
The syndrome of unilateral spatial neglect (USN) after right-hemisphere damage is characterized by failure of salient left-sided stimuli to activate an orienting response, attract attention, and gain access to conscious awareness. The explicit failure processing left-sided visual information is not uniform, however, and patients seem to be more successful performing certain visual tasks than others. The source of this difference is still not clear. We focus on processing of visual scene statistical properties, asking whether, in computing the average size of an array of objects, USN patients give appropriate weight to objects on the left; disregard left-side objects entirely; or assign them an intermediate, lower weight, in accord with their tendency to neglect these objects. The interest in testing this question stems from a series of studies in healthy individuals that led Chong and Treisman [Chong, S. C., & Treisman, A. Statistical processing: Computing the average size in perceptual groups. Vision Research, 45, 891-900, 2005a; Chong, S. C., & Treisman, A. Attentional spread in the statistical processing of visual displays. Perception & Psychophysics, 67, 1-13, 2005b] to propose that processing of statistical properties (like the average size of visual scene elements) is carried out in parallel, with no need for serial allocation of focal attention to the different scene elements. Our results corroborate this suggestion, showing that objects in the left ("neglected") hemispace contribute to average size computation, despite a marked imbalance in spatial distribution of attention, which leads to a reduced weight of left-side elements in the averaging computation. This finding sheds light on the nature of the impairment in USN and on basic mechanisms underlying statistical processing in vision. We confirm that statistical processing depends mainly on spread-attention mechanisms, which are largely spared in USN.


In the framework of Reverse Hierarchy Theory it was suggested that initial vision at a glance brings the gist of the scene to conscious perception using explicit high cortical level representations, which are initially built by implicit bottom-up processing (Hochstein & Ahissar, 2002). Only later return to lower cortical level representations introduces local details to conscious perception. Global statistics of similar elements are perceived rapidly and accurately, suggesting they are included in the initial perception of the gist of the scene, not depending on prior conscious perception of local details. Patients with unilateral spatial neglect have difficulty responding to elements in their contralesional hemifield. However, this deficit is especially pronounced for tasks that require focused attention, i.e., are dependent on the reverse-hierarchy return. We review recent studies that indicate that perception of global statistics is among the spread attention tasks that are somewhat spared from this deficit. Combining these results, we suggest that perhaps the function of global statistics perception might include serving as a basic percept required for finding salient
deviants from the mean, as in rapid odd element feature search paradigms, and perhaps subsequently focusing attention to them.


The Delay-Match-to-Sample (DMS) task has been used in countless studies of memory, undergoing numerous modifications, making the task more and more challenging to participants. The physiological correlate of memory is modified neural activity during the cue-to-match delay period reflecting reverberating attractor activity in multiple interconnected cells. DMS tasks may use a fixed set of well-practiced stimulus images allowing for creation of attractors or unlimited novel images, for which no attractor exists. Using well-learned stimuli requires that participants determine if a remembered image was seen in the same or a preceding trial, only responding to the former. Thus, trial-to-trial transitions must include a "reset" mechanism to mark old images as such. We test two groups of monkeys on a delay-match-to-multiple-images task, one with well-trained and one with novel images. Only the first developed a reset mechanism. We then switched tasks between the groups. We find that introducing fixed images initiates development of reset, and once established, switching to novel images does not disable its use. Without reset, memory decays slowly, leaving ~40% recognizable after a minute. Here, presence of reward further enhances memory of previously-seen images.


Delay match to sample (DMS) experiments provide an important link between the theory of recurrent network models and behavior and neural recordings. We define a simple recurrent network of binary neurons with stochastic neural dynamics and Hebbian synaptic learning. Most DMS experiments involve heavily learned images, and in this setting we propose a readout mechanism for match occurrence based on a smaller increment in overall network activity when the matched pattern is already in working memory, and a reset mechanism to clear memory from stimuli of previous trials using random network activity. Simulations show that this model accounts for a wide range of variations on the original DMS tasks, including ABBA tasks with distractors, and more general repetition detection tasks with both learned and novel images. The differences in network settings required for different tasks derive from easily defined changes in the levels of noise and inhibition. The same models can also explain experiments involving repetition detection with novel images, although in this case the readout mechanism for match is based on higher overall network activity. The models give rise to interesting predictions that may be tested in neural recordings.

