Experimental design and analysis

Hands-on approach to experimental design

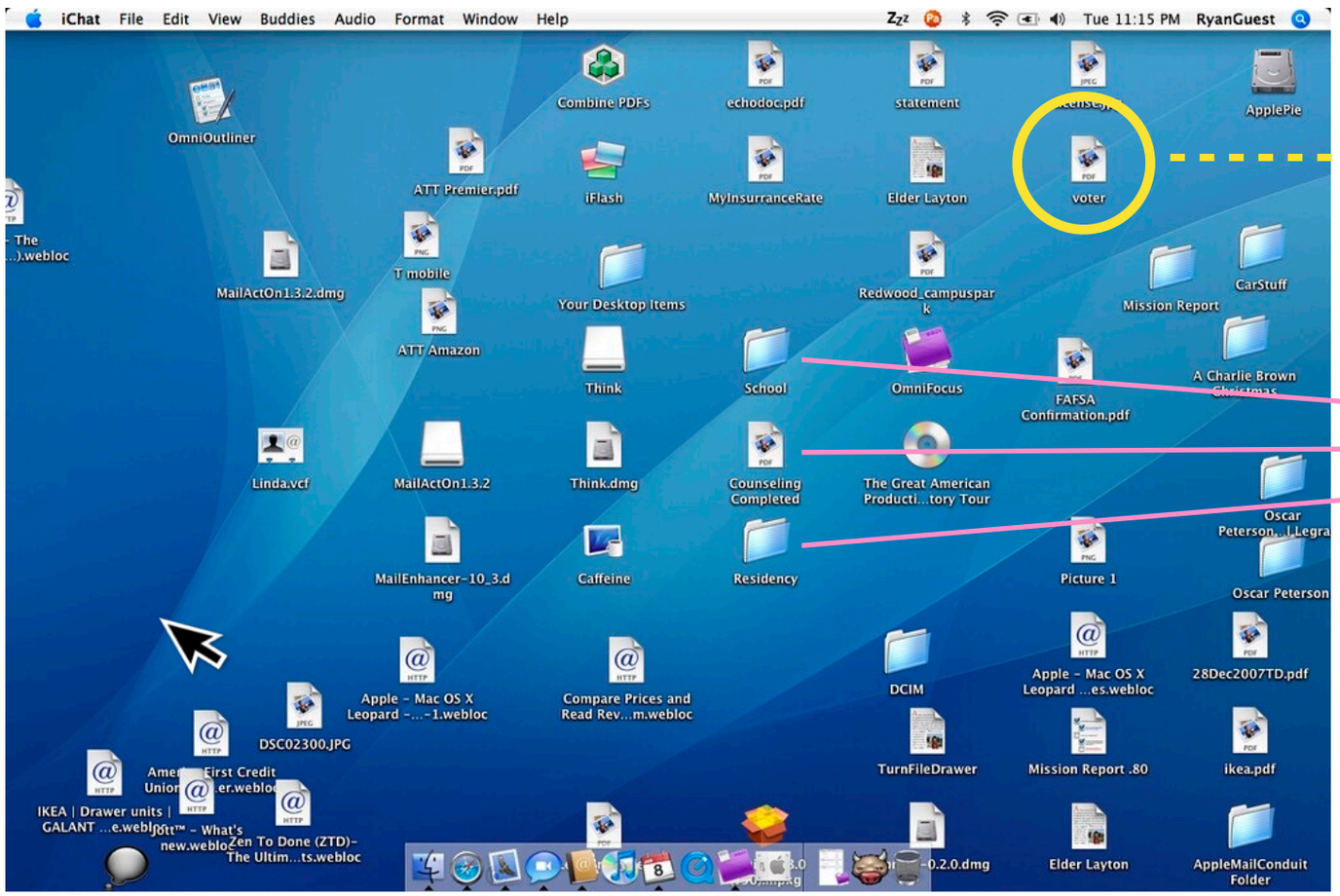
https://www.lri.fr/~appert/eval/

Caroline Appert

