Perceptual organization: Gestalt phenomena, psychophysics and phenomenology

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We discuss three aspects of research on perceptual organization: emergence, epiphenomenalism, and experimentation.

Perceptual organization is a vague term sometimes defined as the process by which we perceive our surroundings as a coherent whole. There is considerable debate about the mechanisms that accomplish perceptual organization. There is also disagreement about the methods we use to study perceptual organization. We believe that some of this disagreement is related to a commonly accepted hierarchical characterization of perception. We offer two theoretically convergent approaches to the study of perceptual organization and show that, although the results from these approaches are commensurate, they lend contrasting perspectives on perceptual organization phenomena.

The Bounds of Perception

Discussions of the hierarchy implicit in contemporary research can be found in (Beck, 2001) and (Ullman, 1996). There is a general consensus that low-level or *sensory* processes differ from high-level *cognitive* processes and that perception involves both. It is not clear, however, whether perceptual organization is intermediate to these categories or the result of their cooperation. This makes it difficult to integrate perceptual organization with the existing hierarchy of perception. Consider the following:

(1) *Low-level* processes function to extract physical properties from the environment (e.g., from light and sound). It is "bottom-up" meaning that physical properties are converted into neural properties, independently of a perceiver's knowledge or intent; it is unconscious and involuntary.

(2) *High-level* processes are concerned with the extraction of higher order properties, the interpretation of information acquired at lower levels for purposes of object recognition and classification. This may be influenced by a perceiver's knowledge or intent.

Although the boundaries between these categories of processes are acknowledged by most as fuzzy, they seem to be less fuzzy in practice. Most who study perception attempt to isolate or eliminate one or the other. This poses a problem for those who study perceptual organization because it shares aspects of both high- and low-level perception. It involves bottom-up processing, but is also influenced by a perceiver's knowledge or intent. It is accessible to consciousness, but not necessarily conscious, and like respiration, it is both voluntary and involuntary (Kubovy & Gepshtein, in press). If we eliminate high-level processes we are left with sensory processes and vice-versa. Only if we assume that perceptual organization is intermediate to either level are we left with anything to study. Otherwise we need to study all levels of perception shared by perceptual organization.

Let us consider why those who study sensory processes wish to eliminate higher-level processes as much as possible.

The scientific study of low-level vision and hearing has seen much success because it is grounded in easily quantified properties of the physical world. Another reason is that it does not attempt to explain our conscious experience of the world.

Conversely, progress has been relatively slow in the scientific study of psychological properties that emerge from perceptual organization and high-level perception. We think this is because these properties are not always easily related to metric properties of the physical world and because researchers too often strive to exclude conscious experience from their experiments.

We present three perceptual organization phenomena and contrast two methods to study each. We show that, although the two methods may produce commensurate findings, there are reasons to favor one over the other.

A Perceptual Grouping Phenomenon

When we look at a collection of discrete elements, we often see organized wholes, or *gestalten*, that exhibit characteristics not shared by the parts that make up these wholes. Consider the Gestalt phenomenon of *grouping by proximity*.

Figure 1 shows a dot lattice that can be perceptually organized into columns. With some effort, the lattice can also be perceived as organized by rows.

Although Gestalt psychologists successfully demonstrated the existence of principles that seem to underly many perceptual organization phenomena, they did not identify these principles with their underlying mechanisms or a theory that could make quantitative predictions. A consequence

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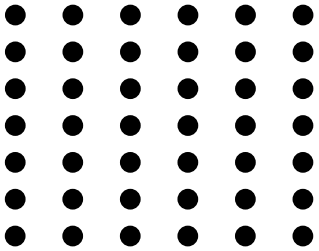

Figure 1. A dot lattice. Although it is ambiguous, it is easier to see as organized by columns than by rows.