Yakovlev, V, Amit Y, Hochstein S. 2013 *It’s Hard to Forget: Resetting Memory in Delay-Match-Multiple-Image Tasks*. [33]. Frontiers in Human Neuroscience. 7 [Abstract][34]

The Delay-Match-to-Sample (DMS) task has been used in countless studies of memory, undergoing numerous modifications, making the task more and more challenging to participants. The physiological correlate of memory is modified neural activity during the cue-to-match delay period reflecting reverberating attractor activity in multiple interconnected cells. DMS tasks may use a fixed set of well-practiced stimulus images
Anyone interested in the study of attention will have had some exposure to the work of Anne Treisman. Anne Treisman has been one of the most influential cognitive psychologists in the last 50 years. Her research and theoretical insights have influenced a variety of disciplines, including vision sciences, auditory sciences, cognitive psychology, cognitive neurosciences, philosophy, psychiatry, neuropsychology, and behavioral neurology. She is best known for her work on attention. Early in her career, much of that work involved auditory stimuli. Her later work has been primarily in the realm of visual attention. She has been especially concerned with the interactions among visual perception, attention, and memory as they relate to conscious and unconscious experience. Her Feature Integration Theory has been one of the organizing ideas in the field for three decades. While still a graduate student at Oxford, she helped launch the modern study of attention. In the present volume, several of her most influential papers are reprinted (including some of the harder to find early work). To accompany these reprints, the editors invited experts to comment and/or to show how their own work had been shaped by Treisman's ideas and findings. The result is a scientifically rich ride through the world of ideas inspired by Treisman's work. The contributed chapters include discussions of auditory and visual attention, the role of features in selection, parallel and serial processing, and automaticity. They describe the roots and evolution of Feature Integration Theory and related models like Guided Search. They explore the interactions of attention and perception at the cognitive, neuropsychological, and biological levels. Readers can consider the critical role of binding in perception, the role of attention in scene perception, as well as the influence of cognitive load, memory, reflection, and perceptual learning on early and late processing. They will see how methods to study conscious perceptual awareness have evolved over the years.


It is well established that cognitive system overload is reflected in the attentional blink (AB), the failure to report a second target when it closely follows detection of a first target within a rapid series of stimuli. However, there is intense controversy concerning the effect of first-target detection in one modality on subsequent dynamics of attentional resources in other modalities. Mixed results were found using an audiovisual AB paradigm: depletion of resources in one modality either impaired performance in the other modality or had no effect. Here, we circumvent the need for task switching by measuring an event-related potential, the mismatch negativity, which reflects implicit auditory change detection without requiring task engagement and is present even for background sounds that participants ignore. Surprisingly, we find that during the visual AB, auditory processing is enhanced rather than inhibited, as would be expected by system overload. We suggest that multimodal attentional resources may be freed rather than engaged during the visual AB. Suppression of irrelevant input may require active control by a central executive, which is preoccupied during the visual AB, and/or there may be no reason to suppress other-modal input since the visual system will miss its second target anyway.

