Psychol Res (1989) 50: 199–201

*Psychological Research*


# PDP and Gestalt: An integration?

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**Summary.** The possibility of a synthesis between parallel distributed processing approaches (PDP) and Gestalt psychology is discussed. The empiricist outlook of PDP is an obstacle to such a synthesis. Gestalt's belief in organization of the *psychological field* as the basic principle is not shared by the PDP approach. It is claimed that, nevertheless, Gestalt psychology can use PDP techniques for modeling organization processes, provided that some constraints are obeyed. From a PDP point of view, importing Gestalt constraints could be a useful strategy for obtaining testable predictions.

In a recent article, Epstein (1988) presents a tantalizingly brief, but highly suggestive, account of Gestalt psychology, and argues that efforts to reanimate Gestalt ideas may take advantage of developments in parallel distributed processing (McClelland & Rumelhart, 1986). Parallel distributed processing (PDP) and Gestalt psychology can be viewed as similar alternatives to neo-Helmholtzian constructivism, in which inductive reasoning is the model for information processing. The reasoning is a form of supervised calculation, and the supervision requires a controlling agent, a homunculus. Both Gestalt and PDP are eager to dispense with the homunculus, and substitute, e.g., relaxation procedures that are most successful in satisfying sets of weak constraints for supervised calculation.

Epstein argues that such a synthesis would be relatively unproblematic, for Gestalt is nearer to modern representation theories, including PDP, than to ecological realism (Gibson, 1979). Koffka (1935) introduced a distinction between the *geographical environment*, the world in which humans operate as physical beings, which is understood in physical or geometrical terms, and the *behavioral environment*, which is the information available to the organism. The organism acts on the basis of this information. A general correspondence between geographical and behavioral environment allows the organism to survive in the world as it is. Epstein clarifies why this insight doesn't lead to a position taken by ecological realism. Ecological realists exploit the correspondence in order to constrain the behavioral environment, in the sense that what is available to the organism is directly picked up from the geographical environment. This does not imply for them that the geographical environment is identified with the physical world as it is described in ordinary textbook physics or geometry. The description of the geographical environment is couched in a form that is relativized to the purposes of the perceiver: e.g., light is described as ambient instead of radiant waves; thus conceived, the light possesses a structure that conveys relevant information for the perceiver. By contrast, Gestalt psychologists did not consider the correspondence between geographical and behavioral environment as a basis for a psychological explanation. It cannot be so, if the organism is supposed to act on the basis of the information given in the behavioral world, for the correspondence is not given to the organism as such. Psychology has to solve the problem of how an organism can act in a certain situation upon how it believes the world to be and not upon how the situation really (i.e., physically or geometrically) is. Gestalt psychology shares this conviction with several theories, including that of cognitive psychology (e.g., Fodor, 1980), which assumes that individuals act upon the way they represent the world. This view is also shared by the PDP approach. In combination with the earlier mentioned antihomuncular attitude toward modeling in science, this shared view seems to provide a direct link between Gestalt and PDP. But if all that Gestalt psychology is to contribute to the new coalition is an anti-homuncular attitude, as Epstein suggests, it is unclear whether PDP has anything to learn from Gestalt psychology.

Koffka claims that the behavioral environment is insufficient as a source of explanation for the totality of our behavior. There are factors determining behavior that occur outside the behavioral environment, such as memory. The totality of these factors was called the *psychological field.* Phenomenologically speaking, if an event is retrieved from memory, there is nothing that allows a subject to differentiate this event from one belonging to the behavioral environment (a perceived event) *if the event is considered in isolation.* Because there are no psychologically relevant data external to this field available to make the discrimination, the differentiation of the behavioral environment from memory has also to be understood theoretically in terms of the organization of the psychological field. The principles of organization, thus, are viewed as more fundamental than the distinction between perception and memory. The PDP approach, in contrast, usually discriminates between behavioral environment and memory in a more static way. The behavioral environment is identified with the activation value of selected channels labeled "input channels", whereas memory is regarded as the strength of the connections between the units. Insofar as organization occurs in the PDP approach, it is generally held to be less

fundamental than the distinction in the architecture between perception and memory. This suggests that there are obstacles in the way of an integration between PDP and Gestalt.

This, however, does not mean that PDP cannot deal with organization. By assuming enough units and connections between them, PDP systems can realize arbitrary input-output mappings. PDP could thus be considered to be a mathematical language, powerful enough also to realize organization functions. It could even be claimed (Massaro, 1988) that models are indeterminate because the mathematical techniques employed possess superpower; one model can simulate behaviors that are incompatible from the viewpoint of psychological theory. This would imply that PDP is neutral toward questions of theoretical significance, such as the puzzle of nativism vs. empiricism. Though these remarks may be correct if only the mathematical aspect of PDP is considered, they do not square with the theoretical preferences expressed by the authors of PDP. For instance McClelland and Rumelhart (1986, p. 140) claim:

"Like good nativists, we have given the organism a starting point that has been selected by its evolutionary history. We have not, however, strapped the organism with the rigid predeterminsm that traditionally goes along with the nativist view. If there are certain patterns of behavior which, in evolutionary time, have proven to be useful (such as sucking, reaching, or whatever), we can build them in, but we leave the organism free to modify or completely reverse any of these behavioral predispositions." This quotation clearly suggests empiricist bias.

