Twice as hot?

by **Colin Foster**

Some time ago, I took a photograph of the sign below outside the NCP Nottingham City car park (Fig. 1). I thought it might be interesting to think about what it could mean for one thing to be "50 times safer" than something else and how this claim might have been arrived at. However, before I got around to doing anything with this, in August 2017 the car park partially collapsed (fortunately, it happened during the night, and no one was hurt). It was immediately declared *unsafe* and the site has since been razed to the ground. I suppose this puts a slightly different perspective on the claim!

Fig. 1 The NCP Nottingham City car park

Since then, I have been looking for examples of proportional claims that need a bit of careful interpretation, and I have found quite a few, mostly involving temperature. Recently, I saw the newspaper headline 'Halfway to boiling' (Fig. 2). Certainly, 50°C is halfway between 0°C and 100 °C, but this depends on the Celsius temperature scale having its zero at the temperature of melting ice, which is an arbitrary choice. If we moved the zero to somewhere else, we could make the ratio of these two temperatures anything we liked. For example, if we kept the size of a degree the same, but put our zero at 49°C, then 50°C would be only about 2% of the way to boiling – a far less dramatic headline!

There is something of a tradition of getting muddled up when using temperature scales without a true zero. John Mason (1998, pp. 246–247) referred to a travel book that stated that "there could be sudden drops of temperature by as much as 10°C (50°F)", pointing out that, although 10°C = 50°F, a *difference* of 10°C is very different from a *difference* of 50°F!

Sweltering cities

Halfway to boiling: the city at 50C

▲ In a city at 50C, the only people in sight are those who do not have access to air conditioning. Illustration: Kevin Whipple

It is the temperature at which human cells start to cook, animals suffer and air conditioners overload power grids. Once an urban anomaly, 50C is fast becoming reality

by Jonathan Watts and Elle Hunt

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About this content

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Imagine a city at 50C (122F). The pavements are empty, the parks quiet, entire neighbourhoods appear uninhabited. Nobody with a choice ventures outside during daylight hours. Only at night do the denizens emerge, HG Wells-style, into the streets - though, in temperatures that high, even darkness no longer provides relief. Uncooled air is treated like effluent: to be flushed as quickly as possible.

Fig. 2 *Guardian* **headline (13 August 2018)**

A commonly-used research methods textbook (Cohen, Manion and Morrison, 2011), in a chapter explaining different kinds of quantitative data, states that:

> "In Fahrenheit degrees the freezing point of water is 32 degrees, not zero, so we cannot say, for example, that 100 degrees Fahrenheit is twice as hot as 50 degrees Fahrenheit, because the measurement of Fahrenheit did not start at zero. In fact twice as hot as 50 degrees Fahrenheit is 68 degrees Fahrenheit (({50 – 32} × 2) + 32)." (p. 605)

I think this is all correct until the final sentence. What I think they mean to say is that 50°F is 10°C and 68°F is 20°C, so 68°F is twice the temperature of 50°F *on the Celsius scale* – but the problem is that the zero on the Celsius scale is no truer than the zero on the Fahrenheit scale! On the *Kelvin* scale, which *does* have a true zero, 50°F is 283K, so "twice this temperature" would be 566K, which is 559°F – somewhat hotter than 68°F!

It can be quite tempting when dealing with temperature to use language such as "twice as hot as" or "twice as much heat as", but these sorts of phrases can be confusing. I have seen this kind of language used in lessons on directed numbers, where adding two ice cubes is supposed to correspond to adding twice as much 'coldness' as adding one, and so should reduce the temperature of something by twice as much. (Even though adding more and more ice cubes to a water/ice mixture at 0°C is not going to reduce its temperature at all!)

I thought I had seen another example of this kind of confusion on a recent trip to the National Space Centre in Leicester (Note 1), when I saw the sign shown in Figure 3, but I think this one is actually fine. The difference between Celsius and Kelvin becomes less and less important as you deal with higher and higher temperatures. Steel melts at around 1400°C, and 3300 ≈ 2 × 1400, but this actually works even better on the Kelvin scale, where the ratio is $\frac{3573}{1673}$, which is even closer to 2. The idea of 'twice as hot' is meaningful on the Kelvin scale, because you can think of the average kinetic energy of the atoms as being about twice as much.

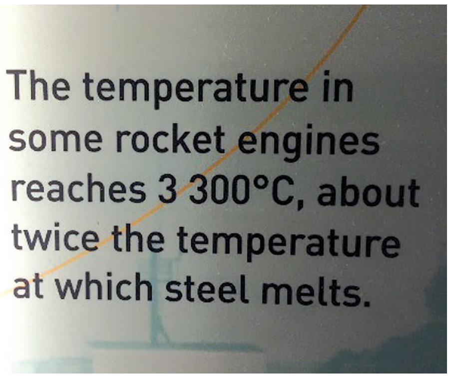

Fig. 3 Sign at the National Space Centre, Leicester

References

Cohen, L., Manion, L and Morrison, K. 2011 *Research Methods in Education*, Routledge, Oxon.

Mason, J. 1998 'Enabling Teachers to be Real Teachers: Necessary Levels of Awareness and Structure of Attention', *Journal of Mathematics Teacher Education*, **1**, 3, pp. 243–267.

Note

1. A terrific place to visit if you are ever near Leicester. I have taken many groups of school students there in the past. See **https://spacecentre.co.uk/** for details.

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