Operationalizing in practice

State your hypothesis

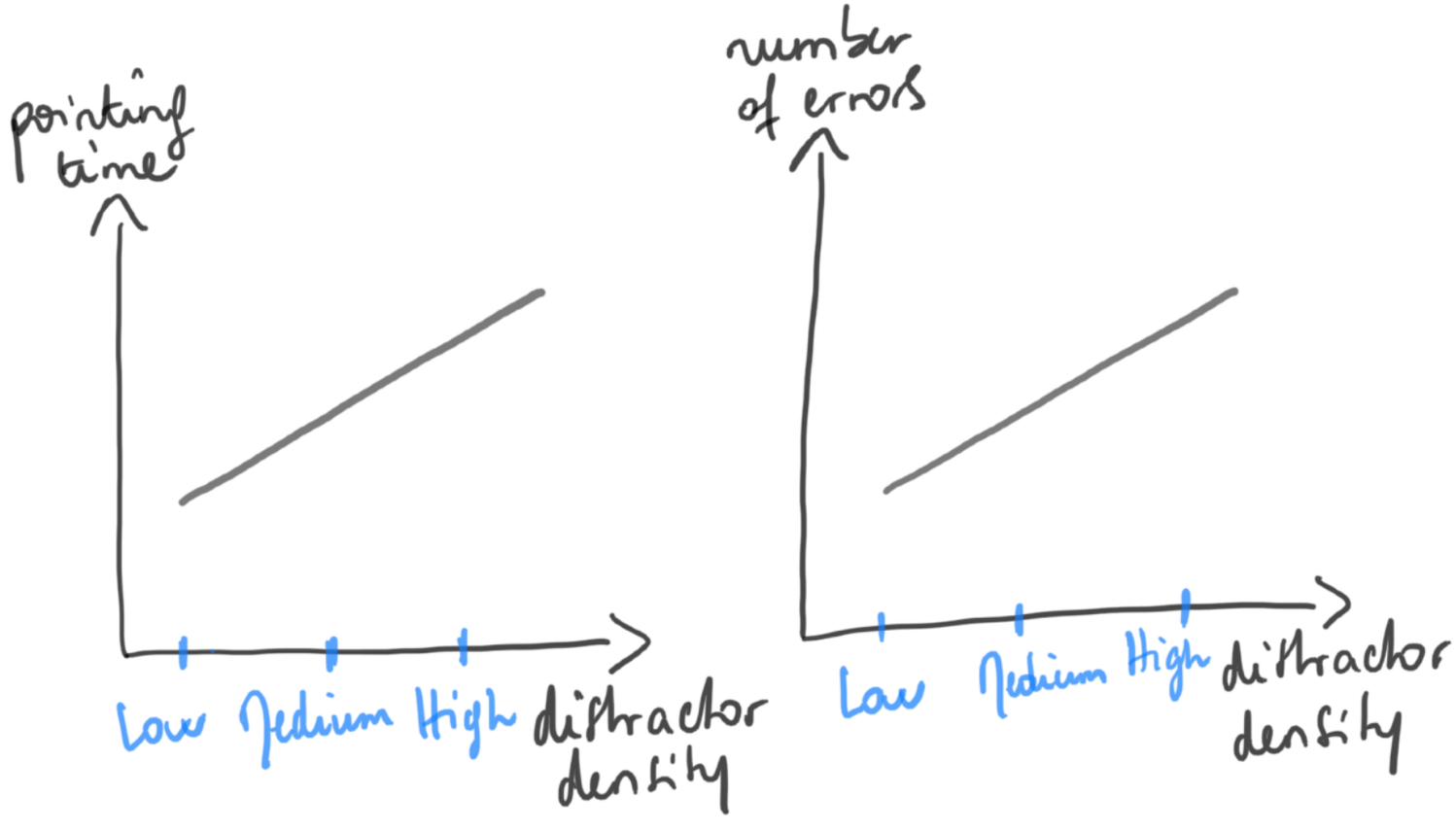
H: The number of distractors has an impact on pointing performance



Operationalize

My advice:

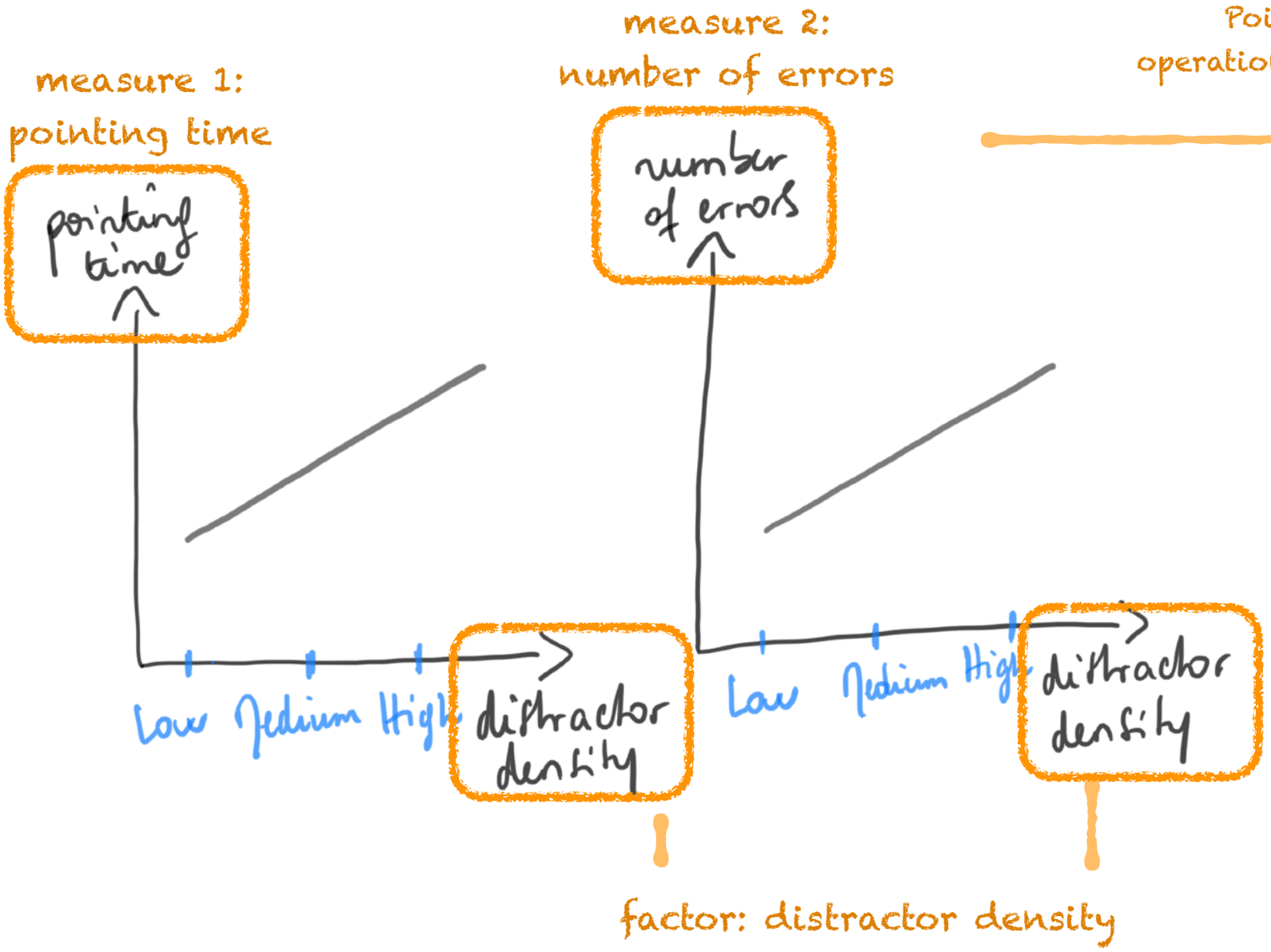
1. start with sketching the charts you would like to report in a paper (i.e., the charts that would support your hypothesis)



