MM/N2" columns show binary representations of the system's state.

System	Focus Pos	Inner Image	Color/Size	Input Word	Inner Word	P/DP	M/MM/N1	M/MM/N2
Start								
Stop					163			
Pause				square	square			
Cont				search	search			
					165			
					166			
					167			
					168			

The Simulation System

-Verbal sequences, reproduction

-Sequences as serial associative prediction; detection of mismatch between prediction and actual percept

The screenshot shows the 'Cognitive Processor' window with the following data:

System	Focus Pos	Inner Image	Color/Size	Input Word	Inner Word	P/DP	M/MM/N1	M/MM/N2
Start	Grid with black square at (1,1)	Grid	Color: White, Size: Black	one	one 114	White	White	White
Stop	Grid with black square at (1,1)	Grid	Color: White, Size: Black	two	two 115	White	White	White
Pause	Grid with black square at (1,1)	Grid	Color: White, Size: Black		three 116	White	White	White
Cont	Grid with black square at (1,1)	Grid	Color: White, Size: Black		four 117	White	White	White
Arousal: 0.65	Grid with black square at (1,1)	Grid	Color: White, Size: Black		five 118	White	White	White
Time: 119	Grid with red square at (1,1)	Grid	Color: White, Size: Black			White	White	White

The screenshot shows the 'Cognitive Processor' window with the following data:

System	Focus Pos	Inner Image	Color/Size	Input Word	Inner Word	P/DP	M/MM/N1	M/MM/N2
Start	Grid with black square at (1,1)	Grid	Color: White, Size: Black	one	one 100	White	White	White
Stop	Grid with black square at (1,1)	Grid	Color: White, Size: Black	two	two 101	White	White	White
Pause	Grid with black square at (1,1)	Grid	Color: White, Size: Black	three	three 102	Grey	Black	White
Cont	Grid with black square at (1,1)	Grid	Color: White, Size: Black	four	four 103	Grey	Black	White
Arousal: 0.65	Grid with black square at (1,1)	Grid	Color: White, Size: Black	six	six 104	White	Black	White
Time: 105	Grid with red square at (1,1)	Grid	Color: White, Size: Black			White	White	White

Conclusions 1

A modular non-numeric neural network has been devised that

- Operates with inner imagery, inner speech
- Acquires information via perception
- Acquires information about its inner states via introspective perception
- Is able to learn and generalize (and fast!)
- Has cognitive functions similar to human brain

What remains to be demonstrated:

- Actual motor output systems
- The effect of needs, drives, planning, will
- Personal history, sense of time
- Self concepts

Conclusions 2

TOWARDS CONSCIOUS MACHINES?

This system has the flow of inner imagery and inner speech, the hallmarks of human consciousness

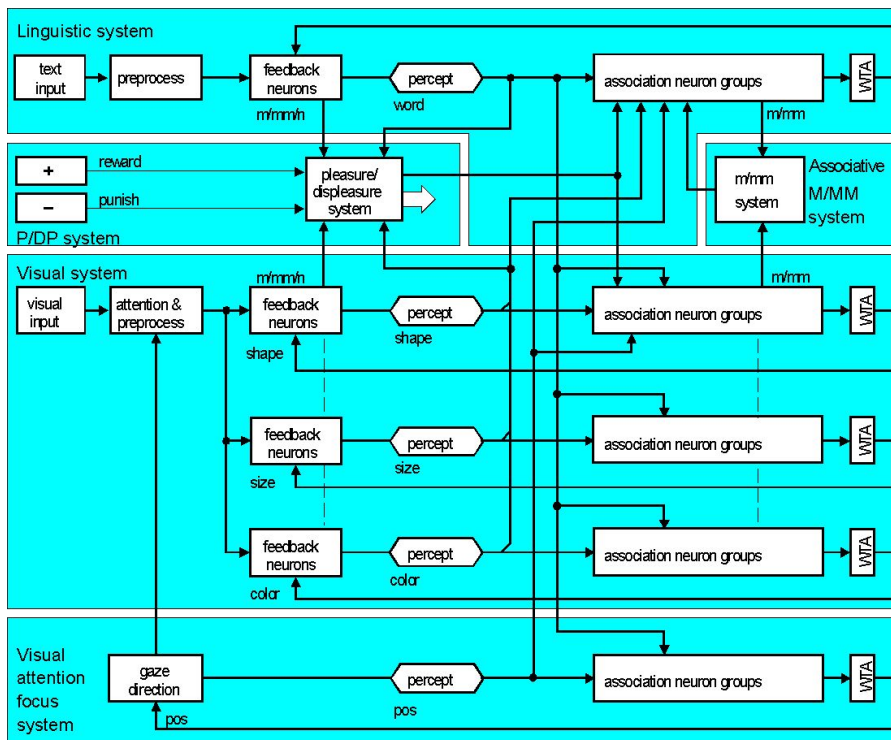
However, the system is not yet able to report on its own that it exists, that it has inner imagery and inner speech

A system's ability to report on its own that it has inner speech, produced by the system self, could be used as a test for machine self-consciousness

The author would like to see the Turing test be replaced by this one.

Thank You !

An Artificial Mind via Cognitive Modular Neural Architecture



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