coherent plaid. Synchrony elicited by coherent plaids was the same as for noncoherent ones. Again, it is probably not spiking activity per se that is ultimately important, but the associated changes in membrane potential and possibly phenomena such as depolarization fields manifested in superficial layers of cortex (Roland 2002).

The various states of Lehar's Gestalt Bubble model can easily be construed as hypothetical neuronal feature detectors. One could not ask for a better set of discriminators of planar properties in depth, and I suspect that something very similar lurks somewhere in the association areas between V1 and the inferotemporal cortex. The transformation from a two-dimensional image on the retina to a three-dimensional percept would follow a process as outlined by Lehar when the stimulus is an everyday, familiar experience with established expectations. For any unfamiliar object, whether presented to the eye or hand, exploratory movement is requisite to clarify ambiguities. Here, Lehar is correct to emphasize the translation/rotation invariance of the perception, divorced from the motion of the explorer. The target is perceived as it relates to its environment external to the viewer. This is the essence of the great transformation from egocentric (parietal cortex) to allocentric representation (presumably in the hippocampus or prefrontal cortex). The constancy of the percept over time as another data sample is added with each exploratory movement is also rightly highlighted.

It is essential that perception integrate over time as well as space. Even within one sampling episode, different sensory attributes such as color and motion are processed at slightly different times, although they are perceived as a unity. Hence, Zeki and Bartels (1998) postulate the existence of multiple "microconsciousnesses" in the brain, which are asynchronous with one another. This raises the problem of how they are integrated. A simple possibility is that everything processed within a finite window is integrated, just as two colors flashed within less than 40 milliseconds are blended together. But it cannot be that simple, because haptic exploration of an object can continue for hundreds of milliseconds.

Figure-ground designation also involves time constraints. Neurons in the inferotemporal cortex that are selective for shape maintain that shape preference when light-dark contrast is reversed (negative image) but not when a figure-ground reversal is made. Just as the perception of shape depends on whether a visual region is assigned to an object or background, so the visual analysis of form depends on whether a region is perceived as figure or ground (Rubin 2001). One cannot relegate the problem of resolving border-ownership of edges to earlier stages in the visual stream. It occurs quickly, within 10–25 milliseconds of response onset and really requires feedback from higher cortical areas. Hence, it is an instantaneous, holistic decision of the entire visual system, presumably selecting the most probable choice.

Lehar's excellent model of perceptual processes gives neurophysiology some precise goals and direction. Hopefully, the outcome will be convincing evidence that every percept is associated with a unique distribution of neuronal activity. An immediate problem, however, is the elucidation of the mechanism for binding elements of a percept in time.

The soap bubble: Phenomenal state or perceptual system dynamics?

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Abstract: The Gestalt Bubble model describes a subjective phenomenal experience (what is seen) without taking into account the extraphenomenal constraints of perceptual experience (why it is seen as it is). If it intends to be an explanatory model, then it has to include either stimulus or neural constraints, or both.

While presenting the theoretical background of his approach, Lehar attempts to keep a critical equidistance toward both indirect and direct realism. However, instead of a radically new approach, he offers a combination of some constructivist and some Gibsonian premises. On the one hand, like many constructivists (e.g., Gregory 1971; Hochberg 1978; Marr 1982; Rock 1983), Lehar adopts a representational paradigm that defines perception as a subjective conscious description or as an internal virtual copy of the external world. On the other hand, inconsistent with the constructivists' perspective and more similar to the views of proponents of direct realism (e.g., Gibson 1979; Shaw & Bransford 1977; Shaw & Turvey 1981), Lehar does not postulate any mediating mechanisms that process the representations within a perceptual system.

Moreover, Lehar's exact position concerning the question of direct perception of distal objects is not quite clear. At one point he explicitly claims that "the internal perceptual representation encodes properties of distal objects rather than of a proximal stimulus" (sect. 9, last para.). At another point he states that "the direct realist view is incredible because it suggests that we can have the experience of objects out in the world directly, beyond the sensory surface, as if bypassing the chain of sensory processing" (sect. 2.1, para. 1). Why would the thesis that distal objects are mapping onto the phenomenological domain without neural intervention be incredible and mysterious, while the idea about the projection of internal representation onto the external perceptual world not be incredible and mysterious? How is it possible that perception is partially indirect (representational), and partially direct (distally oriented)?

