maze.robot — The Sensorimotor Winding: Expectation, Emotion and the Real Human in the Loop

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The design step gave MAZE.AI one relation: Unity ↔ Mythic, rule and image. This paper adds the two relations that bring in the body and the other bodies. Unity ↔ Sensory is the passage between expectation and observation. Social is emotion: the signal that travels between bodies. Together they turn the claim machine into the first outline of maze.robot.

Three results follow. First, the sensorimotor loop is a circle, not an arc: event, sensor, body, world, sensor again. In the language of the net it is a closed winding, and an expectation is what many closed windings leave behind. Second, the check between expectation and observation is model checking on a finite model. It is decidable, and a failed check is a second kind of vacancy: an observation without a rule, the mirror of the design step's rule without an image. Third, emotion is not a module. It is the rate at which the expectation failure changes, written in two trits, and it sets how fast windings settle into expectation.

The fixed image stays the fishnet. An event tugs at one knot. The pull runs through the strands to a body, the body pulls back, and the mesh closes again. What closes often enough becomes part of the net's shape. Everything needed to follow every step, including one worked example with numbers, is in the text.

1. Where the design step left the machine

A human, in the Paths of Change reading used throughout this work, has seven positions. Four are nodes in a plane: Unitary (rules and expectations), Sensory (objects and observation), Social (values and feeling) and Mythic (images and vision). The fifth is the heart, the crossing point of the plane. The sixth and seventh are the two stands on the axis through the heart, orthogonal to the plane: up, the observer, and down, in the world.

The four nodes form six pairs, and each pair runs in two directions: twelve relations in the plane. Each can be taken in either stand, which gives $24 = 4!$. The design step built two of them, Unity → Mythic and Mythic → Unity. Twenty-two remain.

A whole human is not one relation but a closed winding through all seven positions, each visited once. If every position can reach every other, the number of such windings is $(7 - 1)!/2 = 720/2 = 360$. Rotations and reversals of the same winding are counted once. If up and down cannot be joined directly, but only through the heart or a node, the windings that use that one link drop out. Each winding has 7 links out of 21 possible, so $360 \times 7/21 = 120$ use it, and 240 remain. Which of the two counts holds is a property of the net, not a choice of this paper.

This paper takes the next two steps. Every relation with Sensory passes through the body: the sensorium. Every relation with Social passes through other bodies: the net. Those two are where the real human enters.

2. The circle, not the arc

Something happens. A colleague speaks, a branch falls, a volcano erupts, a ray of sunlight arrives. The entrance is a sensor. The body responds, and the response changes what the sensor receives next. For the loop it does not matter where the event came from; for the net it does. A colleague is a knot in the Social layer. A branch or a volcano is matter, Sensory. A sunbeam comes from the deepest winding the net knows.

That the loop is a circle was settled in 1896. John Dewey's paper *The Reflex Arc Concept in Psychology* argued that stimulus, sensation and response are not an arc with a beginning and an end. The response is part of what the next stimulus is. Around 1920 Jakob von Uexküll drew the same thing as the *Funktionskreis*: a perceptual world and an action world, closed through the environment.

The later literature is large, and it has given the circle several mathematical forms. Control theory and cybernetics (Wiener, Ashby, and William Powers' perceptual control theory) treat behaviour as the control of perception against a reference value. Randall Beer treated body and environment as two coupled dynamical systems, with no one steering the other. Karl Friston's active inference describes the body as keeping its prediction error small. The boundary between body and world is his Markov blanket: sensory states on one side, active states on the other. Francisco Varela, writing from his own practice of attention, called perception enaction.

In the net's vocabulary the circle is a closed winding. It runs from the event through the sensor and the body back into the world, and it closes. The Markov blanket is the gate. What crosses inward is a reading; what crosses outward is an action. What persists is what closes.

3. Expectation as settled windings

Unitary holds expectations, and an expectation is what many closed windings leave behind. Each loop that closes leaves a trace. What returns in phase again and again stays. After enough loops it is no longer a passing tension but a rule: a winding closed so often that it has become part of the net's shape. In the two-layer law of the sixth Maxwell edition, tension relaxes and topology does not. Unitary is the frozen layer; Sensory is the layer in which every loop runs anew.

