"awareness," such as awareness of the emergent properties of a visual object at a given moment, for example, and "consciousness," such as the consciousness of being aware of the emergent properties of a visual object and its significance within a general context, for example, would then have to be made.

Lehar writes that it is of central importance for psychology to address what "all that neural wetware" is supposed to do and to determine which of the competing hypotheses presented in the introduction of his target article "reflects the truth." Who said that science has to bother with metaphors such as "truth"? As far as I understand it, science is all about facts and measures collected within a specific context of boring constraints, usually called "conditions," and therefore inevitably requires a diversity of methods and hypotheses. The concept of "truth" does not appear to be of much use here. Are we not often enough reminded to take care not to get trapped by the metaphors we use to construct hypotheses and explanations? The overwhelming "*Unsumme*" (as defined by Metzger 1936) of bits and pieces of philosophy and phenomenological "brain teasers" we are confronted with in this target article somehow shows how easily we can end up like the Sorcerer's Apprentice in Goethe's poem, who tries all sorts of curses and invokes all sorts of spirits, but is finally unable to take control.

In conclusion, whether theories based on or derived from the Neuron Doctrine will ultimately fail to provide a satisfactory approach to the question of consciousness, remains to be seen. The Gestalt Bubble model, as a scientific approach to consciousness, can be filed DOA (Dead on Arrival).

NOTE

1. After Shakespeare, *Macbeth.*

Just bubbles?

Włodzisław Duch

School of Computer Engineering, Nanyang Technological University, Singapore; Department of Informatics, Nicholaus Copernicus University, Torun, Poland. **wduch@phys.uni.torun.pl**
http://www.phys.uni.torun.pl/~duch

Abstract: Lehar misrepresents the Neuron Doctrine and indirect realism. His conclusions on consciousness are unjustified. The Bubble Gestalt perceptual modeling disconnected from neuroscience has no explanatory power.

1. Perception has not evolved for our enjoyment; it serves action, exploration of the world (see O'Regan & Nöe 2001). Although the richness of visual perception may partially be an illusion, sensory data should elicit brain states that reflect important features of perceptual organization. Such functional representation would be very useful, facilitating information retrieval from visual and auditory cortex, stored in attractor neural networks after termination of direct sensory inputs (Amit 1994). Persistent brain activity may be responsible for visual imagery, filling in, illusory contours, and other such phenomena. This internal representation, being a physical state of the brain, is focused and interpreted by other brain areas, gating it to the working memory and facilitating conscious perception. It is constructed from sparse information obtained from eye fixations between saccades (as is evident in the change blindness experiments; O'Regan & Nöe 2001) and hence may not be as faithful and rich as it seems. Because for many people endowed with visual imagination (individual variance seems to be quite large in this respect) visual experiences are rich and vivid, filling in of missing information must be strong.

2. Construction of the inner perspective is a difficult task. Lehar does not even attempt to enumerate the dimensions required for perceptual modeling that could replace (or at least complement) neural modeling. I have argued myself (Duch 1997) that an intermediate level of cognitive modeling should be useful. It should represent mental events in a way that is closer to our inner perspective, acceptable to psychologists, but should also facilitate reduction, at least in principle, to the neural level. Complex neural systems reveal emergent processes (responsible, as Lehar has noticed, for Gestalt phenomena) requiring a higher level of description characterized by new laws and phenomena. The usual approximation to neural activity misses the perceptual level by going from states of recurrent networks (such as Grossberg's adaptive resonant states; Grossberg 1995) to states of finite automata (cf. Parks et al. 1998 for neural models in psychiatry). A shortcut from neuroscience via neural networks to behavior is satisfactory only to behaviorists. Mind states and mental events may emerge as "a shadow of neurodynamics" in psychological or perceptual spaces (Duch 1997). This is in accord with the ideas of Shepard (1987; 1994), who believes that universal laws of psychology may be found in appropriate spaces. Psychological spaces are spanned by subjective dimensions (such as color, shape, and motion), and one may use them to explain subjective perception and to talk about mental events implemented at the neurodynamical level. Therefore, I sympathize with Lehar's goal, although details of his proposal are not satisfactory.

