



Constraints on the architecture of mind: Comments on “logical and psychological partitioning of mind: depicting the same map?” by Philip V. Kargopoulos, Andreas Demetriou

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Kargopoulos and Demetriou advance a provocative and important thesis in this article, both with respect to the particular claims and arguments made *and* with respect to the relatively novel *kinds* of claims and arguments that they exemplify. In earlier work, Demetriou has proposed a mental architecture and a model of development associated with it (e.g., Demetriou et al., 1993a). This architecture consists of five specialized structural systems – the qualitative-analytic SSS, the quantitative-relational SSS, the causal-experimental SSS, the spatial imaginal SSS, and the verbal-propositional SSS – and two general systems – The Hypercognitive System, and The Processing System. Extensive empirical work has been published exploring and testing this architecture and its developmental implications (e.g., Demetriou et al., 1993a). The first part of Kargopoulos and Demetriou (this journal) is an overview of this model and research.

The heart of the paper, however, is something quite different in kind. Kargopoulos and Demetriou would like to argue that this architectural model is not only empirically supported, but that there are inherent, or a priori, reasons why the mind should be expected to have such an architecture. Ideally, such a priori considerations would establish *exactly* both the general systems and the number and particular characters of the five specialized structural systems. Kargopoulos and Demetriou aim for a less ideal conclusion: they focus primarily on the specialized structural systems, and, instead of trying to establish on a priori grounds these exact five, they wish to show that we cannot expect to find one single such system that suffices for all of the proposed five, nor can we expect to find an unbounded proliferation of such systems. That is, five may not be the exact number, but some such smaller number, greater than one and yet small, is necessary on logical grounds.

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Their argument actually focuses still more restrictedly on the threat that the five systems might be collapsible into one, although they claim that the considerations adduced also count against the unbounded proliferation possibility. There is one further restriction in the target of their arguments: instead of considering and attempting to refute all possible reductions among the five structural systems, they consider only the possibility that any of the other four might be reducible to the verbal-propositional SSS. Their reason for this restriction is clear and straightforward: “It is implicit in the computational approach to the mind that if there is one system to which others could be reduced, this has to be the system of sentential and predicate calculus that makes up the kernel of accepted logical theory”.

1. Intrinsic constraints

Before addressing the specifics of the arguments that Kargopoulos and Demetriou present, I would like to comment on the general nature of their proposal. A common and powerful argument in physics has the general form: “If the symmetries of the action have XYZ form, then there will, of mathematical necessity, be conserved quantities A, B, C, \dots and Q ”. For example, invariance with respect to spatial translation yields conservation of momentum; invariance with respect to time yields conservation of energy; invariance with respect to electrical phase yields conservation of electric charge; and so on. This is called Noether’s theorem, after Emmy Noether who proved it in the early decades of this century. Noether’s theorem is at the heart of contemporary fundamental physics (Aitchison and Hey, 1989; Kaku, 1993; Ryder, 1985; Sudbery, 1986; Weinberg, 1995). More generally, Noether’s theorem has the form: “If XYZ is the ontological nature of what is being investigated, then QRS necessarily follows about those phenomena”. That is, the argument proceeds from considerations about the ontological nature of phenomena to properties that necessarily follow from that nature, that are constrained to be so by the underlying ontology. It is a form of argument that particular properties are intrinsic to the ontology of some part of the world. I have called such constraints *intrinsic constraints* (Bickhard, 1992, 1995; Bickhard and D. T. Campbell, in preparation; Campbell and Bickhard, 1986, 1992a).

For all of their enormous power and importance in physics, intrinsic constraint considerations are very rare in psychology. The raw empiricism of behaviorism is *still* dominant, though not as blatant as in decades past, and theory is still supposed to arise from data, not from conceptual and logical considerations (Bickhard, 1992, 1993a). One of the rare examples of intrinsic constraint is Piaget’s model of formal operations. Formal operations are supposed to be operations on the operations of concrete operations. If this ontology of meta-operations were correct, then it would follow intrinsically that formal operations must develop *after* concrete operations: it is not logically possible to have operations on operations prior to having operations per se (Campbell and Bickhard, 1986, 1992a). In this case, I would argue that Piaget did not have the initial ontology fully correct, so the implication fails, at

least in this simple form. Nevertheless, the argument is one of the rare examples of intrinsic constraint considerations in psychology.