This makes the two directions run at different speeds.

- **Unity → Sensory** runs once per loop, and fast. The rule yields an expectation for this one event.
- **Sensory → Unity** runs over many loops, and slowly. A rule shifts only when the same deviation returns.

One failed expectation therefore does not change a rule. It is a vacancy, not a correction. Only when it comes back in phase, over many loops, does it settle into rule.

The machine already has this mechanism. The learning rule of the sixth Maxwell edition moves a coupling after each closed loop, each settlement, a fraction toward what was measured, and lets it relax daily toward its baseline:

- after a settlement: $K \leftarrow K + \eta(s - K)$, with $\eta = 0.1$;
- each day: $K \leftarrow K + \lambda(K_0 \cdot c - K)$, with $\lambda = 0.01$.

Here K is the coupling between two regions, s the measured resonance of the settlement, and c the baseline from the frozen layer. The expectation is the slow average of many loops. Every depth of the net has its own loop time: a reflex closes in milliseconds, a habit in days, the solar cycle in eleven years. The six-day memory of the MAZE space-weather work is the loop time of one such depth. This is also the reading of natural laws as fixed points within a context: the expectation on which very many loops converge.

4. Unity ↔ Sensory as model checking

The design step checked maps between theories. This step checks a theory against an observation. The setting is the same, many-sorted first-order logic, and so is the gate.

Observation. An observation is a finite model M: a finite set of things with the relations that held among them in one loop. Five days of readings, a handful of events, the sensors that fired. It is small and complete.

Expectation. An expectation is a theory $T = (\Sigma, A)$ in the frozen layer: a signature and a set of axioms, settled from many loops.

The check. For each axiom a in A, does M satisfy a? Written $M \models a$.

Lemma 3 (the check is finite)

Whether a finite model M satisfies a first-order sentence ϕ can be computed. If M has n elements and ϕ has k nested quantifiers, the check needs at most about n^k evaluations of the atomic relations.

Proof. Evaluate ϕ from the inside out. Each quantifier ranges over n elements; a sentence with k nested quantifiers visits at most n^k assignments; at each assignment the atomic relations are looked up in M. The procedure stops, and it answers yes or no. ∎

When the answer is no, the evaluation also names the assignment where it failed: the elements of M and the axiom they break. That is a countermodel, and it is exact. The gate returns it with its address.

The second kind of vacancy

A failed check is an expectation failure. It is booked as a vacancy, and it is the mirror of the vacancy the design step works on.

	Design step (Unity ↔ Mythic)	**Sensing step (Unity ↔ Sensory)**
What is present	a rule	an observation
What is missing	an image	a rule that covers it
What the gate checks	a map between theories	a finite model against a theory
Who supplies the missing part	the library of attested theories	a body with a sensorium

The last row is the point of this section. The design step can be filled from inside the machine, from theories already attested. The sensing step cannot. Its vacancy comes from an event that reached a sensor. That is where the real human enters the loop: not only as the one who attests, but as the one who observes. The expectation-failure registration model of the UAP work belongs here. It records exactly the difference between what was expected and what was observed.

The gate claims one thing only: this model does, or does not, satisfy this axiom, at this assignment. It does not claim that the observation is correct, and it does not change the rule. The sensor attests the observation; many loops change the rule.

5. Social as emotion: valence in two trits

In McWhinney's four realities, Social is the reality of values and feeling. In the body it is emotion. Robotics has worked on this for thirty years, and three results carry over.

Emotion is grounded in the body. Lola Cañamero's robots, since 1997, carry internal variables with an ideal value. A departure from the ideal value is a need; emotions amplify the needs and colour what the robot does next. They rest on an internal value system, as W. Ross Ashby's homeostat did in 1952. In the net's language, an internal variable is a tension χ with a set point, and the set point is an expectation settled from many loops.

