

The Brain Uses “2 Per Cent of the Mass and 20 Per Cent of the Energy” Because What It Is Compared With Is Resting

— The brain’s specific power is **14.2857** W/kg against a whole-body average of **1.4286**, a ratio of **10** — But skeletal muscle in exercise runs at **100** W/kg, seven times the brain — The factor of **10** comes from the smallness of the denominator, not the largeness of the brain — [Paper 382]

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— *From thinking to syncing.* —

Abstract

The brain is said to use 2 per cent of the body’s mass and 20 per cent of its energy. This paper asks where that factor of 10 comes from—the answer is not that the brain is high but that the denominator is low. No new mathematical theorem and no new law is claimed. First, a 70 kg body with a 1.4 kg brain gives a mass fraction of **2.0000** per cent (Section 2). Second, a basal rate of 100 W with 20 W to the brain gives **20.0000** per cent, a ratio of **10** (Section 2). Third, the brain’s specific power is **14.2857** W/kg against a whole-body **1.4286** (Section 2). Fourth, this is the core of the paper. Skeletal muscle in exercise runs at **100** W/kg, seven times the brain (Section 3). Fifth, per neuron it is only **232.5581** pW (Section 4). Sixth, the separator is what the denominator is, not a property of the brain (Section 5).

Scope of this paper (scope note): No new mathematical theorem and no new law is claimed—the brain’s metabolic rate, specific power, and basal metabolic rate are all standard. We do not build neuroscience—how the energy divides between synaptic transmission and action potentials is not entered. It is named and no more. We measure nothing—70 kg body, 1.4 kg brain, 100 W basal, 20 W brain are stated assumptions. They follow representative figures from the literature. Evolution is not discussed—the expensive-tissue hypothesis is named and no more. We do not compare with computers—a processor is mentioned once for reference and not used as a comparison. The purposes differ. Individual variation is not treated—age, build, and activity level are not the subject. Relation to earlier papers: Paper 345 showed one logarithm counting a ratio in one place and items in another—there too what one divided by did the work. Paper 364 showed selection alone raising a mean—there too the denominator (the visible group) made the number. Paper 300 showed whether two things share a root is decidable—by that test, “the brain is high” and “the whole-body average is low” have distinct roots. Paper 362 showed the bottleneck lying where nobody was looking—here the source of the surprise lies there. What is added is giving the mass and power fractions as numbers, obtaining the same factor of 10 by two routes, showing the brain is not high against exercising muscle, giving the 232.5581 pW per neuron, and putting the separator on the denominator.

1. Notation and the Question

Setting: Take a 70 kg body with a 1.4 kg brain, a basal rate of 100 W with 20 W to the brain.

$$f_{\text{mass}} = \frac{m_{\text{brain}}}{m_{\text{body}}}, \quad f_{\text{power}} = \frac{P_{\text{brain}}}{P_{\text{body}}}, \quad \text{specific power} = \frac{P}{m}$$

Observation 1.1

“2 per cent for 20 per cent” is a ratio of two fractions. $0.20/0.02 = 10$ —and both numerator and denominator carry a chosen reference.

Observation 1.2

The denominator is the basal rate — the whole body at rest. Doing nothing—and in that state the muscles use almost no power.

Observation 1.3

So changing the comparison changes the number. This paper gives how much it changes—looking at where the factor of 10 actually comes from.

Question: What does the factor of 10 tell us about the brain?

2. The Factor of 10 Arrives by Two Routes

Calculation 2.1: Fractions and specific powers (computed in this paper).

Quantity	Value
Mass fraction	2.0000 per cent
Power fraction	20.0000 per cent
Ratio (power / mass)	10.0000
Brain specific power	14.2857 W/kg
Whole-body specific power	1.4286 W/kg
Ratio of specific powers	10.0000

Observation 2.2

Two routes return the same 10.0000. The ratio of fractions and the ratio of specific powers—the same quantities divided in a different order. A check that the formulae close.

Observation 2.3

The brain's specific power is 14.2857 W/kg. 20 W over 1.4 kg—that is the absolute figure for how much power the brain draws.

Observation 2.4

The whole-body average is 1.4286 W/kg. 100 W over 70 kg—a single 100 W bulb is the whole of a resting person.

Observation 2.5

That low denominator is what does the work. 1.4286 W/kg—a body at rest is doing almost nothing.

3. Exercising Muscle Is Seven Times the Brain

Calculation 3.1: Specific powers side by side (computed in this paper; the muscle figure from the literature).

Object	Specific power [W/kg]	Relative to the brain
Whole body (resting average)	1.4286	0.1000
Brain	14.2857	1.0000
Skeletal muscle (exercising)	100	7.0000

Observation 3.2

This is the core of the paper. Exercising muscle has seven times the brain's specific power—the brain is not the body's most power-hungry tissue.

Observation 3.3

The factor of 10 comes from the low denominator. Not that 14.2857 is high, but that 1.4286 is low—the same number reads as a property of the comparison rather than of the brain.

Observation 3.4

So during exercise the 20 per cent falls. Because the denominator grows—the brain's 20 W has not changed and the fraction drops.

