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News from the field

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DIVIDED ATTENTION

Tracking limits reveal serial attention

Holcombe, A. O. & Chen, W-Y. (2013). Splitting attention reduces temporal resolution from 7 Hz, when tracking one object, to <3 Hz, when tracking three. *Journal of Vision, 13* (1), 12.

Serial sampling of information is slow and inefficient. The majority of work in vision science over the past twenty years has focused on describing the elegant work of parallel processing systems in the brain, especially with respect to problems like object recognition. Sometimes, however, the slow and steady win the race. Serial sampling may solve segregation and individuation problems that parallel processes cannot, therefore a role for serial mechanisms may be crucial for understanding the selective mechanisms of the mind. Holcombe and Chen have argued strongly in their recent paper for a serial theory of visual attention that processes information about moving objects with a periodicity that is dependent upon load. In two experiments, participants were asked to keep track of moving targets, that were identical to and were intermixed with moving distractors, across different speeds and different number of objects. Targets and distractors made up rings of objects rotating about fixation. As such, each speed corresponded to a temporal frequency of the change in visual information at any one point. Results showed that threshold temporal frequencies remained approximately the same across increasing numbers of distractors, but dropped sharply with increasing targets. Spatial interference and visual resolution could not account for the results. A single focus of attention that takes a minimum amount of time to update the representation of a target and serially processes each target in turn would produce such a temporal frequency limitation and load cost. While parallel theories may yet be able to account for these observations, further specification of the source of the load cost is needed for parallel theories to catch up with the straightforward serial account. Further investigation is also needed to understand the basis for the minimum update time, whether it is best characterized by a discrete sampling rate or an interval of temporal integration is unclear. Holcombe and Chen, however, have moved the field forward another step by providing strong evidence and argument in favor of relatively slow, yet steadfast, serial processing.—A. E. S.

TEMPORAL ATTENTION

Slave To The Rhythm

Miller, J.E., Carlson, L.A., & McAuley, J.D. (2012). When what you hear influences when you see: Listening to an auditory rhythm influences the temporal allocation of visual attention. *Psychological Science*. doi:10.1177/0956797612446707

In the recent years there has been a growing interest in cross-modal effects. Thus far, however, most of these cross-modal studies have dealt with the spatial domain of perception. This is particularly true of studies of cross-modal interactions involving attention. Miller, Carlson and McAuley are making a step towards correcting this "spatial bias". They tested whether an auditory rhythm can affect temporal attention—the selective processing of information presented at a specific point in time. Previous work had shown the influence of a regular sequence of tone on response to a subsequent target tone. Thus, if you present a tone every 500 msec, response to a target tone will be faster and/or more accurate if it comes 500 msec after the last of the preceding tones. It is typically assumed that this performance improvement reflects allocation of temporal attention to that specific point of time, much as attention can be allocated to a specific location in space.

Previous studies examined only a single modality. Miller et al. tested whether a similar attentional entrainment can be found when the rhythm is auditory but the target is visual. In three experiments they presented a series of tones that were either regularly spaced (i.e., separated by a constant inter-trial-intervals) or were randomly spaced (i.e., separated by varying inter-trial-intervals). In the first two experiments the target was a peripheral dot that served as the target for an eye movement. In the third experiment, the target was a Landolt square with a gap on one of its sides. Here the task was to indicate the side with the gap. With the dot stimuli, saccadic latencies were the measure. With the Landolt square, the measure of interest was accuracy. The onset of the visual target either matched the rhythmic pattern or did not, and these were distributed equally. That is, the rhythmic pattern did not predict the onset of the target. Better performance—faster saccadic latencies and higher accuracy—was found when the target matched the rhythm than when it did not. Importantly, when the tones were spaced irregularly but the onset of the target matched the average inter-tone-interval, no improvement was found. Thus, an auditory rhythm can affect the allocation of visual temporal attention as measured by motor behavior and accuracy. Moreover, because previous studies have shown that the effects of rhythm can be found regardless of the instructions given to the participants (Rohenkohl et al., 2011), and are not effected by the addition of a concurrent demanding task (de la Rosa et al., 2012) it was concluded that attentional entrainment by a rhythm reflects exogenous selection processes. Given these studies and the fact that the rhythm in this study did not predict the target onset, the observed performance facilitation found when the target matched the rhythm suggests non-volitional cross-modal entrainment of temporal attention.—Y.Y.

