Watercolour Record Formation Experiments

A standalone painting/physics series on wet transit, constraint, and durable record

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Standalone protocol - June 2026

> **Purpose.** These experiments are not part of the current Constraint paper. They are a separate practical series: a way to make the physics of watercolour visible, filmable, and measurable. The point is not to prove a universal law of persistence. The point is to test whether a wet mark's transition into a recoverable dry record can be described better by a channel-indexed rate ratio than by ordinary clock time alone.
>
> The experiments are deliberately ordinary. A brush, paper, water, pigment, a phone camera, a ruler, a board, and a scale are enough. The aim is to show that a watercolour mark is not merely placed on paper. It is negotiated through a field of constraints until mobility is lost and a record remains.

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1. The shared idea

A watercolour mark begins as a mobile system: pigment, binder, water, paper fibre, capillary channels, evaporation, gravity, and surface tension. It becomes a record only when the relevant distinction - an edge, bloom, line, gradient, or tide mark - becomes recoverable after the motion has stopped.

The working ratio is:

```
R_record = Gamma_enroll / Gamma_scramble
```

Plain meaning:

```
R_record high: fixation is beating spreading.
R_record low: spreading, re-wetting, or flow is beating fixation.
```

This should not be oversold. Ordinary drying and colloid physics already say that evaporation, diffusion, capillary flow, particle deposition, and contact-line behaviour matter. The classic coffee-ring work showed how evaporation can drive suspended material to an edge by capillary flow (Deegan et al. 1997). The watercolour series is not claiming to invent that physics.

The possible contribution is narrower and testable:

```
Do different manipulations collapse onto a common recoverability curve
when expressed as R_record better than they do when expressed as
clock time, water mass, board angle, or paper type alone?
```

That is the real bet.

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2. Common variables

For a simple mark, define:

```
Gamma_scramble approx D_eff / L^2
                      + v_cap / L
                      + v_gravity(theta) / L
                      + Gamma_rewet
```

where:

- `D_eff` is effective spreading/diffusion of pigment.
- `L` is the feature scale: the edge, line, or bloom size being preserved.
- `v_cap` is capillary drift through the paper.
- `v_gravity(theta)` is downhill drift from board incline.
- `Gamma_rewet` is mobility reopened by added water or humidity.

The fixation side is:

```
Gamma_enroll approx k_evap + k_ads + k_fix
```

where:

- `k_evap` is drying rate.
- `k_ads` is pigment capture by paper fibre.
- `k_fix` is binder/pigment locking as the wash stops being mobile.

Final recoverability can be estimated by:

```
K_final = SNR_final / (1 + DeltaL / L)
```

where:

- `SNR_final` is final edge signal-to-noise ratio.
- `DeltaL` is final edge broadening.
- `L` is the intended feature size.

The useful prediction is a curve, not a hard universal threshold:

```
K_final should rise as log(R_record) rises.
```

A simple first model is:

```
K_final approx sigmoid(a * log(R_record / R0))
```

This is not sacred. It is a pre-declared shape to test. If it fails, the protocol is still useful: it tells us the variables are wrong or the system is too messy for that compression.

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3. Common equipment

Materials

- One paper for the first pass, ideally Baohong Master 300g cold press or rough.
- One high-contrast colour from the Liverpool 12 Palette: **Indanthrone Blue**.
- Optional second colours for later visual tests: **Quinacridone Rose** or **Azo Yellow**.

- Clean water.
- Board with adjustable incline.
- Ruler or printed millimetre grid.
- Kitchen scale accurate to 0.1 g if available.
- Phone camera on fixed overhead mount.
- Room thermometer/humidity meter if available.
- Timer.

Camera setup

- Keep the phone fixed.
- Lock exposure and focus.
- Put a ruler or grid in frame.
- Keep lighting fixed.
- Film time-lapse, or take one photo every 5-10 seconds for the first few minutes and every 30 seconds after that.

Core measurements

```
w(t)        = edge width / blur width in mm
DeltaL      = final edge broadening
SNR(t)      = edge signal-to-noise ratio
M(t)        = total mass if using scale
M_water(t)  = M(t) - M_dry
```

Drying proxy:

```
k_evap(t) = - d ln(M_water) / dt
```

Spreading proxy:

```
D_eff approx 0.5 * d(w^2) / dt
```

A practical record threshold:

```
recoverable if SNR >= 3
and DeltaL < 0.5 L
and edge motion is below the chosen tolerance.
```

Experiment 1 - Drying-front record threshold

Question

When does a wet mark become a recoverable record?