There are a few additional examples (see Bickhard, 1995; Campbell and Bickhard, 1986, 1992a), but it is, nevertheless, still quite heartening to find additional new instances of recognition of the importance of such intrinsic considerations – and the concomitant rejection of naive empiricism. Kargopoulos and Demetriou are clearly presenting another such instance. They clearly recognize that “Such a theoretical claim cannot be established by empirical grounds alone . . . It is at this point that some support of an a priori nature is called for”. Since, in my judgment, the vestigial naive empiricism in contemporary psychology is deeply pernicious, I wish to acknowledge and applaud the perspicaciousness and wisdom of Kargopoulos and Demetriou in breaking with this tradition.

Focusing more specifically on mind, consider the possibility that there are *no* intrinsic constraints on mind. This would imply that *everything* about the mind is strictly contingent, that it could have been and would have been different if only evolution had proceeded slightly – or not so slightly – differently. In such a case, nothing about mind could be explained except in terms of the pure accidents of evolution. Clearly, this is absurd. No evolutionary path could have produced a developing mind that jumped straight to Piaget’s formal operations, for example, without passing through concrete operations (note that this claim is correct even accepting that Piaget was in error about the nature of formal operations because it has a conditional form: IF formal operations were of this nature, then formal operations could not develop prior to concrete operations). No evolutionary path could have produced a mind that understood calculus before it understood algebra (Campbell and Bickhard, 1992a).

These are not themselves major constraints, but psychology has almost entirely ignored what more substantive intrinsic constraints on mind there might be. Concomitantly with its vestigial empiricism, psychology still seems to assume that its subject matter is behavior, not mind. It is, unfortunately, only a slight overstatement to point out that psychologists are now quite willing to postulate mental structures and processes to account for behavioral data, but not to take mind seriously as itself constituting the subject matter of psychology. Again, Kargopoulos and Demetriou have broken with this mostly unexamined naivete – and again, they are to be highly commended for it.

2. Reducing specialized structural systems

Explanations of phenomena in terms of intrinsic constraints, of course, can be wrong and can be invalid just like any other form of explanation. Piaget’s formal operations argument, for example, seems valid but unsound – the premise about the ontology of formal operations seems to be false. So, such arguments need to be subjected to the same scrutiny as any other. I will turn now to look at the arguments presented by Kargopoulos and Demetriou.

As mentioned, the four SSSs other than the verbal-propositional SSS are examined with regard to their potential reduction and elimination in favor of the

verbal-propositional SSS. The issue is whether there might really be only one SSS, and, if any one of the five could reduce the others, “the system of sentential and predicate calculus that makes up the kernel of accepted logical theory” is the likely candidate, assuming the computational approach to the mind. As expected, barriers are found to each of the four potential reductions.

In each case, some kernel of intuition or semantics of the SSS is found to be irreducible to formal logic: the “specification of essential characteristics” for the qualitative-analytic SSS; the “inclusion of an element to [as an element in: set membership in] a broader quantitative construct” for the quantitative-relational SSS; “causal necessity” for the causal-experimental SSS; and the “representation of wholeness and the analogue nature of representation” for the spatial-imaginal SSS.

The arguments for these claims of irreducibility are sophisticated and well informed concerning the current status of research in the field of logic. I find no problems with the specifics upon which they rest. Nevertheless, I do question two general aspects of the structure of the arguments presented.

First, a number of the arguments turn on considerations such as “is not accepted by all logicians as a fair extension of logic”, particularly with respect to modalities, counterfactuals most centrally. The characterizations given are, I think, accurate, but I am concerned with basing arguments for the intrinsic character of mind on the historically contingent accidents of the contemporary scene in the field of logic. To prove that something is a theorem in logic is, if valid, to prove a timeless truth. But to argue that something is not now well handled by or universally accepted among logicians is not timeless at all. To base an argument for intrinsic nature on such historicity seems to be a category error. Was the basic architecture of mind different a thousand years ago when the field of logic was different from now? Will that architecture be different a thousand (a hundred?) years from now when, presumably, research in logic will have made much progress?

My second question proceeds from the claim that Kargopoulos and Demetriou make that their arguments are a priori. This is not strictly correct; as they mention, their arguments presuppose the computational theory of mind, and, therefore, constitute ontologically intrinsic constraints on mental architecture – assuming that underlying computational ontology.