In his criticism of neurophysiologic modeling, Lehar rejects not only the classical Neuron Doctrine, but also some recent holistic approaches (cf. Crick & Koch 1990; Eckhorn et al. 1988; Singer 1999). Hence, for Lehar, the greatest shortcoming of neural models is not atomism, but rather, the problem of neurophenomenal decoding. That is, how can a fully spatial (topographical) perceptual description be created from spatially less constrained (topological), or even completely abstract, symbolic, and nonspatial neural representation? I find that this epistemological question is a natural consequence of a hidden ontological dualism: How does one domain of reality (consciousness) know how to read and understand the codes coming from the other (neural) domain?

To paraphrase Koffka (1935), the ultimate task for perceptual science is to answer why things look as they do. In the case of Lehar's theory, this question might be formulated as the following: Why is the phenomenal volumetric space such as it is? Why is it nonlinear in a particular way? Implicitly, Lehar proposes that this is an intrinsic property of phenomenal space which is not in a causal relationship with any other domain of reality. My opinion is that without the precise specification of the extraphenomenological aspects of perception, such as the stimulus and neural domains, it is difficult to answer the question related to why the percept looks as it does. For instance, imagine the difficulty in explaining the path shape and velocity of the planet Earth's motion without taking into account the mass and motion of other cosmic objects (moon, sun, other planets, and so on). A description of the Earth's motion is not an explanation of its motion.

Even Gestalt psychologists, who widely utilized the phenomenological method, did not create pure phenomenological explanations of perception. For instance, Koffka (1935) used the soap bubble metaphor, not to describe some phenomenal bubblelike experience, but to point out some basic principles of perceptual (neural) system functioning. Attneave (1982) also used the metaphor "soap bubble system" to describe the economy of perceptual system behavior. Like the soap bubble, which tries to enclose the largest volume within the smallest surface, the perceptual system tends to reduce the global spending of energy (entropy, minimum tendency) while at the same time striving to increase its effective use (dynamics, maximum tendency) (cf. Köhler 1920/1938; 1927/1971; see also Hatfield & Epstein 1985; Marković & Gvozdenović 2001).

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If Lehar intends to create a Gestalt-oriented theory of perception, he has to have in mind that according to the classics of Gestalt theory, the phenomenological Gestalten are the consequences of both internal (neural) and external (stimulus) constraints (Koffka 1935; Köhler 1920/1938; 1927/1971; 1947). Simply speaking, the perceptual system tends to attain the maximum efficiency with the minimum investment (internal neural economy), but the minima and maxima will always be relative to the given stimulus conditions (external stimulus organization). The effect of external "control" of a perceptual economy is an articulation of more or less *prägnant Gestalten,* or as Wertheimer stated in his famous Law of Prägnanz, the phenomenal organization of a percept will be as "good" as the prevailing conditions allow (cf. Koffka 1935).

Bursting the bubble: Do we need true Gestalt isomorphism?

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Abstract: Lehar proposes an interesting theory of visual perception based on an explicit three-dimensional representation of the world existing in the observer's head. However, if we apply Occam's razor to this proposal, it is possible to contemplate far simpler representations of the world. Such representations have the advantage that they agree with findings in modern neuroscience.

Lehar proposes to model visual perception using his subjective visual experience as his source of data. He proposes a perceptual modeling approach because "conventional concepts of neural processing offer no explanation for the holistic global aspects of perception identified by Gestalt theory" (target article, Abstract). This allows him conveniently to ignore current research in visual neuroscience while concentrating on the central issues of the representation of the visual field and of our subjective visual experiences. As he correctly points out, the world we see and experience surrounding us exists only as nerve impulses within our head. Lehar proposes that because our subjective experience of the world is that of a high-resolution three-dimensional volume, and because this representation must exist in our heads, it must therefore be some form of a high-resolution three-dimensional structure. However, this does not necessarily follow. For example, on a computer system it is possible to generate a sparse representation of the world into which it is placed so that the computer could interact with objects in the world in a meaningful manner. Objects could be represented as tokens at such-and-such x, y, and z location, and so forth. There would be no explicit representation of empty space within this sparse representation. Who is to say what the subjective experience of the computer might be?

