Review of: "On the statistical arrow of time"

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The paper is nicely written, and the central theme – that time-asymmetric phenomena grounded in the Second Law can only be only as objective as the concept of entropy itself – is an interesting one. However, the central argument is delivered far too quickly without engaging with the relevant literature, so I must recommend rejection. My two central criticisms are below.

1. The author claims that the arrow of time is often explained via the Second Law of Thermodynamics, which (applied on the largest scale) states that the universe's entropy is overwhelmingly likely to increase. However, it's not completely clear what the author has in mind by the 'arrow of time'. At one point, s/he talks of time's 'flow': this indicates a temporal directionality rather than a mere asymmetry, so it seems like the author means subjective, psychological sense of time's immediate passage. On that same page however, s/he talks of wine glasses falling over, which suggests the author has in mind something more overtly physical: perhaps the asymmetry of causation, or something similar. These and other time-asymmetric phenomena (the counterfactual asymmetry, the record asymmetry, the fork asymmetry, the radiative asymmetry…) often receive very different explanatory treatments in the literature, so I would recommend being very explicit right at the start about which of these is being referred to as the 'arrow of time'.

2. The author's central argument essentially runs as follows: since entropy depends on an observer's ignorance, it is subjective, and therefore unsuitable for grounding what seem to be very objective facts about time-asymmetry (e.g. wine glasses toppling over, but not leaping back onto tables). Here, the author is touching on a very deep and interesting problem in the foundations of statistical mechanics: in order to define entropy, we need to assume a partitioning of phase space into macrostates, but why is it partitioned into the macrostates that *we* happen to observe? The fact that we observe the macrostates that we do (and not others) clearly comes down to our physical makeup. But if that's so, is it the case that macrostates – and by extension, entropy – are infected with a kind of subjectivity?

I'm happy that the author recognises the centrality of this issue to statistical mechanics, and to our attempts to understand time-asymmetric phenomena via that theory. However, her/his conclusion that entropy (and presumably, macrostates as well) is subjective, and hence unsuitable to ground time-asymmetric phenomena, is too quick. Although the macrostates we happen to observe (and which define Boltzmann entropy) are dictated by physical constitutions, they have a perfectly objective and physical basis: they are determined by the correlations that our perceptual states enter into (see Hemmo and Shenker's work listed below). Macrostates/entropy are therefore observer-dependent, but they're not subjective in the stronger sense of lacking a physical foundation. And since the aim of the game is to explain time-asymmetric phenomena that are we humans happen to observe, it's unclear why this makes the status of macrostates/entropy too subjective to

explain said phenomena.

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If the author wants to look further into the topics of how macrostates come about, their observer-dependency, and the implications of this for entropy, I recommend the following readings:

- Hemmo, Meir, and Orly R. Shenker. 2016. Maxwell's Demon. DOI: 10.1093/oxfordhb/9780199935314.013.63: Oxford Handbooks Online.
- Hemmo, Meir, and Orly R. Shenker. 2012b. The Road to Maxwell's Demon: Conceptual Foundations of Statistical Mechanics. New York: Cambridge University Press.
- Gömöri, Márton, Balázs Gyenis, and Gábor Hofer-Szabó. 2017. ‘‘How macrostates come about”. Preprint available at http://philsci-archive.pitt.edu/12762/.
- Shalizi, Cosma R., and Christopher Moore. 2006. ‘‘What is a Macrostate? Subjective Observations and Objective Dynamics”. Preprint available at arxiv.org/abs/cond-mat0303625.

For an old but excellent account of a whole host of different time-asymmetric phenomena, I recommend:

- Horwich, Paul. 1987. ‘‘Asymmetries in Time: Problems in the Philosophy of Science”. MA: MIT Press.