I first note that this is somewhat odd since Demetriou has elsewhere recognized the fundamental problems of that computational ontological assumption (Demetriou et al., 1993a). They are fatal (Bickhard, 1993b, 1996; Bickhard and Terveen, 1995). It is not clear why he now presupposes it.

Furthermore, it is as costly an assumption to make here as it is elsewhere. Logic is without semantics. It is “formal” as Kargopoulos and Demetriou insist. In fact, it is arguable that the very subject matter of logic can be defined in terms of a certain kind of prescinding from semantics (Sher, 1991, 1996). It has proven, however, to be impossible to put the semantics back in once it has been removed. Witness, for example, the empty symbol problem in the computational theory of mind (Bickhard and Terveen, 1995). Witness, furthermore, that the other four SSSs cannot be reduced to logic because they involve dedicated semantics, kernel intuitions, and logic has

none. “It is precisely this content-free quality of logic that accounts for its usefulness in reducing other interpreted systems to logic” (Kargopoulos and Demetriou). Semantics once removed cannot be simply restored.

Kargopoulos and Demetriou argue that it is the formal, contentless, semanticless, character of logic that “accounts for its usefulness in reducing other interpreted systems to logic”, but this is not the same sense of “reduce” as they are investigating with regard to the SSSs. There is *no* semantics that can be captured in formal logic (except a very formal structural invariance – again see Sher, 1991, 1996). In that sense, virtually every field will have one or more kernel intuitions that cannot be captured in formal logic, exactly as Kargopoulos and Demetriou find for the four SSSs. That is, there is *no* semantic domain that can be reduced to logic in the sense in which they would require the SSSs to be reduced to logic. On the other hand, the sense in which formal logic *can* be used to “reduce” other interpreted systems is precisely a sense of “reduce” in which the specific semantics, the specific interpretation, is eliminated in favor of the formal properties that remain without those semantics. In that sense of “reduce”, the four SSSs could be reduced to logic – but there would be, as in *all* such cases, an irreducible remainder of the semantics of the core or kernel intuitions.

Recognizing that it should not be expected that the semantics of *anything* can be eliminatively reduced for formal logic, the arguments presented by Kargopoulos and Demetriou concerning their SSSs should not be surprising. But this does raise the definite possibility of the opposite reduction – “reducing” logic to some semantic domain. If the subject matter of logic is *definable* in terms of certain forms of semantic invariances, of prescinding from semantic content, perhaps logic could also be *derived* in that manner. Perhaps logic arises precisely when only the “formal” properties, with the semantics removed, are considered.

Kargopoulos and Demetriou reject any such possibility, but without much argument. It apparently seems obvious to them – they write: “All the other areas of cognition contain a kernel notion that is understood intuitively yet unanalyzable logically. How could any one of such systems be used as the basis of reduction?” The considerations that I have mentioned above make the answer to this question obvious: By prescinding from those intuitive semantic contents. I suggest that it is, in fact, the centrality of logic in the computational theory of mind that has blinded them to this possibility.

This is not merely a conceptual possibility. In fact, I have proposed a model of the development of logic and rationality that has precisely this character (Bickhard, 1991, forthcoming; Bickhard and Campbell, 1996; – see also Moshman, 1989; Moshman and Eastman, 1994; Moshman and Lukin, 1989; Moshman and Timmons, 1982). Of course, my proposal does not have to be correct in order to undermine the arguments proposed by Kargopoulos and Demetriou. They have not examined such a possibility at all, so their position is vulnerable to even the barest plausibility of such a reduction.

I conclude that the arguments presented by Kargopoulos and Demetriou for the irreducibility of the four SSSs are much shakier than they might appear from within the computational theory of mind.

