Gestalt Theories of Cognitive Representation & Processing

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Commentary on Latimer & Stevens on *Part-Whole-Perception*
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Abstract

Latimer & Stevens (1997) develop a useful framework for discussing issues surrounding the definition and explanation of perceptual gestalts. They use this framework to raise some doubts about the possibility of "holistic" perceptual processing. However, I suspect that these doubts ultimately stem from assumptions about the nature of representation and processing in the brain, rather than from an analysis of part/whole concepts. I attempt to spell out these assumptions, and sketch an alternative perspective (deriving from Gestalt theory) that has the potential to make sense of holism in perception.

Commentary

1. Rescher and Oppenheim's (1955) analysis of the whole/part relationship has the potential to clarify a range of issues in the study and explanation of perception, as Latimer and Stevens amply demonstrate in their thought provoking discussion. However, I think L & S overstate the case when they say that the Rescher & Oppenheim formalism "leads ultimately to doubts about the possibility of mechanisms that can extract global attributes...without prior, elaborate analysis of their local elements" (1997, para.3). Whatever doubts L & S may have in this regard, I don't think they are any consequence of the part/whole formalism on offer. Rather, I suggest that they stem from some fairly strong assumptions about the nature of representation and processing in the human brain. L & S are welcome to adopt and defend those assumptions (which I'll spell out shortly), but they ought to clearly distinguish them from the part/whole analysis being defended. As things stand L & S give the impression that careful attention to the meanings of "part" and "whole" (i.e., a little conceptual analysis) has the capacity to resolve a significant debate in psychology concerning the mechanisms responsible for perceptual gestalts. Philosophers have learned to be suspicious about this sort of claim.

2. The Gestalt movement in psychology early this century was, in large part, a reaction to Wundt's structuralism. The two central planks of this latter position are **atomism** -- the claim that perceptual experience is the sum of numerous indivisible sensory primitives -- and **associationism** -- the claim that the glue which binds these primitives is nothing more than associative processes in the brain. Gestalt theorists rejected both these claims, and in their stead advocated the following: 1) **holism** -- the claim that a perceptual whole is not reducible to the sum of its parts; 2) **organization** -- the claim that experience is structured by the way features of the stimulus interact with constraints built into the nervous system. The research program founded on these assumptions seeks to determine the principles of organisation that condition Gestalt phenomena, and to provide a mechanistic explanation for these principles. Gestalt

theorists have been very successful where the first of these aims is concerned, discovering the familiar laws of grouping, figure/ground organization, and a wide range of other principles. However, it is important to recognise that such principles are not the end-point of explanation; they in effect constitute a richer class of explananda for which a mechanistic basis is still required.[1] So far as this basis is concerned Gestalt theorists have to date been rather less successful. Kohler proposed that the brain is a "physical Gestalt": a holistic physical system that achieves globally "good" organisations by evolving toward stable states of minimum energy. This process brings the elements of perception into line with global *perceptual* constraints by virtue of PHYSICAL constraints intrinsic to the medium of representation. However, Kohler's specific hypothesis (involving the electric fields generated by the brain) was shown to be inadequate by a series of experiments conducted in the 1950s.[2]

3. Many of the insights of the Gestalt movement have been taken on board by cognitive psychology. The various Gestalt principles of organisation are now text-book material, and there is a great deal of work being done to account for the many known global and/or contextual effects in perception, as L & S make clear. Moreover, Holism and Organization, taken as general principles, don't appear terribly strange in light of the cognitive revolution. To say that a whole is more than the sum of its parts is merely to say that a whole is not just a heap, its parts must enter into relations of some kind, and these relations are as much constitutive of the whole as are its parts. From the perspective of cognitive science there is no difficulty here -- relations are just as amenable to computational treatment as objects. And if we interpret "constraints built into the nervous system" in traditional information processing terms then the concept of Organization sounds like one of the founding principles of cognitivism.

