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Comment

The development of Complex Emergent Modularity: A reply to Favela, Amon, & van Rooij (2018)

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Abstract

In our reply to Favela, Amon, & van Rooij (2018) we note points of agreement such as the necessity for the interaction between components in a system for it to be complex emergent and that the Dual Processes approach to human thinking has limitations. We also discuss several critical points of disagreement with the paper. We assert that Complex Emergent Modularity (CEM) does not proliferate the interaction problem but instead proposes a solution to the problem based on the contribution of the global workspace and the process of global broadcast. The nature of the entities which interact is described and emphasized as central to CEM theory.

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We are very pleased to have the opportunity to reply to the commentary by Favela, Amon, and van Rooij (2018). We will shape our comments in two broad categories. First, those areas in which we are in agreement, and, second, those areas where some divergences occur, before finally completing our reply with an overall observation about the developments of Complex Emergent Modularity (CEM) in the four years since the original article (Wastell, 2014) was accepted for publication.

The areas of agreement between Wastell (2014) and Favela et al. (2018) are substantial and central to the core tenets of CEM. We agree with Favela et al. that the concept of Dual Processes in Thinking faces some challenges whilst at the same time we also acknowledge its strengths. We also strongly agree that local components interact globally (Favela et al., 2018, p. 562). It is the nature of these local components that is in need of further clarification. Favela et al. (2018, p. 562) correctly assert that Wastell (2014) builds a model in which modules interact.

However, it must be said that the example provided at this point is a slight misrepresentation of the material cited. In Wastell (2014, pp. 350–351), both the "bat and the ball" problem and the "flyball" problem are discussed, but Favela et al. (2018, p. 562)'s interpretation seems to be a combination of the two when they refer to "countless basic modules" (p. 562) which are never mentioned in Wastell (2014) and then posit their combination with virtual modules to represent the discussion of the flyball and bat and ball problem in Wastell (2014). The essence of both the flyball and bat and ball problems as presented in Wastell (2014) is that fundamental processes interact to effectively deal with the problem at hand. At no point does Wastell (2014) describe these fundamental processes as basic modules. The difference is important as processes are the constituents of modules and are certainly basic but not necessarily modular. As Favela et al. observe (2018, p. 563), and we fully agree, there is extensive work to be done in examining the manner of the application of emergence and complexity theories to thinking and reasoning. Indeed, we have begun the process with several empirical studies into the role of working memory and the global workspace. Finally, we agree that in a fully functioning mind it is very difficult to identify the individual contributions to global behaviour (Favela et al., 2018, p. 564).

The areas of misinterpretation are of two types. The first type consists of those that result from the use of minimally defined concepts in Wastell (2014). The first of these is the term "mid-range" complex processes. This term comes from Page (2009), where he asserts that the four dimensions of complex systems (interdependence, connectedness, diversity, adaptation) produce complex behaviour when they are in their mid-ranges. We interpret him to mean that the level of connectedness is not so tight as to be deterministic or diversity so extreme that the collection of entities is so multifaceted that they are unable to interact.

The second clarification is the use of "emergence" in Wastell (2014). There seems to be some misinterpretation of the example of the "boids" used in Wastell (2014). The example is used to illustrate the *possibility* of coherent behavior emerging from simple

rules, not the exact form of the emergence. We do not assume that the mind acts like a collection of same entities (i.e., "boids"), but that divergent modules interact without central control in the sense of an overseeing super module or other such mechanism. Favela et al. (2018) note that emergence has been seen to be thought of as "interaction dominance." This not what Wastell (2014) understands by emergence. Emergence for Wastell is the generation of more complex adaptive behaviors from simpler components in a cooperative manner without the presence of central control. The more complex behavior is a product of the nature of the modules and their functional requirements and outputs. In the case of CEM, the coherent behavior that emerges does so from the interaction of modules and it is the modus operandi of this interaction that is critical to the theory.

Favela et al.'s (2018) interpretation of the interaction problem seems to be different from that in Wastell (2014). The interaction problem for us is about how the mind determines which system to use and expertise—major critiques on Dual Processes. CEM doesn't "solve" this problem but presents a model that no longer needs a "switch"—no supervisory mechanism is needed to "choose" a module or a system because the trigger for the module to operate is the input. Modules can move from Type 2 to Type 1 through practice as virtual modules are learnt and no longer require working memory. The interaction problem in Favela et al. (2018) seems to be about complexity, how to capture and measure the way that the components interact.

Favela et al. (2018) suggest that "a proper understanding of human reasoning as an emergent complex system dissolves the interaction problem" (p. 564) and later, "*Nonlinear* systems have behavior that results from multiplicative interactions between components. These interactions can lead to sudden qualitative transitions from one stable behavior to another or *phase transitions*" (p. 564). We would strongly agree with the idea of multiplicative interactions both between modules and the environment including feedback and even feed-forward type interactions. We would also agree that the Dual Processes interaction problem can be solved from within an emergent complex system perspective. Our differences seem to revolve around the conceptualization of the components that interact. Favela et al. (2018, p. 564) suggest that just as water transitions from ice to liquid so the mind can be thought of as made up of transitions. We find this analogy problematic. The question that has to be asked in this analogy is what do the water molecules represent in the human mind and indeed how do water molecules interact? The phase transition cited by Favela et al. is the structural reorganization of the water molecules. What in the mind is it that is being structurally rearranged in the transitions that take place as suggested by Favela et al. as the way to dissolve the systems/processes interaction problem of human thinking?

In CEM we postulate that modules do interact. In the intervening period since its publication we have developed a more nuanced position than that originally presented in Wastell (2014). We now understand that the coordinating process is facilitated by a combination of the information transforming processes that constitute the module with the task demands or requirements and the environmental resources in the form of information inputs. The coordination is carried out in the global workspace via global broadcasting utilizing working memory capacity. As Carruthers (2015) has noted, "the main function of working memory appears to lie in its capacity to globally broadcast representations to many different regions of the brain, thereby providing a central workspace that

can coordinate the activities of different components" (p. 87). We must be wary of putting too much weight on Carruthers' use of the term "coordinate." In CEM we view the coordination as the result of information availability and flow, not centralized control.

Complex Emergent Modularity asserts that the components that are interacting are modules. Thus, far from proliferating the incommensurable problem, CEM focuses research on the nature, generation, and functional characteristics of these interacting components. We would assert that CEM offers researchers a testable pathway to examine human thinking without the need to postulate distinct systems/processes and yet to also provide a conceptual avenue for the application of emergent systems theory to the study of the human mind.

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References

Carruthers, P. (2015). *The centred mind*. New York, NY: Oxford University Press.

Favela, L. H., Amon, M. J., & van Rooij, M. M. J. W. (2018). The incommensurability of emergence and modularity in complex systems: A comment on Wastell (2014). *Theory & Psychology*, *28*, 559–567.

Page, S. (2009). *Understanding complexity: Course guidebook*. Chantilly, VA: The Teaching Company.

Wastell, C. A. (2014). An emergence solution to the reasoning dual processes interaction problem. *Theory & Psychology*, *24*, 339–358. doi: 10.1177/0959354314533442

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