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News from the field

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SUMMARY STATISTICS

Weighting for the end

Cheadle, S., Wyart V., Tsetsos, K., Myers, N., de Gardelle, V., Herce Castañón., S., & Summerfield, C. (2014). Adaptive gain control during human perceptual choice. *Neuron, 81*(6), 1429–1441

The dynamics of many neural systems are now well known. For example, Bloch's law tells us that there must be light-sensitive neurones somewhere near the front-end of the visual system capable of integrating luminance over short periods of time with nearly constant efficiency. When stimulation lasts a long time, those neurones adapt, and their responses are attenuated accordingly. By definition, such adaptation qualifies as gain control.

In a heretofore unrelated literature, many scientists have begun studying tasks that require observers to form summary statistics of perceptual stimuli. These tasks have become popular because they offer a way to gauge the efficiencies of cognitive or decision processes, for which hard-wired neural mechanisms are unlikely to exist.

Various subsets of Cheadle's co-authors have previously written about a special kind of summary statistic, and in their latest paper they examine the dynamics of its computation from psychophysical and physiological perspectives. Their findings suggest adaptation beyond the level of stimulus encoding: gain control seems to operate at the level of information integration too.

The task is to decide whether a serial presentation of Gabor elements is—on average—closer to the cardinal axes (i.e. +) or the inter-cardinal axes (i.e. ×). Unlike most of the other statistics currently under scrutiny, this one has the advantage that the (signed) diagnosticity of any two elements becomes more similar as their physical difference increases. For example a vertical Gabor supports the cardinal decision just as much as a horizontal one.

The largest effect recorded by Cheadle et al. is that later Gabors in the series had more impact on decisions and pupil diameter than earlier Gabors had. More interesting is their finding that the impact of an individual Gabor, not only on decision and pupil size but certain BOLD and EEG signals too, varied inversely with the difference between its diagnosticity and that of the preceding Gabor. For example, a vertical Gabor following a horizontal Gabor would contribute more to decisional processes than a vertical Gabor following any tilted Gabor.

Perhaps this study's most important contribution is the model it proposes for the dynamics of information integration, in which both of these effects ("recency" and "consistency") are natural by-products. Quite simply, it's gain control for diagnosticity. We seem to adjust ourselves for maximum sensitivity to incoming evidence that confirms our expectations. Initial impressions and surprises are consequently down-weighted.

Cheadle et al. did not vary the rate of presentation, so we do not yet know how long it takes for the gain-control process to kick in. Is there a Bloch-like epoch, in which all diagnosticity is equally weighted? Only (systematically varying display) time will tell.—J.A.S.

VISUAL WORKING MEMORY

Models of response times

Donkin, C., Nosofsky, R. M., Gold, J. M., & Shiffrin, R. M. (2013). Discrete-slots models of visual working-memory response times. *Psychological Review, 120*, 873–902.

The nature of visual working memory (i.e., discrete slots or continuous resource) has been a matter of debate, mainly based on accuracy data from various tasks. The discrete-slot view assumes that VWM consists of a limited number of slots with fixed resolution, whereas the continuous-resource view assumes that VWM can be divided among all the items, with flexible resolution. Recently, Donkin, Nosofsky, Gold, and Shiffrin (2013) attempted to open new windows on this debate by examining response time data in a visual change-detection task of colors.

Two families of RT models were built, following the discrete-slot and the continuous-resource assumptions respectively. In the former, the subject's response is considered as a combination of either a memory-based evidence-accumulation process or a (slower) guessing-based accumulation process, depending on whether the probed item is stored in the discrete slots or not. Critically, when the memory set size (i.e., the number of squares to be memorized in one trial) increases, the probability of remembering the probed item should decrease, but the speeds of the two accumulation processes should remain invariant. This is because the speeds are determined by memory resolution, which is fixed (all or none) in discrete-slot models. The discrete-slots models predict overall slow-downs with increases in memory set size mainly because there will be an increased proportion of cases in which the slower guessing-accumulation operates. In contrast, the continuous-resource models assume that all items are stored to some extent so that a response always involves a memory-based evidence-accumulation process. Therefore, when the set size increases, the memory resolution of each item declines and the speed of the accumulation process should decrease.

Donkin et al. made concrete predictions based on the conceptual distinctions, described above. For example, the discrete-slot models predict that the RT distributions of the error responses (false alarm and miss) should be invariant with set size since they are all guessing-based, whereas the continuous-resource models predict that the error responses should become slower as the set size increases. The observed RT distributions were more consistent with the former prediction. Donkin et al. have also made other qualitative, as well as quantitative, predictions, and have generally found that the discrete-slot models outperformed the continuous-resource models. A notable exception is that there is evidence for improved resolution of memory when the set size is very small.