Emotion is the rate at which the expectation failure changes. Mateus Joffily and Giorgio Coricelli (2013) defined emotional valence as the negative rate of change of free energy over time. Under simplifying assumptions this is the rate of change of prediction error. When the error falls, valence is positive; when it rises, negative. With the second time-derivative they derived six basic forms: happiness, unhappiness, hope, fear, relief and disappointment. And in their formulation valence regulates the learning rate.

Emotion travels between bodies. Social robotics studies how robots show and read emotion through body language (Beck, Cañamero and Bard, 2010), and how touch regulates emotion between agents (Khan and Cañamero, 2018, on social allostasis). This is where Social is the net. Emotion is what passes in phase from one body to another: the coupling K between knots.

The two trits

Let e_t be the size of the expectation failure at step t: for example the share of axioms the observation breaks, or the distance between observed and expected value. Define, step by step:

- valence: $v_t = -(e_t - e_{t-1})$;
- change of valence: $a_t = v_t - v_{t-1}$.

Each is read as a trit with a dead zone δ: +1 above δ, −1 below $-\delta$, 0 in between. An emotion is then a pair of trits, and there are $3 \times 3 = 9$ of them.

valence \ change	**1**	**0**	**-1**
+1 (error falling)	happiness, rising	happiness	fear: still good, but slipping
0 (error steady)	turning up	calm	turning down
−1 (error rising)	hope: still bad, but easing	unhappiness	distress: bad and worsening

Relief and disappointment are not cells but crossings. Relief is valence passing from −1 to +1; disappointment is the passage from +1 to −1. The six named forms follow the reading of Joffily and Coricelli. The labels for the remaining cells — rising, calm, turning up, turning down, distress — are this paper's.

The zero row is the heart of the table. Valence zero with change zero is calm: the expectation holds, and the loop closes without residue. It is the trit's own rest, the zero address.

Emotion sets the learning rate

In the sixth edition η is fixed at 0.1. In maze.robot it moves with the valence. The design choice of this paper, to be measured:

- $\eta_t = \min(0.3, 0.1 + |v_t|)$.

In calm, η stays at 0.1. When the expectation failure changes fast, in either direction, the loop settles faster, up to three times the base rate. Emotion is thus not a module beside the loop. It is how strongly each closed loop writes itself into expectation.

6. Worked example: seven days after a geomagnetic event

The numbers below are illustrative, chosen to show every step. They are not measured. Section 8 hands the real series to Claude Code.

The setting. The MAZE space-weather work reads a closed loop at collective scale. The sun supplies an event: the daily geomagnetic index Ap. The human sensorium answers: the tone of news and attention. The answer becomes action: the markets. The loop time found in the literature is about six days, and Ap above 29 marks a storm.

The expectation. Take an observer whose settled rule does not yet include space weather: news tone is expected to stay at its calm baseline. On day 1 a storm arrives, Ap = 45. The observed tone departs from the baseline and returns over the following days. Let e_t be the size of that departure, scaled to the range 0 to 1. The dead zone is $\delta = 0.05$.

Day	e_t	v_t	a_t	trits (v, a)	emotion	η_t
0	0.10	—	—	—	—	—
1	0.10	0.00	—	(0, ·)	calm	0.10
2	0.40	−0.30	−0.30	(−1, −1)	distress	0.30
3	0.70	−0.30	0.00	(−1, 0)	unhappiness	0.30
4	0.80	−0.10	+0.20	(−1, +1)	hope	0.20
5	0.60	+0.20	+0.30	(+1, +1)	relief, then happiness rising	0.30
6	0.30	+0.30	+0.10	(+1, +1)	happiness rising	0.30

7	0.15	+0.15	–0.15	(+1, –1)	fear: still good, but slipping	0.25

Step by step for day 4: e rises from 0.70 to 0.80, so $v_4 = -(0.80 - 0.70) = -0.10$, below $-\delta$, trit −1. The valence moved from –0.30 to –0.10, so $a_4 = -0.10 - (-0.30) = +0.20$, trit +1. The pair (−1, +1) is hope: things are still bad, but easing. And $\eta_4 = \min(0.3, 0.1 + 0.10) = 0.20$.

