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News from the field

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PSYCHOPHYSICAL METHODS

Welcome to the psychomatrix
Jogan, M., & Stocker, A. A. (2014). A new two-alternative forced choice method for the unbiased characterization of perceptual bias and discriminability. *Journal of Vision, 14*(3):20.

To get around the problem of bias when comparing stimuli that differ in other dimensions (e.g. comparing directions of global motion when coherence also differs), Jogan and Stocker advise discarding the single-comparison two-alternative, forced-choice (2AFC) paradigm (e.g. "which set of dots drifts in a more clockwise direction") for a two-comparison paradigm (e.g. "which set of dots drifts in the direction most similar to this third direction over here"). Rather than a monovariate psychometric function, this method produces a bivariate function, which Jogan and Stocker call a Psychomatrix. (In the parenthetical example above, the two variables would be the differences in direction between each candidate set of dots and the third "test" direction.)

New data highlight the problem with 2AFC. Merely asking observers which set of dots drifts in a more *counter*-clockwise (cf. the example above) direction proved sufficient to introduce a bias that was consistent with an increased consideration of the irrelevant dimension (coherence) when the relevant dimension (direction) was harder to assess.

Psychomatrices are more complicated than psychometric functions, and consequently old-school adaptive staircases require some modification to work within this new-fangled paradigm. Jogan and Stocker have taken care of that too, explaining how best to determine the differences in direction that would maximize the expected information gained from each response before each trial.

The importance of a solid paradigm for excluding decisional biases from psychometric measurements cannot be overstated. One potentially massive benefit of this research would be a savings of valuable resources that are currently spent investigating "perceptual" biases that have no perceptual component (Morgan, Melmoth, & Solomon, 2013). That is why it is so important to disentangle truly perceptual effects from decisional biases like those rampant in some traditional forms of 2AFC.-J.A.S.

Additional References:
Morgan M.J., Melmoth D., Solomon J.A. (2013). Linking hypotheses underlying Class A and Class B methods. *Visual Neuroscience. Nov 30*(5–6):197–206. doi: 10.1017/S095252381300045X.

VISUAL WORKING MEMORY

Two items as precise as one
Bae, G. Y., & Flombaum, J. I. (2013). Two items remembered as precisely as one: How integral features can improve visual working memory. *Psychological Science*, *24*(10), 2038–2047.

A recent debate attempts to ask whether visual working memory (VWM), which allows the temporary storage of a small set of information, is more precisely characterized as a set of discrete slots, or as a pool of resources that can be divided in a graded manner. Both approaches focus on commodity-like limits on memory, and both approaches agree that memory for only one item is likely to be more precise than memory for two items because all of the commodity can be devoted to one item while it would have to be divided among two or more.

Bae and Flombaum (2013) challenged this view. They proposed that two items might be memorized as precisely as one, and that any apparent two-item cost is not caused by a commodity limit, but by a computational problem—a *correspondence challenge*. When memorizing two items (or more), an observer will need some means of knowing which memory item is mapped to the current response. They hypothesized that, when representations of features are noisy, this should be errors when two items were held in memory, but not when there is only one, in which case there should not be a correspondence challenge.

To test their hypothesis, Bae and Flombaum needed to find a way to mitigate the correspondence challenge. They adopted a creative approach use of integral features. Integral features bind automatically in perception and memory. Thus, shape and size are integral features: when making a judgment on the size of an item, its shape has an obligatory impact. In contrast, shape and color are separable features: when making a judgment on the shape of an item, its color can be completely ignored.

In their Experiment 3, Bae and Flombaum used hue and luminance as integral features and test memory for luminance. It was shape and size memory in Experiment 4 and auditory tone and amplitude in Experiment 5. Generally, they found that the memories of two items was substantially worse than memory for one, as is usually found, when they were presented in the *same* integral feature combination (e.g., the sizes of two triangles). However, memories of two items are no more prone to error than single items, when each item is integrated with a different feature (e.g. remember the size of a triangle & the size of a circle).