Accuracies and RTs are two classic measures in experimental psychology. However, the recent studies on VWM have almost exclusively relied on accuracies, and few researchers have used RT data to distinguish between different VWM models. Therefore, the study of Donkin et al. (2013) fills a very important theoretical gap and provides novel insights. This solid experimental design also allows us to explore relevant questions from this new perspective, which can inspire important future studies.—L.Q.H.

SPATIOTEMPORAL CONTEXT

How past perception influences current perception.
Fischer, J., & Whitney, D. (2014). Serial dependence in visual perception. *Nature Neuroscience 17*, 738–743. doi:10.1038/nn.3689

It has long been known that past perception strongly influences current perception. Such aftereffects have strongly influenced visual theory. To take some examples, color aftereffects formed the basis of great advances in understanding color vision in the 19th century. The waterfall illusion (or motion aftereffect) has intrigued laymen and scientists for centuries, and has provided important information about the operational characteristics of the nervous system and the interpretative processes of visual perception. But history effects in perception have started to play an even larger role in perceptual theory. Perceptual history strongly influences perception of ambiguous displays (Pearson & Brascamp, 2008) and visual attention is strongly determined by what has occurred during previous attention deployments (Kristjánsson & Campana, 2010). Our visual systems may, in this way, use the past to predict the present, using history to aid with assessing continuity in space and time.

A recent study by Fischer & Whitney, on what they call sequential dependence, adds to this growing literature, showing that the perceived orientation of briefly presented gratings is biased in a systematic way towards the orientation of previously presented gratings. This results in actual alterations in the appearance of the currently viewed grating. Their observers viewed sequences of randomly oriented Gabor patches, with a random period of several seconds in between. Reported orientation was attracted to the orientation of the Gabor on the previous trial. Thus, the perceived orientation of the current grating is more like of the previously presented one than it would have been if presented on its own without any spatiotemporal context.

One question that we may ask is how this serial dependence effect is different from other history effects, such as perceptual aftereffects? Let's take the tilt aftereffect as an example. Fischer and Whitney present results indicating that, unlike the traditional tilt aftereffect, serial dependence is not a retinotopic effect. Another notable feature is that serial dependence is modulated by attention (as measured with an attentional cueing task), potentially establishing a link to attentional history effects.

Whether everyone will agree on Fischer and Whitney's interpretation of their results remains to be seen. And whether what we see here is a "missing link" between lower-level adaptation effects and higher-level repetition effects that are attention dependent, is presently unknown, but the results are intriguing and should generate follow-ups. In fact at the annual Vision Sciences meeting last May, Liberman, Kosovicheva and Whitney (2014) showed how the visual system utilizes object's prior physical locations to inform perceived future position. They argued that this will maximize location stability of an object over time, illustrating another aspect of sequential dependence. In any case, this writer predicts that we may see increased interest in history effects in vision in the near future, partly spurred on by this interesting study.—A.K.

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ATTENTION AND REWARD

The power of reward to rewire attention

Failing, M.F., & Theeuwes, J. (2014). Exogenous visual orienting by reward. *Journal of Vision, 14*(5).

Reward-based learning can exert powerful influences on behavior. We all know this. Pigeons learn to peck at paper bags because such pecking is sometimes reinforced by pieces of sandwich that get revealed when the bag breaks open. But what changes are wrought in the pigeon's neural wiring as a result of this learning? Has their low-level visual processing been altered? How does this training change the impact exerted by paper-bag-brown on their visual neurons?

When something moves at the edge of your vision, it grabs your attention automatically and powerfully. Many experiments have documented that such "exogenous cueing" does indeed sensitize an observer to information presented at the cued location and facilitate motor responses. Does paper-bag-brown come to operate as an exogenous cue in the brain of a pigeon that has learned to peck at paper bags? This general question was investigated by Failing & Theeuwes (2014) with human participants (not pigeons). Their experiment had a training phase and a testing phase. On each trial (in each of the training and testing phases) two letters were presented, one each to the left and right of fixation. One of them was a target letter (either "S" or "P"), and the other was a distractor letter (either "H", or "E"). The participant's task was to type an "S" or a "P" depending on which of the two target letters was presented. Now for the paper bags: in each stimulus display each of the two letters was surrounded by a circle that was either red, blue, green or yellow. Two of these colors (different for different participants) were designated as "untrained", and the other two colors were designated as "trained". One of the two "trained" colors is further singled out to be "rewarded", and the other trained color is "unrewarded".