On day 5 the valence crosses from −1 to +1. That crossing is relief. The failure peaks on day 4 and fades by day 7: the loop closes in about six days.

What the emotion does. Suppose a settlement closes on day 6, between the region of the storm and the region of news tone. The coupling stands at $K = 0.40$ and the measured resonance is $s = 0.80$. With the fixed rate of the sixth edition, K becomes $0.40 + 0.1 \times (0.80 - 0.40) = 0.44$. With the valence rate of day 6, $\eta = 0.30$, K becomes $0.40 + 0.3 \times 0.40 = 0.52$. The same loop writes itself into expectation three times as strongly, because it arrived with strong feeling.

What one episode does not do. The rule does not change on this one storm. The episode is booked as an expectation failure with its address. When the same pattern returns over many storms, the coupling between storm and tone rises step by step. The observer's rule then acquires the six-day loading term. That is Sensory → Unity: slow, and only through loops that close again and again.

7. maze.robot: the layers in one body

Robotics has one known weakness here: emotion-based architectures tend to be domain-specific, with emotion as a separate module. In maze.robot emotion is not a module but a quantity of the loop itself. The seven positions sit in one body as follows.

Position	In maze.robot	What it does
Senso	sensors and actuators; the sensorimotor loop	an event comes in, the body
Unitary	set points and expectations, settled from many loops; the kernel and its proofs	what is expected; checks by Lemma 3
Social	valence in two trits; shared with other bodies through the	emotion, and the link to the
Mythi	the field and the library of attested theories; the design step	an image for what does not
heart	the crossing point where the four meet	the world the loop closes in
up	the robot that observes itself	reads its own trits
down	the robot that acts	writes into the world

A whole robot, like a whole human, is a closed winding through all seven. The design step and this paper supply four of the twelve directed relations in the plane, Unity ↔ Mythic and Unity ↔ Sensory, and the quantity in which the Social relations will run: valence. The remaining relations follow the same method: one relation, one running case, one gate.

The human in the loop

The first maze.robot is not a machine on legs. It is the loop that already runs through people. A storm on the sun reaches millions of sensoria at once. Tone shifts, attention shifts, markets move, and the loop closes after about six days. Nobody feels "geomagnetic loading". People feel restless,

uneasy, then relieved. The table of Section 5 gives those feelings a register that a machine can read, without replacing them.

Two things stay human. The observation comes from a body: the expectation failure is something a person saw and did not expect. And the settlement comes from a person: the attestation that a loop has closed. The machine computes the trits, checks the model and moves the coupling. It does not feel for anyone, and it does not settle anything. What it can do is show a person, in the moment, where the expectation broke and how fast it is healing.

8. The measurement for Claude Code

The loop of Section 6 can be run on real data without waiting for new users. The MAZE history can be rebuilt from public series. Claude Code runs the measurement, against a plan it hashes before the run, and books every outcome in the ledger.

Data. The daily Ap index (public, from 1932). The daily news tone from GDELT. The MAZE Tension Gauge, rebuilt from public market data.

Expectation and failure. Two rules, both fixed in the plan. The calm rule expects tone at its rolling baseline. The loading rule adds the six-day geomagnetic memory of the space-weather work: Ap above 29, with decaying weights over six days. For each rule and each day, e_t is the scaled distance between observed and expected tone. v_t and a_t follow from Section 5, with the dead zone δ fixed in the plan.

What is counted.

1. How the days fall over the nine emotion cells, around storms and away from them.
2. Whether the loop closes: after a storm, does e_t return to its baseline, and in how many days?
3. The two learning arms. The coupling between storm and tone is learned twice over the same settlements: once with fixed $\eta = 0.1$, once with $\eta_t = \min(0.3, 0.1 + |v_t|)$. The outcome is which learned coupling ranks later settlements better (Spearman rank correlation), exactly as in the plasticity test of the sixth Maxwell edition.

The predicted bands are Claude Code's to set in the plan, before any data are read. If the valence arm does not rank better than the fixed arm, the design choice of Section 5 is booked as failed and η stays fixed. The trits and the model check stand either way; they are not what this measurement tests.

