

Continuing Commentary

Commentary on **T. A. Stoffregen & B. G. Bardy (2001). On specification and the senses. BBS 24(2):195–261.**

Abstract of the original article: In this target article we question the assumption that perception is divided into separate domains of vision, hearing, touch, taste, and smell. We review implications of this assumption for theories of perception, and for our understanding of ambient energy arrays (e.g., the optic and acoustic arrays) that are available to perceptual systems. We analyze three hypotheses about relations between ambient arrays and physical reality: (1) that there is an ambiguous relation between ambient energy arrays and physical reality, (2) that there is a unique relation between individual energy arrays and physical reality, and (3) that there is a redundant but unambiguous relation, within or across arrays, between energy arrays and physical reality. This is followed by a review of the physics of motion, focusing on the existence and status of referents for physical motion. Our review indicates that it is not possible, in principle, for there to be a unique relation between physical motion and the structure of individual energy arrays. We argue that physical motion relative to different referents is specified only in the *global array*, which consists of higher-order relations across different forms of energy. The existence of specificity in the global array is consistent with the idea of direct perception, and so poses a challenge to traditional, inference-based theories of perception and cognition. However, it also presents a challenge to much work within the ecological approach to perception and action, which has accepted the assumption of separate senses.

Specificity in a global array is only one possibility

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Abstract: The suggestion of seeking specificity in a higher-order array is attractive, but Stoffregen & Bardy (S&B) fail to provide a compelling empirical basis to their claim that specificity exists solely in the global array. Using the example of relative motion, the alternate hypotheses that must be considered are presented.

Many common perceptions are functions of multiple energy arrays, just as many common behaviors have multiple physical referents. In their target article Stoffregen & Bardy (S&B) (2001) took these facts as evidence that perceptual specificity exists solely in a global (higher-order) array. We agree that specificity may, at times, exist in the global array. However, concluding that specificity exists *only* in the global array – that there should be only one “global” mode of perceiving – is premature. We consider the conclusions of S&B to be one of a number of testable hypotheses. Although S&B admit that such testing should be pursued, their continued insistence on one type of specificity is inconsistent with this position. Testing for the existence of one possibility requires acceptance of the possible existence of alternative possibilities. Here we outline alternate hypotheses that must be considered in order to test for specificity in the global array.

The alternative hypothesis that information is detected in separate arrays, only to be combined later, is not an easy option to reject. Apparently, S&B assume that perception is straightforwardly a function of the global array when the perceptual report is a function of relations among energy arrays. In the moving room paradigm of Lee and Lishman (1975), for example, verbal reports and postural behaviors appear to be influenced by both the mechanical stimulation from a moving floor and the optical stimulation of the moving walls. S&B would like to conclude, then, that the action is specified only in the global array. Although this conclusion

is attractive, it may not be warranted. The problem follows from the fact that a perceiver’s perception and a perceiver’s report (or performance) may not be the same (cf. Mandler 1985; Van Orden & Jansen op de Haar 2000). Consequently, the observation that a combination of energy arrays determines a report need not imply that it likewise influenced perception. S&B use this distinction to motivate their reinterpretation of subjective reports, but do not acknowledge that this distinction also weakens their conclusion.

We can generate a simplified model of relative motion in a moving room on the basis of General Recognition Theory (GRT; Ashby & Townsend 1986). This model will be used to illustrate the alternate hypotheses that are generated from a distinction between perception and performance. GRT theory is an extension of signal detection theory in which stimulus information gives rise to a distribution of perceptual effects. When faced with making a response, an individual applies a decision criterion to the perception in order to determine the appropriate response. A given perceptual report, then, is a function of both the sensitivity of the perception to variations along a physical dimension and the decision criterion that is employed. In a moving room, information is available from both the gravitational field (indicating no motion) and the optic array (indicating motion). Assuming that they may be detected separately, we may tentatively conclude that there is a perception of no motion relative to gravity and a perception of motion relative to the walls. These perceptions will result in a postural response when they are combined with some rule(s) for the control of behavior, such as “maintain a fixed distance between the head and the forward wall.” So there are three components to the postural adjustments observed in a moving room: the information, the detection of that information, and the generation of a response on the basis of that information.

In a moving room, movements of the walls produce postural adjustments that would be consistent with movement relative to gravity. But where exactly are the influences of gravity and the optic array combined? Our simplified model shows that these two influences may be combined or separated in any of the three stages. A conclusion of specificity in the global array, however, refers only to a combination of information. Accordingly, there would be a

perception of motion relative to the floor that is a function of both mechanical and optical stimulation (combined in the global array) and the postural adjustments would be some function of this perception. If this model were correct, then there would be ambiguity in either single-energy array, as S&B suggest. However, observing postural adjustments in a moving room does not require us to accept this conclusion. The seeming combined influences of gravity and optics may occur in the perceptions themselves. For example, one may have a perception of moving relative to the floor that is influenced both perceptually by the mechanical stimulation from the floor and cognitively by the perception of moving relative to the walls. This option is commonly referred to as percept-percept coupling and does not imply higher-order invariants in the global array. Moreover, the influences of gravity and the optic array could be combined in the generation of the response. For example, imagine that the perception of moving, relative to the floor, is strictly a function of mechanical stimulation; and the perception of moving, relative to the walls, is strictly a function of optical stimulation. The two perceptions do not influence one another directly. Nevertheless, both perceptions may influence the report if the observer is misled to believe that the floor and walls must move together.

