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Relative motion, not polarity, breaks ‘surface tension’

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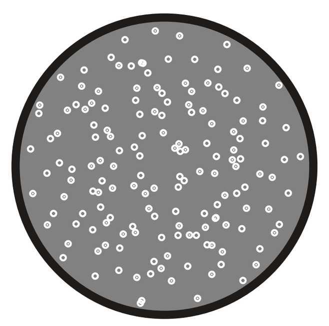
Surface Tension

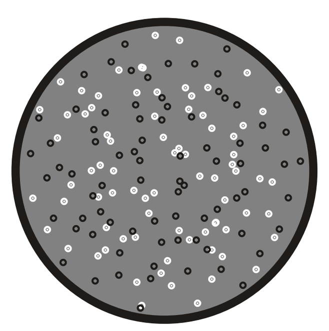
The bits and pieces of visual information in a region of space are held together to form a common surface by their “surface tension”

A scattering of static, co-planar dots has high surface tension.

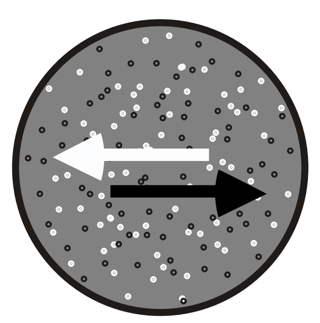


A field of black and white dots has lower surface tension.

Statistically, two regions that differ in polarity likely belong to different surfaces.



If the black and white dots have distinct motion vectors, surface tension is broken.

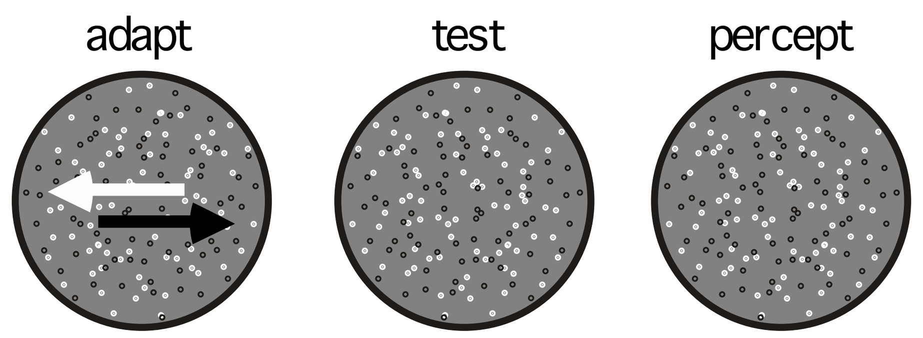


A formalization of surface tension is an ongoing project.

Motion Aftereffect

What are the necessary and sufficient conditions for surface tension to be broken?

For instance, it is notoriously difficult to establish a satisfying ‘transparent’ motion aftereffect (a MAE that appears to contain two motion vectors in the same region).



Here the resulting percept, anti-climactic as it is, is a static field.

This seems strange, because though most of the motion signals induced by adaptation cancel out because they arise from the same place in space and time, the polarity-contingent signals should not.

We know that different motion signals are sufficient to break surface tension (as it did in the adaptation display itself!) .

So, then what happened to the polarity-contingent MAE? Why doesn’t it break the test field into two transparently moving surfaces?

Hypothesis

Surface organization can override local motion information.

More specifically:
The polarity-contingent motion signals alone are too weak to break the surface tension.

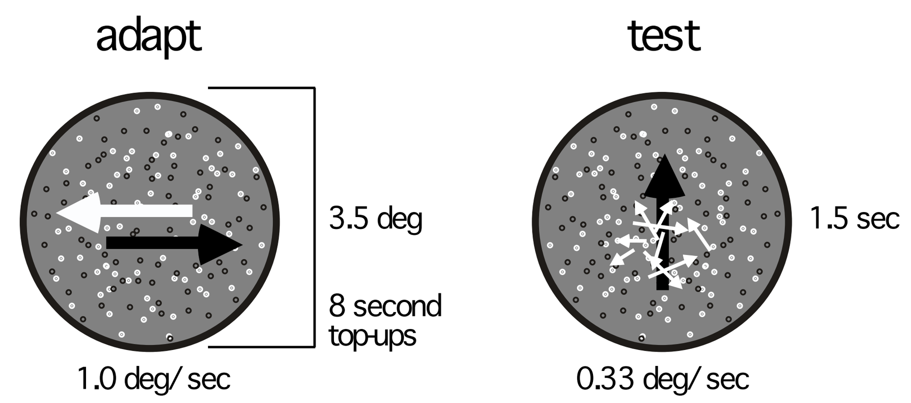
And since a single surface can only be assigned a single direction of motion....

The signals are suppressed.

It stands to reason then, that if we can break the surface tension with some other cue, then the polarity-contingent MAE will be free to express itself.

