What motion transparency has taught us about visual information processing.
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Motion processing is one of the most important faculties of the human brain. Currently, a lot is known about motion processing at the front-end level, often considered as the local motion stage. We are also gaining insight in higher stages of visual motion processing, often indicated by the term ‘global motion processing’. One phenomenon that falls into this category is known as motion transparency or transparent motion (e.g., Snowden & Verstraten, TICS, 1999). I will review the current status and especially focus on recent findings that show that motion transparency can help us to investigate two surface grouping strategies. One based on feature integration and another on temporal synchronicity. Our stimuli consist of dots which are changing their direction periodically over a short distance at a constant velocity. This stimulus allows us to vary the relative strength of the two grouping strategies. The results show that when the timing of the direction changes is random (zero synchronicity between the dots), the configuration results in a compelling percept of streaming motion transparency that cannot be distinguished from continuous motion transparency. As the synchronicity of the dots’ direction changes increases, the percept of streaming motion transparency changes drastically towards a percept of globally oscillating surfaces, that is, a pair of global surfaces is moving back and forth. The experiments also show that local signals, inconsistent with a surface interpretation, are prevented from further visual processing required for conscious perception of the dots.

The spatial extent of centre-surround suppression for complex stimuli
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Natural images have a characteristic second order statistics since their average amplitude spectra fall with spatial frequency (f) as 1/f α, where α is about 1.0. Previously, we have shown that the perceived contrast of a small central texture patch (1x1 deg) is suppressed when it is surrounded by natural images (4x4 deg) of varying α values and that this suppression is maximal around the α value of 1.0. Here we explored the spatial extent of this suppression.

Stimulus images consisted of a central texture patch (1x1 deg) centred on a background image. Images were either photographs or were derived from random luminance patterns (256 grey-levels), filtered to different α values. Stimuli were presented on a 21" monitor (120Hz) using a VSG graphics board. Contrast suppression was measured using a nulling paradigm.

First, we determined the α at which maximal suppression occurred using 4 different surround sizes (1.5x1.5, 3.0x3.0, 6x6 deg). Suppression of the perceived central patch contrast increased with surround size but maximal suppression always occurred with surrounds of α = 1.0. Thus, the tuning to an α = 1.0 appears to be scale invariant at those surround sizes.

Next, we measured the spatial configuration of this suppression by surrounds with an α of 1.0 using surround stimuli of different area and of equal area but with different separation from the centre. We found that, for surrounds with the characteristic statistic of natural scenes (i.e. α = 1.0), the suppressive region is predominantly localised to 0.4 deg, from the edge of the central patch.
Attention and Inference in Vision

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We investigated the role of spatial-temporal priors in visual perception. We performed experiments on human subjects, in which subjects were asked to track a small dot on the screen as it moved towards a vertical occluder, which was clearly visible. The point initially moved purely horizontally. At subsequent time steps the speed was held constant while the direction of the velocity was sampled from a unimodal probability distribution which was symmetric about the current direction. As soon as the dot reached the occluder's side, it emerged on the other side of the occluder and then continued on a path with information about the characteristics of the path with information about the scene. We discuss and model this data in terms of a probabilistic account of motion perception.

Estimating dot motion behind an occluder

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The human visual system often encounters situations in which moving objects disappear behind an occluding surface, such as when a person is behind a car, or a car is behind a car. In such situations, it might be beneficial to predict where the object will emerge on the other side of the occluder. Here we investigate the information in the scene, and in particular the prior distribution, which was symmetric about the current direction. As soon as the dot reached the occluder's side, it emerged on the other side of the occluder, as well as indicating a vertical interval around that point that they were certain would capture the dot as it emerged. Between trials the variance of the distribution increased. The capture region also increased in size with increasing occluder width, however, we found no effect of speed. A circle viewed from the side will appear more circular than the ellipse projected onto it. The position of a moving object can be perceived shifted in the direction of motion when in edge fixation. A target was presented next to one moving Gabor and observers had to report its polarity (dark vs. bright). Before the onset of the trial, the location of the target was hinted by a cue which was valid 75% of the time. As expected, the valid cues led to better discrimination of the stimulus than in valid trials. After invalid cues, a masking effect occurred, but its location was more difficult to detect as it was masked by the motion. This could be explained by examining attentional effects to the front side of the moving object. Four grating masks with different temporal frequencies were presented in front of the moving object. When attention was drawn away from the moving object, a motion-induced masking effect appeared consistently.