According to art theory, pictorial balance acts to unify picture elements into a cohesive composition. For asymmetrical compositions, balancing elements is thought to be similar to balancing mechanical weights in a framework of symmetry axes. Assessment of preference for balance (APB), based on the symmetry-axes framework suggested in Arnheim R, 1974 Art and Visual Perception: A Psychology of the Creative Eye (Berkeley, CA: University of California Press), successfully matched subject balance ratings of images of geometrical shapes over unlimited viewing time. We now examine pictorial balance perception of Japanese calligraphy during first fixation, isolated from later cognitive processes, comparing APB measures with results from balance-rating and comparison tasks. Results show high between-task correlation, but low correlation with APB. We repeated the rating task, expanding the image set to include five rotations of each image, comparing balance perception of artist and novice participant groups. Rotation has no effect on APB balance computation but dramatically affects balance rating, especially for art experts. We analyze the variety of rotation effects and suggest that, rather than depending on element size and position relative to symmetry axes, first fixation balance processing derives from global processes such as grouping of lines and shapes, object recognition, preference for horizontal and vertical elements, closure, and completion, enhanced by vertical symmetry.


Perceptual learning involves modification of cortical processes so that transfer to new task variants depends on neuronal representation overlap. Neuron selectivity varies with cortical level, so that the degree of transfer should depend on training-induced modification level. We ask how different can stimuli be, how far apart can their representations be, and still induce training transfer. We measure transfer across both long distances within the visual field, namely across cerebral hemispheres, as well as across perceptual dimensions, i.e., between detection of odd color and orientation. In Experiment 1, subjects learned feature search using eccentric arrays randomly presented in the right or left hemifield. Odd elements differed in color or orientation, depending on the presentation hemifield. Following training and performance improvement, the dimensions were switched between hemifields. There was little cross-hemifield or cross-task transfer for difficult cases, and the greater transfer found for easier cases could be across hemispheres and/or perceptual dimensions. Testing these two elements separately, Experiment 2 confirmed considerable transfer across task dimensions, training one dimension and testing another, and Experiment 3 confirmed such transfer across hemispheres, training search on one side and testing on the other. Results support Reverse Hierarchy Theory (M. Ahissar & S. Hochstein, 1997, 2004) in that, for easier perceptual tasks involving and modifying higher cortical levels, considerable transfer occurs both across perceptual dimensions and across visual field location even across hemifields.


We construct a mathematical model indicating the information available to the observer regarding each item in a spatial unit in the visual scene, at any given moment, dependant on previous fixations and eye movement scanpath. Dividing the items in the visual scene into discrete units, two processes affect the amount of information available about each unit at each time: an incremental component and a memory decay component. We assume that extracted information is incremented for a scene unit each time the fixation falls on it and increases as a sigmoid or exponential growth function with subsequent fixations and that information decays exponentially between recurring fixations on a unit. Results show that the amount
of available information grows and fluctuates stochastically, varying from unit to unit and from time to time, so that complete information is never reached for the entire scene. Simulations show that the larger the scene, the less information is available, on average, for each scene unit, though more may be available in total, as well as more for favored units. The resulting dynamics of this local available information measure might predict the probability of perceiving a change in stimulation at a corresponding visual unit or its complementary, the probability of change blindness.

Wolf, M, Hochstein S. 2011High level binocular rivalry effects. Frontiers in Human Neuroscience. 5

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Binocular rivalry (BR) occurs when the brain cannot fuse percepts from the two eyes because they are different. We review results relating to an ongoing controversy regarding the cortical site of the BR mechanism. Some BR qualities suggest it is low-level: 1) BR, as its name implies, is usually between eyes and only low levels have access to utrocular information. 2) All input to one eye is suppressed: blurring doesn’t

2010


Even when our attention is dedicated to an important task, background processes monitor the environment for significant events. The mismatch negativity (MMN) event-related potential is thought to reflect such a monitoring process. Nevertheless, there is continuing debate concerning the susceptibility of the MMN to attentional manipulation. We investigated the trial-by-trial relationship between brain activity related to change detection, reflected in the MMN, and visual psychophysical performance--while varying task difficulty. We find that auditory change detection is indeed “automatic” in that MMN remains robust despite increasing (visual) task load. However, the MMN amplitude and latency are susceptible to both visual load and to momentary attentional fluctuations as reflected in success or failure to identify a following visual target. We conclude that background central auditory processing is sensitive to the demands of a visual task, and fluctuates based on moment-to-moment allocation of attentional resources to the visual task.


