Reading Time Since Death from Body Temperature, the Late-Hour Error Is Set by the Air Temperature, Not the Thermometer

— a ±0.1 °C thermometer error is smallest at the inflection point, but mistaking the air temperature by ±1 °C overtakes it at 3.980859 hours and is 8.119852 times as large at 24 hours — the separator is which error the reading is made with (the thermometer's error or the mistaken air temperature) — [Paper 798]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
September 2026

— *From thinking to syncing.* —

Abstract

When time since death is read from rectal temperature, where does the error come from?Taking the Henssge formula as given, three errors are set side by side for each reading time: ignoring the shape of cooling (the plateau), the thermometer's error, and mistaking the surrounding air temperature.No new theorem or law is claimed. First, ignoring the plateau reads the time short by a fixed amount——the shift approaches −3.618931 hours at late times and reaches 90 percent of that at 8.936996 hours (Section 2). **Second, measured in time constants, that shift does not depend on body weight——−2.696992 hours at 50 kg and −5.110465 hours at 100 kg, each 0.223144 time constants** (Section 2). **Third, the time at which the thermometer's error matters least is the inflection point——6.525445 hours (0.402359 time constants), with a time error of 0.126310 hours** (Section 3). **Fourth, and this is the core. Mistaking the air temperature overtakes the thermometer's error——the shift from ±1 °C in air temperature overtakes that from a ±0.1 °C thermometer at 3.980859 hours and reaches 1 hour at 15.354682 hours** (Section 4). **Fifth, at 24 hours the air-temperature shift is 8.119852 times the thermometer's——2.416509 hours against 0.297605 hours** (Section 4). **Sixth, the separator is which error the reading is made with——"time since death can be read from body temperature" does not fix up to what time it can be read until one says whether the reading is limited by the thermometer or by the mistaken air temperature** (Section 5). **Keywords**: time since death, rectal temperature, Henssge formula, Newton's law of cooling, inverse problem, plateau, inflection point.

Scope of this paper (scope note): **No new theorem or law is claimed——that rectal temperature does not fall for a while after death (a plateau), the formula expressing this as a difference of two exponentials (Marshall and Hoare 1962), the Henssge formula fixing the coefficient by body weight (Henssge 1988), and Newton's law of cooling are all known.The Henssge formula is taken as given——the coefficients 1.25, -1.2815 and 0.0284 and the exponent -0.625 are used as in the literature, and their correctness is not discussed. Only the form for lower air temperatures (coefficient 1.25) is used.No corrections are included——clothing, wind, immersion in water, errors in body weight, and individual differences in initial body temperature are left out.The numbers are examples——body weight 70 kg, initial rectal temperature 37.2 °C, air temperature 18.0 °C, a ± 0.1 °C thermometer and a ± 1 °C mistake in air temperature are values for comparison.No practical procedure is recommended——neither the estimation procedure nor how to report it is stated.Relation to earlier papers**: **Paper 465 showed with lumped cooling that halving the size beats changing the material forty times over, and its scope note stated "the internal temperature distribution is not treated—the lumped heat capacity method is used; when the Biot number is large the internal gradient matters and this treatment fails"——Paper 589 sat in that seat first, showing that the ranking of pot materials reverses through the temperature gradient within the pot base. This paper is the second to sit in the same seat, counting the plateau made by the internal gradient from the side of the inverse question, reading time from temperature.Paper 618 showed that freezing time grows in proportion to thickness for thin pieces and toward its square for thick ones——there too, where internal conduction mattered, the lumped estimate failed.**What is added is **showing that the shift of 3.618931 hours from ignoring the plateau is 0.223144 time constants and independent of body weight**, **confirming by closed form and numerically that the thermometer's error is smallest at the inflection point, 6.525445 hours**, **counting that the mistaken air temperature overtakes the thermometer's error at 3.980859 hours**, and **placing the separator on which error the reading is made with**.

1. Notation and the Question

Setting: **let the rectal temperature be $T(t)$, the surrounding air temperature T_a, and the initial rectal temperature T_0 , and set the cooled fraction $Q = (T - T_a)/(T_0 - T_a)$. The Henssge formula and lumped cooling (Newton's law of cooling) take the following forms.**

$$Q_{\mathrm{H}}(t) = 1.25\, e^{Bt} - 0.25\, e^{5Bt}, \qquad Q_{\mathrm{N}}(t) = e^{Bt}, \qquad B = -1.2815\, m^{-0.625} + 0.0284$$

Here m is body weight (kg) and t is time. Q_{H} starts with zero slope and does not fall for a while (the plateau), because the body has an internal temperature distribution and the cooling of the surface takes time to reach the interior. Reading time from body temperature means solving t back from Q, an inverse problem, and a temperature error δT propagates into a time error as follows.

$$\delta t \approx \frac{\delta T}{(T_0 - T_a)\ |dQ/dt|}$$

Question: when time is read from temperature, which error matters, and does that change with the reading time?

