ing does not come from a "humpty-dumpty" approach that tries to put the object "back together again" through computation. The target model is reductionist/empiricist and, as such, is contrary to Gestalt theory (Koffka 1935; Köhler 1947). The relevant properties of things are not computational properties superimposed on the object system, but rather, the intrinsic relational properties within the object and between the object and the perceiver/actor (Köhler 1947). For example, Köhler certainly did not suggest that perception is a mental computation when he wrote: "While climbing once in the Alps I beheld . . . a big dark cloud . . . nothing could be more sinister and more threatening. . . . the menace was certainly in the cloud." The menace stems not from computations on mental images but from physiological sensitivity to relations among environmental physical energies, and between these relations and the state system of the observer/actor. I suggest a dynamic, person-environmental mechanism rather than internal representation and computations. This is consistent with the Gestalt statement: "rules in which we formulate (functional, psychological) relationships imply occurrences of certain functions in a realm that is surely not the phenomenal realm" (Köhler 1940).

A final, critical point concerns isomorphism: Isomorphic relations are ubiquitous, so one needs to be specific. Gestalt "Psychophysical Isomorphism" is a hypothesis that rejects Cartesian dualism and is informed by physiology (Köhler 1969). Lehar, using a digital computer metaphor, suggests a point-to-point isomorphism between the internal image and external objects/space. However, this is not supported by physiology. Cells in the supplementary eye field of the monkey show firing patterns (Olson & Gettner 1995) that do not encode visual space in any one-to-one manner. Rather, they incorporate higher dimensions of information such as attention or purpose (Fox 1999). Hence, even if we accept isomorphic, internal representations, there is neurophysiologic evidence that such representations are more complex than suggested in Lehar's model.

The target model does not accomplish its ambitious goals of presenting a modern Gestalt perceptual model. A more fruitful heuristic for understanding perception is a physiology that has evolved a sensitivity to meaningful environmental relational information, or, as suggested by Clark (1998), one that represents action-oriented systems.

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Linking visual cortex to visual perception: An alternative to the Gestalt Bubble

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Abstract: Lehar's lively discussion builds on a critique of neural models of vision that is incorrect in its general and specific claims. He espouses a Gestalt perceptual approach rather than one consistent with the "objective neurophysiological state of the visual system" (target article, Abstract). Contemporary vision models realize his perceptual goals and also quantitatively explain neurophysiological and anatomical data.

Lehar describes a "serious crisis," "an impasse," and a "theoretical dead end" (target article, sect. 1, para. 1) in contemporary models of vision and advances as a possible alternative his Gestalt Bubble approach, "which is unlike any algorithm devised by man" (Abstract). He also claims that "Gestalt aspects of perception have been largely ignored" (sect. 1, para. 3) by neural models of vision, and then goes on to describe presumed dichotomies between equally desperate attempts to understand how the brain sees. Lehar particularly comments about modeling work by my colleagues and myself, noting that "the most serious limitation of Grossberg's approach . . . is that, curiously, Grossberg and his colleagues did not extend their logic to . . . three-dimensional spatial perception [and] . . . no longer advocated explicit spatial filling-in" (sect. 3, para. 5). He also says it is "impossible for Grossberg's model to represent transparency" (sect. 3, para. 5). These general and specific claims unfortunately do not accurately represent the published literature about neural vision models. Lehar seems motivated to trash neural vision models because his own model makes no contact with neurophysiological and anatomical data about vision.

In reality, there is an emerging neural theory of three-dimensional vision and figure-ground perception called the FACADE theory, for the multiplexed Form-And-Color-And-DEpth representations that the theory attempts to explain (Grossberg 1987; 1994; 1997). Lehar refers to my 1994 article in summarizing the deficiencies of our models. However, this article explains many three-dimensional figure-ground, grouping, and filling-in percepts, including transparency, and uses an explicit surface filling-in process. Later work from our group has developed these qualitative proposals into quantitative simulations of many three-dimensional percepts, including three-dimensional percepts of da Vinci stereopsis, figure-ground separation, texture segregation, brightness perception, and transparency (Grossberg & Kelly 1999; Grossberg & McLoughlin 1997; Grossberg & Pessoa 1998, Kelly & Grossberg 2000; McLoughlin & Grossberg 1998).

