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Infotropism as the underlying principle of perceptual organization ☆

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ABSTRACT

Whether perceptual organization favors the simplest or most likely interpretation of a distal stimulus has long been debated. An unbridgeable gulf has seemed to separate these, the Gestalt and Helmholtzian viewpoints. But in recent decades, the proposal that likelihood and simplicity are two sides of the same coin has been gaining ground, to the extent that their equivalence is now widely assumed. What then arises is a desire to know whether the two principles can be reduced to one. Applying Occam's Razor in this way is particularly desirable given that, as things stand, an account referencing one principle alone cannot be completely satisfactory. The present paper argues that unification of the two principles is possible, and that it can be achieved in terms of an incremental notion of 'information seeking' (infotropism). Perceptual processing that is infotropic can be shown to target both simplicity and likelihood. The ability to see perceptual organization as governed by either objective can then be explained in terms of it being an infotropic process. Infotropism can be identified as the principle which underlies, and thus generalizes the principles of likelihood and simplicity.

1. Introduction

Processes of perceptual organization provide a fascinating insight into the interpretive faculties of the human mind. While we generally have no conscious awareness of any separation between cognitive and perceptual levels of interpretation, visual stimuli can be devised that show this to exist. The two levels can operate quite independently in some situations. The classic demonstration is the Necker cube. This is a wire-frame image of a cube, drawn so as to eliminate the foreshortening that would normally suggest a particular orientation (see Fig. 1). On viewing this image, people usually recognize it to represent a 3-dimensional cube, but report a perception that flips slowly back and forth between two orientations. This reveals the degree to which perceptual organization can operate as an independent process of interpretation.

The Necker cube is far from unique in this respect. Hundreds of examples now exist of visual stimuli that prompt unstable, surprising, impossible, unpredictable, humorous or erroneous interpretations. Such 'visual illusions' demonstrate the remarkable extent to which perceptual processes can march to their own beat (see Figs. 2 and 3). At the same time, they beg the question of principles. The more we recognize the potential decoupling of perceptual interpretation, the more we would like to know the principles that apply. If perceptual organization proceeds according to specific rules, it is important to know what these are.

The attempt to understand the principles of perceptual organization has been underway for well over a century. In the early years of the 20th Century, theorists of the Gestalt school tried to explain perceptual organization in terms of some 114 laws, such as *good continuation*, *symmetry* and *closure* (Pomerantz & Kubovy, 1986; Wagemans et al., 2012). From this set, Boring extracted 14 condensed laws, including *naturalness of form* and *persistence of form* (Boring, 1942, pp. 253–254). It is a key to the Gestalt approach, however, that such laws grow out of the general principle of prägnanz. This asserts, roughly, that stimuli are organized in the way that most simplifies their global structure. The Gestalt approach has thus come to be associated with the proposition that *simplicity* is the governing principle of perceptual organization, i.e., that it is the simplest interpretation of a distal stimulus that is preferred (Attneave, 1954; Hochberg & McAlister, 1953).

Contrasting with this is the Helmholtzian view of perceptual organization. Stemming from the work of von Helmholtz (1860/1962), this also has complex and diverse origins. What is key for present purposes is the commitment made to the *likelihood principle* (Brunswick, 1956; Gregory, 1974). This states that 'sensory elements will be organized into the most probable object or event (distal stimulus) in the environment consistent with the sensory data (the proximal stimulus)' (Pomerantz & Kubovy, 1986, pp. 36–39). The claim, in this case, is that preference is given not to the simplest, but to the most likely interpretation of the distal stimulus.

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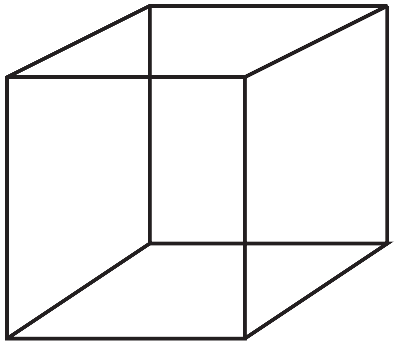

Fig. 1. The Necker cube.

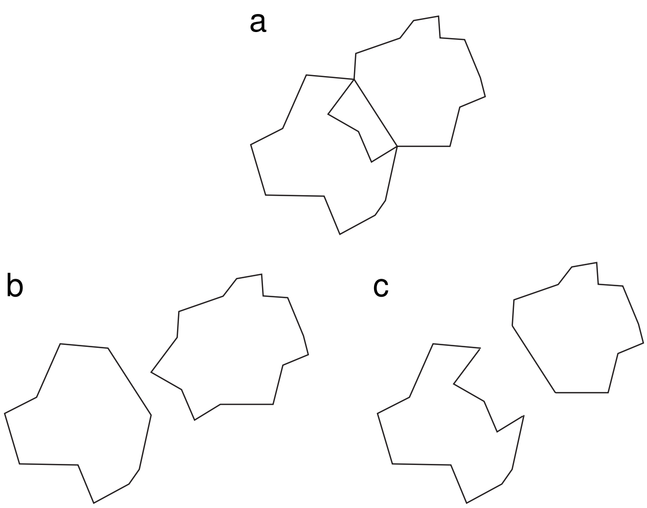

Fig. 2. The pattern in (a) tends to be organized as two superimposed figures, as in (b), rather than (c).

