Why don't people look at targets during multiple object tracking?

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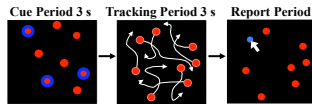
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PAC lab — perception, attention & control

Previous Work

People do not need to make eye movements to keep track of multiple objects moving in their periphery (Verstraten et al., 2001). However, eye movements may reveal strategies that contribute to successful tracking. We have found that people primarily keep gaze close to the center of the virtual shape formed by the targets they are tracking (Fehd & Seiffert, 2008).

Virtual Shape

The **center** is defined as the centroid of the **Virtual Shape** formed by the targets.

Method:
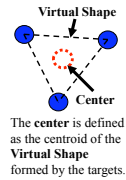
Cue Period 3 s → Tracking Period 3 s → Report Period

• Participants performed a Multiple Object Tracking (MOT) task (Pylyshyn & Storm, 1988) where they tracked 1 or 3 of 8 total dots which moved around the display for 3 seconds.
• Dots were 2.1° in size and moved at 15°/s.
• At the end of each trial, participants selected all of the targets. Only trials in which all targets were correctly selected were used for gaze analysis.

Gaze Analysis Method:

• An ASL video-based eye-tracker recorded participants' eye positions at 120 Hz.
• **Gaze Overlap Time**: The percentage of time that gaze was found to overlap within a window twice the diameter of a dot.

Window — Non-Overlapping Gaze — Overlapping Gaze
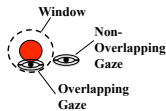
Results:
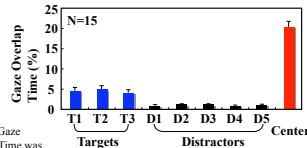
NOTE: Gaze Overlap Time was averaged across targets and averaged across distractors in all other graphs.

Eye gaze was directed to the center of the target array much more than to each of the targets or distractors.

Conclusion:

• Directing gaze to the center, or center-looking, is the predominant eye movement strategy during MOT.

Objective

We investigated why people tend to look mostly at the center of a target array instead of at the targets during tracking.

Experiment 1: Decreasing Dot Size

Predictions:

• If people are center-looking only because peripheral resolution is sufficient to maintain attentional foci on the targets, it should be abandoned when small target size necessitates target-looking.
• Alternatively, if center-looking is important to the tracking process, then it may be maintained when targets are small, despite an increase in target-looking.
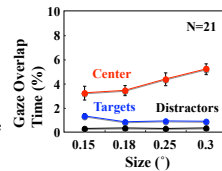
Method:

• Participants tracked 4 of 10 total dots moving at 12°/s.
• Dots were 5 different sizes: 0.06°, 0.15°, 0.18°, 0.25°, and 0.3° of visual angle.

Dot Size = 0.06°   Dot Size = 0.3°
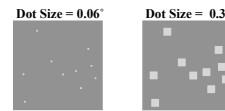
Results:

As dot size decreased, gaze overlapped with the center less $(F(3,54)=4.59, p<.01)$ and targets more $(F(3,54)=4.35, p<.01)$. However, even at the smallest size, gaze was on the center more than each target $(t(19)=2.78, p<.05)$.

NOTE: Results with 0.06° size are not shown because participants failed at the tracking task.

Conclusions:

• As targets become too difficult to detect peripherally, target-looking increases.
• However, center-looking still dominated eye movement behavior, suggesting that there is some value in looking at the center.

Experiment 3: Increasing Target Grouping

Predictions:

• If people are center-looking because they group the targets into a virtual object, then making grouping easier should increase center-looking.

Method:

• Grouping was manipulated by varying the similarity of target movement.
• We varied the differences in direction across targets, either 0° **(completely yoked)**, 6°, 12°, or 360° **(completely random)**.

Target Motion Yoked   Target Motion Random
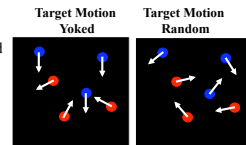
Targets shown here as blue dots for illustration of direction differences. In the experiment, all dots remained red throughout all trials.

