**Is there a cuing effect in terms of reaction time?**

2x3 ANOVA: Cue Type (Exogenous vs Gaze) X Cue Validity (Valid vs Neutral vs Invalid)

* **Main effect of cue type:** *F*(1, 9) = 1.65, *p* = .231 > .05 (non-significant)
  + **Statistical interpretation:** Mean overall reaction times for gaze-cuing trials were not significantly different from mean overall reaction times for exogenous cuing trials.
  + **Practical interpretation:** Participants were just as fast to respond to exogenous and gaze cued trials.
* **Main effect of cue validity:** *F*(1.89, 17.00) = 17.25, *p* < .0001 (significant)
  + **Statistical nterpretation:** There is a significant difference between the mean reaction times of the valid, invalid, and neutral conditions (but we don’t know the direction of these differences until reading our planned contrasts).
  + **Planned contrasts (*t*-tests):**
    - Valid vs Invalid: *t*(9) = -4.80, *p* = .0019 < .05 (significant)
      * Interpretation: Valid trials had significantly faster reaction times than invalid trials.
    - Valid vs Neutral: *t*(9) = -5.099, *p* = .0019 < .05 (significant)
      * Interpretation: Valid trials had significantly faster reaction times than neutral trials.
    - Invalid vs Neutral: *t*(9) = .612, *p* = .556 > .05 (non-significant).
      * Interpretation: Invalid trials did not have signficiantly different reaction times from neutral trials.
  + **Overall statistical interpretation:** There was a significant cuing effect, such that valid trials were significantly faster than invalid trials and neutral trials, but there was no difference between invalid and neutral trials.
  + Practical interpretation: When
* **Interaction of cue type and cue validity:** *F*(1.98, 17.78) = 6.68, *p* = .007 < .05 (significant)
  + **Statistical interpretation:** The size of the cuing effect was different between gaze and exogenous cues, but we’re not sure how yet without doing the planned contrasts.
  + **Planned contrasts (*t*-tests):**

**Research Question 1: Do gaze-cuing and exogenous cuing produce cuing effects?**

**Cuing Effect:**   
There’s two ways of looking at the cuing effect:

1. Valid vs Invalid Trials: Participants are expected to respond faster and/or more accurately to valid trials (i.e., where the cued direction matches the target location) compared to invalid trials (i.e., where the cued direction does not match the target location).
2. Costs vs Benefits: Neutral cues (e.g., a gaze looking straight ahead) are used to measure the “costs” of invalid trials and the “benefits” of valid trials. Typically, there is a “benefit” to valid trials, such that participants respond faster and/or more accurately to valid trials than to neutral trials. There is also expected to be a “cost” to invalid trials, such that participants respond faster and/or more accurately to neutral trials than to invalid trials.

**Hypothesis:**   
There will be a cuing effect (of either type) for both gaze and exogenous cues.

**Hypothesis Test Method:**   
2 x 3 ANOVA of Cue Type (gaze vs exogenous) x Cue Validity (Valid, Neutral, Invalid)

There are two kinds of tests we can do within an ANOVA to investigate these effects:

1. Main Effects: These are overall mean differences, tested with *F*-tests. For example, are the mean reaction times of valid, neutral, and invalid trials **all** the same? Main effects only tell us that there is **some difference** between conditions, but if there’s more than 2 factors in the main effect test (e.g., there’s three for cue validity), then we have to do followup contrasts to understand where these differences come from.
2. Followup Contrasts: Followup contrasts are tested with *t*-tests. When there’s more than two factors in a condition (e.g., for cue validity: valid, neutral, and invalid), these tests help us figure out where the mean differences observed in the main effects come from (e.g., maybe valid trials are faster than invalid trials, but valid trials are no different from neutral trials).

**Hypothesis Test Results:**

Main Effect of Cue Type (Non-Hypothesized):

*Reaction time.* The main effect of cue type was non-significant: participants did not respond significantly faster to exogenous cues than to gaze cues, or vice versa, *F*(1, 9) = 1.65, *p* = .231 > .05.

*Accuracy.* The main effect of cue type was significant: participants responded significantly more accurately when cued by a gaze cue than by an exogenous cue, *F*(1, 9) = 13.20, *p* = .005 < .05.

*Practical Interpretation.* This doesn’t matter. It’s just mandatory to make the ANOVA work.

Main Effect of Cue Validity (Hypothesized):

*Reaction time.* There was a main effect of cue validity, such that the mean reaction times of valid, neutral, and invalid trials were not all the same, *F*(189, 17.00) = 17.25, *p* < .001.

*Accuracy.* There was a main effect of cue validity, such that the mean accuracies of valid, neutral, and invalid trials were not all the same, *F*(1.89, 17.00) = 9.07, *p* = .005 < .05.