4. Despite this apparent openness to Gestaltist ideas, ongoing debates in perceptual psychology suggest that our current framework fails to fully resolve the issues that separated Gestalt theorists and Structuralists. L & S identify two principal sources of tension: 1) the opposition between analytic and holistic processing; and 2) the local versus global precedence debate. The first of these debates revolves around the question: "are patterns recognised by way of processes that extract holistic attributes, local attributes, or some combination of these?" (1997, para.22). The second arises because "it is proposed by one class of theorists that global or holistic attributes are extracted prior to the extraction of local attributes...[while others] have argued that local features are the primary objects of extraction" (para.23). These debate will only be settled, argue L & S, when theorists agree to specify in detail the decompositions, attributes, and background theory presupposed by their accounts. However, for their money "it is difficult to conceive of any device or computer program that is capable of extracting holistic attributes...directly from patterns. In all cases it is first necessary to compute a rich description of local elements and their relationships to each other prior to the computation of global attributes" (para.23).

5. L & S are right to be cautious about the existence of global precedence and holistic processing. (One does, after all, want to be wary of "spooky" processing mechanisms, involving "top-down" causation and the like.) However, this very commendable discretion is, I fear, symptomatic of a failure to appreciate the real insight at the heart of the Gestalt movement: the idea that relations among the elements of perception -- be they part-whole relations, part-part relations, or whatever -- might be determined by *inherent structural properties* of the brain. It is just this idea that motivates Kohler's claim that the brain is a "physical Gestalt". A "physical Gestalt" is a

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[1] Specific perceptual phenomena can be explained in terms of these principles, since they are quite general. Thus, one might offer an explanation for the way a particular stimulus appears to us in terms of, say, a grouping law of some kind, but in the end we want to know how that law comes to operate, i.e., we want to know how it is realised in the brain.

[2] I have relied heavily on Palmer 1992 (pp.40-1) for this material.

mechanism that satisfies global *representational* constraints (constraints concerning the sorts of global perceptual attributes it can represent) by virtue of corresponding *physical* constraints among its components. This approach is quite at odds with current orthodoxy. Contemporary cognitive science takes physical implementation to be ultimately quite irrelevant to cognitive representation. Consequently, perceptual relations (including those that determine global attributes) must either be represented explicitly, or be implicit in the computational processes defined over perceptual representations.

6. Palmer (1978) nicely captures the contrast at issue here when he distinguishes between **extrinsic** and **intrinsic** forms of representation. In order to model the relational structure of, say, visual experience (including its global organisation) one must have a system of cognitive representations that somehow mirror that structure in their own relations. But there are two different means by which a set of (representing) objects can preserve the relational structure of another (represented) set: "Representation is...*intrinsic* whenever a representing relation has the same inherent constraints as its represented relation...[On the other hand] representation is...*extrinsic* whenever the inherent structure of a representing relation is totally arbitrary and that of its represented relation is not" (1978, p.271, the emphasis is mine).[3] In my view, what Gestalt theorists hit upon was the idea that the representation of perceptual objects in the brain might be *intrinsic*. Orthodox computationalism, on the other hand, seems to be committed to the view that representation in the brain is entirely *extrinsic*.[4]

7. It's the latter perspective, I would guess, that informs L & S's views on the analytic/holistic processing debate. If one takes human perception to depend on an *extrinsic* system of representation, then the claim that perceptual wholes are "necessarily underivable and greater than the sum of their parts" -- a view L & S attribute to Gestalt theorists (1997, para.18) -- will appear quite insupportable. The sticking point is underivability. L & S initially suggest that an attribute of a whole is "underivable" if it is not a "logical consequence" of the way the elements of the whole, and their attributes, are characterised (para.15). However, where perception is concerned, L & S seem to have a different interpretation in mind: a global perceptual attribute is "underivable" if it can only be extracted *directly* from stimulus patterns, and not on the basis of computations defined over representations of local elements (see paras.20-23). This kind of underivability fails to mesh with an extrinsic conception of cognitive representation. If cognitive representation is extrinsic then, by definition, the *physical* relations among the brain's representational vehicles need not mirror the relations among the things they represent (see above). In particular, the relations among local elements that determine global attributes are not modelled by corresponding physical relations among the brain states representing those elements. Part-part relations must instead be imposed, via careful arrangement of the *causal/computational* relations among the representations of those parts. On the extrinsic conception everything must be computed.