Method

1. Tape down a small sheet.

2. Mark a 50 mm × 20 mm test rectangle.
3. Lay one clean **Indanthrone Blue** wash across it.
4. Film immediately.
5. Record until sheen has gone and the edge stops moving.
6. Repeat at least three times.

Measure

```
M_water(t)
w(t)
SNR(t)
K_final = SNR_final / (1 + DeltaL / L)
```

Estimate:

```
Gamma_scramble approx D_eff / L^2 + v_cap / L
Gamma_enroll approx k_evap + k_ads + k_fix
R_record = Gamma_enroll / Gamma_scramble
```

For a first version, `k_ads + k_fix` can be treated as a fitted stabilization proxy: the rate at which edge motion slows after the drying front passes.

Look for

The transition point where:

```
w(t) stops increasing
SNR(t) stops falling
edge motion approaches zero
```

Video line:

> The mark is not fixed when the brush touches the paper. It becomes a record when drying and fibre-capture outrun spreading.

Test value

A weak positive result is: drying/fixation predicts edge stabilization better than clock time alone.

A stronger result is: `R_record` predicts final recoverability across repeated trials better than raw time or water mass alone.

Experiment 2 - Re-wetting and metastable records

Question

Is a dry watercolour mark permanent, or stable only while its erasure channels stay closed?

Method

1. Make a dry hard-edged **Indanthrone Blue** stripe.
2. Divide it into three zones.
3. Apply controlled clean-water touches:
   - Zone A: tiny, almost dry brush.
   - Zone B: moderate touch.
   - Zone C: wet touch or small droplet.
4. Film from first contact.
5. Let dry again.
6. Compare edge width and contrast before and after.

Measure

```
w0, SNR0 before re-wetting
w1, SNR1 after re-wetting
Deltaw = w1 - w0
```

Record-loss proxy:

```
lambda_loss = - d ln(SNR(t) / SNR0) / dt
```

Re-wetting load:

```
Rewet_load = W_added / tau_wet
```

where `W_added` is added water and `tau_wet` is visible wet time.

Record survival:

```
SNR1 / SNR0 >= 0.5
and Deltaw < 0.5 L
```

Record failure:

```
SNR < 3
or Deltaw > 0.5 L
```

Look for

A threshold where small water touches disturb but do not destroy the mark, while larger loads reopen mobility and degrade the edge.

Video line:

> Dry does not mean eternal. A record is stable only against the channels that are currently closed.

Experiment 3 - Saturation, backruns, and interface overload

Question

What happens when a boundary receives more water-load than it can absorb while remaining coherent?

Method

1. Lay a flat **Indanthrone Blue** wash.
2. At three stages, drop the same amount of clean water:
   - glossy wet;
   - satin sheen;
   - nearly dry but still cool.
3. Film the bloom/backrun.
4. Repeat with smaller and larger droplets if possible.

Measure

```
R_bloom(t) = bloom radius / width
v_bloom(t) = dR_bloom / dt
SNR_rim(t) = bloom rim contrast
```

Define:

```
S_water = W_added / W_capacity(stage)
```

where `W_capacity(stage)` is the largest water amount that does not produce a bloom above the failure threshold.

Failure threshold:

```
R_bloom_final > 0.5 L
or SNR_rim >= 3 for an unintended bloom boundary
```

Boundary coherence proxy:

```
K_edge = SNR_original / (1 + Deltaw / L)
K_eff approx K_edge / (1 + S_water)
```

Look for

A drying-stage window where added water overloads the interface and creates a cauliflower bloom.

Video line:

> A backrun is an overloaded boundary. The wash had a capacity; the added water exceeded it; the interface failed into a new record.

Experiment 4 - Incline, biased transit, and uphill blooming

Question

How does an imposed directional constraint - board incline - bias the movement of water and pigment before the wash becomes a record?

Method

1. Use the same paper, pigment mix, brush load, and camera setup.
2. Test board angles:
   - 0 degrees flat control;
   - 10 degrees mild incline;
   - 20 degrees moderate incline;
   - 35 degrees strong incline.
3. Apply the same wash or loaded pigment droplet at the same starting point.
4. Film until the mark stops moving.
5. Optional: add a small clean-water touch above, below, or beside the moving wash.

