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COMMENTARY

Four Ways to Reject Directed Perception

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Burton and Turvey (1990) found that two invariants, the first and second moments of mass distribution, were available and used for the perception of the length of a hand-held rod. The first predominated in holding and the second in wielding. They denied, however, that these invariants were information. Thus, they deny directed perception (Cutting, 1986), which allows for multiple specification of objects/events, in favor of direct perception, which preserves a one-to-one mapping between objects/events and perceived qualities. In this commentary, after some introductory questions and answers, I cite some evidence I take in support of multiply specified information for perception. I then outline four schemes for countermanding this evidence. These are (a) the appeal to proximal information identity, (b) the appeal to underlying information identity, (c) the appeal to broken linkage between information and experimental variables, and (d) the appeal to cross-modal holism of information. I claim Burton and Turvey (1990) espouse both (a) and (c).

A new issue has captured the attention of the community of ecological psychologists interested in perception—whether or not multiple sources of completely adequate information can exist for the perception of a single object or event. An approach that follows J. J. Gibson insists on a one-to-one mapping between information and object properties, called *direct perception*. An approach embracing many-to-one mappings is *directed perception*. Burton and Turvey (1990) found multiple invariants available for the perception of the length of a

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hand-held rod, yet denied their status as information. This theoretical response prompted my commentary.

Burton and Turvey (1990) reported a nifty and welcomed result. When individuals hold a rod, they can use its first moment of mass distribution to judge length, but when they wield it they use its second moment, the moment of inertia, for the same judgment. I take this result as further promoting directed perception. Burton and Turvey, however, rejected this idea. Instead they promoted an alternative: Holding and wielding share common information in tissue strains and deformations. They leave unspecified and unmeasured what that information might be, but the idea is attractive and tightly consistent with J. J. Gibson's notion of one-to-one mappings between information and object/event properties in the world (Cutting, 1986, in press).[1]

Burton and Turvey are not alone in their rejection of directed perception. In recent discussions of the issues at stake I find four general procedures for denying the existence of multiple sources of information. Before elucidating these, however, let me pose some questions and offer a few answers to set the stage for discussion.

PRELIMINARIES

What is Directed Perception?

Directed perception is a theory that everyday perception about single objects or events occurs on the basis of the availability of multiple sources of information, each singly and completely specifying what is to be perceived. Sometimes these different sources of information may be integrated (combined and given various weights); sometimes information may be selected (one source in one situation chosen over another source, which is used in another situation); and sometimes information may be integrated but also selected (two sources integrated and a third ignored).

[1]Among the most gratifying aspects of Burton and Turvey (1990) is their acceptance of one of the major terms of debate—that J. J. Gibson's position on direct perception entails a one-to-one mapping between information and percept. Where does Gibson say this? Systematic statements by Gibson on this matter are not easy to find, partly because his accounts were contrasted to information theory and to indirect perception, not to directed perception (which never existed in his lifetime). Typically, one must search for singular modifiers and nouns in Gibson's prose. As an entrée see, Gibson (1959, p. 465) on perception as a function of stimulation, Gibson (1965, p. 68) on invariants and variants, and Gibson (1967, p. 166) on a child's exploration. See also E. J. Gibson (1967, p. 464) on the search for an invariant. Although these references are old within the evolution of Gibson's theories about perception, I claim they are also representative of his later views. I am pleased Burton and Turvey (1990) and Stoffregen (1990) agree.

The tasks for researchers of directed perception are to find out what the information is for any given object or event, and why that information is used and not others. The latter task has only begun.

What is Information and Where Did it Come From?

Information is in the world; it is the measureable basis of perception. It is measured in any medium appropriate to an organism's perceptual systems. For example, visual information is measured in the light, typically on cross-sections of the optic array. To qualify as information, however, it must be demonstrably used by a perceiver. Mere demonstration of the existence of an invariant, for example, does not necessarily make it information.

Here are some of my claims about information: The physics of almost any given natural situation allow for many different patterns of stimulation, each specifying uniquely a given object or event. In vision, each of the ways one can measure these patterns in the light is potential information for perception. Evolution has adventitiously and advantageously exploited these patterns in the development of perceptual systems, sometimes in a promiscuous manner. The exploitation of multiple sources of information has had the desirable outcome of making perception robust against degradation of any single source of information; it may also have promoted biological expansion of animals into new niches by differently designed information pick-up systems.