Operationalize

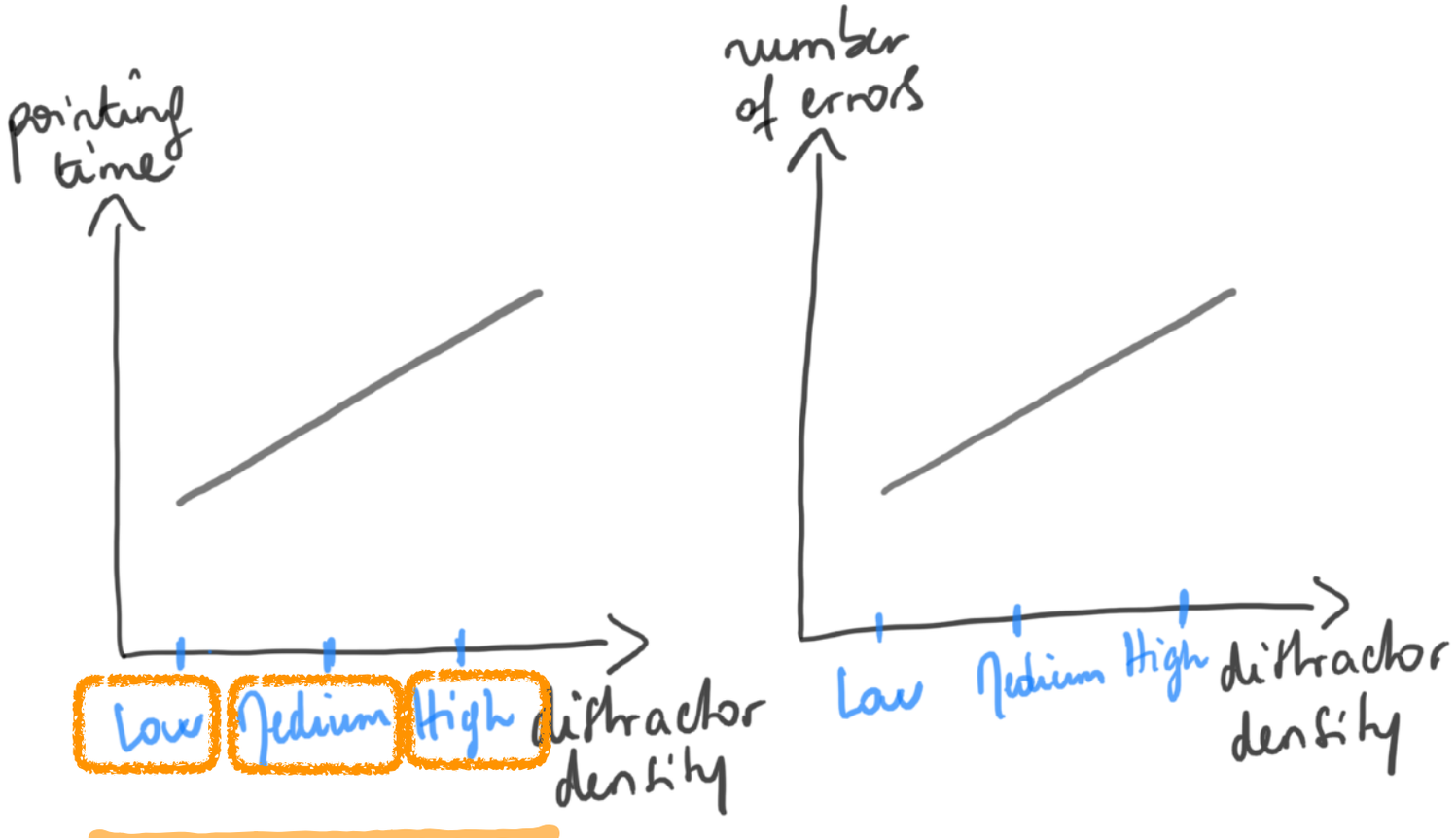
H: The number of distractors has an impact on pointing performance