3. Trivializing the "Neuron Doctrine," Lehar writes about neural networks as the "quasi-independent processors," and "an assembly of independent processors" (target article, sect. 1, para. 3). The whole essence of neural networks is in the interaction of their elements, cooperative computational abilities that facilitate their holistic emergent properties. Recurrent neural networks are certainly not "the atomistic feed-forward model of neurocomputation" (target article, Abstract; cf. Parks et al. 1998). The Neuron Doctrine paradigm has been completely misinterpreted in the target article.

4. The arguments evoked against indirect realism are strange to say the least. Lehar mixes mental and physical levels freely, writing statements like "the world that appears to be external to our head is actually inside our head" and "beyond those perceived surfaces is the inner surface of your true physical skull encompassing all that you perceive" (sect. 2.2, para. 1). How can the physical skull encompass the nonphysical, inner world? "The world inside the head" is a metaphor, and it does not make much sense to invert it, unless one believes that there is some kind of physical world squeezed inside the skull.

Indirect realism claims that we perceive and comment upon the states of our own brain. These states reflect properties of the environment, but interpretation of the spatial structure of the states of the visual system has nothing to do with their physical location. There is nothing strange about it, as there is nothing strange about transmission of the voice and images via wires and radio waves. The spatial world inside the head is there in the same sense as a panoramic image in the integrated circuit of a computer graphic chip. Subjective reversal of a multistable percept follows the change of neural dynamics. It has to be experienced vividly as an inversion of a perceptual data structure, because visual experiences are a reflection of neural dynamics – how else could changes of visual cortex states be experienced?

5. It is certainly not clear "that the most fundamental principles of neural computation and representation remain to be discovered" (target article, sect. 2.4, para. 3). Churchland (1984) had already argued against it 20 years ago, and since that time computational neuroscience has made a lot of progress. It may very well be that Hebbian learning is the only fundamental principle that is needed and that sufficiently complex models of the brain will be able to simulate its emergent functions.

6. It is quite probable that "our own conscious qualia evolved from those of our animal ancestors" (sect. 6.5, para. 3). But certainly the "conclusion" (sect. 6.5, para. 6) "that all matter and energy have some kind of primal protoconsciousness" is not inescapable. In fact, I regularly lose my consciousness in sleep, and anesthetics and damage to the reticular formation lead to coma, obliterating consciousness. Complex organization of matter is not sufficient for consciousness. Instead of looking for conditions necessary for manifestation of consciousness – a fruitful way is to use

here a contrastive approach between perception and reception (Taylor 1999) – Lehar goes down the beaten track of thinking about consciousness as some kind of a substance that is present in all matter, although sometimes in watered-down form. The conclusion of this line of reasoning is absurd: protoconsciousness of soap bubbles.

Of course, because the concept of consciousness is not defined, one may try to extend it to all matter, but talking about stomachs being "conscious" leaves no semantic overlap with the word "conscious" applied to a baby, or to a cat. If consciousness is a function and plays a functional role, as Lehar seems to believe ("It seems that conscious experience has a direct functional role" – sect. 6.5, para. 10), the inescapable conclusion is rather that not all brains are equal. Language is unique to humans, and even though one can extend the concept of language to some more primitive forms of communication, interaction between internal organs of the body or messages passing between components of a computer system is not the same "language" as natural languages. The difference between a "field" in agriculture and "field" in physics is comparable to the difference between animal "consciousness" and "consciousness" of a soap bubble due to the physical forces that determine its shape. We should not be deceived by words.

7. It remains to be seen if the main contribution of the target article, the Gestalt Bubble model, will be useful for understanding or even for a description of perception. The goal of science is not modeling per se but rather explaining and understanding phenomena. Modeling perception should not become an exercise in computer graphics, creating volumetric representations of space and objects. Bubbles of neural activity, as presented by Taylor (1999), have real explanatory power and are amenable to empirical tests. The perceptual modeling proposed by Lehar promises a new language to describe high-level visual perception. Any language that is useful in design and analysis of experiments must reflect more basic neural processes. Nothing of that sort has been demonstrated so far, and it is doubtful that the Gestalt Bubble model can explain observations that have not been hidden in its premises.

Empirical constraints for perceptual modeling

Charles R. Fox

Whitely Psychology Laboratories, Franklin and Marshall College, Lancaster, PA 17604-3003. **charlie.fox@fandm.edu** **http://www.fandm.edu/departments/psych_new/faculty/fox/**

Abstract: This new heuristic model of perceptual analysis raises interesting issues but in the end falls short. Its arguments are more in the Cartesian than Gestalt tradition. Much of the argument is based on setting up theoretical straw men and ignores well known perceptual and brain science. Arguments are reviewed in light of known physiology and traditional Gestalt theory.