Finally, and perhaps my most important assumption, information is analyzable by experimenters. More concretely, there is little or no distance between the variables of ecological research in perception and the information for everyday perception. To be sure, one must be careful in how one devises experiments and chooses variables, but by modeling experimental situations on natural situations, one is not likely to go too far wrong for too very long.

Does Cognition Play a Role in Directed Perception?

No, at least not in terms of consciousness or general problem solving devices. Directed perception is no more cognitively penetrable than direct perception.

Many people have thought directed perception to be somehow a "process" theory, entailing top-down constraints on perception. This is not true (Cutting, 1986, p. 249). Directed perception is the search for adequate information, where adequacy can be obtained by selection or by combination of multiple, property-specific sources of information. The process by which selection is attained might be couched in terms of a racehorse model (one source achieving adequacy earlier in time than another); the process by which combination occurs must be achieved by some type of integration, which could be modeled by any number of

neural networks. I currently like best the idea of additive integration (where selection is accounted for by a weighting of zero), because it seems to support most of my data.

Can the Accounts of Inter- and Intramodal Sources of Information be Different?

Any discussion about perception by multiple sources of information within a modality (e.g., vision) cannot in principle be separated from such multiplicity across modalities. Thus, any theory about the use of intermodal information (Massaro, 1987; Pittenger, 1989) can be no different in kind than the use of intramodal information. Despite this, I confine myself to the latter. The reasons are straightforward, if not completely defensible: The case of intramodal information is most pertinent to the results of Burton and Turvey (1990) and to those of my research in visual perception. Moreover, more deeply, and doubtless due to professional deformities we all share, perceptual psychologists have found it difficult to be clear and quantitatively concrete about information in intermodal situations. With the exception of Massaro (1987), I have seen no discussion of the intermodal information that goes beyond a mere naming of attributes in various modalities (see, e.g., Pittenger, 1989; Stoffregen, 1990).

When is Information Equivalent? When Identical?

J. J. Gibson (1966, p. 55) broached this pair of questions, but provided insufficient resolution. Compare: "The equivalence of different 'stimuli' for perception and behavior has long been a puzzle, but it ceases to be puzzling if we suppose that it results from *equivalent stimulus information being carried by different forms of stimulus energy*" (italics added). Thus, two different forms of energy (or two measures of the same form) can be equivalent in information content. But, on the same page Gibson suggested: "The formula proposed here is not that stimuli are equivalent when they are different but that *stimulus information may be identical when stimuli are different*" (italics added, changed from the original). Thus, two different forms of energy (or two measures of the same form) can be identical in information content. Unfortunately, these two quotations are in conflict over the issue of equivalence and identity.

Equivalence means "having equal power;" equivalence is *functional* identity, in this case functional for a perceiver. Identity, on the other hand, means sameness in essence, where essence cannot be defined by function alone. The equivalence–identity distinction is important; it separates discussions of information in directed and direct perception. Directed perception postulates functional equivalence for different sources of information in the same or in different situations; direct perception, on the other hand, postulates informational identity in the same or in different situations.

The issues surrounding the notions of equivalence and identity of information are deep, and this is not the place to discuss them full scale. Let me state, however, four practical criteria for their separation. By equivalence, I mean information sources are: (a) *nonidentical*, that different information can be measured in different ways without being reduced to notational variants of one another; (b) *equispecific*, that (measurement issues aside) each information source equally specifies the physics of a situation for an object or event; (c) *isolable*, that one can in principle vary one without varying another; and (d) *perceptually useful*, that results of experiments may be causally connected to manipulation of each source in satisfactorily similar, if not identical, situations.

With these preliminaries aside, I now turn to two remaining issues at stake: What is the evidence for intramodal many-to-one mappings of information to object properties?, and How might one ignore that evidence?