Modifying dot motion with haptic priors

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We investigated the role of spatial-temporal priors in visual perception. We performed experiments on human subjects, in which subjects were asked to track a small dot on the screen as it moved towards a vertical occluder, which was clearly visible. The point initially moved purely horizontally. At subsequent time steps the speed was held constant while the direction of the velocity was sampled from a unimodal probability distribution which was symmetric about the current direction. As soon as the dot reached the occluder's side, it emerged on the other side of the occluder, as well as indicating a vertical interval around that point that they were certain would capture the dot as it emerged. Between trials the variance of the distribution increased. The capture region also increased in size with increasing occluder width, however, we found no effect of speed. A circle viewed from the side will appear more circular than the ellipse projected onto it. The position of a moving object can be perceived shifted in the direction of motion when in edge fixation. A target was presented next to one moving Gabor and observers had to report its polarity (dark vs. bright). Before the onset of the trial, the location of the target was hinted by a cue which was valid 75% of the time. As expected, the valid cues led to better discrimination of the stimulus than in valid trials. After invalid cues, a masking effect occurred, but its location was more difficult to detect as it was masked by the motion. This could be explained by examining attentional effects to the front side of the moving object. Four grating masks with different temporal frequencies were presented in front of the moving object. When attention was drawn away from the moving object, a motion-induced masking effect appeared consistently.
was obtained for stimuli with static pedestal, flicker frequencies beyond 4 Hz, and disparities outside Panum's fusional area. Therefore the present result does not support the notion of an early binocular motion system that can integrate dichoptic motion on different depth planes.

Computational motion-stereo model and dichoptic motion stimuli
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We used dichoptic motion stimuli to investigate a computational motion-stereo model (Qian & Andersen, 1997 Vision Research, 37, 1683-1698). The performance of the model is analysed for a set of model receptive fields tuned to different interocular phase differences and velocities. Despite well-established empirical evidence that sinusoidal flicker presented in spatio-temporal quadrature in a Wheatstone configuration is perceived as either left or right motion our simulations demonstrate that the integrated motion-in-depth model fails to produce the same result. For dichoptic motion the motion-stereo model predicts two opposite motions in different depth planes. Therefore, if the model is indeed correct, there ought to be a higher level system that makes a decision about motion and depth based on the output of the motion-stereo model.

Motion Transparency and Depth Perception
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Local and global interactions in motion aftereffects
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The motion aftereffect (MAE) can be observed following protracted observation of a pattern that is translating, rotating, or expanding/contracting: a static pattern appears to move in the opposite direction (reviewed by Wade and Verstraten, 1998). The phenomenon has long been known, and it continues to present novel properties. One of the novel features of MAEs is that they can provide an ideal visual assay for distinguishing local from global processes. Motion during adaptation can be induced in a static central grating by moving surround gratings; the MAE is observed in the static central grating but not in static surrounds. The adaptation phase is local and the test phase is global. That is, localized adaptation can be expressed in different ways depending on the structure of the test display. These aspects of MAEs can be exploited to determine a variety of local/global interactions. The following questions are examined in a series of experiments. How local is the adaptation effect? Is the storage of MAEs influenced by local or global factors? What influence does phase alternation have on the interocular transfer of MAEs? Are attentional effects localized to the adapted or inducing region? Do similar interactions apply to MAEs from translation and rotation?