Observations on the Perception of Time

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Much has been written about both physical and psychological time. The modern view of physical time ranges from a continuum fourth dimension to a discrete, chronon-based quantum time. As is common throughout physics, both extremes have their experimental justification and their strong proponents, but little is done toward providing reconciliation. Curiously, time is also recognised as a component of psychological or perceptual description somehow differentiated from the physical concept. The well-known impact of observation on physical experiment as expressed via the uncertainty principle has long teased psychologists, suggesting that there must be a connection between these two kinds of time. Indeed, it led to synergy between such noted theorists as David Bohm in physics and Karl Pribram in psychology with a holographic theory of both the physical and the psychological worlds. Curiously, after years of denigration these theories have recently seen resurgent respect and interest.

The asymmetry or directionality of physical time was given a new important basis by Eddington when he noted that it could be correlated with increase in entropy. This principle of statistical thermodynamics serves well through most of physics, perhaps breaking down in the quantum region. That it does, in fact, break down is a widely held view, but one which I would like to call into question *en passant*. The problem is that it is difficult to define entropy in a consistent manner when the number of objects in a quantum system is quite small. In particular, what does it mean to speak of the statistical entropy of a single quantum?
If we relate entropy algebraically to other parameters such as some kind of "configuration" energy, we inherently assume a continuum background. In effect, we must change the definition of the statistical population in order to obtain something with enough granularity for the definition of entropy to work. We "rechunk" our description of a physical system as we move from macroscopic objects to molecules to

atoms to elementary particles and so on. As long as this "rechunking" is a classical reductionist or decomposition hierarchy, the definition of entropy and the corresponding arrow of time can be consistent. However, if it is not true that the objects counted at a lower (more granular) level of description can be composed to as to recover exactly the objects counted at a higher (less granular) level, then the meaning of entropy between the two levels cannot be made consistent. The key conclusion here is that the directionality of time as identified with increase in entropy cannot be made consistent at all levels of decomposition. In effect, we must observe this as a breakdown in the direction of time, with processes being able to move backward and forward in time once we cross into a descriptive realm in which the reductionist hierarchy has failed.

Curiously, chunking is a peculiarly psychological notion, having almost as much to do with description as anything inherent in the system observed. Chunking of psychological experience is an extremely important phenomenon and has many effects (beyond the scope of this note) on reasoning and memory. For example, almost everyone knows the "7 ± 2" rule of memory: human beings are much better at recall and reasoning if the number of items to be remembered (and differentiated) or reasoned about does not exceed the range of seven plus or minus two. We often forget that such chunking is volitional and so can be used to advantage or disadvantage. Observe that these considerations remain true even in describing physical systems, whether at macroscopic or quantum. Ultimately, chunking is about managing information, a fact that deserves much more attention than it has been given.

Shannon observed that entropy was equivalent to information. When combined with Eddington's observation, it follows that we can define the direction of time as increasing with increase in information. Although much was written starting in the early 1960s about Heisenberg uncertainty, entropy, and information as applied to psychological models (including computing the maximum amount of information the human brain can process without "boiling over"), this particular dictate has been applied to physical systems insofar as I am aware. A few moments consideration of the implications for psychological experience produce an interesting conclusion.

As we observe, presumably we acquire information. That is, our experience of the direction of time is inherent in our ability to take in information. Indeed, most of us have had the experience of time "dragging on" when we are bored and have little sensory input (i.e., are acquiring information at a lowered rate) and its converse of wondering "where the time went" when we are very busy (i.e., are acquiring information at an increased rate). Thus it seems that common experience would validate the combined Eddington-Shannon theory of time direction.

There is another way of looking at this phenomenon. Suppose, hypothetically, that we were able to observe a physical process going backward in time. By definition, we would know something at the end of this process that we did not know at the beginning of the process. Thus, information would be increasing and by Eddington-Shannon, time would be going forward. But this is contradicts our hypothesis, and it follows that – overall – *human beings cannot experience backward time.*[1]

This result applies to all physical systems, not just human beings, and says that *no physical system can detect backward time.* To detect backward time in some subject physical system, the detecting physical system must obtain information from the subject system and so its local time must be forward time. Thus any description of the subject system is, at best, one consistent with forward time. This gedanken experiment raises a curious paradox: How can a system moving backward in time communicate with a system moving forward in time? I leave the resolution of this paradox, or the discovery that one does not exist, as an exercise to the reader or listener as the case may be.

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[1] It is, of course, possible that the "observer" experiences a relative lose of total information due to other processes such as memory loss. Thus it might be possible in physical systems for there to be local processes that can be described as having backward time embedded in a matrix of processes, the global description of which would have forward time. I am uncomfortable with such descriptions and suspect that they will always involve some form of inconsistency between the local and global descriptions.