*Practical Interpretation.* There was a cuing effect, but we don’t know what kind of cuing effect it was (Valid vs Invalid or Costs vs Benefits), and we don’t know whether the cuing effect was different between gaze cues and exogenous cues. To find that out what kind of cuing effect we have overall, we’d have to do followup contrasts. And to find out whether the type of cuing effect was different between exogenous and gaze cues, we’d have to test the interaction effect of Cue Type x Cue Validity.

Followup Contrasts of Cue Validity:

*Reaction time.* We observed the first type of cuing effect (Valid vs Invalid): participants responded significantly faster to valid trials than to invalid trials, *t*(9) = -4.80, *p* = .002 < .05. We also observed the “Benefits” portion of the Costs vs Benefits cuing effect: participants responded significantly faster to valid trials than to invalid trials, *t*(9) = -5.10, *p* = .002 < .05. The “Costs” portion, however, was non-significant, *t*(9) = 0.612, *p* = .56 > .05.

*Accuracy.* We observed the first type of cuing effect (Valid vs Invalid) for accuracy: participants responded significantly more accurately to valid trials than to invalid trials, *t*(9) = 3.35, *p* = .03 < .05. We also observed the “Costs” portion of the second type of cuing effect (Costs vs Benefits): there were significant “Costs” to invalid trials, such that participants responded significantly less accurately to invalid trials than to neutral trials, *t*(9) = -2.74, *p* = .046 < .05.

*Practical Interpretation.* We observed both types of cuing effects: participants responded faster and more accurately for valid trials than for invalid trials. Participants also showed “Benefits” for valid trials (compared to neutral trials) in terms of faster reaction time for valid trials, and “Costs” for invalid trials (compared to neutral trials) in terms of lower accuracy for invalid trials. We do not know yet without testing the interaction effect whether the cuing effects differed between gaze and exogenous cues.

Interaction of Cue Type x Cue Validity (Non-Hypothesized):

*Reaction time.* There was a significant interaction between Cue Type (gaze vs exogenous) and Cue Validity (Valid vs Neutral vs Invalid), such that the mean reaction times of all the combinations of cue types and cue validity were not equal, *F*(61.98, 17.78) = 6.68, *p* = .007 < .05.

*Accuracy.* There was a significant interaction between Cue Type (gaze vs exogenous) and Cue Validity (Valid vs Neutral vs Invalid), such that the mean accuracies of all the combinations of cue types and cue validity were not equal, *F*(61.98, 17.78) = 6.68, *p* = .007 < .05.

*Practical Interpretation.* Somewhere along the way, there is a difference in the cuing effects produced by gaze and exogenous cues. But without contrasts, we have no idea how to interpret this.

Followup Contrasts of the Interaction of Cue Type x Cue Validity:

*Reaction time.* We did not observe either cuing effect for gaze cues, in terms of reaction time: for gaze cues, valid trials were not significantly faster than invalid trials, *t*(9) = -3.27, *p* = .10 > .05. There were no “Costs” to invalid (compared to neutral) gaze cued trials, *t*(9) = 2.41, *p* = .32 > .05, and no “Benefits” to valid (compared to neutral) gaze cued trials, *t*(9) = -0.85, *p* = 1.00 > .05. We did, however, observe cuing effects for exogenous cues, in terms of reaction time: for the first type of cuing effect (Valid vs Invalid), participants responded significantly faster to valid exogenous trials than to invalid exogenous trials, *t*(9) = -3.90, *p* = .04 < .05. We also observed the first half of the second type of cuing effect (Costs vs Benefits): participants responded significantly faster to valid exogenous trials than to neutral exogenous trials, *t*(9) = -4.95, *p* = .01 < .05. But participants did not respond significantly faster to neutral exogenous trials than to invalid exogenous trials, *t*(9) = -.92, *p* = 1.00 > .05.

*Accuracy.* Again, we did not observe either cuing effect for gaze cues, in terms of accuracy: for gaze cues, valid trials were not significantly faster than invalid trials, *t*(9) = 1.71, *p* = .60 > .05. There were no “Costs” to invalid (compared to neutral) gaze cued trials, *t*(9) = -1.87, *p* = .60 > .05, and no “Benefits” to valid (compared to neutral) gaze cued trials, *t*(9) = -.012, *p* = 1.00 > .05. We also did not observe either cuing effect for exogenous cues, in terms of accuracy: for exogenous cues, valid trials were not significantly faster than invalid trials, *t*(9) = 3.50, *p* = .08 > .05. There were no “Costs” to invalid (compared to neutral) exogenously cued trials, *t*(9) = -2.48, *p* = .34 > .05, and no “Benefits” to valid (compared to neutral) exogenously cued trials, *t*(9) = 2.55, *p* = .34 > .05.

