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The role of object-oriented concepts in cognitive models

Mather[1] has recently argued that there are strong conceptual similarities between the object-oriented (OO) approach to computation that has emerged within Computer Science and a growing number of contemporary computational models of perceptual and cognitive processing. He suggests that the OO approach, in which computation is effected by message passing between encapsulated "computational objects", contrasts with the dominant view of computation within Cognitive Science – as sequential or stage-wise information processing. Mather advocates embracing the OO approach, in anticipation that it "might promote the development of more sophisticated OOP models."

Mather is correct in his identification of the relation between the two approaches to computation, and his call for an explicit acknowledgement of that relation is well-advised. However, Mather undersells the utility of OOP within cognitive modelling by presenting a case that is in some respects misleading and in others incomplete.

The presentation is misleading in its juxtaposition of object-oriented concepts and object-based models of visual perception and attention. Whilst such models may incorporate OO concepts, they are only illustrative: the OO approach is orthogonal to issues of object representation. In particular, the computational concept of an object (within an the OO approach) is distinct from any concept of an object in a visual scene or the concept of a visual object representation.

A second misleading aspect of Mather's discussion concerns the claim that OOP models are non-modular. This claim appears to rest upon the presupposition that modules must be sequenced – i.e., that the inputs of one module are the outputs of another, and there are no feedback relations or other forms of processing interactions between modules. This is not a necessary feature of modular systems. In fact, as Mather correctly points out, a central tenet of the OO approach is information encapsulation within (computational) objects. Yet informational encapsulation is one of Fodor's defining characteristics of a module[2]. Other defining characteristics of Fodorian modules are also shared by objects (e.g., limited access of external processes to internal representations and computations, domain specificity and mandatory processing of inputs). The OO approach is therefore far from incompatible with modularity. Rather, it would appear to provide a computationally precise instantiation of the modularity theses.

Mather's presentation is also incomplete in two respects. First, it focusses on one feature of the OO approach – message passing between encapsulated objects – while neglecting another – the concept of generalised object classes with the objects that comprise an OO system being specialised instances of those classes. (For example, an OO language might provide an abstract "information storage" class, with instances of the class being responsive to two kinds of message – "store" and "retrieve" messages – and with properties of the class governing access and decay.) This aspect of the OO approach is relevant to the modelling of cognitive systems because neurophysiological evidence suggests that some neural subsystems may also be specialised instances of generic computational entities[3]. Specifically, cortical plasticity suggests that structures such as cortical columns may be generic computational components that develop into specialised instances for processing specific information (e.g., visual, auditory or linguistic information), possibly as a result of specific inputs. This apparent similarity between neural subsystems and the OO approach suggests that OO concepts may be even more appropriate for cognitive modelling than Mather suggests.

A second respect in which Mather's account is incomplete concerns the prior use of the OO approach within Cognitive Science. At least one object-oriented language for cognitive modelling has already been developed. COGENT[4,5] provides a set of object classes which are abstractions of computational components that feature in many cognitive box and arrow diagrams. Instances of each object class may be configured, specialised and linked through message channels to yield a variety of behaviours. To date, COGENT has mainly been applied to higher cognitive processes[6,7], but it is also applicable to the modelling of perceptual and attentional processes.

In closing, it is relevant to consider the implications of OOP models for the symbolic/connectionist debate. OOP makes no commitment to the processing substrate in which objects are implemented. Consequently OOP is consistent with symbolic, connectionist or even hybrid models, in which different objects within a single model are based on different computational approaches. The essential point is that each object must conform to the message-passing presuppositions (or interface requirements) of those objects with which it communicates. Thus, a further advantage of the OO approach is that it allows one to focus on the functional structure of a system while avoiding lower-level (and arguably unproductive) arguments about connectionist or symbolic processing substrate.

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References

1 Mather, G. (2001) Object-oriented models of cognitive processing. *Trends Cognit. Sci. 5*, 162–164.

2 Fodor, J.A. (1983) *The Modularity of Mind*. The MIT Press. Cambridge, MA.

3 Johnson, M.H. (1997) *Developmental Cognitive Neuroscience*. Blackwells.

4 Cooper, R. (1995) Towards an object-oriented language for cognitive modelling. *Proceedings of the 17th Annual Conference of the Cognitive Science Society* (Moore, J.D., and Lehman, J.F., eds.), pp. 556–561. Erlbaum.

5 Cooper, R. & Fox, J. (1998) COGENT: A visual design environment for cognitive modeling. *Behav. Res. Meth. Instr. Comps., 30*, 553–564.

6 Cooper, R. (1996) Perseverative subgoaling in production system models of problem solving. *Proceedings of the 18th Annual Conference of the Cognitive Science Society* (Cottrell, G.W., ed.), pp. 397–402. Erlbaum.

7 Yule, P., *et al.* (1998) Normative and information processing accounts of medical diagnosis. *Proceedings of the 20th Annual Conference of the Cognitive Science Society* (Gernsbacher, M.A. and Derry, S.J., eds.), pp. 1176–1181, Erlbaum.