Target recognition stages were studied by exposing observers to varying controlled numbers of target fixations. The target, present in half the displays, consisted of two identical cards (Identity Search Task; Jacob & Hochstein, 2009). Following more fixations, targets are better recognized, indicated by increased Hit-rate and detectability (according to Unequal Variance Signal Detection Theory), decreased Response Time and growing confidence, reflecting current stage in recognition process. Thus, gathering information over a specific scene region results from a growing number of fixations on that particular region. We conclude that several fixations on a scene location are necessary for achieving recognition.

Findings from numerous studies suggest that multiple neural systems are involved in category learning. Specifically, it is often argued that acquiring a representation of different category structures (e.g., rule-based vs. prototype-based representation) involves different computational challenges, which are resolved by different neural circuitries in the human brain. Here we present an alternative approach for studying neural mechanisms of category learning: We refer to the idea that any category learning task involves mapping common features shared by same-category members, distinctive features discriminating members of different categories, or both. We argue that since these processes are psychologically and computationally distinct, they differ in their usability for category learning. Our participants learned novel categories of complex visual stimuli by comparing either pairs of objects from the same novel category or pairs of objects from different categories. Object pairs were chosen so that the objective amount of information they contained was identical in the two category learning conditions, equally enabling learning the predefined objective category structure. We find that the neural circuitry involved in detecting important between-categories differences is associated mainly with the dorsal striatum (bilaterally) and the right hippocampus. On the other hand, mapping within-category similarities and differences is restricted to high-level visual brain areas. We suggest that multiple neural mechanisms are involved in category learning enabling us to face different computational challenges associated with different basic types of induction processes that differ in their usability for learning different category structures.


Faces are detected more rapidly than other objects in visual scenes and search arrays, but the cause for this face advantage has been contested. In the present study, we found that under conditions of spatial uncertainty, faces were easier to detect than control targets (dog faces, clocks and cars) even in the absence of surrounding stimuli, making an explanation based only on low-level differences unlikely. This advantage improved with eccentricity in the visual field, enabling face detection in wider visual windows, and pointing to selective sparing of face detection at greater eccentricities. This face advantage might be due to perceptual factors favoring face detection. In addition, the relative face advantage is greater under flanked than non-flanked conditions, suggesting an additional, possibly attention-related benefit enabling face detection in groups of distracters.


Two observers looking at the same picture may not see the same thing. To avoid sensory overload, visual information is actively selected for further processing by bottom-up processes, originating within the visual image, and top-down processes, reflecting the motivation and past experiences of the observer. The latter processes could grant categories of significance to the observer a permanent attentional advantage. Nevertheless, evidence for a generalized top-down advantage for specific categories has been limited. In this study, bird and car experts searched for face, car, or bird photographs in a heterogeneous display of photographs of real objects. Bottom-up influences were ruled out by presenting both groups of experts with identical displays. Faces and targets of expertise had a clear advantage over novice targets, indicating a permanent top-down preference for favored categories. A novel type of analysis of reaction times over the visual field suggests that the advantage for expert objects is achieved by broader detection windows, allowing observers to scan greater parts of the visual field for the presence of favored targets during each
Category learning can be achieved by identifying common features among category members, distinctive features among non-members, or both. These processes are psychologically and computationally distinct, and may have implications for the acquisition of categories at different hierarchical levels. The present study examines an account of children's difficulty in acquiring categories at the subordinate level grounded on these distinct comparison processes. Adults and children performed category learning tasks in which they were exposed either to pairs of objects from the same novel category or pairs of objects from different categories. The objects were designed so that for each category learning task, two features determined category membership whereas two other features were task irrelevant. In the learning stage participants compared pairs of objects noted to be either from the same category or from different categories. Object pairs were chosen so that the objective amount of information provided to the participants was identical in the two learning conditions. We found that when presented only with object pairs noted to be from the same category, young children (6 and up) performed significantly worse than adults. Young children may have difficulty in acquiring a subordinate category when they are not provided with information about the difference between category members and non-members.