8. L & S betray their allegiance to this approach when they claim "it is difficult to conceive of any device or computer program that is capable of extracting holistic attributes...directly from patterns" (para.23). A mechanism for holistic processing -- processing that bypasses the computation of local properties and relations -- is indeed difficult to imagine if one assumes that

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[3] A familiar example of intrinsic representation is the way a map models the spatial relations among a set of geographical locations via the spatial relations among a set of points on a sheet. (In the general case the representing relations need not involve the same physical property as the represented relations.) These same spatial relations can be modelled extrinsically via the numerical relations among a set of vectors. Such vectors are governed by Cartesian equations that establish an isomorphism between vectors and geographical locations, and do so without reference to the physical form of the vectors.

[4] Palmer's **intrinsic/extrinsic** distinction arguably amounts to the distinction between **analog** and **digital** representation. I am thus suggesting that a "physical Gestalt" is some variety of *analog* computational device.

cognitive representation is extrinsic. Likewise, it is difficult to see how global attributes could have precedence over local attributes: "[in] all cases it is...necessary to compute a rich description of local elements and their relationships to each other prior to the computation of global attributes" (para.23).

9. But all of this changes when one moves to an intrinsic conception of cognitive representation. What makes a scheme of representation intrinsic is that it employs the inherent physical relations among a set of representational vehicles in order to capture the relational structure of the things they represent. An intrinsic scheme for representing objects that stand in part-whole relations of some kind must thus employ representational vehicles whose physical relations mirror those part-whole relations. The beauty of such a scheme is that when one represents the parts, representation of the wholes come for free. If cognitive representation is intrinsic then, by virtue of generating representations of parts, the brain immediately represents the relationships among those parts, and thereby any wholes of which those parts might be constituents. And it does so without computing (in any traditional sense) the requisite relationships. One might rightly call this style of processing *holistic*, even though it doesn't actually bypass the representation of local elements, because representations of global attributes are an inevitable product of representing local elements. Moreover, as a direct consequence of this quasi-holism, it is possible to sidestep the local versus global precedence debate. A holist need not be committed to what L & S deny (viz., global precedence) because the dichotomy they assume -- *either* local attributes first *or* global attributes first -- doesn't apply to a computational system that employs an intrinsic scheme of representation. Such a system computes local and global properties *simultaneously*.

10. The preceding would be so much hot air if we didn't have some idea how the brain might physically realise an intrinsic medium of representation -- in Kohler's terms, how the brain might act as a "physical Gestalt". Kohler's specific hypothesis isn't borne out by the evidence, but today we have a computational framework (connectionism) explicitly modelled on those (structural) properties of the brain that appear to support its information processing capacities. Palmer (1992) has suggested that treating the brain as a collection of connectionist networks looks like a promising way to do justice to Kohler's insight. Limitations of space prevent a detailed defence of this claim, but I will make a few brief remarks. Let us suppose that the visual system, say, is a *network* of connectionist networks, each coding for some attribute or element of visual experience. Because activation passing can occur both *within* networks and *between* networks, it is possible for this system to be coordinated so that its constituent networks all arrive at a stable configuration simultaneously. More importantly, *inter*-network activation passing has the capacity to constrain each individual network to represent the world in a way that is consistent with all of the others. What we have here is a quasi-holistic processing mechanism, in which local perceptual elements are made to conform to global constraints, and in which neither local nor global attributes take priority. There is nothing "spooky" about such an arrangement -- it can be given a quite detailed explanation in both structural and physiological terms -- but it looks like it might do justice to Gestalt thinking about the physical basis of perception.

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