The Bottom-Up Approach: Benefits and Limits

A Reply to Aaron Gutknecht

Holk Cruse & Malte Schilling

Aaron Gutknecht supports our bottom-up approach, specifies possible limits and highlights interesting future aspects. His added perspective is valuable and interesting to us. As we fully agree with his view, we only add some complementary remarks.

Keywords
Bottom-up approach | Concept clarifying machine | Emergence | Emotions in arthropods | We-model

Authors

Holk Cruse
holk.cruse@uni-bielefeld.de
Universität Bielefeld
Bielefeld, Germany

Malte Schilling
malte.schilling@uni-bielefeld.de
Universität Bielefeld
Bielefeld, Germany

Commentator

Aaron Gutknecht
aaron-gutknecht@gmx.de
Johann Wolfgang Goethe-Universität
Frankfurt a. M., Germany

Editors

Thomas Metzinger
metzinger@uni-mainz.de
Johannes Gutenberg-Universität
Mainz, Germany

Jennifer M. Windt
jennifer.windt@monash.edu
Monash University
Melbourne, Australia

1 Introduction

We appreciate the comments given by Aaron Gutknecht very much, in particular his discussion and clarification of the term “emergence” and its philosophical background. This discussion comprises a sensible completion of our article going beyond the scope of our expertise. In this context, Aaron Gutknecht correctly states that our way of using the term “emergence” may cover two aspects, one called “weak emergence”, the other he addressed as “implementational emergence”. We have – possibly forming some kind of common denominator - a third characterization in mind, one that covers different description levels: a phenomenon is considered emergent if it turns out that known properties of the network could also be characterized on a different level of description than the one currently used. On this different level the phenomenon conceptually constitutes a term or definition. If we, for example, describe the structure and function of reaCog on the neuronal level, we may realize at some point that there are behavioral aspects which could, by an outside observer, be characterized by a term that is not defined at a neuronal level of description, such as, for example, "intention".

2 The bottom-up approach

This way of using the term emergence is directly related to the bottom-up approach applied here. This approach is inspired by Feynman, who stated that we understand a system only when we are able to construct it (in Hawking 2001) and may be even dated back to Giambattista Vico (1710). The bottom-up approach allows us to study the extent to which linguistic concepts proposed in the literature may correspond to properties realized by our artificial system. If one was not prepared to accept that a specific concept would correspond to selected properties of the artificial system, either the linguistic concepts might be adapted accordingly, or the artificial system might be judged as to show deficits. The latter case could then give rise to adapt the current simulation model to better match the verbal proposal given. This capability of the bottom-up approach led Manuela Lenzen (2014) to characterize reaCog as a "concept clarifying machine" ("Begriffspräzisierungsmaschine").

3 Possible limits of the bottom-up approach

Aaron Gutknecht further proposes a well-chosen list of issues that should be taken into account when following a bottom-up approach as proposed here, namely "adequate matching criteria", "biological plausibility" and "transparency".

Concerning the first issue, "adequate matching criteria", Aaron Gutknecht addresses a possibly critical point. In section 8 (*Emotions*), we characterize happiness by the property that risky decisions are made more probable. We admit that our example is formulated in a sketchy way, only addressing one basic aspect for illustration. There are, however, more deeply founded examples that have been briefly referred to in the main text and will be explained in more detail here. Two recent studies, one in crayfish, the other in the fruitfly, provide strong hints that emotion-like states can be found in simple organisms as arthropods or, more specifically in the latter-case, insects. In crayfish, Fossat et al. (2014) have convincingly shown that context-independent, anxiety-like behavior can be induced by experimentally applied stress or by application of serotonin. Both methods lead the animals to avoid illuminated sections of their environment which they are normally interested to explore. Anxiety is related to fear but considered a secondary emotion that occurs after the stressing signal has disappeared. Thus, the probability of selecting specific behaviors, in this case exploration of illuminated places, is decreased. This avoidance behavior could be abolished after application of drugs that are known to have anxiolytic effects in mammals. Applied to reaCog, these results could be interpreted in the following way. Emotion-like states would not only influence the global WTA net, but also thresholds of local, lower level WTA networks that are responsible for switching between different procedures.

Another interesting case has been reported by Yang et al. (2014) in Drosophila. These animals learnt that various behaviours selected in trying to avoid a problem, in this case escape from a heated ground, were not successful. As a consequence, they ended up in a state of passivity. This result has been discussed as an example of "learned helplessness", which is considered an animal model of depression. In our framework, this could simply be realized by freezing activity in the Spreading Activation Layer network that provides input to the WTA net (section 4).

