

## Appendix SD – The SPH in context of other ideas about human and/or cultural Evolutionary Transitions in Individuality

Refers to main article Andersson and Czarán, *The transition from animal to human culture – simulating the social protocell hypothesis*, Proc. Roy. Soc. B (2023)

Let us briefly comment on the SPH in the context of two other ways of considering a human and/or cultural major evolutionary transition, both of which are exemplified by other contributions to this issue.

The first category concerns partial explanations of a larger major transition. For example, the evolution of cellular life via the biotic protocell is associated with the evolution of integrated genomes via cooperation between proto-genes. The relation between these accounts is not essentially competitive. Ideally, such partial explanations should undergo a synthesis where they are mutually adjusted into an integrated and more refined understanding. The protocell tells us why and how the increasingly close cooperation between proto-genes, ending up in an integrated genome, is plausible. At the same time, explanations focused on the evolution of genetic cooperation provides a concrete example of the consequences of the potential for closer cooperation that the protocell provides.

Several articles in this issue concern such partial perspectives. Dor's [1] account focuses on two transitions in information, namely in computation and communication. Kish Bar-On and Lamm [2] cover the emergence of novel social psychological systems in *Homo*, playing essential coordinating and regulatory roles in collective behavior within groups. Prentiss's *et al.* [3] account exemplifies an even more specific sub-transition, at a specific stage in human pre-history, where the political system of communities appears to go from one qualitative state to another. A prime further example (among many) is, of course, the evolution of language.

Their relation to the SPH mirrors the complementary relation described above. The SPH tells us why and how evolutionary cultural integration would be plausible in the first place. How did this begin, and why did it begin only in *Homo*? The SPH thereby serves an *enveloping* role in a system of explanations. If we can explain how and why, in principle, hominin culture underwent accelerating integration and organization, then such an understanding will affect and support explanations of more specific innovations and trajectories along the way, such as language, norm systems, or collective computation. At the same time, only by successfully scaffolding such stories will the SPH in the end be able to prove its worth.

The second category concerns the enveloping story directly. The article by Carmel [4] in this issue exemplifies such an account, among which we may partly place most cultural group selection ideas e.g., [5], [6], although, as opposed to Carmel [4], these tend to be implicit about units and mechanisms, focusing on establishing *that* group selection appears to have happened, and the proximal mechanisms (such as inter-group conflict).

Carmel brings out an important and central contention. If we suspect there was an ETI, what lower-level units became integrated into a higher-level unit? The SPH is specifically based on cultural units, while Carmel's account (and other accounts, more or less explicitly,) names humans as units. We think this makes for a weaker account and we will end the article by briefly outlining why we think so.

Carmel argues that human communities have undergone (and in undergoing) a steady increase in certain markers of evolutionary individuality, namely size, inseparability, and specialization. We note, however, that the argument does not specifically imply a human ETI. To the contrary, the arguments involve culture much more than biology. First, humans are clearly not physiologically specialized (in the style of social insects or somatic cell types) for the plethora of roles and professions that emerged since we became sedentary. Political systems that enable larger societies are, likewise, clearly cultural. The same goes for the ties of social identification and material dependencies that make us inseparable from society.

Cognitive and psychological features of course underpin these cultural systems, but they strongly under-define them, and more of them than we think may be cultural [7], consider writing and mathematics - while we know they are cultural, they affect cognition in a way that we tend to associate with innate features, see e.g. , [8].

The room for cultural variation within the range permitted by our physiological constitution is immense. With culture as the most plastically flexible part of the human-culture system, it seems more reasonable to put culture as the part that went before, and biology as the part that followed as argued in this article; see also [9], [10]. Naturally, biological novelty related to the cultural capacity would tend to unlock potential for much more cultural configurations than whatever selection pressure was that drove it, precisely because it underpins but under-defines culture. This is, we suspect, also what ultimately brought the explosive growth of human cultural societies over the past few millennia. The situation, arguably, looks more like an ecosystem where all ecological modes of interactions blend and mix see e.g., [11], than a steady march toward the absence of internal conflict that we see in organisms.

Moreover, presumably, an ETI involving humans as biological units of selection would be a fraternal ETI [12], [13] between undifferentiated conspecifics. The tell-tale division-of-labor in such an ETI (directly underpinning the individuality of the whole) would be in reproduction, which clearly has not happened in *Homo*. There is nothing like a caste of humans performing the reproduction task for their communities, and we must ask what, in such case, would instead have kept separately reproducing cheaters from spreading? In biology, there are detailed accounts of this, both in the abstract and in the specific.

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