*Practical Interpretation.* Exogenous cues produce both types of cuing effects: faster and more accurate responses to Valid than to Invalid trials, and faster responses (i.e., “Benefits”) for valid trials than for neutral trials. Gaze cues, however, did not produce either form of cuing effect. Our hypothesis that gaze cues would produce a cuing effect like exogenous cues, then, is falsified.

**Research question 2: Does gaze-cuing produce illusory line motion, like exogenous cuing?**

**Illusory Line Motion:**

Recall how the attention hypothesis for illusory line mtoion works: it claims that lines will be incorrectly perceived as being drawn in the direction opposite the cued side. So, for example, if a flash occurs on the left side, the line will appear to be drawn towards the right. It follows, therefore, that there are two ways to assess illusory line motion:

1. Static lines: When a line is drawn all at once, the line should appear as being drawn in the direction opposite the cued side.
2. Moving lines: When a line is drawn either towards the left or the right, the perception of motion should be cancelled out if the cue appears on the same side the line is being drawn in. For example, if the line is being drawn to the right and the cue appeared on the right, then the line should appear as being drawn all at once.

These two measures of the illusion are not mutually exclusive: for example, gaze cues could produce illusory line motion for static lines without cancelling out motion perception for the moving lines. This would tell us, then, that the illusion is weak for gaze cues (especially if exogenous cues also cancel out motion perception for the moving lines; recall, Bavelier found that the line motion illusion for gaze cues is very tiny).

**Hypothesis:**

Our primary hypothesis is that gaze cuing will produce illusory line motion, like exogenous cuing. This breaks into two secondary hypotheses:

1. Gaze-cuing will produce illusory line motion in the static line trials, in the direction predicted by the attention hypothesis.
2. Gaze-cuing will cancel out line motion in the real line motion trials, when gaze cues appear on the same side the line is being drawn in.

We’re assuming, for argument’s sake, that exogenous cuing will produce both of these effects (but we might find it doesn’t!).

**Hypothesis Test Method:**

2 x 3 ANOVA of Cue Type (gaze vs exogenous) x Line Direction (Static, Left, Right)

There are two kinds of tests we can do within the ANOVA:

1. Main Effects: Like for detection, these are tested as overall mean differences with *F*-tests. For example, are the mean line motion ratings of gaze and exogenous cues the same?
2. Followup Contrasts: As with detection, followup contrasts are tested with *t*-tests. So, if there are main effects, these tests help us understand what conditions the main effects come from. For example, participants may have illusory line motion in the static line condition without cues cancelling out perceptions of real line motion.

Really, what we care about here are the contrasts, rather than the main effects.

**Hypothesis Test Results:**

Main Effect of Cue Type (Non-Hypothesized):

*Line Motion Ratings.* There was no significant difference in the line motion ratings of gaze and exogenous cues, *F*(1, 9) = 1.02, *p* = .34 > .05.

*Practical Interpretation.* The sizes and magnitudes of line motion ratings, averaged across all three line tasks (static, left, and right) did not differ overall for gaze and exogenous cues. We had no hypothesis for this and there’s no reason to care about a difference here anyways. It’s just mandatory to report since we need to include it for the ANOVA to run.

Main Effect of Line Type (Non-Hypothesized):

*Line Motion Ratings.* The mean line motion ratings between static, left, and right lines was significant, *F*(1.39, 12.55) = 50.79, *p* < .001.

*Practical Interpretation.* This makes sense: obviously, we wouldn’t expect people to report the exact same direction for leftward motion as for rightward motion, or for directional motion (left or right) as for static line drawing. So this isn’t surprising. But without contrasts, we have no idea where these differences emerged from.

Followup Contrasts of Line Type:

*Line Motion Ratings.* There were significant differences of line motion ratings in all three combinations: leftward line motion drawings were perceived as being more “leftwards” than static line drawings, *t*(9) = 5.67, *p* < .001. Rightward line motion drawings were perceived as being more “rightwards” than static line drawings, *t*(9) = -6.55, *p* < .001. Finally, perceptions of rightward motion were stronger than perceptions of leftward motion, *t*(9) = -8.15, *p* < .001.

*Practical Interpretation.* As you might expect, when lines were actually drawn as moving to the left, they were perceived as moving to the left (compared to static lines that were drawn all at once).When lines were actually drawn as moving to the right, they were perceived as moving to the right (compared to static lines). This is not surprising. Somewhat surprising is that people perceived the rightward line motion as being stronger than the leftward line motion. But I can’t think of a reason to care about this at this point, just something to keep in the back of our minds.