Bae and Flombaum's finding has important implications on the understandings of visual working memory. Specifically, it points out an important factor (i.e., correspondence challenge) that has often been neglected. The classic frameworks used for VWM, slots or resource, will need to be fundamentally revised to consider this new factor. This very novel finding also points to many interesting follow-up questions. For example, does this constant precision generalize beyond two items, and if so, how far? Is there any other way to relieve the correspondence challenge? Hopefully, explorations of these questions can lead to new findings and better understanding of VWM.–L.Q.H.

TEMPORAL REPRODUCTION

Music to avoid regression

Aagten-Murphy, D., Cappagli, G., & Burr, D. (2014). Musical training generalises across modalities and reveals efficient and adaptive mechanisms for reproducing temporal intervals. *Acta Psychologica, 147*, 25–33.

In the field of time perception, it is well-known that the estimation of a time interval is prone to context effects. For instance, when embedded in a series of intervals of different lengths, a short interval tends to be over-estimated and longer one to be under-estimated. In the timing literature, this effect is referred to as Vierordt's Law, a sort of regression towards the mean. Aagten-Murphy et al. tested whether this robust effect could be attenuated by musicians, given the strong need for accurate timing in musical performances. In their first experiment, the authors asked their participants to reproduce a series of intervals of different lengths, but based around one of three mean values: 671 ms (short distribution: 494–847 ms), 847 ms (intermediate distribution : 671–1,023 ms) and 1,023 ms (long distribution: 847–1,200 ms). The participants' task was to reproduce an interval by holding the space bar after being presented a continuous visual event marking the beginning and end of the interval to be reproduced, by tapping twice after the presentation of two brief flashes marking the interval, or by tapping once, after the presentation of two brief flashes, at the moment when a third visual flash would have occurred for marking a second interval of the same length as the first (a so-called ready-set-go condition). With all three reproduction methods, while the regression towards the mean effect was robust for non-musician participants, musicians exhibit reproductions that remained close to the interval to be reproduced. In a second experiment, only the ready-set-go method was employed, using either visual signals or auditory signals for marking time. The experiment was limited to the 847-ms condition (intermediate), but the distribution of values was manipulated, as well as the number of presentations of the intervals to be reproduced. Overall, the regression towards the mean was stronger when the distribution of values was larger; this regression effect was stronger in the visual than in the auditory condition; and this regression was once again more important for participants with less musical expertise. In brief, in addition to showing the robustness of Vierordt's Law, the investigation showed that musical expertise reduces this regression effect, either with auditory or visual signals marking the intervals. This latter fact is interpreted as a demonstration that pattern-analyzing aspects of temporal perception contain an amodal component. Finally, the authors also provide a Bayesian framework for modeling temporal reproduction and the regression effect.-S.G.

MOTION PERCEPTION

Working memory and decision-making

Ester, E.F., Ho, T., Brown, S.D., & Serences, J.T. (2014). Variability in visual working memory ability limits the efficiency of perceptual decision making. *Journal of Vision, 14*(4). doi: 10.1167/14.4.2

Consider the following task: You are presented with a multi-frame movie composed of dots all moving with the same speed but in various different directions. On any given trial the average velocity of the dots in the movie is either directly rightward or else it is directly leftward. Your task is to press one of two buttons to indicate the target direction as quickly and accurately as you can. This task requires you to integrate information across time about the evidence accumulating in favor of a "rightward" vs a "leftward" response. This means that this task requires memory. Note, however, that this task might not require MUCH memory. One can imagine, for example, a process in which dot-motion information is accumulated across time and visual space and coded by the firing rate of a single neuron somewhere upstream from MT. Under this model, when the firing rate of this neuron hits one of two boundaries (one for the "rightward", the other for the "leftward" response), the participant responds. Note that this "single neuron" model does not require that any raw image information be retained across time at all. Another possibility, however, is that the process that integrates dot-motion information across time makes use of visual working memory (WM) to maintain image information across space and time and that the speed and accuracy of a participant in this task is limited by the capacity of his/her WM. Ester et al. (2014) have conducted a lovely sequence of experiments to resolve this issue.