Here's what happened in the training phase: On any given trial, the target letter was always surrounded by a circle either of the rewarded or the trained-but-unrewarded color, and the distractor is always surrounded by one of the two untrained colors. If the participant responded correctly, and if the target was surrounded by the "rewarded" color, then with probability 0.8 he/she is rewarded with 10 points (which translated into money to be paid out at the end of the experiment) and with 0 points otherwise. If the participant responded correctly, and if the target was surrounded by the trained but unrewarded color, then he/she is always receives 0 points. If he/she responded incorrectly or took too long to respond he/she lost 10 points.

The rules changed in the testing phase (which took place on the same day as training). The participants continued to perform the same task (i.e., they strove to type the target letter presented on each trial). However, in this phase, no feedback was given, and the target and distractor letters occurred with equal probability in circles of all four different colors.

The question was: would the rewarded color continue to influence responding even though the contingencies that had been in effect during training were removed during the testing phase? The answer was yes: the previously rewarded color operated powerfully and coercively to control responding. In comparison to responses on trials in which both the circles were painted with untrained colors, responses were (1) faster to targets when they were surrounded by the previously rewarded color and (2) slower to targets when the distractor was surrounded by the previously rewarded color. No such effects were observed for the trained-but-unrewarded color. As the authors state in their abstract, these results provide "direct evidence that stimuli associated with reward have the ability to exogenously capture spatial attention independent of task-set, goals and salience."—C.C.

COLOR VISION

The "geopolitics" of basic color terms

Lindsey, D. T., & Brown, A. M. (2014). The color lexicon of American English. *Journal of Vision, 14*(2).

What words do you use if you are asked to name to colors of things? Wikipedia has a "list of colors" that confirms that there are lots of choices. Here, for instance, are the 13(!) color names that begin with "ba": "Baby blue, Baby blue eyes, Baby pink, Baby powder, Baker-Miller pink, Ball blue, Banana Mania, Banana yellow, Bangladesh green, Barbie pink, Barn red, Battleship grey, Bazaar." Suppose, however, you were restricted to monolexemic terms (single words with no modifiers) and suppose the word had to apply to anything of that color (Can you have a "blonde" car?). Now, the list of color terms that you would use would be much more limited. Berlin and Kay (1969) called these "basic color terms (BCTs)" and proposed that English had 11 of them: black, white, red, yellow, green, blue, brown, orange, pink, purple, and gray. Other groups of people use fewer than 11 BCTs and Berlin and Kay proposed a theory about how color lexicons with more BCTs evolve from those that have fewer. They suggested that the 11 BCTs might be the endpoint of that evolution; But is it? Some languages like Russian and Turkish seem to honor more than 11 BCTs. Moreover, there is evidence that new BCTs might be evolving in the American English color lexicon. Lindsey and Brown's new work is an effort to take a snapshot of the current state of that evolution.

How might a new basic color term evolve? We can imagine this in geopolitical terms. Think about BCTs as kingdoms. The Blue and Green realms might have started as local unambiguous principalities of color. Overtime, the Blue and Green kingdoms expand and come in contact with each other. In this Blue-Green boundary land are colors that are not perfectly affiliated with either Blue or Green. In this chromatic no-man's-land, a new BCT buffer kingdom might arise with a name like "Teal". A kingdom like "Purple", one the other hand, might be compared to a multi-national state that, at some point, splits into two BCTs with a new "Lavender" or "Lilac" entity taking over some of the Purple real estate in color space. Berlin and Kay favored the latter, seccession model. Levinson (2000) advocated for the former, boundary story. In fact, Lindsey and Brown see evidence for both processes in current American English usage. They asked 51 Americans to name the color of each of 330 color patches. In one run, they used a "free-naming" method. Their observers were told to use a single word that could be used for anything of that color (the basic BCT rules). In a "constrained-naming" run, observers were required to use the 11 BCTs proposed by Berlin and Kay. In this way, Lindsey and Brown could look at where on the color map new candidate BCTs might be emerging.

Almost every patch could be readily named in the constrained-naming run. The most unhappiness was expressed by observers when it came to assigning a BCT to patches in the "peach-beige" neighborhood. "Peach" maybe making the strongest current claim to BCT status; a new kingdom in the red-orange-yellow neighborhood. In free-naming, everyone used the 11 classic BCTs but 111 other names were used. Many of these could be grouped together. Thus, teal, turquoise, aquamarine, aqua, jade, ocean, and seafoam all describe a similar piece of the blue-green borderland. A boundary color like "Teal" may be enroute to BCT status. While Lindsey and Brown argue that the evidence is strongest for new BCTs emerging at the borders between BCTs, partition-based BCTs seem possible, as well. Thus, terms like "Lavender" and "Lilac" seem to be partitioning part of the Purple real estate in color space.