Interaction of Cue Type x Line Type:

*Line Motion Ratings.* There was a significant interaction of cue type and line type, such that there were differences in how strongly motion was perceived between exogenous and gaze cues, and the size of these differences varied by the line type, *F*(1.31, 11.83) = 7.72, *p* = .012 < .05.

*Practical Interpretation.*There is no practical interpretation of this result that is coherent without doing the followup contrasts.

Followup Contrasts of the Interaction of Cue Type x Line Type:

What we’re mainly interested in here are two things: (1) did gaze cues and exogenous cues produce illusory line motion in the static line drawing condition? (2) did gaze cues cancel out the perceived line motion in the real line motiong rating conditions?

*Line Motion Ratings.*

**Research question 2: Does gaze-cuing produce illusory line motion, like exogenous cuing?**

**Illusory Line Motion:**

Recall how the attention hypothesis for illusory line mtoion works: it claims that lines will be incorrectly perceived as being drawn in the direction opposite the cued side. So, for example, if a flash occurs on the left side, the line will appear to be drawn towards the right. It follows, therefore, that there are two ways to assess illusory line motion:

1. Static lines: When a line is drawn all at once, the line should appear as being drawn in the direction opposite the cued side.
2. Moving lines: When a line is drawn either towards the left or the right, the perception of motion should be cancelled out if the cue appears on the same side the line is being drawn in. For example, if the line is being drawn to the right and the cue appeared on the right, then the line should appear as being drawn all at once.

These two measures of the illusion are not mutually exclusive: for example, gaze cues could produce illusory line motion for static lines without cancelling out motion perception for the moving lines. This would tell us, then, that the illusion is weak for gaze cues (especially if exogenous cues also cancel out motion perception for the moving lines; recall, Bavelier found that the line motion illusion for gaze cues is very tiny).

**Hypotheses:**

We have two primary hypotheses, which each have an accompanying secondary hypothesis:

1. Participants will experience illusory line motion in the static line trials, in the direction predicted by the attention hypothesis.
   1. This effect will be true for both gaze cues and exogenous cues (which we will find out by performing followup contrasts on our ANOVA results).
2. Cuing will cancel out line motion in the real line motion trials, when the cued side is the same side as the direction the line is drawn in.
   1. Gaze-cuing will cancel out line motion in the real line motion trials, just as powerfully as exogenous cues do (again, also to be determined by our followup contrasts).

**Hypothesis Test Method:**

2 x 3 x 3 ANOVA of Cue Type (Gaze vs Exogenous) x Cue Location (Left, Neutral, Right) x Line Direction (Left, Static, Right)

This is a very complicated ANOVA, so we’re only going to report effects that matter (since most of the possible followup constrasts are literally meaningless).

**Hypothesis Test Results:**

Main Effect of Cue Type (Non-Hypothesized):

*Line Motion Ratings.* The line motion ratings between gaze cues and exogenous cues, when averaged across line types (left, static, right) were not significantly different, *F*(1, 9) = .75, *p* = .41 > .05.

*Practical Interpretation.* This doesn’t really matter, it’s just necessary to report since we need to include it for the ANOVA to run.

Main Effect of Cue Location:

*Line Motion Ratings.* There was a significant difference in the line motion ratings depending on whether the cue directed attention leftwards, rightwards, or didn’t direct attention at all (neutral), *F*(1.36, 12.23) = 15.87, *p* < .001.

*Practical Interpretation*. This is hard to interpret without followup contrasts, since we have no idea whether this effect is just being driven by the fact that directional cues make a big difference to non-directional cues.

Followup Contrasts of Cue Location:

*Line Motion Ratings.* Compared to neutral cues, when cues appeared on the left, participants were more likely to report rightward line motion, *t*(9) = 2.49, *p* = .034 < .05. This effect was weaker, however, for the right side: though rightward cues produced perceptions of leftward line motion, this effect was small in comparison to neutral cues, for which participants reported on average more rightward than leftward motion, *t*(9) = 4.64, *p* = .002 < .05. In general, perceptions of rightward motion in response to left-side cues were stronger than perceptions of leftward motion in response to right-side cues, *t*(9) = 5.07, *p* = .002 < .05.

*Practical Interpretation.* These results suggest our participants were biased towards reporting rightwards line motion: even when the cues were neutral, they were reporting the line as moving slightly to the right, and when the cues were directional, the attention effects were bigger when the cue appeared on the left than on the right. There was still a tiny attention effect on the right, but small in comparison to the left.

Compared to neutral cues, when cues appeared on the right, participants were more likely to report leftward line motion as opposed to no line motion, *t*(9) = 4.64, *p* = .002 < .05. Leftward cues produced

Main Effect of Line Type (Non-Hypothesized):

*Line Motion Ratings.* There was a significant difference in the perceived line motion of static, left, and right-drawn lines, *F*(