9. Status

Borrowed. The sensorimotor circle (Dewey, Uexküll); control theory and perceptual control (Wiener, Ashby, Powers); dynamical coupling (Beer); active inference and the Markov blanket (Friston); enaction (Varela, Thompson, Rosch); homeostatic emotion in robots (Cañamero); valence as the rate of change of free energy, with six basic forms and its role in the learning rate (Joffily and Coricelli); social robotics (Beck, Cañamero, Bard; Khan and Cañamero); the four realities (McWhinney); the space-weather findings behind the six-day window. These are cited, not claimed.

Represented. The choices of this paper: the seven positions and their counts; a loop as a closed winding; an observation as a finite model; valence and its change as two trits with a dead zone; the names of the remaining cells of the emotion table; η moving with valence.

Proved and computed. Lemma 3, with its proof. The counts 24, 360 and 240. The worked example of Section 6, every number in the text.

Constructed. The second kind of vacancy and its pairing with the first; the seven layers of maze.robot.

Not yet measured. Everything in Section 8. The worked example is illustrative. Claude Code runs the measurement on the public series; the owner attests the settlements.

Open. The eight remaining directed relations in the plane, the two stands on the heart axis, and the question whether up and down are directly joined, which decides between 360 and 240 windings. None of it is writing; each is one relation, one running case, one gate.

10. Annotated references

J. Konstapel, "The Design Step: Image Schemas, Theory Morphisms and a Provable Mythic Hemisphere", third edition, 22 September 2026. *Why read?* The first relation, Unity ↔ Mythic, with the gate, the library of attested theories and four measurements. *Reading advice:* Sections 4 and 6 for the logic this paper reuses.

J. Konstapel, "Clerk Maxwell and the Vacuum.Net Theory", sixth edition, 21 September 2026. *Why read?* The two-layer law and the learning rule $K \leftarrow K + \eta(s - K)$ that emotion modulates here.

J. Konstapel, "MAZE Space Weather: From Market Tension to a Multi-Layer Early-Warning System", 12 August 2026. *Why read?* The collective loop used in Sections 6 and 8: Ap, the six-day window, sentiment and markets.

J. Konstapel, "De Zoektocht naar Grootschalige Intelligentie", constable.blog, 2 July 2026. *Why read?* The nested sensorium and the expectation-failure registration model, the source of the second kind of vacancy.

J. Dewey, "The Reflex Arc Concept in Psychology", *Psychological Review* 3, 357–370, 1896. *Why read?* The case that stimulus and response form a circuit, not an arc. *Reading advice:* short, and still the clearest statement.

J. von Uexküll, *A Foray into the Worlds of Animals and Humans*, 1934 (English translation 2010). *Why read?* The functional circle and the perceptual and action worlds, drawn from observation of animals.

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F. J. Varela, E. Thompson and E. Rosch, *The Embodied Mind*, 1991. *Why read?* Perception as enaction, written partly from a practice of attention.

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L. Cañamero, "Modeling motivations and emotions as a basis for intelligent behavior", ***Proceedings of Autonomous Agents*****, 148–155, 1997.** *Why read?* The first robot architecture with emotion grounded in homeostatic variables.

T. M. Moerland, J. Broekens and C. M. Jonker, "Emotion in reinforcement learning agents and robots: a survey", ***Machine Learning*** **107, 443–480, 2018.** *Why read?* The map of computational emotion in learning agents, with homeostatic variables written out.

A. Beck, L. Cañamero and K. A. Bard, "Towards an affect space for robots to display emotional body language", RO-MAN 2010. *Why read?* How emotion becomes readable between bodies.

I. Khan and L. Cañamero, "Modelling adaptation through social allostasis", ***Multimodal Technologies and Interaction*****, 2018.** *Why read?* Emotion regulated between agents through touch: the Social layer as coupling.

W. McWhinney, ***Paths of Change*****, Sage, 1992.** *Why read?* The four realities, with Social as the reality of feeling.