There is much more to enjoy in this colorful article (one of the best recent arguments for color figures in our journals) but the central conclusion is that the color lexicon continues to evolve.—J.M.W.

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TIMING

Autocracy versus democracy in a string quartet

Wing, A. M., Endo, S., Bradbury, A., & Vorberg, D. (2014). Optimal feedback correction in string quartet synchronization. *Journal of the Royal Society. Interface, 11*, 93. doi:10.1098/rsif.2013.1125

In speech, music or sport activities, timing is a key component of success. It is therefore important to understand the properties of the perceptual or motor systems, and the mechanisms involved in the timekeeping activities. Sometimes, the success is based not only on the individual capability to perform a timing task, but also to the coordination of effort with others over time. Because success is tightly linked to synchronization between group members, it is crucial to study how group cohesion is accomplished.

Wing and collaborators address this problem by studying the control of relative timing in ensemble music performance. They proposed a feedback correction model of timing that includes correction gain terms within each pair of players (linear phase correction), a method for capturing subtle contrasts in music ensemble synchronization. They conducted their investigation with two internationally recognized string quartets. In a quartet, where notes are scored to be played together, performers try to synchronize their tone onsets. Wing and collaborators asked musicians to repeatedly perform a short 12-bar musical excerpt (from the fourth movement of Haydn's quartet Op. 74 no. 1). More specifically, musicians were asked to introduce expressive variations in timing, expecting that this instruction would induce fluctuating asynchronies between players that they would try to compensate. The correction gains for all pairs of players were estimated with the time series analysis of successive tone onset asynchronies. Both quartets showed quite similar mean and variability of inter-tone intervals, and average asynchrony correction gains. However, in addition to observing individual differences between players (e.g., cellos more dependent on the others than vice versa), Wing and collaborators reported differences in the degree of correction between quartets as well. While in one quartet, the first violinist exhibited less adjustment to the others compared with their adjustment to her, in the second quartet, the levels of correction by the first violinist matched those exhibited by the others. The authors interpreted these correction patterns as reflecting contrasting strategies of first-violin-led autocracy versus democracy. Future work with this type of analyses could include investigations with other musical passages, or with quartets having different styles or skill levels. In brief, what is proposed in this study is a tool for revealing the nature and expertise of cooperative timing in small musical ensembles.—S.G.

ARTISTIC SKILL AND OBJECT PERCEPTION

Drawing skill: neither the eye nor the hand, but something in between

Perdreau, F., & Cavanagh, P. (2014). Drawing skill is related to the efficiency of encoding object structure. *I-Perception*, *5*(2), 101–119.

What are the cognitive functions that underlie drawing ability? Typically, we might think that people skilled at drawing might have better motor skills than the rest of us, or perhaps they have improved perceptual abilities and are able to see an object more veridically in order to draw it. But recent evidence suggests that neither of these stories are true. Drawing skill is not associated with either motor coordination or perceptual advantages. In this interesting paper, Perdreau and Cavanagh suggest that the advantage lies in the ability to robustly encode object structure in a single glance.

The experimenters gathered a sample of participants with a range of drawing abilities. They measured drawing ability directly in their experiment by asking participants to copy a photograph of an inverted house, and computed the error in the relative placement of a set of critical junctions in the house's structure (this measurement was highly correlated with subjective judgments of which drawings more closely matched the original photograph).

The ability to encode object structure was measured by the ability to discriminate impossible objects from possible objects. In a masking experiment, they found that better drawing skills were associated with shorter exposure durations needed for the impossible/possible discrimination task, irrespective of object size. This advantage was specific to the object task; there was no such relationship for lexical decision. In a second experiment, objects for the discrimination task were presented, unmasked, at variable distances from fixation, and the size of the objects was varied. Participants with better scores on the drawing task were able to accurately perform this peripheral object discrimination task on smaller objects than participants with worse drawing scores. From this result, the authors infer that drawing skill is associated with less self-crowding between object features in the periphery. A control experiment established that this was not due to better peripheral acuity.

The key to superior drawing ability, according to this paper, is the ability to rapidly encode the structure of objects (which may also be accompanied by improved attentional resolution). Since the copying task typically involves many eye movements back and forth between the object to be copied and the evolving drawing, a better understanding of the objects' structure would allow better planning of eye movements, as well as better error-detection in comparing the drawing and the model.

These experiments, of course, cannot tell us whether this superior structural encoding ability is a result of training or reflects an innate talent that leads people into an artistic career. However, it would be interesting to see whether the relationship could be driven the other way: would training people up on object discrimination task improve their drawing ability? Art school curriculum committees might take notice.—T.H.