A Body Clock Need Not Be Accurate; It Need Only Be Reset Each Day

— With a free-running period of **24.18** hours the daily correction is **10.800000** minutes, which is **0.007444** of the period — the separator is whether the synchronising signal arrives — [Paper 695]

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

— From thinking to syncing. —

Abstract

The human clock does not run at exactly 24 hours. That this causes no trouble follows from its being reset every day.That the requirement is not accuracy but entrainment width is shown here in the drift and the margin.No new theorem or law is claimed. First, the error itself is small——a free-running period of 24.18 hours calls for a daily correction of 10.800000 minutes, which is 0.007444 of the period (Section 2). **Second, left alone, it accumulates ——1.260000 hours in a week, 5.400000 hours in thirty days and 65.700000 hours in a year** (Section 2). **Third, and this is the core. A year of neglect turns day and night around——a drift of 2.737500 days, so that whoever was waking at a given hour comes to be sleeping at it** (Section 2). **Fourth, and yet, being resettable, it is no trouble——an entrainment range of ±1 hour a day covers periods from 23.00 to 25.00 hours, leaving 5.555556 times the margin this clock needs** (Section 3). **Fifth, so the requirement moves——the design requirement is not "build an accurate clock" but "how far can it be shifted each day"** (Section 3). **Sixth, the separator is whether the synchronising signal arrives——while it does, the error never appears; once it stops, the error appears at 10.800000 minutes a day** (Section 4). **Keywords**: circadian rhythm, free-running period, entrainment, range of entrainment, phase drift, accuracy against resettability.

Scope of this paper (scope note): No new theorem or law is claimed——that the human free-running period is close to 24.2 hours, entrainment by light and the range of entrainment are all standard (Czeisler et al. 1999, Pittendrigh and Daan 1976).Mechanism is not treated——clock genes, the suprachiasmatic nucleus and the shape of the phase response curve are not treated.The period is not claimed——24.18 hours is representative and moves between people over roughly 23.5 to 24.6 hours.Health effects are not discussed——jet lag, shift work and sleep disorders are not the subject.Only light is considered——entrainment by meals or exercise is not treated, and the entrainment width is taken as given.Relation to earlier papers: Paper 691 showed that having a period and having a clock are two different things, the phase diffusing as $\sqrt{k}$ without an outside clock and saturating at $\sigma/\sqrt{2K}$ with one——there the forced case was an abstraction placed for comparison. Here a real instance is put on that side, and the margin carried by the entrainment width is given a number.What is added is setting the drift out by day, week, month and year, showing a year to turn the clock by **2.737500** days, showing the correction to be only **0.007444** of the period, giving the entrainable range for each width together with the margin **5.555556**, and placing the separator on whether the synchronising signal arrives.

1. Notation and the Question

Setting: let τ be the period with no synchronising signal. Matching an outside day of 24 hours needs a correction of $\tau - 24$ each day. With an entrainment width Δ, entrainment succeeds when $|\tau - 24| < \Delta$.

$$d = \tau - 24, \qquad D(n) = nd, \qquad |\tau - 24| < \Delta, \qquad \text{margin} = \frac{\Delta}{|\tau - 24|}$$

Take $\tau = 24.18$ hours.

Question: what is asked of a body clock: accuracy, or the ease of resetting it?

2. Left Alone, Day and Night Change Places

Computation 2.1: the daily correction is 10.800000 minutes, which is 0.007444 of the period.

Computation 2.2: the drift with no synchronising signal was derived.

elapsed	drift
one day	0.180000 hours
one week	1.260000 hours
thirty days	5.400000 hours
one year	65.700000 hours

A year of drift amounts to 2.737500 days.

> **Observation 2.3**
>
> **this is the core: what goes unnoticed in a day turns day and night around in a year.Ten point eight minutes lies within the error of a single day, and three hundred and sixty-five of them come to 2.737500 days——being small and not accumulating are different things.**

> **Observation 2.4**
>
> **as a clock, its accuracy is in fact rather good.The correction is 0.007444 of the period, under one per cent——that would be ample for a mechanical clock, and it still turns day and night around within a year.**

3. Being Resettable Is Enough

Computation 3.1: **the entrainable range of free-running periods was derived for each entrainment width.**

shift available per day	entrainable period
±0.5 hours	23.50 to 24.50 hours
±1.0 hours	23.00 to 25.00 hours
±2.0 hours	22.00 to 26.00 hours

At ±1 hour a day the margin is 5.555556 times the 0.18 hours this clock needs.