These studies laid the foundation for a breakthrough in understanding how some of these processes are organized within identified laminar circuits of cortical areas V1 and V2, notably processes of cortical development, learning, attention, and grouping, including Gestalt grouping properties (Grossberg 1999a; Grossberg & Raizada 2000; Grossberg & Seitz 2003; Grossberg & Williamson 2001; Grossberg et al. 1997; Raizada & Grossberg 2001; 2003; Ross et al. 2000).

This LAMINART model has been joined with the FACADE model to develop a three-dimensional LAMINART model that quantitatively simulates many perceptual data about stereopsis and three-dimensional planar surface perception, and functionally explains anatomical and neurophysiological cell properties in cortical layers 1, 2/3A, 3B, 4, 5, and 6 of areas V1 and V2 (Grossberg & Howe 2003; Howe & Grossberg 2001), using three-dimensional figure-ground and filling-in concepts to do so. More recently, the three-dimensional LAMINART model has been generalized to explain how three-dimensional percepts of slanted and curved surfaces and of two-dimensional images are formed, and to clarify how three-dimensional grouping and filling-in can occur over multiple depths (Grossberg & Swaminathan 2003; Swaminathan & Grossberg 2001). This work includes explanations of how identified cortical cells in cortical areas V1 and V2 develop to enable these representations to form, how three-dimensional Necker cube representations rival bi-stably through time, how slant aftereffects occur, and how three-dimensional neon color spreading of curved surfaces occurs even at depths that contain no explicit bottom-up inputs. All these studies are consistent with the grouping interpolation properties that Kellman et al. (1996) have reported (p. 51), and with the three-dimensional grouping properties summarized in Lehar's Figure 16, which he seems to think cannot yet be neurally explained.

These modeling articles show that many of the perceptual goals of Lehar's Gestalt Bubble model are well handled by neural models that also provide a detailed account of how the visual cortex generates these perceptual effects. In summary, we do not need analogies like the soap bubble (sect. 8.2), or rod-and-rail (sect. 8 and Fig. 6), or different local states to represent opaque or transparent surface properties, as Lehar proposes. The brain has discovered a much more interesting solution to these problems, which links its ability to develop and learn from the world with its ability to see it.

Lehar makes many other claims that are not supportable by present theoretical knowledge. He claims that "we cannot imagine how contemporary concepts of neurocomputation . . . can account for the properties of perception as observed in visual consciousness [including] hallucinations" (sect. 2.4, para. 3). Actually, current neural models offer an explicit account of schizophrenic hallucinations (Grossberg 2000) as manifestations of a breakdown in the normal processes of learning, expectation, attention, and consciousness (Grossberg 1999b).

Contrary to Lehar's claims in section 8.7, recent neural models clarify how the brain learns spatial representations of azimuth, elevation, and vergence (see Lehar, Fig. 14) for purposes of, say, eye and arm movement control (Greve et al. 1993; Guenther et al. 1994). Lehar defends "the adaptive value of a neural representation of the external world that could break free of the tissue of the sensory or cortical surface" (sect. 8.8). Instead, *What* stream representations of visual percepts should be distinguished from *Where* stream representations of spatial location, a distinction made manifest by various clinical patients.

Lehar reduces neural models of vision to capacities of computers to include navigation as another area where models cannot penetrate (see sect. 6.1 and sect. 9). Actually, neural models quantitatively simulate the recorded dynamics of MST cortical cells and the psychophysical reports of navigating humans (Grossberg et al. 1999), contradicting Lehar's claim that "the picture of visual processing revealed by the phenomenological approach is radically different from the picture revealed by neurophysiological studies" (sect. 9, para. 1). In fact, a few known properties of cortical neurons, when interacting together, can generate emergent properties of human navigation.

Lehar ends by saying that "curiously, these most obvious properties of perception have been systematically ignored by neural modelers" (sect. 10, penultimate para.). Curiously, Lehar has not kept up with the modeling literature that he incorrectly characterizes and criticizes.

Steven Lehar's Gestalt Bubble model of visual experience: The embodied percipient, emergent holism, and the ultimate question of consciousness

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Abstract: Aspects of an example of simulated shared subjectivity can be used both to support Steven Lehar's remarks on embodied percipients and to triangulate in a novel way the so-called "hard problem" of consciousness which Lehar wishes to "sidestep," but which, given his other contentions regarding emergent holism, raises questions about whether he has been able or willing to do so.