In their first experiment, they tested around 50 participants in three different tasks. Task 1 was a variant of the motion-direction decision task described above. In Task 2 (a WM task), the participant viewed a three-frame stimulus in which frame 1 (100 ms) was a collection of colored squares, frame 2 (1,000 ms) was a blank gray field, frame 3 contained a single square at the location of one of the squares in frame 1. The task was to judge whether the square in frame 3 had the same color as the square at that location in frame 1. In Task 3 (another WM task), the participant first viewed (for 1,000 ms) a stimulus comprising four circles, each of which contained dots moving perfectly coherently in a random direction; then the participant viewed a blank screen for 1,000 ms; finally, the participant was prompted with an empty circle at the location of one of the four circles in frame 1 and mouse-clicked the point on the circle toward which he/she judged the dots in that circle to have been moving in the first display.

The motion-decision task data from each participant were fit with a reaction-time model in which the parameter reflecting the sensitivity of the decision process to the visual input was called "drift-rate." The data from each of the two working-memory tasks modeled in order to obtain an estimate of WM capacity. The key finding was that drift-rate was robustly correlated with WM capacity for each of the two WM tasks.

One might be concerned that the motion-decision task is a special kind of decision task in that the information required to make the judgment is made available only gradually to the participant. In a second experiment, the authors show that the same effect can be obtained using a letter identification task instead of the motion-decision task. In aggregate, these results make a strong case that working memory and the memory used in accumulating sensory information for making decisions are "directly linked."–C.C.

TEMPORAL ATTENTION

Prioritizing space and time

Rohenkohl, G., Gould, I. C., Pessoa, J., & Nobre, A. C. (2014). Combining spatial and temporal expectations to improve visual perception. *Journal of Vision, 14*(4):8, 1–13.

If we know that a stimulus, relevant for our current goals, is likely to appear in a specific location, we can prioritize the processing of information gathered at that location. Numerous behavioral studies have shown that such space-based prioritization can substantially improve performance, and physiological and neurophysiological studies suggest that this performance improvement is mediated by increased neuronal activity at the expected location. But what if we know that a relevant stimulus is likely to appear at a specific point in time? Can we also prioritize time and similarly improve the processing of information presented at that point in time? By now, enough studies have been conducted to suggest, rather convincingly, that this is indeed the case. However, much uncertainty still remains regarding the mechanism by which prioritizing a specific point in time leads to improved performance.

Rohenkohl and colleagues test the intriguing hypothesis; that prioritizing a point in time affects performance via space-based mechanisms—further strengthening the enhancement of neuronal activation brought about by the prioritization of a location in space. To test this hypothesis they employed visual precues that indicated, simultaneously, the likely location and point in time of the upcoming target. Their cue was a central arrow. On 80 % of the trials, it pointed at the location at which the target would appear (left or right), and on the rest of the trials, it pointed at the other possible location. Independently, the color of the arrow (pink vs. blue) indicated, with 80 % validity, the likely time interval between the cue onset and the target onset (800 ms vs. 2,000 ms). The task was to indicate the orientation of a Gabor patch, and since the authors were interested in top-down prioritization they instructed their participants to utilize the space and time 'forecast' generated by the cue. They found that prioritizing a location always improved performance, regardless of time prioritization. Performance was significantly better at the expected location compared to the unexpected location, regardless of whether or not the target appeared after the expected interval. In contrast, prioritizing a point in time improved performance only when it matched space prioritization. Performance was better when the target appeared after the expected interval compared to the unexpected interval, but only when it appeared at the expected location. When it appeared at the unexpected location there was no effect of temporal expectations. Thus, in accordance with the authors' hypothesis, temporal expectations affected performance only when those expectations concurred with spatial expectations. In other words, temporal expectations helped when they could enhance the effects of spatial expectations (i.e., when the target appeared at the expected location). However, when the target appeared at the unexpected location there was no space-based enhancement to further strengthen, and therefore there was no effect of temporal expectations. These findings are the first behavioral demonstration of an asymmetric treatment of space and time prioritization, and we do not yet know how robust it is. Still, these findings are consistent with the view that the visual system is biased towards the spatial domain. It will be particularly interesting if a different pattern of results will emerge with auditory stimuli, as the auditory system seems to be more biased towards the temporal domain.-Y.Y.