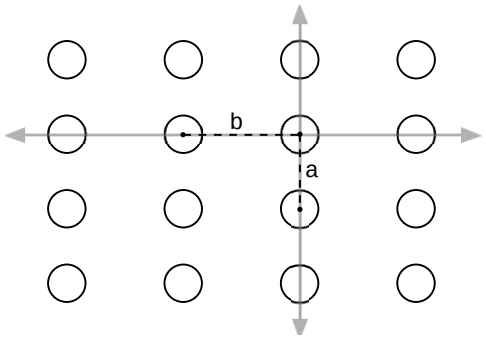

Figure 2. A rectangular lattice.

of this failure is that their work "dissolved into the fog of subjectivism." (Marr, 1982, p. 8).[1] We will show that the power of phenomenological demonstration can be harnessed to yield a quantitative theory and reveal a previously undescribed mechanism.

Psychophysics

Experimental psychology rests on the assumption that there exists a lawful relation between two worlds: a physical world and a mental world. Fechner (1860/1966) embraced this dichotomy and proposed a theory of *psychophysics*. Psychophysics is concerned with the correspondence between quantitative variations in a physical stimulus and the mental experience of the perceiver. In traditional psychophysics a perceiver's performance on a task, say detecting a dim light, is dependent upon his ability to correctly perceive the state of the physical world: Was a light present or not?

Fechner not only believed that the "sensory side of mind [has an] exact connection" (Fechner, 1860, p. 12) with the physical world, he was also confident that this is true of emergent psychological properties.

> Indeed, I feel that the experience of harmony and melody, which undoubtedly have a higher character than single tones, is based on the ratios of the vibrations that themselves underlie the separate sensations, and that these ratios can exchange only in exact relationship to the manner in which the single tones are sounded together or follow one another. Thus, harmony and melody suggest to me only a higher relation, and not one lacking a special relationship of dependency between the higher mental sphere and its physical basis. [p. 13]

We will compare two experimental methods as applied to grouping by proximity in dot lattices. We will also present two related phenomena and the methods we used to investigate them. Finally, we will discuss the role of phenomenology in the psychology of perception.

Experimental Methods

The stimulus

Bravais (1850/1949) pioneered crystallography by developing an exhaustive classification of lattices. We will only consider one of these, the *rectangular* lattice (Figure 2). The rectangular lattice can be specified by its two shortest translations along *a* and *b*.[2]

Figure 3 shows four possible orientations of *phenomenal contours* (PCs), groups of dots that can be connected by a straight line. We will call the ratio of the two shortest distances the *aspect ratio* (AR). An experiment is necessary to determine the relation of AR to the probability of spontaneously perceiving a particular PC.

Traditional psychophysics

We could use traditional psychophysics to assess the effect of AR on the probability of seeing a PC. Observers would see a briefly presented (<500 milliseconds) lattice and asked to indicate whether they saw one of the four PCs in Figure 3 (upper left). We will call this the *target* PC (*t*PC). The *t*PC would be always be the shortest distance between dots, or the second shortest distance. Observers would be shown the orientation of the *t*PC *before* each presentation of a lattice. This procedure would be repeated for a variety of lattices with different ARs, in a variety of orientations, for each of the *t*PCs.

From the data we would compute the probability of seeing the *t*PC as a function of AR. We might expect a function like that shown in Figure 4.

Talk about priming? Mental set? Demand characteristics, etc.

Phenomenogical psychophysics

We offer a variant of psychophysics called *phenomenological psychophysics* (Kubovy & Gepshtein, in press), in which

[1] We are not in agreement with Marr's statement, but use it to remind the reader that current approaches to perceptual organization are not sympathetic to the methods used by Gestalt psychologists.

[2] In fact, *all* lattices can be specified this way. The interested reader can learn more about the mathematics of lattices and other patterns in Martin (1982), Grünbaum and Shephard (1987).