SOME INTRAMODAL EVIDENCE FOR DIRECTED PERCEPTION

1. Cutting and Millard (1984) showed that three texture gradients—perspective, compression, and density—equally specify the perception of both flat and curved surfaces. Nonetheless, most perceptual weight was given to the perspective gradient, some to density, and none to compression when judging flatness; and essentially all weight given to the compression gradient when judging the presence of curvature. These gradients are logically and naturally separable and they are based on different assumptions about how the world is furnitured. Todd and Akerstrom (1987) questioned our analysis of compression, but did not question the issue of independence and separability of information.

2. Bruno and Cutting (1988) found that three standard sources of pictorial information—relative size, occlusion, and height in plane—were additively combined with motion parallax in perceivers' judgments about the relative depth of three objects in space. Dosher, Sperling, and Wurst (1986) found the same for relative size and stereopsis. Massaro (1988) questioned claims of Bruno and Cutting concerning additivity of information, but applauded the use of multiple sources of information in our experiments.

3. Cutting (1986) found that the invariant cross ratio of four parallel lines could be used to judge the rigid flatness of a rotating surface, but found that a different invariant, the yoked velocities of optical flow, were used for the perception of rigid flatness in a translating surface. In the latter case, the invariant cross ratio was ignored in favor of another invariant. Niall (1987) questioned my formulation of the cross ratio, but did not impugn the independence and separability of the two types of information.

4. Cutting (1986) found that differential motion parallax in the retinal array could be used to find one's way in a cluttered environment within one degree of

visual angle, the accuracy needed to negotiate objects safely. Warren, Morris, and Kalish (1988) questioned this finding, and found the same accuracy using information in radial outflow in the optic array. The pickup of differential motion parallax does not rely on decomposition of flow fields, whereas the pick-up of global radial outflow does. In principle, at least with current analyses and the uncertain status of decomposition, both sources of information may be available to moving observers.

5. Larish and Flach (1990) demonstrated additive effects of optical edge rate and global optical flow rates as contributors to the perception of translatory movement. Edge rate depends on ground speed and texture density, not on altitude; global flow rate depends on altitude, not on ground speed or texture density. Edge rate accounted for more variance.

6. Burton and Turvey (1990) found that either of two moments of mass distribution could specify the length of a rod; the first moment predominated in holding, the second in wielding. In principle, the second moment cannot be present in holding, but both are present in wielding. Results generally supported the selection of the second moment over the first in the situation of wielding. This case is directly analogous to Item 3.

Because Burton and Turvey did not interpret these results in favor of directed perception, more must be said. This introduces four possible means of denying multiply effective information for perception, the first and third of which, I think, are fairly attributable to Burton and Turvey. Moving through the list I think each gambit is increasingly radical; increasingly desperate.

FOUR WAYS TO REJECT DIRECTED PERCEPTION

The Appeal to Proximal Information Identity

One way to stave off the demons of multiplicity is to look for unitary information proximal to the variables manipulated in an experiment. This is one gambit used by Burton and Turvey (1990):

> We suggest that they [holding and wielding] share common information, despite the distinction between them in the relevant mechanical variable. In both holding and wielding a rod, tissues of the body are deformed by torques that are proportional to invariant characteristics of the rod (the moments of the mass distribution) relative to the pivot point. That is to say, in both cases, perceived extent is specific to information of one and the same kind. (p. 321)

Thus, the invariant is at the level of tissues, at the proximal point of stimulation. Indeed, Burton and Turvey concluded by suggesting "the structuring of strains

by the torques of holding and wielding contain an invariant patterning specific to rod extent" (pp. 321–322).

As I see it, there are at least three problems here. First, translated to the terms of vision, a proximal identity cannot be found in the other five items just reported; that is, the proximal (retinal) information already corresponds to the gradients (Item 1), invariants (Items 3 and 4), and other sources of information (Item 2 and 5) used. Second, because tissue strains were not measured, this account fails one of the criteria proposed by Rosen (1978), which Burton and Turvey otherwise espoused for satisfactory abstraction of natural situations into experimental ones. Third, it assumes a single proximal invariant (structuring of tissue strains) where a distal pair of invariants (the first two moments of mass distribution) is acknowledged and shown to exist and be strongly correlated with the data. Thus, on this account, the invariants in the world are multiple, and now there are two kinds (distal and proximal) to coordinate in our theories.