VISUAL SEARCH

Who Will Watch The Searchers?

Miyazaki, Y. (2013). Increasing visual search accuracy by being watched. *PLoS ONE*, *8*(1), e53500. doi:10.1371/journal.pone.0053500.g003

In the lab, speed-accuracy tradeoffs are generally considered nuisances. We conduct elaborate analyses to convince reviewers that our results are not artifacts of the dreaded speed-accuracy tradeoff. Some researchers turn the tables and explicitly measure the speed-accuracy tradeoff function (McElree & Carrasco, 1999). The assumption behind both approaches is that any two points along the same speed-accuracy tradeoff function (SATF) are equivalent, representing the same level of difficulty.

In the real world, however, points along a common SATF may have different utilities. We would like the security officers at the airport to be thorough, of course, but we really want to get through the security line in time to make our flight. A radiologist must get through the day's work but can take more time with a single case. How can we adjust the behavior of real world visual searchers so that they find the sweet spot along the SATF? In the laboratory, this is often simply accomplished via instructions. In a thousand reaction time studies, observers are asked to be as fast and accurate as possible. More sophisticated methods might force observers to respond within a specified time window, and then vary that window (Ivanoff & Klein, 2006). Such methods are difficult to transplant to the real world. More realistic, perhaps, are methods that use payoff matrices to manipulate observer behavior (Navalpakkam, Koch, & Perona, 2009). Even these methods, however, may be difficult to implement when the ground truth is not known: cancer screening and diagnosis, airport baggage screening, and so forth. In these situations, if the searcher misses a target, it may never be known. It would be difficult to reward accuracy in these situations.

Fortunately, in a recent paper in PLoS One, Miyazaki (2013) provides a new suggestion: just tell the searcher she's being watched. Miyazaki had participants search for rotated Ts among rotated Ls in noise, a fairly common difficult search task. Searches were conducted in a testing booth that contained two digital video (DV) cameras. In the *watched* condition, the DV cameras were positioned to monitor the participant's behavior from two angles, and the participant was told that the experimenter in the next booth was watching and analyzing their behavior in real time. In the *unwatched* condition, the booth next door was empty, and the cameras were covered with opaque cloths. In the watched condition, participants produced longer reaction times and fewer errors, relative to the unwatched condition. Signal detection analyses showed that sensitivity was roughly equivalent between the two conditions, indicating they were probably along the same SATF. However, participants adopted a more liberal criterion when being watched. Miyazaki also varied set size, and showed that participants were searching more slowly when observed, rather than taking more time at the decision stage.

Of course, it might be considered extravagant to have an additional person constantly observing every radiologist or Transportation Security Officer. In a second experiment, Miyazaki (2013) repeated the procedure, except that the watched condition was replaced with a *videotaped* condition in which participants were told that their performance was being recorded for later, offline analysis. Remarkably, the effects on RT, miss rate, and criterion were, if anything, slightly larger when participants thought they were being videotaped, as opposed to observed in real time.

There are of course a number of questions about how far one can generalize these results. Would the effect still hold if participants knew that there was a chance that there videotaped performance might never actually be watched? What if the videos would only be watched in the distant future? How does the identity of the observer play into this?

While I have been emphasizing the practical side of this research, it also serves as a salutary reminder that social forces, particularly the experimenter-participant relationship, can have a profound effect on attention and perception.—T.H.

Ivanoff, J., & Klein, R. M. (2006). Inhibition of return: Sensitivity and criterion as a function of response time. *Journal of Experimental Psychology: Human Perception and Performance*, *32*(4), 908–919. doi:10.1037/0096-1523.32.4.908

McElree, B., & Carrasco, M. (1999). The temporal dynamics of visual search: Evidence for parallel processing in feature and conjunction searches. *Journal of Experimental Psychology: Human Perception and Performance*, *25*(6), 1517–39.

Navalpakkam, V., Koch, C., & Perona, P. (2009). Homo economicus in visual search. *Journal of Vision*, *9*(1), 31.1–16. doi:10.1167/9.1.31

AUDITION

Auditory restoration

Kuroda, T., Nakajima, Y., & Eguchi, S. (2012). Illusory continuity without sufficient sound energy to fill a temporal gap: Examples of crossing glide tones. *Journal of Experimental Psychology: Human Perception and Performance*, *38*(5), 1254–1267.

