# Colors experiment

**Theoretical Question:**

How is the verification of different determiners affected by the number of colors present in a trial?
*'more than n/more than half/most of the dots are blue'*

At least three dimensions could be tested:

- Counting determiners vs. proportional determiners
- Finger-counting strategy vs. vote-counting strategy
- Direct involvement of non-target dots in verification vs. indirect involvement of non-target dots.
  - ⟦more than half⟧(A)(B) = |A∩B| > ½ |A|
  - ⟦most⟧(A)(B) = |A∩B| > |A – B|
  - ⟦most⟧(A)(B) = |A∩B| > |A|– |A ∩ B|

We use *more than n* as a baseline and believe that it is the least affected by a color manipulation.
The ordering of *more than half* and *most* in terms of RTs is less clear.

- If color affects *more than half* and *most* the same, and we think that vote-counting is easier than finger-counting, we might expect *most* << *more than half*
- If color affects *most* more than *more than half* the we expect *most* to be more sensitive to the manipulation, and therefore *more than half* << *most.*

**Independent variables (3x3 design):**

- Independent variable1: Determiner – *more than n, more than half, most*
- Independent variable2: Number of colors – 2C, 3C, 4C

**Hypotheses:**

Colors:

$H_0$: No interaction or main effect of Color for the different determiners.

$H_1$: No interaction but main effect of Color

Increasing the number of colors has some effect, but it is constant across determiners.
We suspect that the transition: 2C→3C is more costly than the transition: 3C→4C.

$H_2$: Interaction of Color and Determiner

Increasing the number of distractor colors affects determiners differently.

- *More than n* should not be affected by the color manipulation. Any effect will be caused solely by the properties of the visual system. RT: 2C=3C=4C.
- *More than half* is affected by 2C→3C but less (or not at all) by 3C→4C.
  We suspect that the total is arrived at by counting the target dots and adding to that an estimation of the number of non-target dots. The main cost is for transitioning from enumerating a homogeneous set to a heterogeneous one. RT: 2C << 3C, 4C.
- *Most* is affected by 2C→3C, and possibly also by 3C→4C.
  - If *most* is verified by comparing the target dots to the total minus the target dots, we expect an effect similar to that of *more than half*. RT: 2C << 3C, 4C.
  - If *most* is verified by comparing the target dots to the non-target dots, we might expect more of an effect by adding a fourth color. RT: 2C << 3C < 4C.

- If calculations that are due to the relational reading of *most* are also being made, then we expect an effect of 3C→4C as well. In that case, we expect sub-comparisons between the target color and each of the distractor colors; the number of comparisons increases with the number of colors RT: 2C <<< 3C << 4C.
  We suspect that sub-comparisons are more saliently present in all-at-once presentation, but we hope we might be able to observe an effect in the sequential presentation as well.

Results confirming each hypothesis:

$H_0$: No interaction but main effect of Answer

Giving a positive answer is always easier than giving a negative answer, but the difference is constant across all determiners. True<False (2,3,4C).

$H_1$: Interaction of Answer, Color and Determiner

- *More than n, more than half* are affected to the same extent by the T/F condition. Regardless of number of colors, True is always somewhat easier than False. True<False (2,3,4C).
- *Most* could be more affected by the T/F condition, if sub-comparisons are being made. In the True condition, the sub-comparisons and the total-comparison point to the same conclusion. In the False condition, the sub-comparisons support the opposite conclusion than the total-comparison. True<False (2C), True << False (3C), True <<< False (4C).
- If *most* does not involve sub-comparisons, we expect a main effect: True<False (2,3,4C) = $H_0$.

Accuracy:

We don't have a clear hypothesis but we suspect that accuracy should not be affected, or it should be affected to the same extent, at least for the proportional determiners.

**Self-paced counting:**

- Invites counting in the *more than half* and *more than n* cases. This gives us the differentiation we need between *most* and *more than half*.
- Control of when new colors are introduced.

**Design:**

- Determiners:: *more than n, more than half, most*.
- Color manipulation: 2C, 3C, 4C. Colors vary between target/distractor items across trials.
- Array sizes: 21,23 dots; 24 covers.
- Ratios: only the low ratio – 12:11, 11:10.
- Presentation: self-paced sequential presentation.
- Frames: 8 frames. 3rd color introduced in frame 4, 4th color introduced in frame 7.
- Frame specifications: At least 1 target dot per frame (felicity condition of *most*);
  At least 2, at most 3 dots revealed per frame (subitizing).
- Proportions: 2nd color > 3rd color > 4th color, to accommodate the gradual introduction of colors.

'True'

| | | |
|---|---|---|
| #23 | 2 colors | 12 : 11 |
| | 3 colors | 12 : 7,4 |
| | 4 colors | 12 : 5,3,3 |
| #21 | 2 colors | 11 : 10 |
| | 3 colors | 11 : 6,4 |
| | 4 colors | 11 : 4,3,3 |

'False'

| | | |
|---|---|---|
| #23 | 2 colors | 11 : 12 |
| | 3 colors | 11 : 7,5 |
| | 4 colors | 11 : 5,4,3 |
| #21 | 2 colors | 10 : 11 |
| | 3 colors | 10 : 6,5 |
| | 4 colors | 10 : 5,3,3 |

**Size calculations:**
6 cells * 3 dets * 2 (T/F) * 2 stimuli per cell
72 target items
184 filler items
**256 items in total**.

**72 Target items:**
24 >n: 8 2C, 8 3C, 8 4C; 4T, 4F; 2 #21, 2#23
24 >1/2: 8 2C, 8 3C, 8 4C; 4T, 4F; 2 #21, 2#23
24 most: 8 2C, 8 3C, 8 4C; 4T, 4F; 2 #21, 2#23
The statements are of the sort: Det of the dots are Color;
Statement appears throughout the trial, until the answer frame.

**184 Filler items**: (Different ratios; varying #frames, #dots)
36 target-det fillers:
12 >n,
12 >1/2,
12 most.
- 3rd, 4th colors in the first frames
- distractor color in first frames not from the most numerous sub-set

64 many/few items
18 very few,
18 few,
18 many,
18 very many

36 more X than Y
12 more X than Y,
12 more X than all of the other colors,
12 more X than each of the other colors.

24 n
6 "7",
6 "8",
6 "9",
6 "10".

24 others
6 almost all,
6 all,
6 barely any,
6 several

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27 Early answer:
3 several (F), 3 barely any (F), 3 all (F), 3 almost all (F), 3 "9" (T), 3 "8" (T), 3 "7" (T), 6 very few (F)