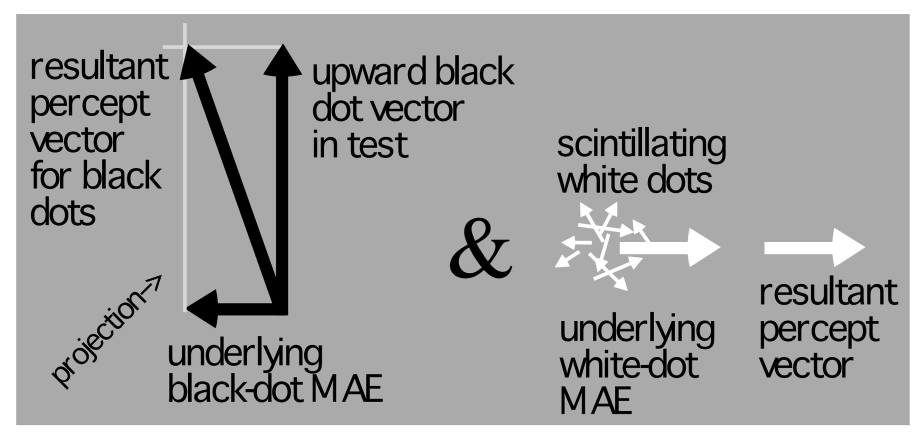
Test

To force the test display to appear as two surfaces, we introduce a strong relative motion cue, orthogonal to the adapting motion.



For instance, here black dots move upward, while white dots scintillate (static dots with limited lifetimes)

If the polarity-contingent MAE reappears, the axis of the motion of upward black field will tilt. White dots will drift.



We can measure the angle of this tilt, from which we can derive the strength of the underlying polarity-contingent MAE (the projection of the percept vector onto the adaptation axis). We can also measure the drift of the scintillating field directly.

Results

Two expert and one naive observer show both the tilts and drifts consistent with the re-expression of the polarity-contingent MAE.

After adaptation with a top-up procedure, depending on condition, observers judged tilt (clockwise or counter-clockwise) or drift direction. A Quest staircase procedure manipulated the angle or drift speed of a nulling test stimulus to determine thresholds.

Table of results:

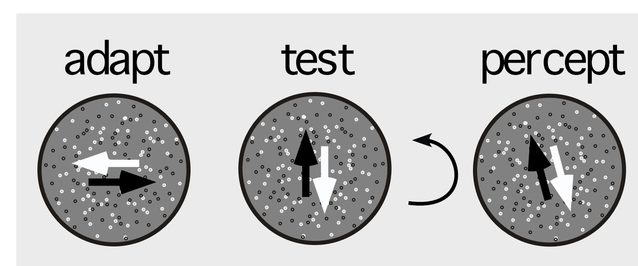
	angle	proj.	drift	std. MAE
EB	6.13	0.035	0.030	0.145
ZV	4.16	0.024	0.081	0.184
CL	6.71	0.039	0.048	0.100
	degrees deviation from vertical	deg/ sec	deg/ sec	deg/ sec

These results are collapsed over polarity.

‘Standard’, non-contingent, single field MAE magnitudes are shown for comparison.

In another condition, black moved upward and white downward in the test stimulus. Observers judged the tilt of the shear. These results support those above:

	angle
EB	3.16
ZV	2.84
CL	3.63
DM	4.03
TP	5.04
WS	8.28

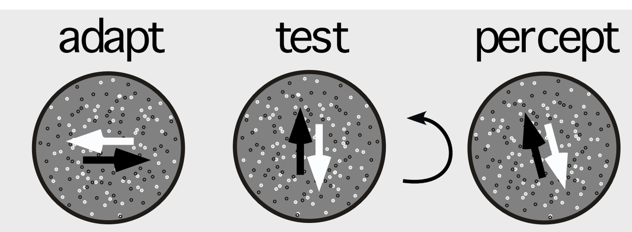


Conclusions

Dot polarity, coupled with polarity-contingent motion signals are insufficient to break the ‘surface tension’ of a field of white and black dots.

However, these suppressed motion signals can be resurrected if surface tension is broken by using another cue - this study used relative motion.

Novel test



A nice feature of the adapt-test paradigm we used is the fact that all but the contingent adaptation signals cancel out; while the addition of further surface cues can tease out reclusive effects.

Selected references:

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Purpose. To investigate the rules that underlie visual surface integration and segmentation. **Methods.** Observers viewed motion transparency: two fields of superimposed, drifting dots. One field (of black dots) drifted rightward, the other (white dots) leftward. This stimulus was used as the adaptor in a motion aftereffect (MAE) paradigm. **Results 1.** When tested with a static field of black and white dots, no MAE was reported; i.e. the expected polarity-contingent MAE was not expressed. Any polarity-contingent MAE would have to have shown up as a transparent MAE (that is, with the black dots in the test field undergoing illusory motion to the left simultaneously with the superimposed white dots undergoing illusory rightward motion); such effects are notoriously difficult to produce (because, we hypothesize, such a stimulus is treated as a single surface, which is assigned a single direction of motion). However, we reasoned that if we facilitated the segmentation of the black and white surfaces during testing, the MAE could be expressed. **Results 2.** Using the same adaptor described above, we then introduced a relative motion cue into the test (white dots moving upward, black downward). Now any horizontal polarity-contingent MAE would be added to these vertical motion vectors, producing a, in this case, clockwise deflection of the perceived shear axis. Four observers perceived tilts of 4-8 deg. **Conclusions.** Polarity alone was not sufficient for segmentation of the two surfaces (a likely necessary condition if each are to move in different directions), and hence the polarity-contingent MAE was either actively suppressed, or too weak to break this ’surface tension’. Only when a powerful relative motion segmentation cue was added was the surface tension broken, and the polarity-contingent MAE expressed. Ongoing studies are quantifying the contribution and interaction of such surface segmentation cues.