Observation 3.2

the requirement moves from accuracy to entrainment width.The clock need not be built to run at exactly 24.00 hours; the daily shift available need only exceed the error——“build it accurately” and “make it resettable” are different designs.

Observation 3.3

margin is usually cheaper to buy than accuracy.Moving the period from 24.18 towards 24.02 means rebuilding the body; widening the entrainment is a matter of the receiving side, of how bright the light is and when it falls——what can be put outside is usually cheaper outside.

Observation 3.4

the margin has edges, though.At ± 1 hour a day it runs from 23.00 to 25.00 hours, and whoever falls outside cannot entrain and free-runs——“it can be reset” holds only within a width, not unconditionally.

4. The Separator

Observation 4.1

the separator is whether the synchronising signal arrives.While it does, that τ is not 24 never once appears; from the moment it stops, it appears at 10.800000 minutes a day——one clock looks accurate or inaccurate according to its surroundings.

Observation 4.2

beside Paper 691.Paper 691 showed the phase to diffuse as $\sqrt{k}$ without an outside clock and to saturate at $\sigma/\sqrt{2K}$ with one——there the forced case was an abstraction placed for comparison; here a real instance occupies it, and the entrainment width appears as a quantity a designer can choose.

Observation 4.3

what is not said.Mechanism and health effects are not treated, and both period and width are representative——what is shown is that the requirement moves from accuracy to entrainment width.

5. Roll Call and Closing

1. **daily correction 10.800000 minutes** (Computation 2.1): **at $\tau = 24.18$ hours.**
2. **0.007444 of the period** (Computation 2.1): **under one per cent.**
3. **1.260000 hours in a week** (Computation 2.2): **it begins to pile up.**
4. **5.400000 hours in thirty days** (Computation 2.2): **nearly half a day.**
5. **65.700000 hours in a year** (Computation 2.2): **the core.**
6. **that is 2.737500 days** (Computation 2.2): **day and night change places.**
7. **23.00 to 25.00 hours at ± 1** (Computation 3.1): **the entrainable range.**
8. **margin 5.555556** (Computation 3.1): **against the error.**
9. **the requirement moves to width** (Observation 3.2): **not to accuracy.**
10. **does the signal arrive** (Observation 4.1): **the separator; Paper 691.**

Closing: **A body clock need not be accurate.A free-running period of 24.18 hours calls for a daily correction of 10.800000 minutes, 0.007444 of the period——ample accuracy for a mechanical clock.Left alone it still accumulates to 1.260000 hours in a week, 5.400000 hours in thirty days and 65.700000 hours in a year, turning day and night around by 2.737500 days——being small and not accumulating are different things.Yet an entrainment range of ± 1 hour a day covers 23.00 to 25.00 hours and leaves 5.555556 times the margin this clock needs.So the design requirement is not “build an accurate clock” but “how far can it be shifted each day”——and whoever falls outside that width cannot entrain and free-runs.The separator is whether the synchronising signal arrives.Placed among the earlier papers——in Paper 691 the forced case was an abstraction for comparison; here a real instance occupies it.To be honest——mechanism and health effects are not treated, and both period and width are representative.**

References

1. Czeisler, C. A., Duffy, J. F., Shanahan, T. L., Brown, E. N., Mitchell, J. F., Rimmer, D. W., & Kronauer, R. E. (1999). Stability, precision, and near-24-hour period of the human circadian pacemaker. *Science*.
2. Pittendrigh, C. S., & Daan, S. (1976). A functional analysis of circadian pacemakers in nocturnal rodents. *Journal of Comparative Physiology*.

3. Yamagishi, Y. (2026). *Having a Period and Having a Clock Are Two Different Things* [Paper 691]. Zenodo. 10.5281/zenodo.23014848

— 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)