Like the authors, we are intrigued by the theoretical possibility of higher-order, or even global, invariants. But S&B fail to demonstrate a compelling empirical basis for their hypothesis. To do this, they must first acknowledge the alternate hypotheses, because these hypotheses remain valid alternatives that must be rejected. Failing to do so could lead to the inappropriate conclusion that there is information-action specificity in a higher-order array when, in fact, the data show only a cognitive effect or a response bias. In the end, it is impossible for S&B to conclude both that specificity in the global array is testable and that it is the only option.

Teleological perception without a biological perceiver?

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Abstract: Strong between- and within-animal differences during spatial activities lead us to claim that a given animal is directly sensitive to a given substructure of the global array. This vicarious subset is not cut out by the senses but by redundancies emerging from physical properties. We argue that the subset is not a single ambient array, or a combination of single ambient arrays, but a complex holistic part of the global array.

The assumption that perception is not divided into separate senses does not imply that animals are directly sensitive to the structure of the global array (GA). This is rather often not the case; because of the animal/environment mutuality, the GA should be broken down or filtered into subsets according to each animal's idiosyncrasy. We assume that these within- and between-animal differences are not linked to senses but to physical properties of the ambient array. In any case, animals can only pick out a subset of the physical reality. Actually, as they are driven by reinforcement (Skinner 1984), their major purpose is to achieve actions, and not merely to extract an accurate perception of the reality, an assumption which would be teleological. Therefore, some subsets of the reality are sufficient and the multidimensional GA is not necessarily systematically sampled out.

Strong between-animal differences both in spatial activities and

in spatial disorders provide evidence that senses work in order to give a sufficient idiosyncratic perception based on a functional subset of the GA (Ohlmann & Marendaz 1991). Biological systems (Schull 1990) do not have a predetermined or a priori solution for the world with which they are coping. In mild conditions, such as walking regularly or stabilizing one's posture on a flat resistant surface, redundancies can give rise to precise covariations between the different subarrays. In such a case, a quasi single array is indifferently *sufficient* to control the task. Is there anybody or anything that obliges the animal to work at a higher level? This question has nothing to do with the issue of separate senses. Clearly, in the perception of a subset of the GA such gravito-inertial (GI) forces involve a large set of senses: Golgi receptors, vestibular system, motor proprioception, kidneys (Mittelstaedt 1997), tactile pressures, body fluids, and so forth.

Moreover, in many circumstances there is no need to perceive reality accurately; indeed, action should be easier if one discards some disturbing aspects of the reality. In many cases, animals actively or passively make use of filter-like systems which are brought into play by the characteristics of the situation and/or of the individual.

According to Kimura's "neutralism model" (Kimura 1968; Kimura & Ota 1972), the level of constraints directly entails consequences about the between-animal differences. When an animal is confronted with low constraints, redundancies lead to a vicarious diversity (Reuchlin 1978). Therefore, if some information (data, senses, tools, affordances, part of the GA, etc.) is substitutable for some other information, then a given animal will rely on one kind of information whenever it finds itself in a similar situation.

A clear example of the non-necessity of picking out the GA each time is given by the visual Romberg's Ratio (Amblard et al. 1985). Body movements are successively recorded in total darkness and in illuminated environment. Postural stability is dramatically increased when optics are available. However, there is a strong between-animals variability caused by the extraction of a non-GA, with some subjects (Lacour et al. 1997) keeping the same level of stabilization in darkness and in an illuminated environment. Isableu et al. (1997; 1998) have shown that field-independent subjects (Asch & Witkin 1948) do not need visual information to stabilize their body even in a complex stance. In order to achieve almost the same level of postural control, field-dependent subjects need full optical information. Some subjects appear to be sensitive to both *geometrical and kinematic* optical information (Gueraz et al. 1998), while others rely on *dynamics* (either static or kinetic). These subsets constitute vicarious referents not based on senses but on physical properties of information. Pick (1974) assumed that nonvisual spatial information can be "coded" in a visual mode because of physical properties of optics independent of the visual modality per se. This was expanded by de Volder et al. (1999) who demonstrated that early blind subjects, fitted with ultrasonic devices, exhibited a distinct activity (PET) in the primary visual area. Furthermore, some other subjects showed a high sensitivity to forces, whatever their nature (inertial, frictional, gravitational), which led them to refer primarily to moments of inertia (Pagano et al. 1996), static moments, or gravito-inertial forces. For example, they easily found subjective or postural vertical, either directly by vestibular system, tactile compression, interoception, or by the dynamics of balance (Stoffregen & Riccio 1988; Riccio et al. 1992). Their superiority in any domains involving moto-somato-sensorial control could be easily explained by a postural scheme extracted from the inertial tensor associated with each rotating corporal segment. Finally, this vicariousness even appears at cell level. Waespe & Henn (1977; 1979), showed that in vestibular nucleus of awake monkey, one given cell works either with a visual stimulus or an inertial stimulus, or with a combined visuo-vestibular stimulus.

Why are between-subject differences about motion sickness so dramatic? The postural hypothesis of motion sickness, developed by Stoffregen and Riccio (1991) is unable to account for these dif-