2. Clearly name factors and measures



Operationalize

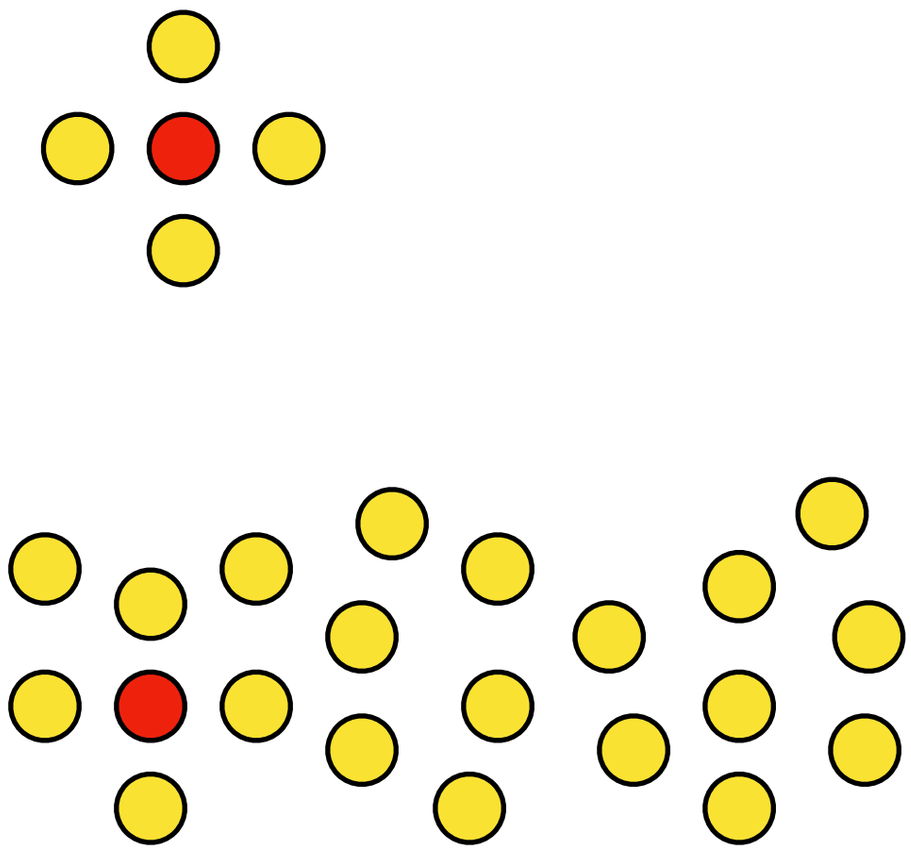
2. Clearly name factors and measures



Values for factors: start with values that seem reasonable to you, and then refine with pilot studies