Measure

```
x_down(t) = downhill displacement
x_side(t) = sideways displacement
x_up(t)   = uphill bloom displacement, if present
w(t)      = edge width
SNR(t)    = edge contrast
```

Velocities:

```
v_down = dx_down / dt
v_side = dx_side / dt
v_up   = dx_up / dt
```

Incline term:

```
v_gravity(theta) proportional to sin(theta)
```

Full scrambling proxy:

```
Gamma_scramble approx D_eff / L^2
                      + v_cap / L
                      + v_gravity(theta) / L
                      + Gamma_rewet
```

Bias ratio:

```
Bias_ratio = v_down / (abs(v_up) + abs(v_side) + small offset)
```

Look for

- Flat board: more symmetrical spreading.
- Mild incline: slight downhill shift, with possible sideways bloom.
- Moderate incline: clear downhill displacement.
- Strong incline: directional runs unless fixation occurs early.
- Uphill or sideways blooming: local capillary or wetness-gradient effects beating the global gravitational bias.

Video line:

> Incline makes transit directional. Gravity pulls downhill, but capillary tension, wetness gradients, and drying can still write the record another way.

Other useful painting-physics episodes

A. Gravity reversal mid-drying

Start inclined one way, then rotate 180 degrees partway through drying.

```
if the mark changes direction -> still in transit
if the mark barely changes -> transaction already occurred
```

Core line:

> A mark is not history just because it exists. It is history when later constraints can no longer rewrite it cheaply.

B. Hairdryer as forced early fixation

Apply warm air at 5, 15, and 30 seconds after laying the wash.

```
k_evap increases
Gamma_enroll increases
R_record tends upward
```

But airflow may also disturb the wash, raising the scrambling side.

C. Paper as constraint architecture

Repeat the same trial on different papers: cellulose, Baohong Academy, Baohong Master, rough, cold press.

```
k_ads, v_cap, D_eff, k_fix all change
```

Core line:

> The paper is not passive support. It is the local constraint architecture that decides how motion becomes record.

D. Pigment persistence profiles

Compare staining, granulating, heavy-settling, and mixed colours from the Liverpool 12 Palette. Some records are not edges but internal textures, granulation fields, and sediment bands.

E. Hard boundaries and admissible paths

Use masking fluid, tape, wax, or a pre-dried painted barrier. The boundary changes possible flow paths: stop, pool, run along the edge, or fail into bloom.

F. Surface-tension perturbation

Salt, alcohol, or a wetting agent changes capillary velocity, spreading, and local surface-tension gradients. The pigment may be the same, but the constraint field is changed.

Data table

Trial	Paper	Colour	Board angle	Water load	Humidity	Stage	M_water start	M_water end	Edge width start	Edge width end	SNR start	SNR end	Centroid shift	Outcome
1A	Baohong Master	Indanthrone Blue	0			fresh wash								record / dissolved
1B	Baohong Master	Indanthrone Blue	0			fresh wash								record / dissolved
2A	Baohong Master	Indanthrone Blue	0	tiny rewet		dry								survived / failed
2B	Baohong Master	Indanthrone Blue	0	medium rewet		dry								survived / failed
2C	Baohong Master	Indanthrone Blue	0	heavy rewet		dry								survived / failed
3A	Baohong Master	Indanthrone Blue	0	fixed drop		glossy								no bloom / bloom
3B	Baohong Master	Indanthrone Blue	0	fixed drop		satin								no bloom / bloom
3C	Baohong Master	Indanthrone Blue	0	fixed drop		nearly dry								no bloom / bloom
4A	Baohong Master	Indanthrone Blue	10			fresh wash								downhill / sideways / uphill bloom
4B	Baohong Master	Indanthrone Blue	20			fresh wash								downhill / sideways / uphill bloom
4C	Baohong Master	Indanthrone Blue	35			fresh wash								downhill / sideways / uphill bloom

What would count as a strong result?

A public painting series only needs visible relationships:

1. Edge stabilization tracks drying/fixation better than clock time alone.
2. Re-wetting reopens mobility in proportion to water load and contact time.
3. Backruns appear near a boundary-capacity threshold, not at random.
4. Board angle produces directional bias, while local capillary or re-wetting conditions can still beat gravity.

A stronger research result would require cross-channel compression:

```
R_record predicts K_final better than:
- elapsed time alone;
- water mass alone;
- board angle alone;
- paper type alone;
- visible drying stage alone.
```

That would not prove a universal law. It would show that record formation in watercolour can be organized by a useful persistence coordinate.

References

Deegan, R. D., Bakajin, O., Dupont, T. F., Huber, G., Nagel, S. R., & Witten, T. A. (1997). Capillary flow as the cause of ring stains from dried liquid drops. *Nature*, 389, 827-829.

Hu, H., & Larson, R. G. (2006). Marangoni effect reverses coffee-ring depositions. *Journal of Physical Chemistry B*, 110(14), 7090-7094.