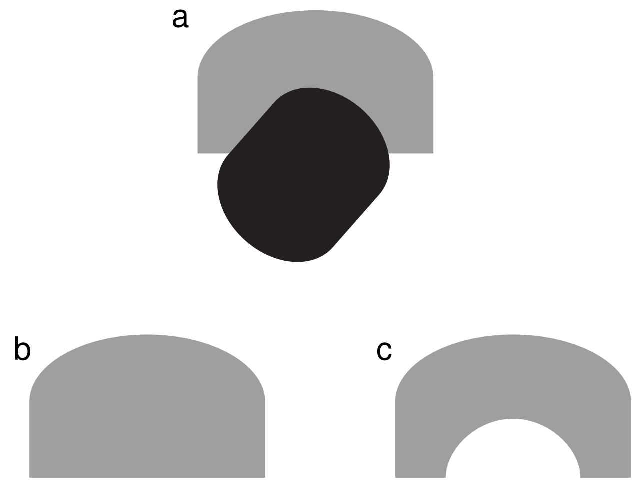

Fig. 3. A perceptual preference relating to an occluded shape. The dark area in (a) tends to be perceived as a shape occluding (b) rather than (c).

To some degree, the attempt to explain perceptual organization has come to be framed as a debate between those who take perceptual organization to be governed by simplicity, and those who take it to be governed by likelihood (Hatfield & Epstein, 1985; Leeuwenberg & Boselie, 1988; van der Helm, 2000). But the possibility of these principles being intimately related is also considered plausible. Brunswick argues that they might co-exist (Brunswick, 1956). Mach proposes that the visual sense operates in conformity with both Mach (1906/1959). Attneave (1982) suggests they may be two sides of the same coin. Chater (1996) argues they are undifferentiable. He makes the point that a more probable perceptual representation can always use default assumptions to a greater degree, thereby increasing apparent simplicity. He also sets out a mathematical proof which demonstrates that simplicity and likelihood are formally equivalent.[1]

If simplicity and likelihood are two sides of the same coin, the disagreement between the Gestalt and Helmholtzian positions looks set to dissolve. But there then arises a strong desire to know if the two principles can be reduced to one. Is a unification feasible? Applying Occam's Razor in this way seems particularly desirable given that, as things stand, an account that references one principle alone cannot be completely satisfactory. If it invokes the simplicity principle alone, it misses the point about likelihood. If it invokes the likelihood principle alone, it misses the point about simplicity.

The present paper takes the position that the two principles can indeed be reduced to one. The proposal, specifically, is that the equivalence of simplicity and likelihood can be explained in terms of *infotropism*, which is the label the present paper gives to information seeking. It is shown that processing which behaves in this way acts in conformity with both principles. Any explanation in terms of simplicity or likelihood can thus be reduced to an explanation in terms of infotropic processing.

The argument is developed over four main sections. The section immediately to follow (Section 2) introduces inverse information measurement, which is key for characterizing infotropic processing. Section 3 demonstrates the sense in which infotropic processing of representations has the effect of targeting both simplicity and likelihood. Section 4 discusses related work, and examines the more general implications of the proposal. Information theory is the main reference throughout. But the information-theoretic concepts used are at the simpler end of the mathematical spectrum, and they are all explained informally within the text. A full understanding of Shannon information theory is not required. Two technical points are also worth mentioning at the outset. Many of the examples in the text cite information values. These are rounded to two decimal places where necessary. Logarithmic values are calculated to base 2 in all cases.

2. Inverse information measurement

It is almost a century since R.L. Hartley first proposed the principle of logarithmic measurement on which information theory is based. Hartley noted that the informational value of an outcome drawn from a choice of N is naturally measured using a logarithm of N (Hartley, 1928). Assuming logs are calculated to an integer base, this is the number of digits (in that base) required to identify or communicate the outcome. Given use of base 2, information values can then be expressed in terms of binary digits or 'bits'. The informational value of an outcome drawn from a choice of N is said to be $\log_2 N$ bits. This is just the number of binary digits required to communicate a 1-in-N outcome. The metric can be applied to any situation that presents a well-defined choice of outcomes. There is no requirement for a communications context. Consider, for example, a party cracker that contains either a paper hat or a gift. Here, there are just two outcomes. Given $N = 2$, the informational value of an outcome is $\log_2 2 = 1$ bit. The outcome obtained by pulling the cracker has an informational value of 1 bit.

[1] Chater uses Kolmogorov complexity theory (Chaitin, 1966; Kolmogorov, 1965; Li & Vitanyi, 1997; Solomonoff, 1964) for this. The proof is not uncontroversial, however. In the view of Feldman (2009, p. 885), Chater shows in a 'a very general but also somewhat abstract sense' that the two principles are identical. But van der Helm argues the proof is invalid due to mistaking 'the Bayesian formulation of the Occamian simplicity principle for the Helmholtzian likelihood principle' (van der Helm, 2011, p. 340; see also van der Helm, 2000).