The contrast between the claimed indeterminacy and the theoretical preferences expressed by the authors of PDP shows, in my opinion, that the link between the mathematical techniques of PDP (which may indeed be theoretically neutral) and the empiricism is itself only a predisposition that could be modified or even completely reversed. The Gestaltist had reasons to reject empiricism. According to Koffka (1935, p. 432), if we were to explain organization empiricistically we would rely on *cumulative dispositions* to react in a certain way, given a stimulus due to prior experience. For example, if a tune is played, the input given to the system is one note at a time. When we come to the final note, the meaning of the whole sequence, the melody, is present in our mind. But in the "cumulative disposition" view, the presence of the melody must be viewed as a disposition to react to the last note of the tune, which is absurd. The cumulative disposition view could claim that the input is kept in a time buffer, so that the whole tune could be viewed as synchronous input. However, it is not clear what defines a buffer, since is seems to be related to functional aspects of the input. The determination of what the size of the buffer should be, and what the elements in the buffer are, therefore remains obscure. Moreover, no matter how large the size of such a buffer, we can construct similar problems for temporally extended wholes that last longer than the assumed size of the buffer. The explanation of temporally extended wholes cannot be treated without the concept of organization of the psychological field. This insight should not be sacrificed in order to obtain a quick integration with PDP approaches.

The problematic aspect of accepting the Gestalt position lies, in Epstein's opinion, in the suggestive character of the notion of the psychological field. It was especially suggestive for the Gestaltists themselves, in view of their eagerness to cover both psychological and neurophysiological data by one theory. For these reasons they assumed a physiological field that was isomorphic to the psychological one (Koffka, 1935, p. 62). "Isomorphism, a term implying equality of form, makes the bold assumption that the 'motion of the atoms and molecules of the brain' are not 'fundamentally different from thoughts and feelings' but in their molar aspects, considered as processes in extension, identical." Because the principle of isomorphism was soon discredited by experiments, and because this principle seemed the only plausible account of organization in the psychological field, this characteristic aspect of Gestalt psychology was discredited.

I believe that the principle of isomorphism can be dispensed with, because the explanation of organization as a pervasive property of the psychological field can be obtained without a physiological theory. Such an approach is more in the spirit of the first Gestalt psychologists (Ehrenfels, 1890), who believed that organization is an intrinsically mental property which could be studied regardless of the physiological substrate. This view has recently gained new impetus in the investigation into the formal properties of mental representations by H. Buffart (1986, 1987). Buffart demonstrates that if mental representations are to have organizational properties, or, in Ehrenfels's terms, *Gestalt qualities*, they must fulfill a condition, called the *hierarchy constraint*. This constraint prescribes that representations be hierarchical in a formal, mathematical sense. In order to explain organization phenomena, Leeuwenberg, Buffart, and their co-workers have proposed a representation system (Boselie & Leeuwenberg, 1986; Leeuwenberg, 1971; Leeuwenberg & Buffart, 1983) that can be shown fundamentally to meet the hierarchy constraint (Mellink & Buffart, 1986). Leeuwenberg's representation system describes multiple alternative hierarchical organizations for arbitrary configurations in the psychological field. An *economy principle* is used to predict which of the possible alternative organizations will be dominant. The economy principle, however, has not been further explained by these authors.

I believe that it is possible to use the mathematical techniques developed in the PDP approach in order to explain the working of the economy principle, in such a way that empiricist biases of the PDP approach are dispensed with. Adopting the Gestalt theoretical position could help to resolve the indeterminacy resulting from the super-power of the mathematical techniques employed, because this theoretical position constrains the modeling. In fact, a model that prefers economical organization was proposed and tested in van Leeuwen, Buffart, & van der Vegt (1988). Implementations of this model by van der Vegt are provided in this volume (van der Vegt, Buffart, & van Leeuwen, 1989). Her models have been submitted to constraints that are enforced by the Gestalt point of view. One of the constraints is that organization is more fundamental than the distinction between perception and memory. For this reason, the same elements in her model have both a perceptual and a memory function. Perception, as in the usual PDP models, is expressed as the activation of units. But memory is viewed in the same way, not as in the empiricist PDP models in which memory processes modify the connections between the units. The connections between the units in van der Vegt's model are not modifiable, nor are

