point at which to *refrain from further analysis*. Thus, you don't talk about quarks or gluons when you explain the gas law. In general, explanation must use concepts from another stratum of experience (for example, pressure explained in terms of velocities of molecules). Thus, if it is said that an explanation exists if a decomposition into meaningful parts is possible, then it must be stated what is meant by meaningful. The meaning of explanation differs for the psychologist, neurologist, electrophysiologist, biochemist, or what have you. It is largely a matter of taste whether you consider the chaotic motion of molecules as an explanation of pressure: at the molecular level there is no pressure.

Within a single stratum of experience things *interact*, that is, change quantitatively but not qualitatively. In different strata the concepts ("things") are qualitatively different. Explanation of a concept is explanation in terms of qualitatively different concepts. If the latter concepts are not further analysed (by my choice), the explanation is complete. Only if you still adhere to certain nineteenth-century prejudices can you hope to arrive at a complete explanation not by choice but because *nature* has nothing further to offer.

In *perception* the case is more intricate than in physics: if you talk about meaning or information you must specify whether these terms refer to the person having the percept ("me") or another person ("the scientist"). Thus DVP for me may be a complex phenomenon needing further analysis for the scientist. This dichotomy is regretably played down by Ullman. It is a pity because he so often talks about "information" in a sense that is not clear. In nature there is *structure* (information in Shannon's sense), but no *meaning*. Meaning (the kind of information meant by Ullman) exists only relative to mechanisms receptive to it. Only if structure is able to change the state of the perceiver, that is, influence his future behaviour, can you speak of information in the sense of meaning. If you can perceive the solid shape of moving bodies, then it follows that you are receptive to the relevant structures. "Solid shape" is not present in nature but is a mutual property of perceiver and environment. This answers Neisser's question cited by Ullman: "If percepts are constructed, why are they usually accurate?" – the percepts are nature itself. (There is an obvious answer to a variant of Neisser's question: "If scientific concepts are constructed, why are they usually accurate?" For science is nothing but perception extended by different means – to pervert Clausewitz's famous dictum.)

The meaning of a physical measurement exists only because of our theory. It is not in nature (for example, the fact that the meniscus of a mercury column coincides with a certain mark may indicate barometric pressure, temperature, the height of the mercury in a communicating vessel, an amount of radon, and so on, ad infinitum. It is only theory which gives the fact its meaning.

In a like fashion the meaning of percepts exists only in our "internal representations." Without such you cannot obtain meaning. Thus you do not "extract" what is already there: what is there depends on *me*. In this sense I do not become attuned to things: the things are what they are because I am what I am. In this sense the term DVP is a harmless (but also scientifically useless) tautology.

Of course any physical theory and also any "internal representation" is based on recurring experiences, that is on *invariances*. This also holds true for solid shape (as Ullman concedes in the eighth footnote). But there is no compelling reason for such invariances to be composed of other (simpler) invariances, as Ullman seems to imply. That solid shape cannot so be analysed does not count against the extraction of invariances as such. Also the fact that perception does not utilize all available information is no argument. In the last instance, the basis for any invariant is change, not other invariances. Identity arises out of the neglect of differences.

In summary, I think that there are circumstances in which it makes sense to speak of DVP. These are the instances in which you choose to refrain from further analysis. This is generally the case for the perceiver himself. But it is the object of science to push back the level of analysis as far as possible. This can only be done at the cost of the introduction of qualitatively new concepts. If I want to stop at the Mona Lisa's smile, then DVP is the theory for me. For the scientist a closer study of who knows what is compulsory. It makes the smile no less of an enigma. DVP is no scientific theory exactly *because* it refrains from explanation, that is from phenomenology on different levels. Thus it is a tautological truth.

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Visual perception: the shifting domain of discourse

1. What is a "domain of discourse"? Ullman has launched an attack on the Gibsonian view by raising the critical question of exactly what it means for perception to be immediate. Essentially, Ullman's claim is that any process, including perception, can be considered immediate (direct) if that process cannot be broken down into constituents that are "meaningful within the domain of discourse." Ullman then goes on to argue persuasively that within a psychological domain of discourse, various interesting relations between stimuli and percepts *can* be broken down into more elementary constituents; therefore perception cannot be considered to be a direct process.