Operationalize

3. Design a task to collect measures in response to variations in factors' values



Distractor density: low

Distractor density: high

Measures

pointing time: interval between appearance of scene and click on red target

Errors: number of clicks out of red target

Operationalize

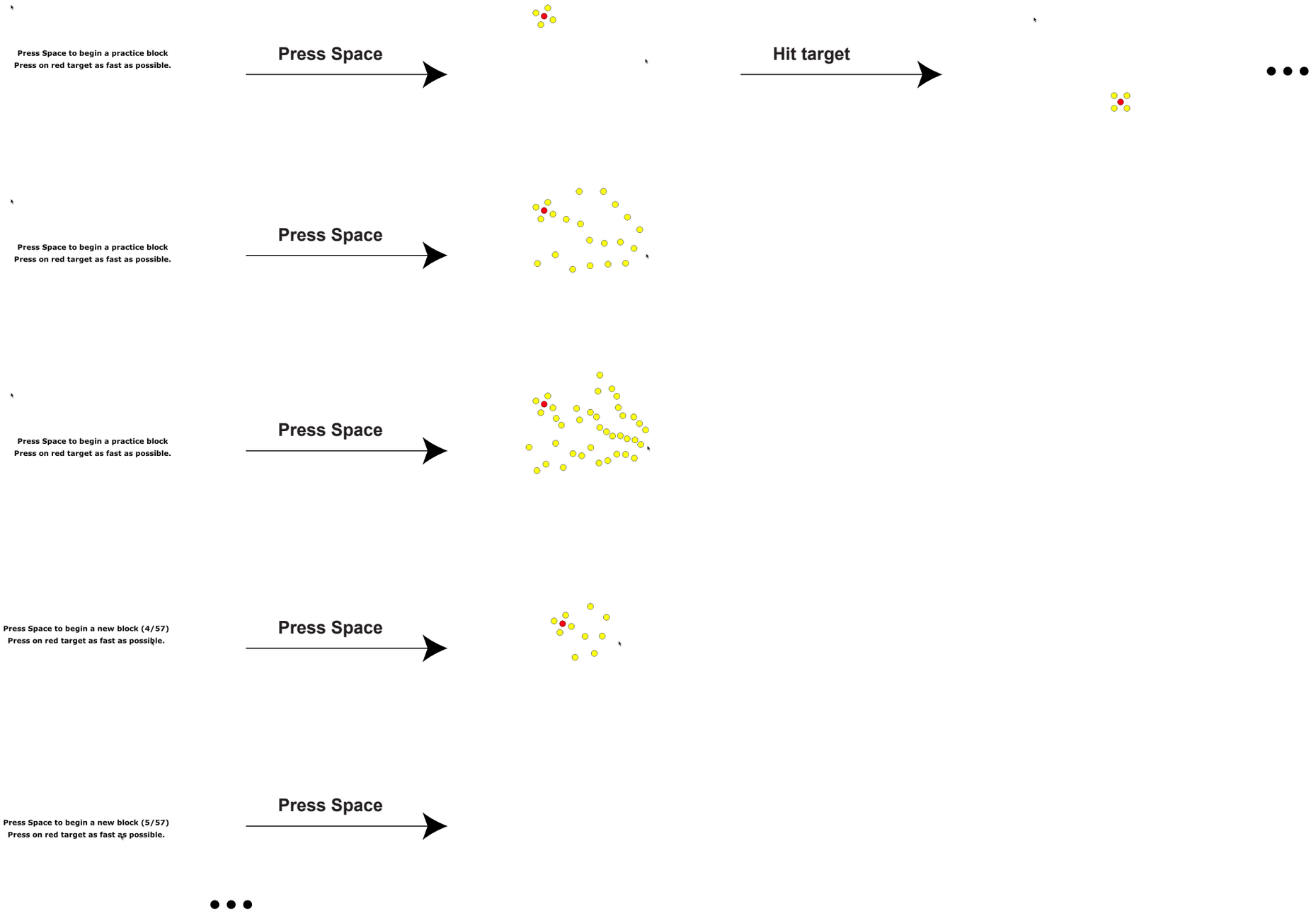
4. Iterate on your design

    Is there any bias in my design? In particular, what about the internal/external validity?

For a pointing experiment, we could add two factors, movement amplitude (A) and target width (W), to represent different pointing difficulties and thus increase the external validity of our observations.