the units themselves. The units of the model are a fixed set of representations. The representation system used by van der Vegt is essentially identical with the structural descriptions used by Leeuwenberg, Buffart, and their co-workers, and meets Buffart's hierarchy constraint. For instance, the structural description $x\,y\,x\,x\,y\,x\,x\,y\,x$ (nine variables, of which the first, third, fourth, seventh, and ninth are identical to each other and the second, fifth, and eighth are also identical to each other) is a representation in the system, because it can also be viewed as a sequence $(x\,x\,x)$ of three identical groups $x\,y\,x$. By contrast, the expression $x\,y\,x\,x\,y\,x\,x\,x$ is not hierarchical and is therefore not allowed as a representation in the model. Each representation in the system possesses a superstructure and substructures which themselves are also present in the model as representations. Therefore, the relations between a representation and its super- and substructures can be viewed as theoretically prescribed. For instance, the representation $x\,y\,x\,x\,y\,x\,x\,y\,x$ has a theoretical relation with its substructure $x\,y\,x$ and with its superstructure $x\,x\,x$. These theoretical relations correspond to links in a network model, through which the representations can influence each others' activation values. As in other PDP models, information processing is viewed in terms of automatic, parallel activation spreading through the links of the units. The strength of a unit is expressed by its activation value, the units most activated correspond to the representation that is dominant in perception or memory. The tendency for the most economical representation to become dominant could be simulated (van der Vegt, Buffart, & van Leeuwen, 1989) by assuming an activation spreading function of which the most characteristic consequence (van Leeuwen, Buffart, & van der Vegt, 1988) is the following: a unit with many theoretical relations loses a larger proportion of its activation through spreading. In consequence, the unit with the least number of relations tends to become the most activated one, regardless of actual stimulation and regardless of history. This inherent tendency models the Gestalt principle of *Prägnanz* (see van Leeuwen, 1988): in the model assumed, a unit with relations is a representation with a more univocal hierarchical structure. With this assumed property of the activation function, some of the experimental results of van Leeuwen et al. (1988) could be simulated. Prägnanz in organization could thus be modeled by using PDP techniques, not as the outcome of learning procedures, given an empiricist distinction between perception and memory, but in accordance with the theoretical principles of Gestalt itself.

Gestalt psychology might be realizable in PDP models only to a limited degree, because technical restrictions have to be taken into account. For instance, the simulations of van der Vegt et al. (1989) are restricted to the more simple experiments of van Leeuwen et al. (1988). This need not deter Gestalt psychologists from using PDP techniques as long as more suitable modeling techniques are not available, since the simulations of van der Vegt that approach the ideal of Gestalt more closely are also the more succesful ones. Insofar as this modeling can be called successful, it serves as a good illustration of Epstein's suggestion that Gestalt psychology can indeed take advantage of PDP modeling.

*Acknowledgements.* The author would like to thank Nico Frijda for comments on earlier versions of this article.

## References

Boselie F, & Leeuwenberg, E. (1986). A test of the minimum principle requires a perceptual coding system. *Perception, 15,* 331–354.

Buffart, H. (1986). Gestalt qualities, memory structure, and minimum principles. In F. Klix & H. Hagendorf (Eds.), *Human memory and cognitive capabilities* (pp. 189–204). Amsterdam, NL: North-Holland.

Buffart, H. (1987) Principles of invariance and memory structure. Paper presented at the 2nd Meeting of the ESCP, Madrid.

Ehrenfels, C. (1980). Über Gestaltqualitäten. *Vierteljahresschrift für wissenschaftliche Philosophie, 14,* 249–292.

Epstein, W. (1988). Has the time come to rehabilitate Gestalt theory? *Psychological Research, 50,* 2–6.

Fodor, J. (1980). Methodological solipsism considered as a research strategy in cognitive psychology. *Behavioral and Brain Sciences, 3,* 63–109.

Gibson, J. (1979). *The ecological approach to visual perception.* Boston: Houghton Mifflin.

Hatfield, G. C., and Epstein, W. (1985). The status of the minimum principle in the theoretical analysis of visual perception. *Psychological Bulletin, 97,* 155–186.

Koffka, K. (1935) (3rd impression 1950) *Principles of Gestalt psychology.* London: Routledge & Kegan Paul.

Leeuwen, C. van (1988). Representational constraints and the law of *Prägnanz. Proceedings of the Fechner Symposium.* Leipzig (in press).

Leeuwen, C. van, Buffart, H., & Vegt, J. van der (1988). Sequence influence on the organization of meaningless serial stimuli: economy after all. *Journal of Experimental Psychology: Human Perception and Performance, 14,* 481–502.

Leeuwenberg, E. (1971) A perceptual language for visual and auditory patterns. *American Journal of Psychology, 84,* 307–349.

Leeuwenberg, E., and Buffart, H. (1983). An outline of coding theory: a summary of related experiments. In H.-G. Geissler, H. F. J. M. Buffart, E. L. J. Leeuwenberg, and V. Sarris (Eds.), *Modern issues in perception.* Amsterdam, NL: North-Holland.

Massaro, D. W. (1988). Some criticisms of connectionist models of human performance. *Journal of Memory and Language, 27,* 213–234.

Mellink H., & Buffart, H. (1986). Abstract code network as a model of perceptual memory. *Pattern Recognition, 20,* 143–154.

McClelland, J. L., & Rumelhart, D. E. (1986). *Parallel distributed processing.* Cambridge, Mass.: MIT Press.

Vegt, J. van der, Buffart, H., & Leeuwen, C. van (1989). The "Structural Memory": a network model for human perception of serial objects. *Psychological Research, 50,* (this issue).

Received December 23, 1988