Steven Lehar's article purports to present a new model of perception based on Gestalt principles. Lehar raises some interesting issues but in the end falls short of his claims. His heuristic model is more Cartesian than Gestalt and much of his argument is based on setting up straw men. He ignores much of what is known in perceptual and brain science. I will confine myself to these issues, although there are others.

Lehar maintains the Cartesian mind-body distinction and assumes internal representation as a requirement. He also ignores the distinction between conscious perception as active construction and the perception/action continuums implied by physiology and direct perception data. Lehar recycles the Cartesian machinelike body now inhabited by the "ghosts" of mental representations and computations. This dualism is at odds with traditional Gestalt theory (Köhler 1969).

The target article ignores the contemporary distinction between (1) perceptual mechanisms that subserve action; and (2) the cognitive mechanism of recall and analysis; instead, it suggests the latter as the sole perceptual mechanism. This emphasis stems from Lehar's belief that "introspection is as valid a method of investigation as is neurophysiology" (sect. 2.3, last para.). This is not the position of traditional Gestalt theory, which states that "a satisfactory functional interpretation of perception can be given only in terms of biological theory" and warns that "The value of biological theories in psychology is not generally recognized." Gestalt psychology adopted the program of building bridges between psychological rules and the activities of the central nervous system (Köhler 1940; 1947; 1961). Köhler recognized this task as "beyond present *technical* possibilities." These purely technical limits are being overcome today, yet the target article ignores a large body of empirical physiological evidence, some of which is presented below (see also Milner & Goodale 1995 and Gallese et. al. 1999 for summary of some areas). Although we should not limit our theories to physiology, theory must account for known physiology. The target model does not. To take a specific example, the model ignores the important role of eye movements even though they were of concern to the early Gestalt theorists (Koffka 1935) and are a critical part of contemporary perceptual theory (Ebenholtz 2001). More generally, there is ubiquitous evidence, collected over many decades, for the important role of physiological systems in perception. Simply consider the differential perceptions resulting from anatomical and physiological states of sensory end organs. Visual perception in the myopic, dark-adapted, or macular-degenerated eye is more influenced by anatomy and physiology than by computations on a mental image.

Lehar emphasizes computational neuroscience at the expense of known physiology despite his assertion that "most fundamental principles of neural computation and representation remain to be discovered" (sect. 2.4, para. 3). This leads to oversimplification to the point of error. For example, he dismisses direct perception because "No plausible mechanism has ever been identified neurophysiologically which exhibits this incredible property" (sect. 2.2, para. 3) and "all that computational wetware" (sect. 2.1, para. 2) must serve some "purpose" (i.e., "produce an internal image of the world"; sect. 2.1). Yet there is growing physiological evidence to the contrary. As I have discussed elsewhere (Fox 1999), area MST in monkeys (similar to area V5 in humans) shows cells that are responsive to three-dimensional motion information that is characteristic of the type of flow field emphasized by direct perception theory (Duffy & Wurtz 1995; 1997a; 1997b). More recently, direct perception theorists have examined the relation of neural information systems to Tau, a property of environmental optics (Grealy 2002; Lee et al. 2002). Hence, contemporary physiology supports an emerging model suggestive of an environmentally adapted physiology rather than the metaphor of representational/computational "wetware."

Lehar further misrepresents direct perception theory as describing perception "as if perceptual processing occurs somehow out in the world itself rather than as a computation in the brain" (sect. 2.1, para. 1). Using the term "perceptual processing" or "computation" is a serious misrepresentation of direct perception (Gibson 1966; 1979), regardless of where one attributes it. Gibson contends that the perceptual system is sensitive to "affordances" that are naturally occurring and require no processing but rather are directly perceived. The exact characteristics of affordances are disputed, but a recent paper (Chemero 2003) provides a critical analysis and comprehensive definition of the concept of affordances and makes it very clear that affordances are perceived relations that are dynamic but neither computed nor components of computations. This is consistent with the physiology described above.

Gestalt psychology is also misrepresented as a representational/computational approach. I content that a key – perhaps *the* key – insight of Gestalt theory is that adequate knowledge of wholes, such as objects, comes from observing wholes. Such understand-

https://doi.org/10.1017/S0140525X03240097 Published online by Cambridge University Press