2. The Shift from Ignoring the Plateau

Computation 2.1: for body weight 70 kg ($B = -0.061660$ per hour, time constant 16.217948 hours), $T_0 = 37.2$ °C and $T_a = 18.0$ °C, the body temperature from the Henssge formula was read with Newton's law of cooling using the same B.

time (hours)	body temperature (°C)	time read by Newton's law	shift
1	37.038324	0.137143	−0.862857
2	36.624609	0.493456	−1.506544
4	35.355601	1.637932	−2.362068
8	32.247407	4.838388	−3.161612
12	29.332919	8.550079	−3.449921
24	23.461232	20.389787	−3.610213
48	19.244045	44.381093	−3.618907

> **Observation 2.2**
>
> ignoring the plateau reads the time short by a fixed amount.The shift approaches $\ln 1.25 / B = -3.618931$ hours in the following form and reaches 90 percent of that at 8.936996 hours——the time during which the clock stood still on the plateau is never recovered later.

$$t_{\mathrm{N}} - t = \frac{\ln\left(1.25 - 0.25\, e^{4Bt}\right)}{B} \longrightarrow \frac{\ln 1.25}{B}$$

Computation 2.3: body weight was varied and the late-time shift derived.

body weight	B (per hour)	time constant (hours)	late-time shift (hours)
50 kg	−0.082738	12.086353	−2.696992
70 kg	−0.061660	16.217948	−3.618931
100 kg	−0.043664	22.902141	−5.110465

> **Observation 2.4**
>
> measured in time constants, the shift does not depend on body weight.For all three weights the shift is 0.223144 time constants——a heavier body is misread by longer only because its clock runs more slowly; the shape of the plateau is the same.

3. The Thermometer’s Error

Computation 3.1: the time error from measuring body temperature to ±0.1 °C was derived for each reading time (body weight 70 kg).

time (hours)	time error (hours)
1	0.328819
2	0.196322
4	0.137890
8	0.128535
12	0.149363
24	0.297605
36	0.622123
48	1.303654

Observation 3.2

the time at which the thermometer's error matters least is the inflection point.The minimum found by golden-section search is at 6.525445 hours and agrees with the closed form for the inflection point of Q_{H} to within -2.705×10^{-8} hours. It is 0.402359 time constants, and the time error there is 0.126310 hours. The window readable within 0.5 hours is 0.613195 to 32.452748 hours——the time of steepest fall is the easiest to read.

$$\frac{d^2 Q_{\mathrm{H}}}{dt^2} = 0 \quad \Longleftrightarrow \quad t = \frac{\ln 5}{4\,|B|}$$

Observation 3.3

what makes early times hard to read is the plateau.At 1 hour the time error is 0.328819 hours, larger than the 0.126310 hours at the inflection point——with the slope near 0, the same $0.1\ ^{\circ}\mathrm{C}$ turns into a long stretch of time.

4. Mistaking the Air Temperature

Computation 4.1: taking body temperature as measured correctly, the shift in the read time was derived when the air temperature was mistaken as $19\ ^{\circ}\mathrm{C}$ or $17\ ^{\circ}\mathrm{C}$ (truly $18\ ^{\circ}\mathrm{C}$).

time (hours)	shift if set to $19\ ^{\circ}\mathrm{C}$	shift if set to $17\ ^{\circ}\mathrm{C}$
2	$+0.061458$	-0.056444
4	$+0.138941$	-0.126601
8	$+0.351193$	-0.314121
12	$+0.656048$	-0.573822
16	$+1.076974$	-0.916931
24	$+2.416509$	-1.908798
32	$+4.911771$	-3.429893

Observation 4.2

this is the core: mistaking the air temperature overtakes the thermometer's error.The larger shift from ±1 °C in air temperature overtakes that from a ±0.1 °C thermometer at 3.980859 hours (a shift of 0.138116 hours there) and reaches 1 hour at 15.354682 hours——the more the gap between body and surroundings closes, the larger the share of that gap a 1 °C mistake takes.

