

# Information about all items is actively held in mind when computing ensemble statistics about a set

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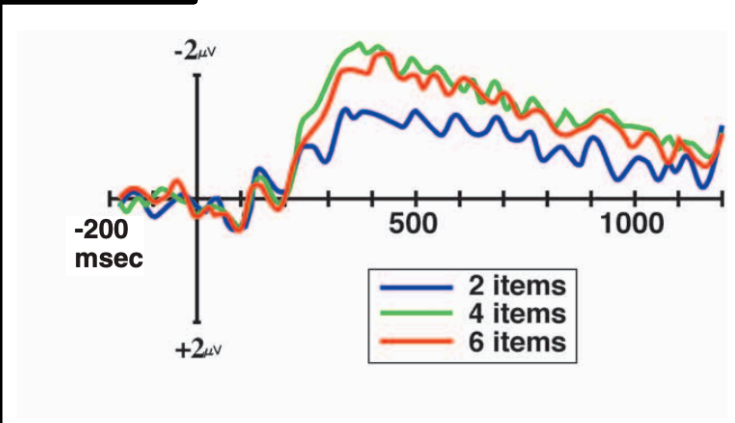
## Background and Question

We can extract summary statistics about a set, such as its mean or variance – a process referred to as ensemble perception. While this process is typically characterized as effortless and independent of individual item information, we wanted to critically test if this is the case by asking:

**How much information is held in mind when remembering ensemble statistics about a display?**

## CDA

- Our EEG measure of amount of information in working memory



(McCollough, Machizawa, & Vogel, 2007)

The CDA is a negative ERP over parietal-occipital cortex contralateral vs. ipsilateral, typically plotted as a contra – ipsi difference wave.

**The CDA indexes how much information is actively held in mind.**

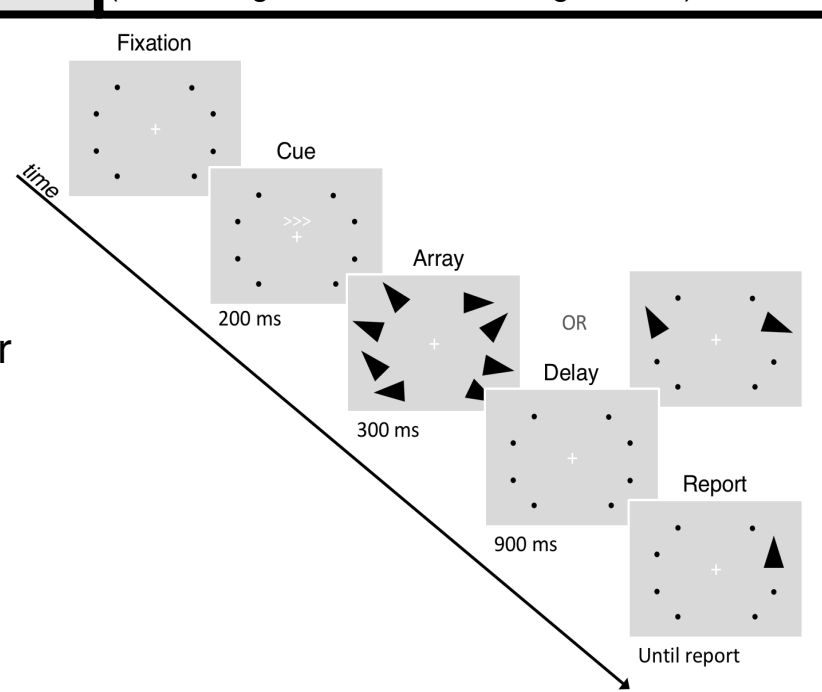
## Task Design

Subjects (N=20) performed 3 different tasks in a blocked (8 mini-blocks of 20 trials each) design while EEG was recorded.