The immediate question that arises from this line of reasoning is how to define the "appropriate domain of discourse," not only for perception but for any research problem. There does not, it seems to us, appear to be an unequivocal answer to this question. Rather, the answer must depend on personal preference or some assessment of the common explanatory concepts currently extant in the field of concern. In some absolute sense, this weakens Ullman's case, since perception could be defined to be either direct or not direct simply by restricting or expanding what one takes to be the appropriate domain of discourse.

This difficulty could of course be resolved were researchers in a particular field to agree a priori on an "allowable" set of theoretical constructs, that is, an allowable domain of discourse. In practice, this does not seem to happen, at least not explicitly. But is does occur implicitly, and as a research endeavor evolves, one can, in general, at least detect boundaries on the explanatory concepts that come to be used. For example, it is unlikely that the magnetic structure of recording tape would be used to assess the difference between a Beethoven symphony and a Bach sonata or that the effectiveness of a football strategy would be explained in terms of nerve physiology.

2. The appropriate domain of discourse for perception. We would like to offer two comments about what seems to us to be a currently acceptable domain of discourse in the area of visual perception; both comments, we feel, would strengthen Ullman's position. The first concerns the use of physiological and anatomical terms as explanations for perceptual phenomena, and the second deals with the setting of perceptual research within the more general field of cognitive psychology.

2.1 Explanations based in anatomy and physiology. Ullman implies that anatomy and physiology are not within the domain of discourse that is appropriate for the discussion of perception. We find this a difficult proposition to accept; rather we would argue that the boundary between anatomy/physiology on the one hand and perception on the other is fuzzy and becoming fuzzier. In our view, there is abundant evidence of anatomical/physiological data being used as explanations for perceptual phenomena. Two examples will illustrate: one classic, and one more recent.

The classic example is that of dark adaptation. As shown early in this century (for example, by Hecht 1934), the function relating visual threshold to time in the dark is discontinuous, reaching one apparent asymptote after 4–5 minutes but then dropping to a second asymptote that occurs about 30 minutes later. The universal explanation for this result (see Kling & Riggs 1972, pp. 283–89) is in terms of two anatomically and functionally distinct sets of retinal photoreceptors, the rods and cones, which adapt at different rates.

The second example is that of visual masking. It has been known for some time that two stimuli presented in close spatial and temporal configuration will inhibit one another in various ways with respect to an observer's ability to detect them. Various explanations using a "perceptual" domain of discourse have been offered (for example, Kahneman, 1967). However, the most compelling accounts of masking rely heavily on explanation at an anatomical/physiological level. Breitmeyer

and Ganz (1976), for example, have offered a comprehensive theory of masking at the heart of which is the existence of two anatomically distinct (sustained and transient) visual channels.

To reiterate: these examples, as well as many others, represent instances of explanations of perceptual phenomena that are pitched at the level of neurons. If such explanations are permissible – which they certainly appear to be – then perception surely cannot be direct, because neurons must intervene between the environment and the percept.

2.2 Perception and cognitive psychology. Over the past two decades, the field of cognitive psychology has come into its own as a bona fide, well-recognized area within psychology. As we see it, research in cognitive psychology seeks to study the flow of information through the nervous system and subsumes the areas of attention, perception, memory, and mental representation. Any one of these research topics – perception is the case at hand – is rarely studied in isolation. Rather, within the framework of cognitive psychology, perception is viewed as one aspect of a larger cognitive system. Of interest are relations between the various components of the system. One major research endeavor concerns the interface between perception and memory, which in turn places heavy emphasis on an account of the mechanisms by which perception of one stimulus is affected by the perception of other stimuli presented nearby in space or time. The point we wish to stress is that an interest in these issues in and of itself precludes the notion that perception can be direct – that is, the question of how perception of stimulus A is affected by the prior perception of stimulus B presupposes that perception of stimulus A is not completely determined by the information in stimulus A. We will illustrate by considering once again the topic of visual masking, and in addition we will make some remarks about the highly related topic of subliminal perception.

Suppose a target stimulus such as the letter "G" is briefly presented to an observer. Under ordinary circumstances, this stimulus will be "perceived," in the sense that the observer will be able to report that the target occurred. But perception can be prevented (that is, the observer's ability to report the target can be driven to chance) by presenting a visual mask following the presentation of the target. Furthermore, it can be shown that different kinds of masks can halt the flow of information corresponding to the target at different points prior to where conscious perception (defined as the ability to report the letter) occurs. When, for instance, a random-noise mask (random dots, overlapping the target in space) or a homogeneous light flash is used, the information corresponding to the target appears to be obliterated early, probably at a retinal level (cf. Turvey 1973). In a metacontrast situation, on the other hand, the contours of the mask do not have any spatial overlap with the contours of the target. Here, the information corresponding to the target appears to be barred from consciousness at a much later level in the system, as indicated by the fact that the target can be "unmasked" by a second mask that masks the first (Dember & Purcell 1967); the target, unperceived though it is, can still initiate a reaction-time response (Fehrer & Raab 1962); and evoked potentials corresponding to the target are undeterred by the mask (Schiller & Chorover 1966). We emphasize that perception of the original target can hardly be direct if (a) it can be masked by a temporally nonoverlapping stimulus to begin with and (b) different types of masks can preclude perception of the target at different places in the nervous system.