Observation 4.3

at 24 hours the air-temperature shift is 8.119852 times the thermometer's.Body temperature is 23.461232 °C, the gap to the surroundings has closed to 5.461232 °C, the shift from setting the air to 19 °C is 2.416509 hours, and the thermometer's is 0.297605 hours——at late times a better thermometer hardly improves the reading.

5. The Separator

Observation 5.1

the separator is which error the reading is made with.Before 3.980859 hours the thermometer's error matters, after it the mistaken air temperature, and the 3.618931-hour shift from ignoring the plateau persists to late times apart from both——"time since death can be read from body temperature" does not fix up to what time it can be read until one says which error the reading is made with.

Observation 5.2

beside Papers 465, 589 and 618.Paper 465 compared size and material with lumped cooling and stated that the internal temperature distribution was not treated. Paper 589, first to sit in that seat, showed that the ranking of pot materials reverses through the gradient within the pot base, and Paper 618 showed that internal conduction pushes freezing time toward the square of thickness——this paper is the second in the same seat, counting the plateau made by the internal gradient from the side of the inverse problem of reading time.

Observation 5.3

what is not said.The correctness of the Henssge constants, corrections for clothing, wind and water, errors in body weight, individual differences in initial temperature, and practical estimation procedures are not treated——what is shown is that the error that matters changes with the reading time.

6. Roll Call and Closing

1. **shift from ignoring the plateau, -3.618931 hours** (Observation 2.2): **the time the clock stood still.**
2. **90 percent reached at 8.936996 hours** (Observation 2.2): **soon constant.**
3. **0.223144 time constants** (Observation 2.4): **independent of weight.**
4. **inflection point, 6.525445 hours** (Observation 3.2): **easiest to read.**
5. **error there, 0.126310 hours** (Observation 3.2): **at 0.402359 time constants.**
6. **error at 1 hour, 0.328819 hours** (Observation 3.3): **the plateau.**
7. **overtaking at 3.980859 hours** (Observation 4.2): **the core.**
8. **1 hour reached at 15.354682 hours** (Observation 4.2): **the air-temperature side.**
9. **8.119852 times at 24 hours** (Observation 4.3): **a better thermometer does not help.**
10. **which error the reading is made with** (Observation 5.1): **the separator; Papers 465, 589, 618.**

Closing: **When time since death is read from body temperature, the error at late hours is set not by the thermometer but by the air temperature.Following the rectal temperature of a 70 kg body with the Henssge formula, reading it as lumped cooling while ignoring the initial plateau gives times 3.618931 hours too short at late hours, a shift of 0.223144 time constants independent of body weight——the time the clock stood still on the plateau.The error from a ± 0.1 °C thermometer is smallest at the inflection point, 6.525445 hours, at 0.126310 hours, but the shift from mistaking the air temperature by ± 1 °C overtakes it at 3.980859 hours, reaches 1 hour at 15.354682 hours, and at 24 hours is 8.119852 times the thermometer's——the more the gap between body and surroundings closes, the more the mistaken air temperature matters.The separator is which error the reading is made with (the thermometer's error or the mistaken air temperature).Placed among the earlier papers——Paper 589 sat first, with the gradient in the pot base, in the seat for the internal temperature distribution that Paper 465 left open. This is the second in the same seat, counting the side of the inverse problem of reading time.To be honest——the Henssge formula was taken as given, and neither corrections nor practical procedures are treated.**

References

1. Henssge, C. (1988). Death time estimation in case work. I. The rectal temperature time of death nomogram. *Forensic Science International*.
2. Marshall, T. K., & Hoare, F. E. (1962). Estimating the time of death: the rectal cooling after death and its mathematical expression. *Journal of Forensic Sciences*.
3. Newton, I. (1701). Scala Graduum Caloris. *Philosophical Transactions of the Royal Society*.
4. Yamagishi, Y. (2026). *Halving the Size Beats Changing the Material Forty Times Over* [Paper 465]. Zenodo. 10.5281/zenodo.22733260
5. Yamagishi, Y. (2026). *The Ranking of Pot Materials Reverses Between Spreading Heat and Storing It* [Paper 589]. Zenodo. 10.5281/zenodo.23014379
6. Yamagishi, Y. (2026). *Freezing Time Grows in Proportion to Thickness for Thin Pieces and Toward Its Square for Thick Ones* [Paper 618]. Zenodo. 10.5281/zenodo.23014498

— From thinking to syncing. —

Yuuki YAMAGISHI (山岸 勇輝)

© 2026 Yamagishi Complexity Torus Lab, Japan · Licensed under Creative Commons Attribution 4.0 International (CC BY 4.0)