Revealing the relationships between perceptual representations in the brain and mechanisms of adult perceptual learning is of great importance, potentially leading to significantly improved training techniques both for improving skills in the general population and for ameliorating deficits in special populations. In this review, we summarize the essentials of reverse hierarchy theory for perceptual learning in the visual and auditory modalities and describe the theory’s implications for designing improved training procedures, for a variety of goals and populations.


Information for category learning may be provided as positive or negative equivalence constraints (PEC/NEC)-indicating that some exemplars belong to the same or different categories. To investigate categorization strategies, we studied category learning from each type of constraint separately, using a simple rule-based task. We found that participants use PECs differently than NECs, even when these provide the same amount of information. With informative PECs, categorization was rapid, reasonably accurate and uniform across participants. With informative NECs, performance was rapid and highly accurate for only some participants. When given directions, all participants reached high-performance levels with NECs, but the use of PECs remained unchanged. These results suggest that people may use PECs intuitively, but not perfectly. In contrast, using informative NECs enables a potentially more accurate categorization strategy, but a less natural, one which many participants initially fail to implement-even in this simplified setting.


Why do we perceive some elements in a visual scene, while others remain undetected? To learn about the sequence of events leading to detection, we directly compared fixations on detected vs. undetected items.
Our novel Identity Search task display comprised twelve cards, all different except for two pairs of identical cards. Participants search for one pair. Task properties allow us to monitor fixations on distinct card regions and study search dynamics. We find that detected pair cards were fixated more often and for longer times than undetected pair cards. Within the search sequence, there are fewer intervening fixations between detected than undetected pair cards. Only at an advanced stage of the search do fixations on pair cards become closer. We suggest that both the absolute number of fixations and their temporal proximity influence detection. In the dynamics of search, a bifurcation point is observed, when these differential characteristics begin. Analysis of the break point in the sequence of fixations on to-be-detected cards suggests that there is an early—perhaps unconscious—recognition stage, followed by more fixations and only later by detection. We suggest that several target fixations are needed for processing visual information to achieve recognition.


We investigated explicit and implicit properties of the internal representation of illusory-contour figures by studying potential priming effects of this representation. Using a primed matching paradigm (Beller 1971, Journal of Experimental Psychology 87 176-182), we found that illusory ‘Kanizsa’ squares and triangles prime later matching of the same shapes, respectively, and not of the alternative shape. This priming effect is present despite the use of an illusory figure as a prime and real shapes as tests. To determine whether implicit processing mechanisms sufficiently induce a representation of the illusory shape so that it can lead to this priming effect, we used a novel method of presentation of the inducing pattern, based on Rock and Linnet’s (1993, Perception 22 61-76) method for separating (implicit) retinal and (explicit) world-coordinate images. Presence of the implicit retinal image is confirmed by its producing an afterimage. While the retinal image is only implicitly produced by the inducing pattern of pacmen, it is nevertheless available for real-shape match priming. We conclude that Kanizsa-type inducer patterns are processed implicitly until formation of illusory-figure shapes. These are represented at relatively high cortical levels, and shape-matching priming must occur here, too. These results are consistent with the claim of the reverse hierarchy theory that bottom-up processing is generally implicit and that conscious perception originates at high cortical levels.