Experiment 2: Decreasing Dot Speed

Predictions:

• If center-looking is the default gaze position that is used because saccades to targets take time away from tracking, then when dots move more slowly there will be more target-looking and less center-looking.
• Alternatively, if center-looking is useful for tracking, then the dominance of center-looking should be maintained at slow speeds.
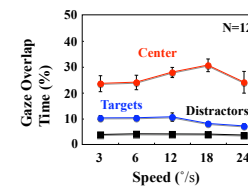
Method:

• Participants tracked 4 of 10 total dots sized 2.1°
• Dots moved at 5 different speeds: 3°/s, 6°/s, 12°/s, 18°/s, 24°/s

Dot Speed = 3°/s   Dot Speed = 24°/s
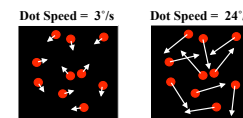
Results:

Gaze overlapped with targets marginally more at slower speeds $(F(4,32)=2.49, p=.06)$, but the amount the center was viewed did not vary $(F(4,32)<1)$.
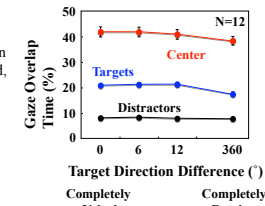

Conclusion:

• Targets were viewed slightly more when the dots moved slower, but gaze still returned to the center, suggesting that eye movement avoidance is not the cause of center-looking.

Results:

As the differences between target directions decreased, grouping increased and gaze overlapped with the targets more $(F(3,30)=14.6, p<.01)$. However the amount the center was viewed did not vary $(F(3,30)<1)$.

Completely Yoked — Completely Random

Conclusion:

• Decreasing direction differences between targets had a minimal effect on gaze behavior either because grouping did not promote center-looking or because decreasing direction differences did not increase grouping.

Experiment 4: Is center-looking helpful?

Predictions:

• If center-looking is helpful for tracking, then instructing participants to look at the center of the targets will produce higher tracking accuracy than restricting gaze to targets.
• Alternatively, if center-looking is a by-product of lazy gaze behavior and not beneficial, then enforcing center-looking should be harmful.

Method:

Target-looking Strategy: Always look at one of the targets and do not look at the center of the targets.

Center-looking Strategy: Always look at the center of the targets or at a target. Saccade back to the center before looking at another target.

*Session 1*: Only **Free-looking** trials; no eye movement instructions were given.
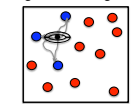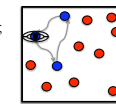
Session 2: In separate blocks, participants were instructed to engage in **Target-looking**, **Center-looking**, or **Free-looking** eye movement strategies while tracking 3 of 12 total 1.8° sized dots moving at 12°/s.

Results:

Tracking accuracy, defined as the percentage of trials where all targets were correctly selected, was higher for Center-looking than Target-looking, though both were impaired in comparison to Free-looking.
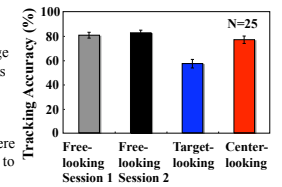
Viewing times shifted as expected with instructions, indicating that participants did follow the strategy directions.
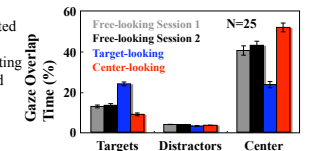
Conclusions:

• Center-looking is beneficial to multiple object tracking.
• Free-looking produced superior tracking performance to Center-looking, indicating that Center-looking is only an approximation of participants' natural viewing tendencies.
• The center was still looked at when people were directed to look only at targets, suggesting that looking at the center is a dominating tendency.

Why don't people look at targets during multiple object tracking?

Because there is value in looking at the center instead of the targets during tracking.

References

Fehd, H. M., & Seiffert, A. E. (2008). Eye movements during multiple object tracking. *Cognition, 108*(1), 201-209.

Pylyshyn, Z., & Storm, R. (1988). Tracking multiple independent targets: evidence for a parallel tracking mechanism. *Spatial Vision, 3*(3), 179-197.

Verstraten, F. A., Hooge, I. T., Culham, J., & Van Wezel, R. J. (2001). Systematic eye movements do not account for the perception of motion during attentive tracking. *Vision Research, 41*(25-26), 3505-3511.