There is no doubt that my subjective experience of the world is that of a three-dimensional solid environment which I perceive in equal detail in all directions. Yet, as visual scientists and practiced observers, we know that this is patently not the case. Each of our eyes responds to incoming photons in a non-uniform manner and this non-uniformity is further exaggerated in the cortex. The over-representation of the fovea is magnified between the retina and cortex, and the multiple interconnected cortical regions amplify this distinction even further. Most naïve observers are surprised to discover that they have a fovea and amazed that they have a blind spot in each eye. How do we fool ourselves?

The very fact that we are genuinely fooled (until we make careful observations) calls into question the use of subjective experience as the basis for theories of visual perception. Furthermore, although the Neuron Doctrine is indeed the foundation for most modern neuroscience research, I refute the notion that this doctrine implies purely feed-forward models of neurocomputation. Certainly, recent findings in both neuroanatomy (e.g., Angelucci et al. 2002; Bosking et al. 1997) and neurophysiology (Kapadia et al. 2000; Levitt & Lund 1997) emphasize the roles played by feedback and lateral connections in visual processing. Likewise, a number of popular modern computational theories make use of feed-forward, feedback, and lateral connections (e.g., Grossberg 1994). If a Gestalt Bubble model subserves perception, then why do we have so many visual areas, each containing a retinotopic map of visual space?

Is there any evidence for Gestalt-like processes at work neurophysiologically? Recent electrophysiological recordings from as early as the lateral geniculate and V1 have found interactions well outside the classical receptive field (e.g., Blakemore & Tobin 1972; Felisberti & Derrington 2001; Jones et al. 2000; 2001; Kapadia et al. 2000; Levitt & Lund 1997; Solomon et al. 2002; Stettler et al. 2002). Although the source of these interactions (whether they are mediated by feedback or by lateral connections) remains to be elucidated, it is clear that many aspects of grouping, completion, and emergence may well arise from such nonlocal interactions. In addition, recent neurophysiological studies in the primate (e.g., Livingstone & Hubel 1988) suggest that different aspects of a visual scene are represented primarily in different visual streams and areas. Although there is some disagreement as to the amount of segregation of function, numerous neuropsychological studies in humans back up the suggestion that multiple representations exist for different attributes and/or functional roles. One such patient studied by Humphrey and Goodale (1998) suffered from visual-form agnosia (Farah 1990). She was unable to discriminate between visual forms, let alone recognize her friends and family, yet her color vision was close to normal and she could recognize shapes when placed in her hands. Such case studies suggest that the brain encodes the external world using multiple representations, each one perhaps subserving a different role or task rather than a single isomorphistic one.

What Lehar seems to have forgotten is that the high-resolution representation is generated only when we pay attention to the input and focus our eyes on the object or texture under inspection. We need not represent even our immediate environment in high resolution unless we need to interact directly with it. Why waste time and space representing the world in vivid detail when we interact with only a small part of it at any one time? Surely our central representations should be goal-directed. We can always direct our vision to different locations in a scene to find out what is there, and given that most useful scenes are dynamic, why waste effort representing space in high resolution when it is constantly changing? O'Regan (1992) argued along a similar line when he suggested that "seeing constitutes an active process of probing the environment as though it were a continuously available *external memory*" (p. 484, emphasis in original). He suggests that seeing does not involve the reification of a three-dimensional spatial representation of the external world in the observer's head but rather depends on one's ability to interrogate the environment through directed eye movements. It may well be that we have a fuzzy three-dimensional representation of the external world in our heads that we use to help direct eye movements, but I remain to be convinced that we would need or want anything more complex. If we need the detail, we look.

Given the lack of physiological evidence for such a complex and computationally expensive representation, coupled with the lack of necessity for such a complete representation, Occam's razor suggests we burst this Gestalt Bubble model.