Distinct effects of memory and cue validity on orientation judgments

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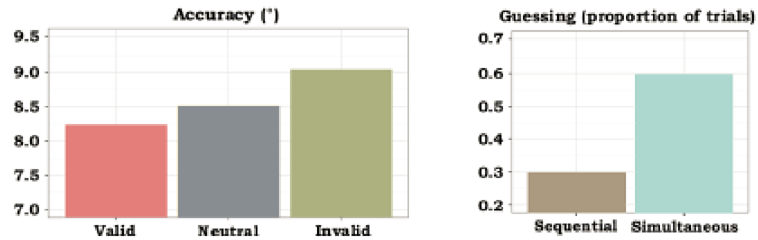
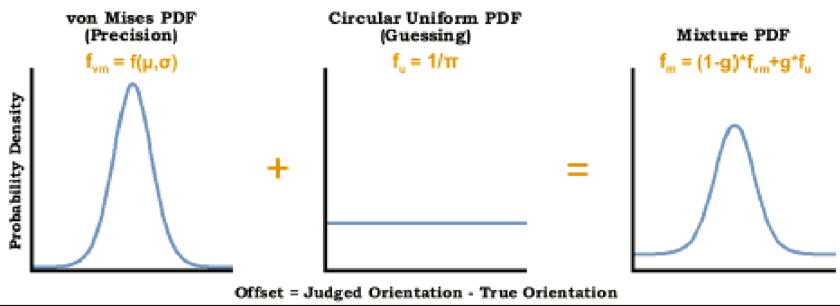
1

We know that attention improves the accuracy of orientation judgments[1] while memory-load increases the proportion of guesses made.[2]



2

Accuracy can be improved because responses were more precise or fewer guesses were made. The distribution of responses is a mixture of both.



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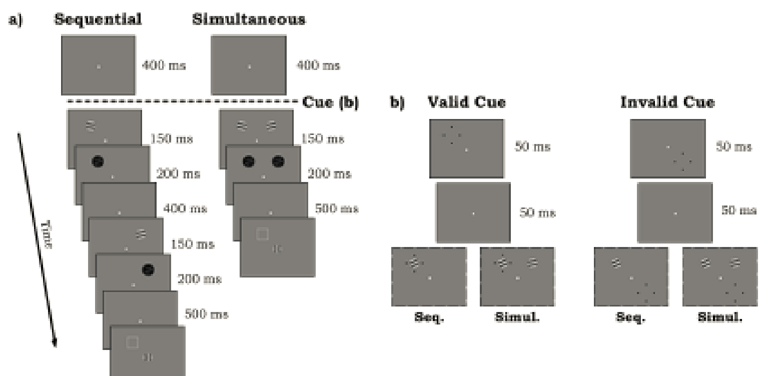
We were interested in investigating the effect of attention and memory-load on guessing and precision when they were manipulated in the same task.



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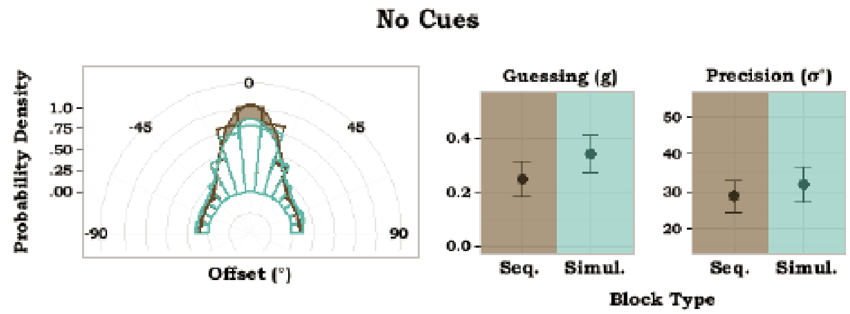
More guesses were made on simultaneous trials, but the precision of responses was unaffected by block type.



