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Book Review of *Emergence in Context*, by Robert C. Bishop, Michael Silberstein and Mark Pexton (2022)

Contextual emergence is a relatively simple but disruptive concept. It undermines the claim that emergence is necessarily a form of supervenience, often repeated by philosophers. It bucks the "false forced choice" between weak and strong emergence (14). It is scientifically grounded but challenges the prevailing reductive worldview in science. It has much to recommend a detailed philosophical treatment, such as this one. This book is thus a welcome treatise on a timely topic.

Emergence in context is authored by three philosophers: Marx Pexton, who has a PhD in Philosophy from University of Leeds; Michael Silberstein, Professor of Philosophy at Elizabethtown College; and Robert Bishop, Professor of Physics and Philosophy at Wheaton College. All three specialize in philosophy of physics alongside other interests. Correspondingly, the book is largely focused on physics: of the three applied chapters, two focus on physics (classical and quantum, condensed matter) and one focuses on biology and neuroscience. I should start by acknowledging that I am not a philosopher of physics, but an empirically-informed philosopher of mind who nonetheless makes use of the concept of contextual emergence (see, e.g., Jennings 2020).

Prior to this book my understanding of contextual emergence came from Bishop and Atmanspacher (2006), who discuss it in terms of the necessary and sufficient conditions obtaining between a whole and its parts: contextual emergence occurs when the parts are necessary but not sufficient for the whole. This can be contrasted with

- *radical emergence*, in which the parts are neither necessary nor sufficient for the whole (also sometimes called "strong" emergence),
- *ontological reduction*, in which the parts are necessary and sufficient for the whole (sometimes called "weak" or "epistemic" emergence), and
- *supervenience*, in which the parts are sufficient but not necessary for the whole.

This approximate definition is also provided by Pexton, Silberstein, and Bishop: while in "ontological reduction" one domain offers all conditions that are necessary and sufficient for another domain, "contextual emergence" occurs when one domain is necessary but not sufficient for another (27). They say that this emergence occurs due to stability conditions, "such as an equilibrium state being maintained by the dynamics damping out such perturbations" (27). Later in the book they write that "contextual emergence in various forms is not only well confirmed by the biological, cognitive, and neural sciences, but even constitutes textbook science" (213).

They provide a wide range of evidence to support this claim. The most charming is the tale of firefly synchronization at the beginning and end of the book: fireflies sometimes synchronize their flashes across large swarms, and this is thought to occur only when specific environmental conditions are met (xix). More rigorously specified is the example of Rayleigh–Bénard convection used throughout the book, in which the heating of fluid sometimes leads to the appearance of "cells" of fluid with their own dynamics: "the Bénard cells emerge out of the local dynamics of fluid parcels as a large-scale, nonlocal dynamical process; in turn, these cells constrain or shape the states of motion accessible to fluid

parcels" (41). While the authors call these cells "a concrete case of ontological emergence," this is not the typical description, which is normally in terms closer to weak, or epistemic emergence—"the spontaneous appearance of properties that cannot be understood, or predicted, from the full knowledge of a system's constituents" (Artime and De Domenico 2022). The authors contend that contextual emergence is the better fit here, since these cells only appear with certain constraints and since once they appear they in turn constrain the fluid that makes them up.

A stumbling block for most readers will be the high level of technicality in this book. There are many formalizations, covering topics such as the probability density function, set theory, topology, dimensional analysis, and the algebraic approach in physics, among others. There are many sentences I found difficult to parse, apparently against the authors' expectations. For example, the authors write: "It might be naively expected that a description of the FQH effect would follow from writing down a Hamiltonian for the electrons in a 2D plane subject to a magnetic field" (183). Reader, I am not even naïve. The next page continues "In the case of a topological phase of matter, invariance under a diffeomorphism means that the only locally defined nonzero operator is the identity matrix, which leaves the wavefunction unchanged" (184). This kind of language, used in many chapters, and covering many areas of science (but especially physics), was hard to follow and prevented me from thoroughly assessing the claims of the book.

I am best suited for the chapter on biology and neuroscience. The language is just as technical here: "Microglia…are involved in memory formation by activating NDMA [sic] receptors related to long-term potentiation via amino-acid D-serine, thereby changing synaptic structure and gene expression, all of which in turn involves regulatory RNA networks" (222). I get the gist of this sentence—something outside the cell influences the way the cell encodes memory—but I suspect a good many philosophers of science (even neuroscience) would not. This is unfortunate, because the authors suggest that clarifying scientific concepts is one of the goals of the book (2). The technical language also obscures the overall message; this evidence is used to support a section called "Contextual emergence in neuroscience and cognitive science," but "ruthless reductionists" claim the same phenomenon as their own (see, e.g., Bickle and Barwich 2022), and it isn't clear why we should prefer the authors' take from this description alone.

In general, I found the chapter on biology and neuroscience lightly and selectively cited. I was, for example, surprised to see the claim that "there is growing evidence that the networks of trillions of bacteria in the gut's microbiome communicate with various neural networks in the brain" (219). While this sentence does not include a citation, later supporting passages provide three: Wu et al. 2021, Ahmadzai et al. 2021, and Boehme et al. 2021. Only the first and third of these concern a relationship between the gut and the brain (Ahmadzai et al. 2021 discuss only the relationship between glia and neurons in the gut itself). Wu et al. 2021 show that the removal of all microbiota can increase stress responses in mice and thus alter their social behavior. How should we compare this to the finding that removal of a mother increases stress responses in the infant that alter its social behavior (see, e.g., Levine, Weiner, and Coe 1993)? Does the absence of the mother "communicate" with the infant? Boehme et al. 2021 found that memory impairments were less severe

when older mice received a transplant of microbiota from younger mice. How should we compare this to the finding that blood replacement in aging mice reverses cognitive aging (see, e.g., Castellano et al. 2017)? Does blood also "communicate" with the brain? I am very sympathetic to this claim by Pexton, Silberstein, and Bishop, but I didn't find adequate support for this and other claims in the book.[1]

I suspect the stronger case for contextual emergence is made in the chapters on physics, both of which I found fascinating and informative. For example, in the chapter on classical and quantum physics it is noted that "individual particle states do not have a temperature" (102) and that temperature relies on "a particular kind of stability for thermodynamic systems" (103). Likewise, the chapter on condensed matter physics asserts that the underlying laws of physics do not allow one to predict the laws of a condensed matter system unless one first investigates that system (160). It claims that all of the existing ways to account for this phenomenon are essentially forms of contextual emergence. While I do not feel qualified to assess these claims, I found the arguments convincing as stated.

Ultimately, I found much to recommend this book. It is original and rich with detail. Philosophers of physics will be better positioned to evaluate the promise of this approach for their field, but I can certainly see its potential for biology and neuroscience, criticisms notwithstanding. Should philosophers be convinced that context is "as fundamental on all scales as anything to which philosophers typically point" (257)? I remain skeptical of this and other of the bolder claims in the book. Should we join the authors in "embracing contextual emergence" (326)? I answer with a clear and resounding "yes!"

References

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[1] Similarly, there is an entire paragraph on how oscillatory activity in the brain has an impact on individual neurons—a topic dear to my heart—that doesn't have a single citation (222).

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