**Remember 1 (R1):** Subjects remembered the orientation of a single cued triangle over a delay

**Remember 4 (R4):** Subjects remembered the orientations of four cued triangles over a delay

**Report Mean (RM):** Subjects computed the mean orientation of four cued triangles



## Predictions

If ensemble perception is effortless and independent of item information:

$$RM\ CDA = R1\ CDA$$

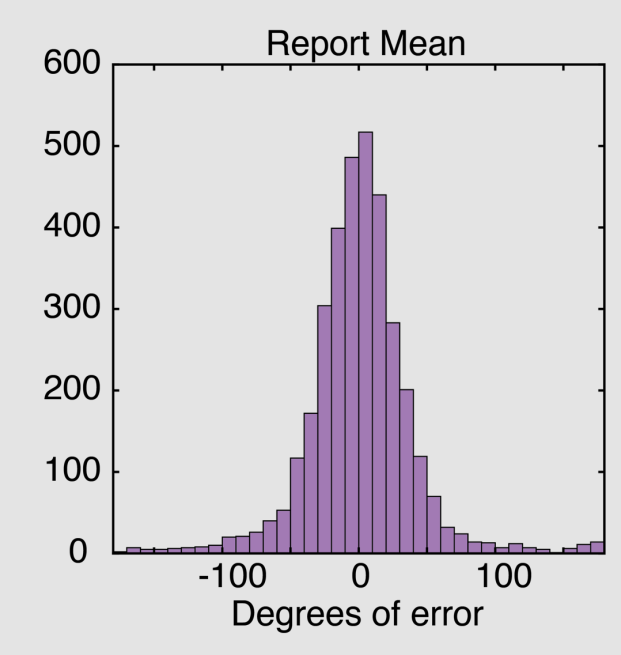
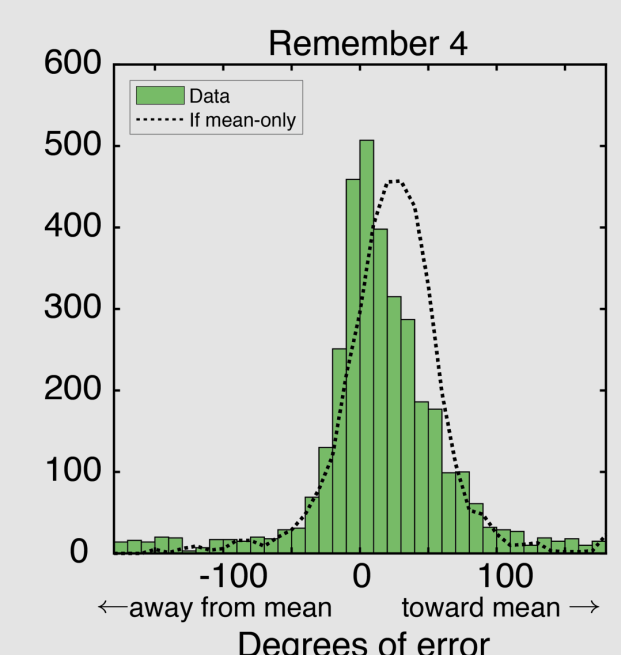
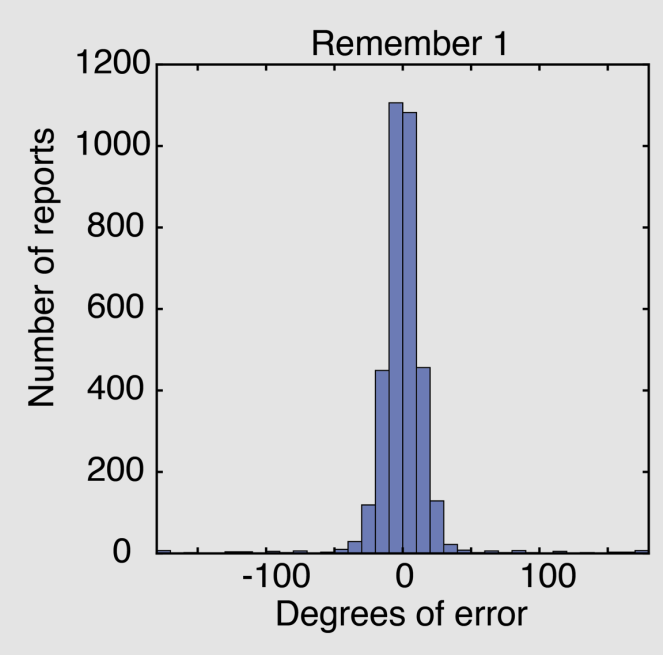
If item information is maintained while computing ensemble statistics:

$$RM\ CDA = R4\ CDA$$

## Behavioral Results

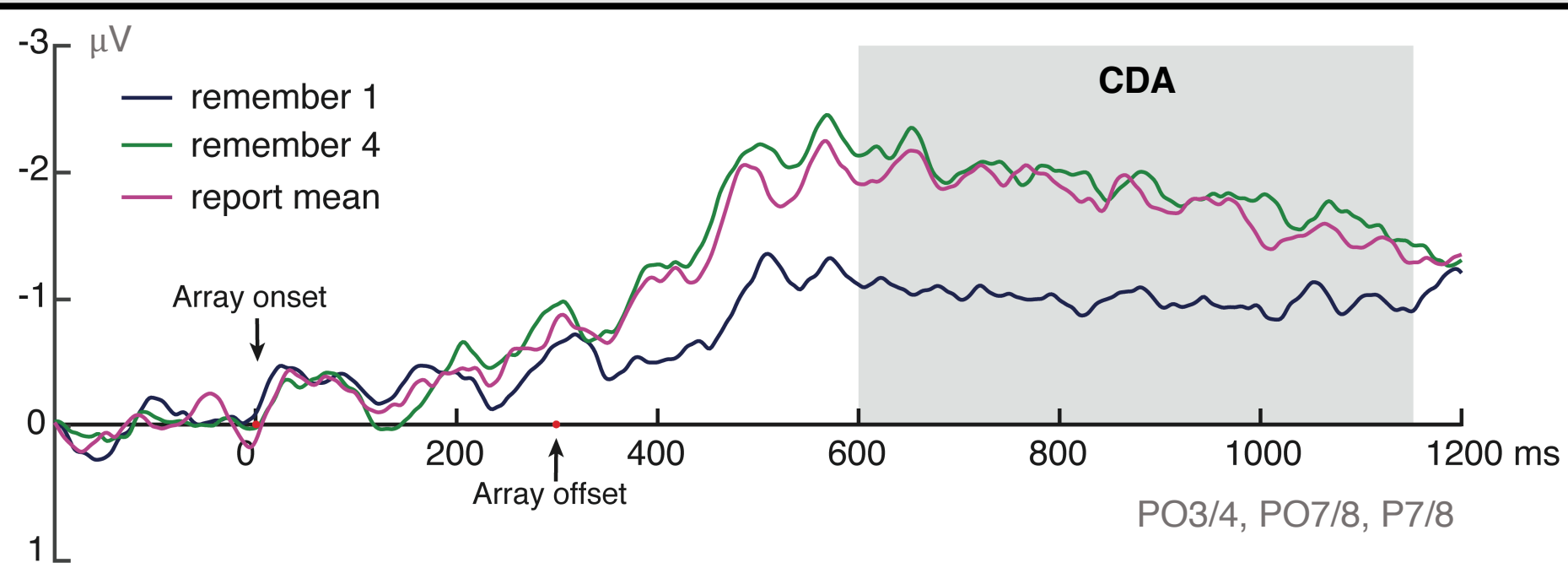
Subjects were precise in their reports and did not simply report the mean of the set when asked to remember 4 items.

Note that individual item reports were biased toward the mean of the set when remembering 4 items! For more information about this effect, see poster #476 by Utochkin & Brady!



## CDA Results

We found that CDA amplitude was approximately equal in the R4 and RM tasks, and significantly larger than in the R1 task.



CDA amplitude indicates that subjects were holding the same amount of information in mind when asked to report the mean of a set of four items as when they were asked to active hold four items in mind.

## Discussion

The present results argue against ensemble perception as a rapid, effortless process independent of individual item information.

Instead, we propose that subjects hold information about all items in mind while computing ensemble statistics – but without individual location information. We think of this as a “population coding” account, in which subjects maintain information about all items in relevant neural populations and then extract the mean, variance, or range of this feature information when prompted.