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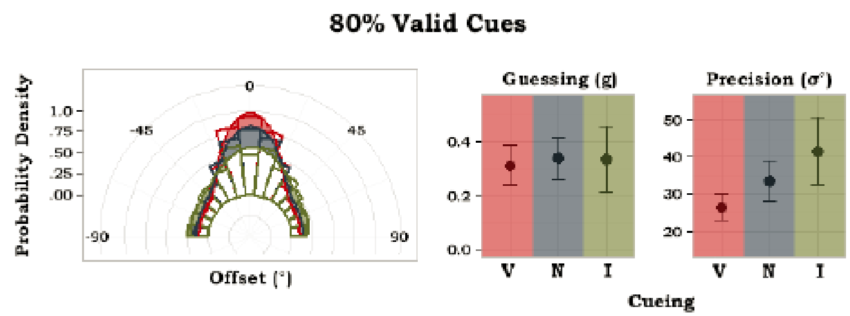
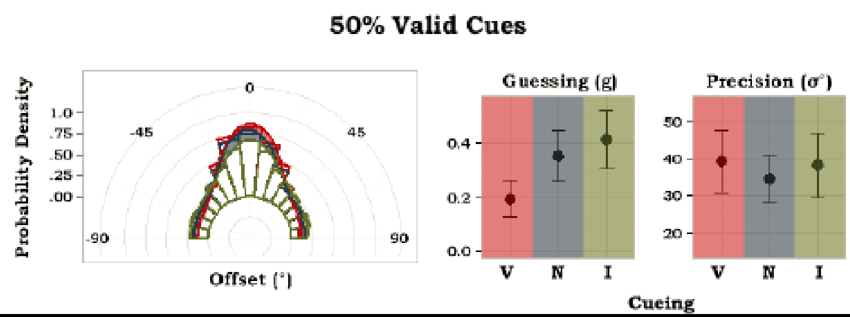
Informative cues improved precision, but did not affect guessing. In contrast, non-informative cues reduced guessing, but did not affect precision.





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References:

[1]Anderson, B., & Druker, M. (2013). Attention improves perceptual quality. *Psychon Bull Rev* , *20*, 120-127.

[2]Liu, T., & Becker, M. W. (2013). Serial Consolidation of Orientation Information Into Visual Short-Term Memory. *Psychological Science*, *24* (6), 1044–1050.

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1. Anderson and Druker (left) demonstrated that orientation judgements are more accurate when attention is accurately directed to the location the target will appear in (valid), and they are less accurate when attention is misdirected (invalid).

Accuracy improvements can result because:
1. The precision of responses was improved
2. The item was more likely to be consolidated into memory, and consequently guessing was reduced

A mixture model (described in the next section) can be fit to the distribution of errors in order to estimate the precision and proportion of guessing in a set of data.

Liu and Becker (right) fit such a mixture model and showed that the accuracy benefit conferred by presenting two stimuli sequentially versus simultaneously resulted from fewer guesses.

We were interested in:
1. Investigating the mechanism by which attention improves accuracy (guessing vs. precision)
2. Contrasting attention and memory when they are manipulated in the same task

2. The offset between judged orientation and true orientation on each trial is calculated by subtracting the true orientation from the judged orientation and wrapping it to an interval between -90° and +90°. A mixture model, which estimates precision and proportion of guesses, can then be fit to the offset data.

The mixture model assumes that performance is the result of a combination of trials in which participants fail to consolidate the stimulus into VSTM and therefore guessed (probability of guessing is denoted by g), and trials in which the stimulus was consolidated and responses are from memory ($1-g$). Trials in which participants guessed should produce a uniform distribution of offsets and trials in which participants recalled from memory should produce a circular normal distribution, which we operationalised with a von Mises distribution of mean (μ; representing bias) and standard deviation (σ; representing precision).

3. a) The experimental trials consisted of sequentially and simultaneously presented stimuli, which were presented to participants blocked. Two circular gratings, which were backwards masked, were displayed. In the sequential condition the gratings were presented one after the other and in the simultaneous condition they were presented at the same time. When prompted for a response, a white square appeared in a location previously occupied by a grating to indicate which grating should be recalled. Participants were required to rotate a central response grating to match the angle of the indicated grating.

b) On half of the experimental trials a spatial pre-cue, consisting of four black dots, appeared before the presentation of the stimuli. The stimuli and the cue disappeared together. Three cue validities were used in three experiments: 100%, 80 and 50%.

4. This is data from Experiment 1 from trials in which no cue appeared. The aggregate distributions were not different in Experiment 2 and Experiment 3. The circular plot shows the density of participant responses (the bars), and the mixture model as fit to the aggregate data (the curve). The point-and-whisker plots show the mean, individual guessing proportion (left) and precision (right). We replicated the results of Liu and Becker: precision was unaffected by block type, but fewer guesses were made on sequential trials.

5. 100% (E1) and 80% (E2) cues affected responses the same on valid trials, so only results with the 80% cue are shown. These data (80% and 50% cues) are from only simultaneous trials as the cue was found to be weakly effective on sequential trials.

We found that informative cues (80%) improved the precision of responses, but did not affect guessing. In contrast, non-informative cues (50%) reduced guessing, but precision was unaffected. For informative cues, the likelihood of having misdirected attention away from the target by allocating attention at the cued location was low; therefore, the cost of errors was also low. Consequently, attention can be strongly and narrowly focused at the cued location without much sacrifice to overall accuracy. As a result, precision was improved. In contrast, the cost of errors is higher for non-informative cues because the likelihood of having misdirected attention is greater. Consequently, while some attention was captured by the spatial cue, its focus was weaker and wider in comparison to informative cues. As a result, the target was more likely to have been seen, reducing guessing, but was not afforded a processing benefit. **Taken together, our results suggest that the perceptual system considers the cost of errors when allocating spatial attention.**