Steven Lehar's Gestalt Bubble model (GBM) is said to emphasize the often ignored fact "that our percept of the world includes a percept of our own body within that world, . . . and it remains at the center of perceived space even as we move about in the external world" (sect. 6.4). I offer here a friendly, if folksy, example of a *simulation* of shared first-person subjectivity designed to reinforce Lehar's brief but interesting claims concerning the prominence of the embodied percipient in visual perception. This example leads to other questions regarding his analysis. I have labeled the example elsewhere, and with variations, the Cinematic Solution to the Other Minds Problem, and invoked it earlier against B. F. Skinner's view of subjective privacy and scientific inquiry, also objected to by Lehar for his own reasons (Gunderson 1971; 1984).

Suppose a film director wishes to treat us to the subjective perceptual experiences of another person, say Batman, as he gazes on the traffic far below from some window perch. How is this best done? Not, to be sure, by simply showing us the whole scene: the superhero perched on the ledge with the traffic moving by on the street below. This would not be anything like being privy to Batman's subjective perceptual experience. It would only amount to our own visual experience coming to include Batman. Instead, what is characteristically done is that Batman's filmed body (or at least the better part of it) is somehow (gradually or suddenly) subtracted from the screen in such a manner that we become insinuated into roughly whatever space and orientation Batman's body occupies and are thereby made party to the visual field (sense of height, traffic passing below, etc.), which we can assume would be Batman's from that perspective. We cannot, of course, literally occupy (even cinematically) exactly the same space that Batman does – a prerequisite to having his visual experience – but the tricks of the art permit us to enjoy a simulation of such an occupancy. It is the sleight-of-camera with respect to our seemingly ubiquitous embodied presence in visual perception that carries with it tactics for conjuring a sense of the usual "subjectivity barrier" between us and another percipient being breached. And here it occurs in a florid phenomenological manner, obviously different from the "relational information" that can cross that barrier, as described by Lehar (sect. 5.1). Notice too, that a "preset" feature of the whole typical movie experience involves the darkened theater and no focused sense of our own body being either present in the audience or included in the screen action. The effect is that where we are not assuming specifically Batman's perspective, we are assuming one belonging to no one in particular, or rather one "belonging" to anyone in the vicinity, as it were.

So the possibility of the cinematic simulation of shared subjectivity seems to presuppose the inclusion of an embodied percipient in our visual perceptions, along lines suggested by Lehar. But the apparent friendliness of the example has a complicated provocative side as well. For if what it takes to create the illusion is the clever collapsing of our perspective (or someone else's) into another's, then the epistemic-ontic primacy of the first-person point of view becomes obvious, and the "hard problem" of consciousness can be rephrased with respect to it this way: There is no analogous thought experiment that would render subjectivity or a point of view (one's own or another's) as being somehow manifest in any set of neurophysiological processes to begin with, such that another consciousness might appear as somehow insinuated into it. But there should be, if consciousness is to be modeled (displayed, illustrated) within any third-person physicalistic conceptualization. This rather flat and crude-sounding point is not, I think, irrelevant or naïvely realistic. In a nutshell, that there can be no cinematic-type simulation of a solution to the mind-body problem parallel to another mind's, can be seen to stem from our inability to cling to our sense of experiencing a point of view while being in some neurophysiological locus (however this is represented).

For Lehar, the salient residual problem(s) is this: Although the contents of all our subjective visual experience for the GBM are subsumed under the subjective, we lack *any* vivid demonstration of how *having* a first-person point of view in itself, which is a prerequisite to there being any such phenomenal contents, lies within that experience. Simply specifying *underlying* neurophysiological conditions for consciousness takes us nowhere we have not already unsatisfactorily been. That there is, and how there is, any locus at all for our perceptions remains unexplained within any micro or macro frame of reference. We think, of course, that the *locus of our locus* of perceptions lies in some way within the embodied. But to be apprised of all this does not thereby help us to see how any subjective perspective occurs in the first place, or why it is uniquely ours! (See Nagel 1965.) The problem of explaining it arises independently of whatever type of metaphysical substance the perceiver is believed to be embodied in, even as part of a *panpsychic* or *panexperientialist* scheme such as Chalmers' (as in sect. 6.5). And it can be reiterated with respect to any type of substance of any kind of complexity, as far we can tell.

Now, Lehar wishes to "sidestep" these latter matters by casting the GBM *wholly within the subjective.* Our perceived worlds –

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