Concerning the second issue, "biological plausibility", we fully support Gutknecht's perspective and have only a minor aside. Application of non-spiking neurons is not necessarily biologically implausible. Rather, non-spiking neurons do exist in invertebrate and in vertebrate brains. They play important functional roles, but are generally less well-known, mainly because investigating them involves methodological problems that are more difficult than those of spiking neurons. The third issue, "transparency", addresses the view that the bottom-up strategy may eventually exhaust its potential when the complexity of the system is further increased. Although we agree with Gutknecht here, we would like to add that the bottom-up approach still bears the advantage that, as the details of such a system are known, its properties can be thoroughly analyzed by physical and/or mathematical methods. This ability, of course, does not guarantee that one will find answers in such a hypothetical case, but there are various methods available to address such questions. Further, we believe that the problem of lacking transparency may not happen to occur too often. This belief is supported by the observation that already our simple system, reaCog, appears to be able to reach integration levels characterized by terms such as intention, volition and consciousness.

4 What should be done next?

Aaron Gutknecht closes his comments by considering future aspects. Again, we agree with his recommendations and have, partly, indeed started with two of the aspects addressed. We applied the internal model in a cooperative scenario in which the visual impression of another agent performing an action was mapped onto the system's own internal body model. In this way the internal model was driven by the visual input and the internal model reenacted what the other agent was doing. This mapping allows one to connect the experiences of somebody else to one's own action repertoire as one steps into the shoes of the other (Schilling 2011; see also Gallese & Cuccio this collection). Second, as mentioned in the main text, shared circuits are required for an agent to represent the action of a partner (Cruse & Schilling this collection, figure 9). In order to allow for ToM, an additional separate representation of the partner's memory is required (figure 10). To be able to apply a supermodel (or we-model, Tomasello 2009), a more complex model is required (see Cruse & Schilling 2011, figure 6).

5 Conclusion

The bottom-up approach advocated here to understand higher-level phenomena may be considered a non-Platonic approach that aims to construct artificial, but strongly biologically inspired systems. These systems should be able to simulate complex behavioral tasks, but do so by application of simple elements, artificial neurons, and a simple decentralized neuronal architecture. If successful one could then study whether more abstract concepts introduced in psychology or philosophy, for example, could sensibly be applied to such a system. We claim to have shown an example supporting this approach.

References

Cruse, H. & Schilling, M. (2011). From egocentric systems to systems allowing for theory of mind and mutualism. In R. Doursat (Ed.) *Proceedings of the ECAL 2011, Paris* (pp. 731-738). Cambridge, MA: MIT Press.

——— (2015). Mental states as emergent properties. In T. Metzinger & J. M. Windt (Eds.) *Open MIND*. Frankfurt a. M., GER: MIND Group.

Fossat, P., Bacqué-Cazenave, J., De Deurwaerdère, P., Delbecque, J.-P. & Cattaert, D. (2014). Anxiety-like behavior in crayfish is controlled by serotonin. *Science*, *344* (6189), 1293-1297. 10.1126/science.1248811

Gallese, V. & Cuccio, V. (2015). The paradigmatic body. In T. Metzinger & J. M. Windt (Eds.) *Open MIND* (pp. 1-23). Frankfurt a. M., GER: MIND Group.

Hawking, S. (2001). *The universe in a nutshell*. London, UK: Bantam Press.

Lenzen, M. (2014). Der sensible Hector - Interaktion mit Robotern. *Frankfurter Allgemeine Zeitung* (2043.9.2014, p.N3)

Schilling, M. (2011). Learning by seeing - Associative learning of visual features through mental simulation of observed action. In R. Doursat (Ed.) *Proc. of the ECAL 2011, Paris* (pp. 731-738). Cambridge, MA: MIT Press.

Tomasello, M. (2009). *Why we cooperate*. Cambridge, MA: MIT Press.

Vico, G. (1710). De antiquissima italorum sapientia. In R. Parenti (Ed.) *Opere*. Naples, I: F. Rossi.

Yang, Z., Bertolucci, F., Wolf , R. & Heisenberg , M. (2014). Flies cope with uncontrollable stress by learned helplessness. *Current Biology*, *23* (9), 799-803. 10.1016/j.cub.2013.03.054