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1 Editorial: Perceptual Grouping - The State Of The Art

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4 Perceptual neuroscience has identified mechanisms of *perceptual grouping* which account for the
5 ways in which visual sensitivity to ordered structure and regularities expresses itself, in behavior and
6 in the brain. The need to actively construct order, notably representations of objects in depth, is
7 mandated as soon as visual signals reach the retina, given the occlusion of retinal signals by retinal
8 veins and other retinal elements or blur. Multiple stages of neural processing transform fragmented
9 signals into visual key representations of 3D scenes that can be used to control effective behaviors.
10 Since our survival depends on our abilities to pick up order in the physical world, and since we
11 conceive the physical world as an ordered one, our perception of it must somehow be sensitive to
12 order. The articles from this collection illustrate how texture dissimilarity, boundary completion,
13 surface filling-in, and figure-ground segregation generate perceptual order. Structural regularities are
14 required for a visual texture to be discriminated from random noise by human observers, as shown in
15 <https://doi.org/10.3389/fpsyg.2015.00734> , where Katkov, Harris and Sagi compare the performance
16 of human observers to those of an Ideal Observer and an Order Observer model. The Order Observer
17 model, based on the capture of statistical regularities in textures, is shown to closely reflect the
18 sensitivity of the human visual system. Spatiotemporal boundary formation is critical to the
19 perception of shape boundaries and global motion <https://doi.org/10.3389/fpsyg.2016.00910>, as
20 shown here by Erlikhman and Kellman, who demonstrate boundary integration from spatially and
21 temporally sparse transformations of texture. The visual system uses positions and times of element
22 transformations to extract local structural regularities such as edge fragments, which then connect by
23 interpolation processes to produce larger shapes with a spatiotemporal integration constraint of ~80
24 ms between elements. Structural ambiguity and uncertainty pose a specific problem here. *Perceptual*
25 *grouping* not only accounts for the ways in which physically defined order is processed by the visual
26 system, but also how such order may be inferred in cases of uncertainty, and how this may give rise
27 to the perception of "illusory" or "phantom" shapes. Roncato, Guidi, Parlangei and Battaglini
28 discuss a new phenomenon <https://doi.org/10.3389/fpsyg.2016.00959> in which illusory streaks
29 irradiate from the vertexes of angular contours, connecting pairs of figures and forming phantom net
30 shapes that are only clearly visible in a specific figural context, as discussed here in the light of
31 several theories of object contour detection. The real world conditions or configurative order to
32 which *perceptual grouping* is sensitive also determine our aesthetic perception, as shown already
33 elsewhere in a large body of previous work on aesthetic preferences for structural regularities. Here,
34 Pinna, Porcheddu and Deiana <https://doi.org/10.3389/fpsyg.2016.01051> discuss a novel variant of
35 *perceptual grouping* called *accentuation for perceptual coupling*. New conditions for grouping that
36 cannot be explained in terms of the classical Gestalt principles (similarity etc) are shown. This new
37 work reveals the supremacy of dissimilarity as an important figural complement to similarity in the
38 genesis of aesthetic structure, involving novel dynamics of perceptual grouping they call *coupling*.
39 The visual system organizes incoming information early on and interprets a 2D image in terms of the
40 real world, producing configurative order that provides perceptual continuity and enables object-
41 based attention. In <https://doi.org/10.3389/fpsyg.2015.02054> Grossberg reviews the Form-And-
42 Color-And-DEpth (FACADE) model and its laminar cortical embodiment and extension by the 3D
43 LAMINART models. These have explained, simulated, and predicted many perceptual and
44 neurobiological data about how the visual cortex carries out 3D vision and figure-ground perception,
45 and how these cortical mechanisms generate 3D percepts from 2D pictures of occluding and
46 occluded objects. The models provide a unified explanation of neurophysiological data about cortical
47 area V2 cells reported in a remarkable series of articles from the von der Heydt laboratory. Properties

48 of border ownership, contrast preference, binocular stereoscopic information, selectivity to side-of-
49 figure, Gestalt rules, strength of their modulation by attention and temporal properties are explained.
50 The segregation of image parts into foreground and background requires border ownership
51 assignment by the visual system and recordings from monkey visual cortex show that many neurons,
52 especially in area V2, are selective to border ownership. These neurons are edge selective and have
53 classical receptive fields (CRF). Their responses are modulated (enhanced or suppressed) depending
54 on the location of a 'figure' relative to the edge in their receptive field. Each neuron has a fixed
55 preference for location on one side or the other. This selectivity is derived from image context far
56 beyond the CRF. In <https://doi.org/10.3389/fpsyg.2015.01695> von der Heydt reviews evidence
57 indicating that border ownership selectivity reflects the formation of early object representations,
58 which he terms 'proto-objects'. The evidence includes experiments showing (1) reversal of border
59 ownership signals with change of perceived object structure, (2) border ownership specific
60 enhancement of responses in object-based selective attention, (3) persistence of border ownership
61 signals in accordance with continuity of object perception, and (4) remapping of border ownership
62 signals across saccades and object movements. Grouping, persistence, and remapping are shown to
63 be manifest in low-level visual areas, which challenges some of the traditional views and top-down-
64 only models of *perceptual grouping*. To generate perceptual judgments relative to figure and ground,
65 polarity-invariant and polarity-specific object properties are used by the visual brain. Dresch-Langley
66 and Grossberg <https://doi.org/10.3389/fpsyg.2016.01102> demonstrate conditions under which figure-
67 ground is determined by the orientation of contrasts, not by their relative sign (Dresp, 1998; Dresp &
68 Fischer, 2001; Dresp & Langley, 2005). Psychophysical data from human observers responding to
69 structurally ambiguous, fragmented 2D shapes with varying local contrast signs reveal polarity-
70 invariant perceptual grouping predicted by the earliest version of the FACADE theory and, more
71 recently, by the 3D LAMINART models. Research into processes of *perceptual grouping* has
72 important societal and technological aspects, for visual interface design and, in particular, image-
73 guided surgery platforms and simulators. Such implications, brought forward here by Dresch-Langley
74 in <https://doi.org/10.3389/fpsyg.2015.01565> illustrate why boundary completion and figure-ground
75 segregation are not only essential for realistic scene perception, but also for visually guided action
76 planning (Bonnet & Dresp, 2001), visual consciousness (Dresp-Langley & Durup, 2009; 2012) and
77 behavior.

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