MULTIPLE SPECIFICATION OF ECOLOGICAL INFORMATION?

Organized by Bob Shaw and John Pittenger

Multiple Specification of the Environment: Issues to be Resolved

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The question of whether or not perceived aspects of the environment are uniquely specified in arrays is a core issue in the debate between direct, directed, and indirect theories of perception. The decision to hold today's symposium demonstrates the importance of the problem. The diverse nature of the papers to be presented suggests that we are far from a generally accepted resolution. I shall attempt to set the stage for today's presentations by describing some of the major issues in contention and by proposing work required to give us a basis for a resolution. A number of common-place events suggesting the existence of multiple-specification will be discussed, as will some experimental results purporting to demonstrate the consequences of multiple-specification for perceptual processing. The paper will close with proposals for new work. While this includes further development of ecological concepts, I shall argue that the developments proposed in published comments on my 1989 essay are not wholly adequate. In addition, it will be suggested that resolution of the problem requires both new analyses of the information available for specific events and completion of new empirical studies of event perception.

Multiple Sources of Information in Perception and Action

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Any question about the number of sources of information and the number of potential behaviors is necessarily an empirical one. Given this situation, a paradigm for psychological study of this question will be described, along with specific examples of research. Factorial and expanded factorial designs are used to manipulate several potential sources of information independently of one another. An observer is tested repeatedly under all of these conditions, and makes perceptual judgments, identifications, categorizations, or actions. The results are used to test among competing theories and models of performance. The models are quantified and tested against the results and compared to one another.

Using this research strategy, a fuzzy logical model of perception (FLMP) has been shown to provide a good description of performance in a variety of perceptual domains: depth perception, object recognition, speech perception, reading, sentence interpretation, location perception, memory retrieval, person impression, and decision making. The central thesis of this model is that there are multiple sources of information available to a perceptual or cognitive system, and all of these sources are evaluated and integrated to achieve perception, cognition, and action. The assumptions central to the FLMP are 1) each source of information is evaluated to give the degree to which that source specifies various alternatives, 2) the sources of information are evaluated independently of one another, 3) the sources are integrated to provide an overall degree of support for each alternative, and 4) perception, categorization, interpretation, or action follows the relative degree of support among the relevant alternatives. In summary, we conclude that there are many different mappings between environment and behavior. Well-learned patterns are recognized in accordance with a general algorithm, regardless of the modality or particular nature of patterns.

Multiple Specificity: An Evolutionary Argument

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The notion of 'specificity' has come under heated debate, both within and without the ecological community. Cutting's 'directed perception' relies on n:1 relationships while, for instance, Burton and Turvey (1990) defend 1:1. Where Cutting as well as Burton and Turvey explicitly adhere to Gibson's basic tenets, it should be acceptable to the debatants, we argue, to take (changes in) action as the right hand side of the equation. The question, then, becomes if the mapping Δflow→Δforce is 1:1, n:1, 1:n, or n:n.

Classical determinism envisaged a world of microscopic physics where all relationships were 1:1 (Gassendi, Huygens, Laplace). Thermodynamics came to show that the macroscopy of systems has special properties. To date, we study systems with a macroscopy that is, up to a limit, perturbation resistent. Environmental changes may lead such a 'self-organizing' system to an instability where several things may occur: Stochasticity is needed to overcome the unstability. For these systems, then, the right hand side of the macroscopic equation should read as n rather than 1. Moreover, given the state of a system, there will be several 'environmental' changes that lead to (the same!) perturbation only, other ones to (the same!) transition: These system (behave *as if* they) 'select' relevant information. We end with 'n:n' for physical relationships in self-organizing systems.

The macroscopy of biological organisms, qua self-organizing systems, obeys the same laws. 'Ordinary' self-organizing physical systems, however, are limited to the here-and-now. 'Biologically' self-organizing physical systems, on the other hand, are able to anticipate (Rosen). Darwinian variation and selection in a high-level of 'self-simplification', solidified into structure (Pattee), is essential to the explanation of this ability. Falling back to the 1:1 of classical determinism would deny the biology of variation and selection.

Edelman's Darwin III has shown the potential of variation and selection at the level of the perception-action coupling. There is a crucial need for ecologically valid experiments to show that organisms select from several sources of information while retaining the capacity to do several things at a transition point. Bootsma's work may offer a case in point: Table tennis players time their smash by using both relative dilation and disparity (n), while either starting the arm movement earlier or doing a step backwards (n). Such n:n relationships, we argue, are a physical as well as an evolutionary necessity.

Unique Versus Multiple Specification: A Tolerance Geometry Adjudication of the Controversy

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Tolerance geometries and fuzzy set theory, two related approaches to perceptual theory, may be used to clarify the role of cues, invariant information, as well as issues regarding multiple and unique specification: Assume there are separate sources of information for an environmental property (e.g., layout), then a mechanism of perceptual integration seems needed to compose them into a meaningful whole (Bruno & Cutting, 1988; Massaro, 1988). However, a case can be made that separate information sources may only be perceptually integrable if they are parts of a whole that may be perceptually differentiable. Stated simply: *Multiple specification requires integration which holds only if unique specification does.* The abundant richness of the natural environment in nested textural contrasts makes the differentiation hypothesis reasonable if perceptual information is to achieve the specificity required to allow useful dimensions of the environment to be exploited by action (i.e., for affordance goals to be individuated by intentions and realized by effectivities). For instance, we must detect the uniquely specific properties of objects if we are to grasp them successfully. By contrast, the relative paucity of information and relatively incoherent structure of contrived laboratory displays makes the integration hypothesis seem necessary. For multiple 'sources' of perceptual information must somehow become related if environmental layout is to be detected as a relatively coherent structure. Finally, it is argued that in the rich natural environment these two approaches are not really competing processes but complementary (dual) expressions of the perceiving-acting cycle; namely, differentiation helps animals to become perceptually attuned to specific goal-parameters needed to act successfully while integration helps them survey the environment for suitable action goal possibilities. Numerous examples are discussed and the worth of the tolerance geometry approach is appraised.

The Information-Perception Specificity Hypothesis

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By my reading a simple formula expresses Gibson's ecological approach: Perception is specific to information and information is specific to the environment and to one's movements; hence perception is specific to the environment (exteroperception) and to one's movements (proprioperception). *Information* refers to specificity between the structured energy distributions available to a perceptual system and the environmental and movement properties causally responsible for that structure. The specificity is sought at a macroscopic level of description and is expected to be revealed in terms of observables that, in general, have not yet been identified in physical theory. I will argue that the proposed specificity of perception to information comprises a hypothesis that imposes significant constraints on the conducting of research within the ecological perspective: For every property perceived, however subtle, there is a property of the structured energy distribution, however complex, to which the perceived property is uniquely specific. This generalized hypothesis of information-perception specificity directs investigation to the uncovering of one-to-one mappings between information and perception. A particular perception results if and only if a particular informative structure is detected. At a more profound level, the challenge of the hypothesis is understanding how specificity is preserved over the components of an animal-environment system, and the perception-action cycles that it manifests. I will review a variety of data to underscore the strategic significance of the information-perception specificity hypothesis and the scientific challenges that it poses. And I will argue that claims for many-to-one mappings are usually premature, pursuant to an incomplete analysis of the given perceptual situation.