The Appeal to Underlying Information Identity

A second way to deny the utility of multiple sources of information is to appeal to underlying unity. This might be a yet-higher order invariant, or it might be something else. This gambit was not used by Burton and Turvey, but is common in my experience when talking about directed perception (see also J. J. Gibson, 1967, p. 166). That is, two invariants, or two other sources of information, might both be captured by some other, as yet unmeasured quantity. Applied to the situation of Burton and Turvey, there may be an invariant underlying the two already measured invariants to the first and second moments of distribution.

This idea, too, seems attractive and there is reasonable logic behind it. Two experimental variables (say, two invariants) might be correlated with a third variable (another invariant, unmeasured in the experiment, even undefined). Both measured invariants might show significant partial (orthogonalized) correlations with the data, but the best correlation would have been shown with the third invariant had it been measured.

There are three problems with this gambit, although it always remains possible as an account for all the items on my list. First, as before, none of us yet have a clue as to what this underlying unitary source of information might be in Burton and Turvey's (1990) case or in any of the first five items on my list. Second, it denies the efficacy of the measurement of the invariants and their correlation with results. Third, and again, it proliferates levels of invariants.

The Appeal to Broken Linkage Between Information and Experimental Variables

Like the first, the third gambit was employed by Burton and Turvey. It is related to the second, but more sophisticated. This strategy is, in essence, to deny that

the variables in our experiments are information. That is, in their abstraction of natural situations, they have reduced the moments of mass distribution to mere experimental variables; the information for determining rod length from holding and wielding is something else. The *fractionation* (Rosen, 1978) of the natural act of picking up a rod has led us, falsely, to entertain two different sources of information because it has broken the natural linkages between information and experimental variables.

This gambit has two of the problems of the previous—it promotes as yet unknown and unspecified information, and it denies the efficacy of invariants in the face of solid results. Third, although Rosen's (1978) proclamations have a ring of proper caution about them, as an experimental psychologist I find them extremely depressing. Rosen presented the real world as a matrix of shifting sand that we can rarely abstract (fractionate) in our experiments with any confidence; it makes conclusions uncertain, even from experiments with cleanly manipulated variables. My retort is this: Until I can determine how and why the quantum considerations that promoted Rosen's (1978) ideas might be made relevant to human perception, I relegate them to subecological realms. Quite simply, I prefer the optimism of thinking about the world as a collection of nearly modular (fractionable) systems (Marr, 1982), whether they be physical, neural, or psychological.

The Appeal to Cross-Modal Holism of Information

This final approach is taken by most clearly Stoffregen (1990). For him, "Redundancy among 'sources' of information is information for one thing, while non-redundancy among these same sources is information for something else. . ." (p. 7). What specifies an event, in Pittenger's (1990) interpretation of Stoffregen, is in the "whole complex of co-ordinated patterns across the arrays of all relevant perceptual modalities" (p. 8). This view is a logical extension of one of Rosen's (1978) ideas to perception. That is, the unimodal study of objects and events, whether in vision or in haptics, is misguided; it fractionates events along modalities, and necessarily fractionates information.

As I see it, this gambit has three problems. First, whereas there is no principled count of the number of objects and events in our world to be perceived, it is clear many of them are unimodally specified in natural settings. Indeed, the first five cases just cited all deal with surfaces and environmental layout beyond one's reach, and it is difficult to deny the solely visual character of their perception. Thus, to appeal to holism here must reduce to either the aforementioned second or third gambit, and it has their problems. Second, in situations where multimodal information normally rules, as in face-to-face conversation with a friend, this idea offers no aid to our understanding of their unimodal perception, as in conversation over a telephone. Third, and empirically most important, it offers no easy way to discuss or measure information, except in terms of natural language. Such cross-modal information would seem to have no metric units.

CONCLUSION

I think these four routes to deny the multiplicity of information, and hence directed perception, have serious problems. Some of them are logical, some merely practical. The practical ones could be shunted aside, and perhaps the logical ones recast. But, of course, there is another way! One could simply accept directed perception.

There may be other, and better, ways to get around the issue of multiple specification of objects and events, but I have yet to see them. At present, I think the costs of avoiding directed perception are considerably greater than the costs of embracing it. But what I find truly salutary is that the issue is being discussed.

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