The old issue of subliminal perception has recently received renewed attention, much of it deriving from the work of Marcel (in press). The main thrust of Marcel's research has been to show that a stimulus masked from consciousness (whose presence is reportable only at a chance level) can nontheless exert considerable influence over other stimuli presented close in time. Perhaps the most dramatic of Marcel's results involves a lexical decision paradigm. In a lexical decision paradigm (see, for example, Meyer & Schvaneveldt 1971) reaction time to decide whether a letter string (for example, DOCTOR) is a word is reduced if the word is preceded by an associated word (NURSE) relative to when it is preceded by an unrelated word (FROG) or by no word at all. Marcel's contribution was to show that this result follows *even when the preceding word has been masked out of conscious awareness*. Surely the masked word must be said to have been perceived in the sense that it exerts many of the standard effects within the cognitive system that are exhibited by normally (consciously) perceived stimuli. This result is of interest from the present perspective for two reasons. First, like the masking example described above, Marcel's results demonstrate perceptual phenomena that can be explained only via recourse to a multistage processing system, thereby weighing against the notion of direct perception. Second, as alluded to by Ullman, a convincing demonstration of subliminal perception removes the percept itself from the realm of conscious experience, which is rather at odds with Gibson's (for example, 1972, p. 215) assertion that perception implies (presumably conscious) experience, and his dismissal of the computer metaphor (p. 217) on the grounds that a computer cannot have the experience of being "there."

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Perceptual activity and direct perception

Ullman's version of direct perception is not Gibson's. Indeed, Gibson would have disputed the view Ullman calls direct perception at least as vigorously as Ullman does. Gibson did not believe that perception was a matter of pairing stimuli with percepts, and he did not believe that there is no meaningful decomposition of the registration process. But understanding what Gibson was getting at requires a broader review of his system. The differences between Ullman and Gibson are far greater than Ullman seems to appreciate. These should be clarified.

Comparing representative cases. In comprehending and comparing scientific theories it is useful to notice what concrete cases lie at their core. One can ask what a thoroughly representative instance looks like. For Ullman a paradigmatic instance of perceiving would be a case of object or event identification in which one imagines some unknown presented to a perceiving system and the job of the perceiving system is to say what the unknown is or what some if its properties are. Perceiving is a kind of question-answering system. Thus Ullman identifies a class of problems as problems of the *recovery* of structure. For recovering structure from motion the problem is to show how a system might draw explicit conclusions about 3D arrangement when access to the real 3D arrangement can only be had through a changing 2D array. Where accomplished, one can say that the 3D structure was *recovered* from the sequence of 2D changes. Ullman understands the problem of perceptual theory to be that of designing systems which can bridge the "gap between the physical stimulus and the perception of objects." For vision, light distribution at the receptors is input, percepts are output. Perception is kept distinct from action. I hope this is a fair rendering of his position. I take it to be roughly the view shared by nearly everyone who works on perception except Gibson.

Gibson's paradigmatic case of perceiving is perceptually guided locomotion. Animal movement must be regulated with reference to the environment (Bernstein 1967, Turvey, Shaw & Mace 1978). Even in the limiting case of upright standing, an animal is oriented to the surface of support as the object of its activity. To think about perceiving in Gibson's way, one must think of specific animals and specific activities, then inquire as to what environmental support is required to perform those activities, and what perceptual information and abilities must be present for the adequate regulation of those activities. Over the years, Gibson became increasingly impressed with the tight link between perceiving and acting. As he developed his position that the changing optic array was far more informative about the environment than a nonchanging array (Gibson, Olum & Rosenblatt 1955; Gibson 1958; Gibson, Kaplan, Reynolds & Wheeler 1969), he saw that it was advantageous, if not absolutely necessary, for an animal to move about in order to satisfy conditions for adequate perceiving. "So we