2008

Jacob, M, Hochstein S. 2008 Set recognition as a window to perceptual and cognitive processes. [152]. Perception & psychophysics. 70(7):1165-84. Abstract

The Set visual perception game is a fertile research platform that allows investigation of perception, with gradual processing culminating in a momentary recognition stage, in a context that can be endlessly repeated with novel displays. Performance of the Set game task is a play-off between perceptual and conceptual processes. The task is to detect (among the 12 displayed cards) a 3-card set, defined as containing cards that are either all similar or all different along each of four dimensions with three possible values. We found preference and reduced response times (RTs) for perceiving set similarity (rather than span) and for including cards sharing the most abundant value in the display, suggesting that these are searched preferentially (perhaps by mutual enhancement). RT decreases with number of sets in the display according to a horse race model, implying independence of simultaneous searches. Central cards are included slightly more often, but set card proximity seems irrelevant. A supplementary experiment
determining dimensional salience showed consistent but individual preferences, yet these seemed not to affect set identification. Training induced gradual improvement, which generalized to a new version of the game, suggesting high-level learning. We conclude that elements of perception such as similarity detection are basic for finding sets in this task, as in other real-world perceptual and cognitive tasks, suggesting the presence of basic similarity-perceiving mechanisms. The findings confirm the conclusion that conceptual processes are affected by perception.


We previously found a dominant eye perceptional advantage in feature search (Vision Research, 2006). We now ask if this advantage extends to difficult conjunction search, which requires focused attention and depends on different cortical hierarchy levels. We determined eye dominance by the Hole-in-the-Card test. Using red-green glasses, subjects viewed a briefly presented, backward-masked, array of red/green dotted squares and filled circles. On half of the trials a filled square target replaced one dotted square. There was significantly better performance when the target was seen by the dominant eye, suggesting its visual processing priority in slow, as in rapid search, perhaps including augmented attention to dominant eye representations. Binocular conjunction targets were found faster than monocular targets, though binocularity—as utrocular information—was insufficient to support reasonable detection levels.


Macaque monkeys were tested on a delayed-match-to-multiple-sample task, with either a limited set of well trained images (in randomized sequence) or with never-before-seen images. They performed much better with novel images. False positives were mostly limited to catch-trial image repetitions from the preceding trial. This result implies extremely effective one-shot learning, resembling Standing’s finding that people detect familiarity for 10,000 once-seen pictures (with 80% accuracy) (Standing, 1973). Familiarity memory may differ essentially from identification, which embeds and generates contextual information. When encountering another person, we can say immediately whether his or her face is familiar. However, it may be difficult for us to identify the same person. To accompany the psychophysical findings, we present a generic neural network model reproducing these behaviors, based on the same conservative Hebbian synaptic plasticity that generates delay activity identification memory. Familiarity becomes the first step toward establishing identification. Adding an inter-trial reset mechanism limits false positives for previous-trial images. The model, unlike previous proposals, relates repetition-recognition with enhanced neural activity, as recently observed experimentally in 92% of differential cells in prefrontal cortex, an area directly involved in familiarity recognition. There may be an essential functional difference between enhanced responses to novel versus to familiar images: The maximal signal from temporal cortex is for novel stimuli, facilitating additional sensory processing of newly acquired stimuli. The maximal signal for familiar stimuli arising in prefrontal cortex facilitates the formation of selective delay activity, as well as additional consolidation of the memory of the image in an upstream cortical module.


Recent studies stressed the importance of comparing exemplars both for improving performance by artificial classifiers as well as for explaining human category-learning strategies. In this report we provide a
theoretical analysis for the usability of exemplar comparison for category-learning. We distinguish between two types of comparison -- comparison of exemplars identified to belong to the same category vs. comparison of exemplars identified to belong to two different categories. Our analysis suggests that these two types of comparison differ both qualitatively and quantitatively. In particular, in most everyday life scenarios, comparison of same-class exemplars will be far more informative than comparison of different-class exemplars. We also present behavioral findings suggesting that these properties of the two types of comparison shape the category-learning strategies that people implement. The predisposition for use of one strategy in preference to the other often results in a significant gap between the actual information content provided, and the way this information is eventually employed. These findings may further suggest under which conditions the reported category-learning biases may be overcome.
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