Observation 3.5

To be stated honestly—100 W/kg is a representative figure from the literature, not computed here. It varies greatly with intensity—it is used as a comparison and no precision is claimed.

Observation 3.6

Something about the brain is still unusual. Not that its specific power is high, but that it does not fall at rest——muscle drops below 1 W/kg when idle; the brain does not.

4. Per Neuron It Is 232.5581 pW

Observation 4.1

20 W over 8.6×10^{10} neurons is **232.5581 pW**. 2.3256×10^{-10} W——not even a nanowatt.

Observation 4.2

Seen from the individual, it is strikingly small. While the total is 20 W——being numerous and being individually large are different things.

Observation 4.3

One number gives two impressions. “20 per cent” and “232.5581 pW”——the first sounds large and the second small. They are the same 20 W.

Observation 4.4

The same shape as Paper 345. There one logarithm counted a ratio and items—here one 20 W makes different impressions as a fraction and as a per-unit figure.

Observation 4.5

To be stated honestly—this paper does not compare the brain with a processor. Setting operations per watt beside it compares different purposes—the form “numbers side by side therefore a comparison” is not taken.

5. The Separator: What the Denominator Is

Observation 5.1

The separator—what one divided by; not a property of the brain.

Compared with	Its specific power	Brain relative to it	Impression
Whole body (resting)	1.4286 W/kg	brain is 10×	the brain is greedy
Skeletal muscle (exercising)	100 W/kg	brain is 1/7	the brain is frugal

Observation 5.2

Nothing on the brain’s side has changed. 14.2857 W/kg in both rows—only the comparison changed, and the impression reverses.

Observation 5.3

Distinct roots by the criterion of Paper 300. “The brain’s specific power is high” is fixed by the brain’s metabolism; “it is ten times” by the whole-body average—the latter is not a statement about the brain.

Observation 5.4

The separator can be moved. Change the denominator from resting to exercising—which is the “right” comparison is settled by what one wants to know.

Observation 5.5

To be stated honestly—14.2857 and 232.5581 pW are values on stated assumptions. Another build gives other numbers—what does not move is the structure: the factor of 10 arises from the low denominator.

Observation 5.6

One last thing—a figure of the form “ N times” is also a statement about what it was compared with. Saying the brain is ten times, half the sentence is about the whole-body average—be surprised without checking where the surprise came from, and you are surprised at the wrong thing.

6. The Census and the Close

1. Mass fraction 2.0000 per cent (Calculation 2.1): **1.4 kg of 70 kg.**
2. Power fraction 20.0000 per cent (Calculation 2.1): **20 W of 100 W.**
3. Ratio 10.0000 (Calculation 2.1): **the same by two routes.**
4. Brain specific power 14.2857 W/kg (Calculation 2.1): **the absolute figure.**
5. Whole-body 1.4286 W/kg (Observation 2.4): **one light bulb.**
6. Exercising muscle 100 W/kg (Calculation 3.1): **seven times the brain.**
7. What is unusual is not falling (Observation 3.6): **not being high.**
8. 232.5581 pW per neuron (Observation 4.1): **not even a nanowatt.**
9. One 20 W, two impressions (Observation 4.3): **fraction and per-unit.**
10. The brain’s side did not change (Observation 5.2): **only the comparison did.**

Closing: The brain is said to use 2 per cent of the body’s mass and 20 per cent of its energy—and half of that factor of 10 is a statement about what it was compared with. The numbers are right—a 70 kg body with a 1.4 kg brain gives a mass fraction of **2.0000** per cent; a basal rate of 100 W with 20 W to the brain gives **20.0000** per cent; the ratio is **10.0000**, and the same 10.0000 returns whether one takes the ratio of fractions or of specific

powers. But in absolute terms the brain is not especially high——its specific power is **14.2857 W/kg**, and skeletal muscle in exercise, at **100 W/kg**, is seven times that. The brain is not the body’s most power-hungry tissue. The factor of 10 appears because the whole-body average is a low **1.4286 W/kg** — a body at rest is doing almost nothing. So during exercise the brain’s **20 W** stays put while the fraction falls. Seen from the individual it is smaller still——**20 W** over 8.6×10^{10} neurons is **232.5581 pW**, not even a nanowatt. “20 per cent” and “232.5581 pW” are the same **20 W**, and the first sounds large while the second sounds small. The same shape as one logarithm counting a ratio and items in Paper 345. One thing separates them——what one divided by; not a property of the brain. The brain stays at **14.2857 W/kg** in both rows and only the comparison changes, yet “greedy” and “frugal” swap. By the criterion of Paper 300 they have distinct roots: “the specific power is high” is fixed by the brain’s metabolism, “it is ten times” by the whole-body average — and the latter is not a statement about the brain. To be said honestly——**100 W/kg** is a representative literature figure and not computed here, varying greatly with intensity. And something about the brain is still unusual: not that its specific power is high, but that it does not fall at rest. Muscle drops below **1 W/kg** when idle; the brain does not. One last thing——a figure of the form “*N* times” is also a statement about what it was compared with. Saying the brain is ten times, half the sentence is about the whole-body average. Be surprised without checking where the surprise came from, and you are surprised at the wrong thing.

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