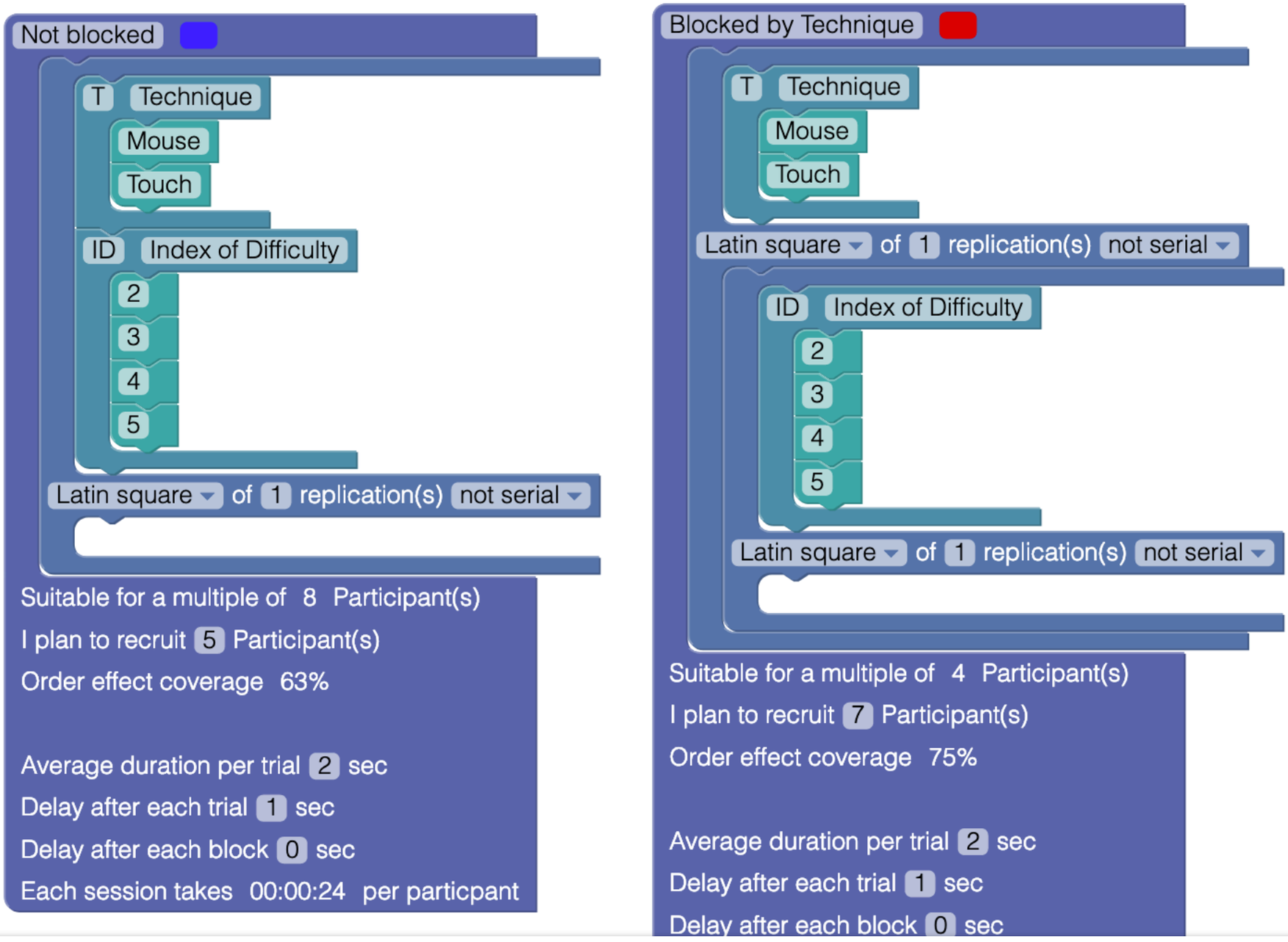
Experiment storyboard

4. Detail how the different tasks will be presented, and what actions participants will do



Formalizing your design

TouchStone 2 [Eiselmayer et al., CHI '19]



TouchStone 2 offers a visual language based on interactive bricks to specify your factors, blocking and replication strategies