VISUAL ATTENTION

Search templates

Ackermann, J. F., & Landy, M. S. (2014). Statistical templates for visual search. *Journal of Vision*, *14*(3). doi: 10.1167/14.3.18

Spotorno, S., Malcolm, G. L., & Tatler, B. W. (2014). How context information and target information guide the eyes from the first epoch of search in real-world scenes. *Journal of Vision*, *14*(2). doi: 10.1167/14.2.7

Two broad sources of information guide visual search when we are looking for target items in scenes. First, there are the features of the target. If the target is known to be red, we guide attention to red objects in the field. Second, there is the relationship of the object to the scene. If you are looking for a plate, it makes more sense to guide your attention to tables and cupboards than to floors or beds. This “scene guidance” can be thought of as a form of expertise. Because we have so much experience with a broad variety of scenes, we are all “plate experts”. Experts in more specialized domains learn to guide their attention in specific kids of “scenes” from abdominal x-rays to satellite images.

Two recent articles in the Journal of Vision shed new light on aspects of the guidance of attention. Ackerman and Landy tackle the problem of what it means to guide to target features. Sometimes that is straight forward, as when observers are looking for a red vertical line. It is much less obvious if you are looking for something like a specific kind of bark. The texture of oak may be different from maple, but a simple template or even a template that can rotate to handle different orientations is going to have a hard time dealing with such a target. Ackerman and Landy propose that texture decomposition algorithms, like the popular Portilla and Simoncelli algorithm, can provide a rich description of a texture target. This description can then be used to create a summary statistic template that models human behavior better than a more conventional target template.

Spotorno, Malcolm, & Tatler try to address the relative contributions of feature and scene guidance in visual search for realistic objects in scenes. Does one source of guidance take precedence over the other? The problem with scene search is that it is very hard to get parametric control over the stimuli. Spotorno et al. use rather simple scenes with two well-defined regions (e.g. field and sky). They then place well-defined objects (e.g. a hot air balloon and a cow) in the appropriate or inappropriate region of the scene. Using this relatively uncluttered situation allows them to orthogonally cross scene- and object-based guidance, and to look where the eyes go when the scene appears. They find evidence that both forms of guidance are used from the start of the trial. The forms of guidance interact but, in their situation, a good target template (i.e. being cued with the picture of the target) tends to override scene information. If you are looking for This Cow, you are not particularly disturbed when it turns out that the cow is in the sky.

Both of these studies advance our understanding of search though, in each case, they also serve to illustrate that a complete understanding is some distance off. In the Ackermann and Landy case, it is interesting to wonder how a summary statistic model could be scaled up to deal with search for categories of target like “threats” in a security search task. Is there a ‘texture’ of threat? Do we learn multiple sets of statistics and deploy them simultaneously? In the Spotorno et al. paradigm, we are faced with the problem that, once you have seen a couple of cows in the sky, your rules of scene guidance are altered for the current task. While the syntax and semantics of scenes may be a very powerful guide to attention in the normal world, one can imagine that feature guidance might very well trump scene guidance once the observer learns that cows fly in the world of this experiment.–J. M. W.