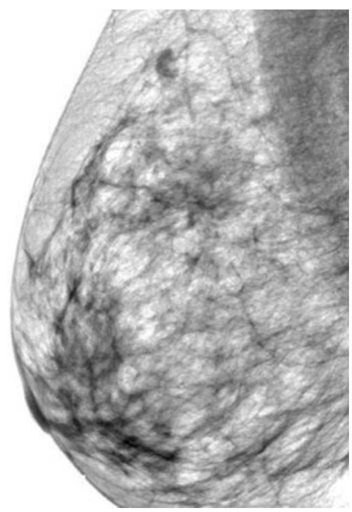
It seems to be widely accepted that the sustained excitation of peripheral auditory neurons would lead to the subjective continuity of sounds. In other words, if a sound input continuously stimulates some sets of peripheral neurons, the sound is thought to be perceived as continuous. Although supported by many studies, does this idea really apply to every sound? In speech sounds, for example, spectral properties, including fundamental frequency, change with the lapse of time. If each neuron could respond to only limited frequency, its excitation for such sounds is sustained for only a brief span. It seems difficult in this case to posit that the sustained excitation is an efficient cue for perceiving sound continuity.

Kuroda, Nakajima and Eguchi investigated the mechanism of the gap transfer illusion. In this illusion, a silence gap inserted in a longer glide (of frequency moving on time) is perceived as belonging to a crossing shorter, physically continuous glide, instead of the longer one. The longer glide is thus perceived as continuous and the shorter glide as discontinuous. The authors reported that the illusion disappeared when these glides differed in intensity but still remained when the shorter glide was 9 dB weaker than the longer one. In other words, the missing part (gap) of the longer glide could be perceptually restored even when it was filled with only sound energy of 9 dB weaker (from the shorter glide). Note that the longer glide was perceived as discontinuous when the shorter glide was far weaker. This indicates that some amount of sound energy to fill a gap is needed for the perceptual completion of the longer glide. However, the amount of energy required for perceptual completion is clearly lower than what was expected on the basis of the idea that a continuous sound would be perceived when the excitation of peripheral auditory neurons is sustained.—S.G.

MEDICAL IMAGE PERCEPTION

New uses for stereopsis

D'Orsi, C. J., Getty, D. J., Pickett, R. M., Sechopoulos, I., Newell, M. S., Gundry, K. R., et al. (2013). Stereoscopic digital mammography: Improved specificity and reduced rate of recall in a prospective clinical trial. *Radiology, 266* (1), 81–88.



A standard mammogram, used to screen women for breast cancer, is a 2-D x-ray of the breast. That x-ray renders the breast as texture of filamentous structures with various larger densities. The figure reverses the usual luminance polarity so that the image will print well. The radiologist's task is to look for various signs of cancer including masses, collections of small, bright dots of calcium, and what is called "architectural distortion", typically a rather subtle change in the patterns formed by those filaments. As an exercise in medical image perception, this is made more difficult by the fact that the breast is a 3D object rendered as a 2D projection image. If you look at the figure here, you will immediately appreciate that it is hard to tell if some contours that intersect in the image are part of the same structure or are separated by a substantial distance. If this were a real, transparent object, your stereoscopic vision would resolve that question (like looking at tree branches against the sky with one or two eyes open). Could stereopsis come to the aid of breast cancer screening?

Some years ago, David Getty (second author here) developed a system for taking two images of the breast and combining them in a mirror stereoscope. This paper is the report of a clinical trial, using that method. The authors have found evidence that the addition of stereoscopic information does, indeed, have a clinically relevant benefit in breast cancer screening. What was the nature of that benefit? A few more cancers were found with the stereo system (not statistically reliable, in part, because cancer is rare) but the real benefit came in the reduction in false alarm errors. Those of us, outside of the medical trade, tend to think of miss errors as the big problem in medical tests and, of course, no one wants to miss a potentially treatable cancer. However, false alarms are a serious issue, too. The reason lies in the base rates. You can expect to find 3 or 4 cancers in a screening population of 1,000 North American women. There will be something requiring further study in about 10 % of women. Obviously, the vast majority of those 'somethings' will turn out to be nothing. However, that nothing will have frightened the patient and her family and will have run up medical bills. Reducing the false alarm rate, even by a modest amount, has a positive effect on many women and that is what stereomammography promises to do. Basically, it allows the radiologist to decide that some findings, that would be suspicious in a standard image, do not require further examination. It is a lovely piece of applied vision science.—J.M.W.