3. Minor points

These difficulties with the arguments against the reducibility of the five SSSs are the major questions that I wish to raise for Kargopoulos and Demetriou. I do have, however, several more minor points:

- Kargopoulos and Demetriou repeatedly claim that Piaget's model is unstructural in a sense that assumes that "the only structure available to the thinker will somehow apply on the input". Chapman (1988) has persuasively argued that this interpretation of Piaget is, and always has been, a *misinterpretation*. I would be interested in Kargopoulos and Demetriou's response to Chapman on this issue.
- In view of the centrality of modal considerations to the arguments that Kargopoulos and Demetriou present, it would be interesting to know their views on Piaget's claim that development originates with an indifferentiation among modal categories (Bickhard, 1988; Piaget, 1987; Smith, 1993).
- Kargopoulos and Demetriou seem to equate logic with axiomatics (e.g., "yet is unable to axiomatically determine"). Where do they wish to place model theory (Chang and Keisler, 1990)? Or structural approaches to logic (Koslow, 1992) (or to mathematics, given that they seem to regard mathematics as necessarily based on set theory – Parsons, 1990; Resnik, 1981; Shapiro, 1993 – and, in that regard, what about category theoretic approaches to mathematics – Lawvere, 1966; MacLane and Moerdijk, 1992)? Or Sher's approach (Bickhard, forthcoming; Sher, 1991, 1996)? How do their arguments fare if an alternative conception of logic is adopted?
- Concerning the possibility that the proposed five SSSs may not be sufficient, how do they handle, for example, knowledge and reasoning concerning action, esthetics, social processes? Are these, in fact, reducible to the five favored SSSs?
- It may, or may not, be correct that "most linguists" (not in Europe!), "most cognitive scientists" (this just strikes me as an odd claim), "many philosophers" (certainly correct), and "many psychologists" (also obviously correct) are convinced by Chomsky's arguments for the innate character of a universal grammar. Chomsky's arguments, nevertheless, are invalid: they do not, for example, take into consideration at all the possibility of there being intrinsic constraints on language – constraints that are neither environmental nor genetic (Bickhard, 1995). Chomsky argues that he can eliminate environmental constraints as being sufficient, and concludes that there must be genetic constraints. The details of his argument are contestable at many points (Bickhard and Campbell, 1992; Campbell and Bickhard, 1986, 1992b), but such an argument by elimination depends most deeply on the exhaustiveness of the possibilities that are considered. Chomsky considers only two, claims to eliminate one, and concludes the other. He is wrong: there are at least three possibilities.
- For a small bit of historical scholarship, Kargopoulos and Demetriou claim that it has not been noted before that "the inferential processes underlying the lower stages of cognitive development cannot be differentiated from the inferential processes of higher stages on the basis of logical criteria". I would like to suggest, as at least a partial anticipation: "we find a group of displacements on arm position in the sensory motor stage, a group of locomotor displacements on body position in

preoperations, a group of addition on the integers in concrete operations, and a group of logical operations on propositions in formal operations. In each case, the abstract structure is a group, but the elements involved are qualitatively very different. ... the structures per se cannot be the definitive characteristics ... This would suggest that all other structures could, in principle, also be manifested at any stage” (Bickhard, 1973, p.77; published as Bickhard, 1980 – see also Bickhard, 1978; Campbell and Bickhard, 1986 – and note that each of these examples is taken from Piaget’s own writings).

- Finally, note that Kargopoulos and Demetriou have not focused on the empirical and methodological supports for their model of cognitive architecture in this paper. Correspondingly, I have not addressed such issues. For an interesting interchange concerning Demetriou’s model more generally, including such empirical and methodological considerations, I would point initially to Campbell (1993) and the reply by Demetriou, et al. (1993b).

4. Conclusions

I have criticized the arguments put forward by Kargopoulos and Demetriou for the irreducibility of all five of Demetriou’s SSSs to one. I take their attempt, however, to be exemplary of the highest understanding of the limitations of the empiricism that still dominates psychology, and of the power and necessity of conceptual and intrinsic constraint analysis. In my judgment, these recognitions are of fundamental importance. That I have found things to critique concerning the particulars of their arguments is only to be expected: criticism, whether empirical, logical, conceptual, methodological, or ontologically intrinsic, is what drives science (Bickhard, 1991, 1992, forthcoming; D. T. Campbell, 1974, 1988, 1990; Bickhard and D. T. Campbell, in preparation; Bartley, 1987; Popper, 1965). But that point cuts both ways: Kargopoulos and Demetriou may well come up with counter arguments to mine or corrections or improvements to theirs that save or even strengthen their conclusions. Again, they are to be deeply commended for initiating a dialogue of a kind that is extremely rare in psychology, but of fundamental importance and power, nevertheless.

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