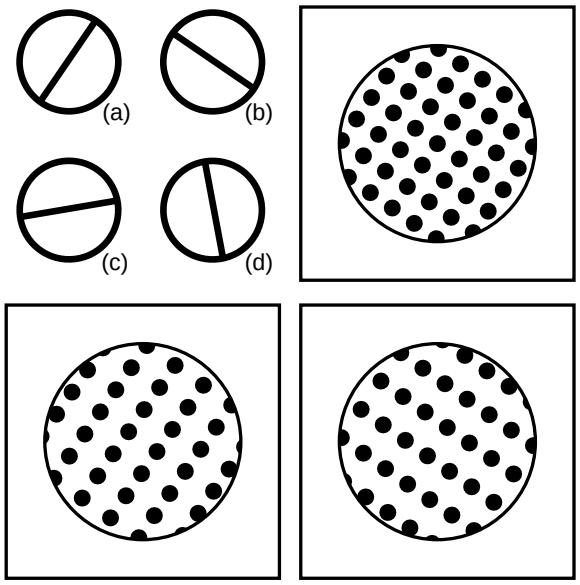

Figure 3. Upper-left: Possible perceived orientations of PCS in three dot lattices. In the top-right lattice, the shortest distance between dots is equal for two orientations, *a* and *b*; the distance between *c* and *d* is also equal. In the bottom two lattices, the shortest distance between dots pertains to orthogonal PCS, *a* and *b*.

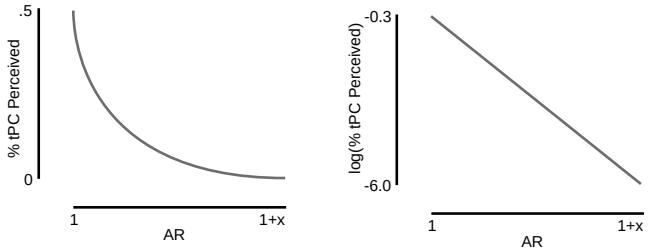

Figure 4. Hypothetical data from a traditional psychophysics experiment using dot lattices.

the response of an observer is a report of phenomenal experience. This response is not labeled "correct" or "incorrect" based on the state of the physical world. To understand the the difference between traditional psychophysics and phenomenological psychophysics, consider the following.

Kubovy and colleagues (1995, 1998) used a different procedure to obtain the probability of seeing a *t*PC as a function of AR. Instead of telling observers what to look for, they presented observers with lattices (for $<$500 milliseconds) and had them choose one of the four PCs in Figure 3 *after* the lattice was presented. From this they obtained what they call an *attraction function*. The attraction function is the probability of seeing the PC with the shortest inter-dot distance.

We see that the end result of either method is similar: the probability of perceiving a particular organization as a function of relative distance. The difference lies in the task. The goal of traditional psychophysics is to measure of performance on an objective task. There is some disagreement on

Other grouping phenomena

An experiment in audition

A psychophysics of pointing

We will now consider an experiment that address grouping by proximity in auditory perception.

We will see that traditional psychophysics is not easy to apply to auditory streaming.

Phenomenology

Perhaps we can insert a short dialogue here?

Locke (date?) distinguished two qualities (and a "power" – footnote) of the psychological world: primary qualities (those that are qualities of both the physical world and the mental world; "ideas are like the properties of the objects that produce them" p.175, Boring), and secondary qualities (only pertain to the latter; "ideas do not resemble the properties of the object at all" – same pg.). Note: primary qualities reside in the object; they are NOT subjective. Secondary qualities, though they are NOT ideas, but they produce ideas just like primary qualities, are NOT in the objects, but rather, "powers" of the primary qualities.

We will not address philosophical problems associated with this distinction. Instead, we will show how we have exploited this distinction in our attempts to understand the mental world as a function of the physical world. In particular, we will focus on emergent properties that exhibit lawful behavior. We will show that the lawfulness of this behavior can be articulated as a *psychophysical* law that explains the relation between manipulations of the physical world and the phenomenological consequences for the mental world (Fechner -1860?).

One psychophysical theory, the Theory of Signal Detectability (TSD), uses a combination of statistical decision theory and the concept of the ideal observer to model an observer's sensitivity to events in its environment. TSD is stimulus-oriented, because properties of the stimuli are used to determine the theoretically best, or ideal, observer for a given detection task. This observer may then be used to compare the performance of human, and other, observers. For instance, the ability of humans to detect simple acoustic waveforms can be modeled as a linear system consisting of a filter, rectifier, integrator, and sampler.

Gestalt psychologists were interested in emergent properties: phenomena wherein the whole is different from the sum of the parts. We will distinguish two types of emergent properties. One is *preservative*, the other *eliminative*.

relation to resultants? (as opposed to emergents, no?)

(seemingly) emergent psychological properties.

quantification of stimulus (physical world) and relation to measurement of psychological properties

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