FACE PERCEPTION

Faceless bodies

Brandman T, & Yovel G. (2012). A face inversion effect without a face. *Cognition, 125*, 365–372.

Faces are enormously powerful social signals. We easily recognize individuals from their faces, from the guy down the street to our own grandmother. One view of how we accomplish this perceptual feat holds that the ability to perceive and recognize faces relies on the operation of specialized neural mechanisms. A signature of this specialized processing is thought to be the face inversion effect (FIE) in which recognition of faces, but not other types of visual stimuli, suffers when items are presented in an inverted as compared to an upright orientation. This effect of inversion may result from a type of configural processing for internal features specific to faces. However, recent research suggests that faceless heads presented in the context of a body also engage ostensibly face-specific mechanisms. Brandman and Yovel investigated the perception of faceless stimuli with and without body contexts in order to determine if and under what conditions faceless stimuli would produce a full inversion effect. Across conditions, participants were presented with heads having full to minimal body contexts, with and without faces, and in inverted and upright positions, as well as with headless bodies and bodies viewed from the back. In Study 1, participants were asked to complete a sequential matching task in order to measure the magnitude of the inversion effect. A full inversion effect was found not only for stimuli with faces, but also remarkably for faceless stimuli presented with a body context. Minimal to no inversion effect was found for headless bodies, faceless heads without a body, and bodies seen from the back. The pattern of results suggests that a full inversion effect occurs even for stimuli that lack internal facial features, as long as presented in the context of a body. In Study 2, participants completed a face detection task with the same set of stimuli. The results showed that faces were detected to a greater extent for the stimuli, even faceless ones, that produced a robust inversion effect relative to those stimuli that produced a minimal inversion effect. These findings suggest that a FIE may be found for faceless stimuli lacking internal facial features when presented in the context of a body. The body context appears to induce a facial percept in the faceless stimuli, engaging face-processing mechanisms.–L.C.N.

VISUOMOTOR INTERACTIONS

Giving Attention A Hand

Gozli D.G., West G.L., & Pratt J. (2012). Hand position alters vision by biasing processing through different visual pathways. Cognition, *124*, 244–50. doi:10.1016/j.cognition.2012.04.008

Attention is typically used in conjunction with action, which involves coordinating the body with objects in the environment. Since the discovery of bimodal neurons, which respond to both visual and body-based somatosensory inputs, behavioral studies have examined the possible consequences of these neurons. To understand how bodily inputs influence visual attention, several recent papers have coupled hand position manipulations with well-studied attention tasks (see Brockmole et al., in press Curr. Dir. Psychol. Sci). In their recent paper, Gozlie and colleagues attempt to understand the specific influence that hand position exerts on visual processing. Based on their results, Gozli et al., (2012) suggest that hand position might bias processing toward the magnocellular visual pathway.

To distinguish processing on the magnocellular and parvocellular pathways, Gozli et al. used two tasks, a spatial gap discrimination that required high spatial resolution (parvo task) and a temporal gap discrimination that required high temporal resolution (magno task). Participants performed these tasks with their hands near the monitor (placed on either side of the monitor) or far from the monitor (in their lap). The spatial gap discrimination task presented a single Landolt circle with a gap of varying size, and participants reported the side of the gap. The temporal gap discrimination task presented a circle that remained visible or flickered briefly, and participants reported if the stimulus remained stable or flickered. Perceptual sensitivity to spatial and temporal gap detection exhibited an interaction between the task and hand position. When the hands were near the display, spatial discrimination was poorer than when the hands were farther from the display. The results were opposite for temporal discrimination, which was poorer when the hands were far from the display than when near the display.

Gozli and colleagues discuss their results in terms of the hypothesized functions of the two visual pathways. Hand position appears to bias processing toward the magnocellular system and the functions it supports, such as temporal perception. The hands might increase magnocellular pathway processing because of the association between this pathway and the dorsal pathway into the parietal lobe, the latter being part of the "how" visual pathway involved in directing visuomotor actions.—S.P.V.