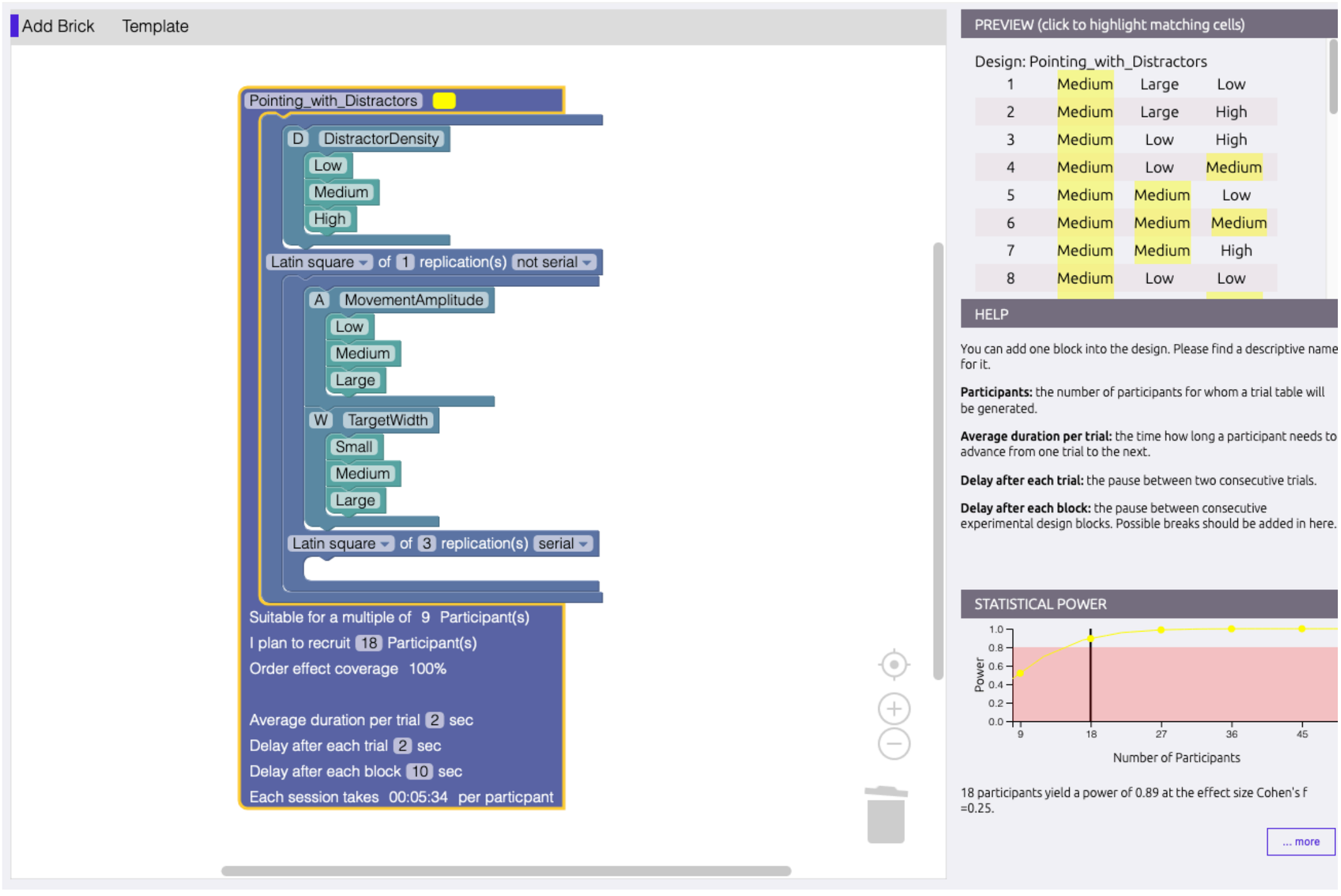
Launch

Got to https://www.touchstone2.org/

Click Try it out online

TouchStone 2

Design in TouchStone 2



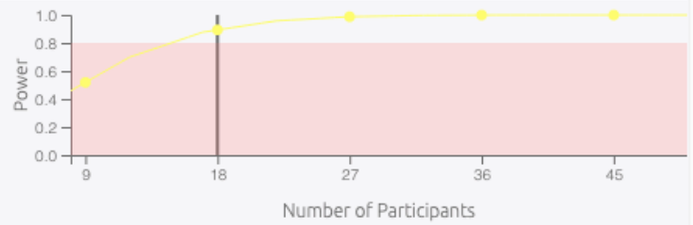
TouchStone 2 export/save

I plan to recruit 18 Participant(s)
Order effect coverage 100%

Average duration per trial 2 sec
Delay after each trial 2 sec
Delay after each block 10 sec
Each session takes 00:05:34 per particpant

Delay after each block: the pause between consecutive experimental design blocks. Possible breaks should be added in here.

STATISTICAL POWER



18 participants yield a power of 0.89 at the effect size Cohen's f =0.25.

... more

o highlight matching cells)

Toggle Fisheye

ith_Distractors

Export design: XML TSL Export trial table: CSV

		Participant 2				Participant 3				Participant 4				Participant 5			
Large	Low	82	High	Large	Medium	163	Low	Large	High	244	Medium	Low	Low	325	High	Low	Medium
Large	Low	83	High	Large	Medium	164	Low	Large	High	245	Medium	Low	Low	326	High	Low	Medium

Saves the design as a xml or tsl file so you can reload it in TouchStone2 and visualize and edit it if needed.

TouchStone 2 export/save

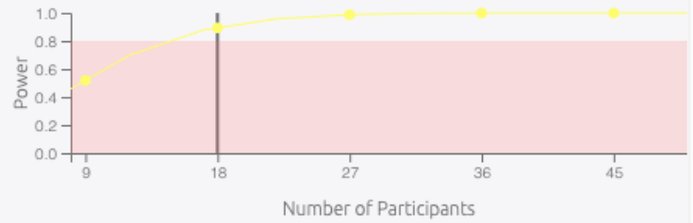
I plan to recruit 18 Participant(s)
Order effect coverage 100%

Average duration per trial 2 sec
Delay after each trial 2 sec
Delay after each block 10 sec
Each session takes 00:05:34 per particpant

Delay after each trial: the pause between two consecutive trials.

Delay after each block: the pause between consecutive experimental design blocks. Possible breaks should be added in here.

STATISTICAL POWER



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Export design: XML TSL Export trial table: CSV

Participant 2						Participant 3				Participant 4				Participant 5			
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Large	Low	83	High	Large	Medium	164	Low	Large	High	245	Medium	Low	Low	326	High	Low	Medium

```
DesignName,ParticipantID,TrialID,Block1,Block2,D,A,W
Pointing_with_Distractors,1,1,1,1,Medium,Large,Small
Pointing_with_Distractors,1,2,1,1,Medium,Large,Small
Pointing_with_Distractors,1,3,1,1,Medium,Large,Small
Pointing_with_Distractors,1,4,1,2,Medium,Large,Large
Pointing_with_Distractors,1,5,1,2,Medium,Large,Large
Pointing_with_Distractors,1,6,1,2,Medium,Large,Large
...
Pointing_with_Distractors,18,1456,3,9,Medium,Large,Small
Pointing_with_Distractors,18,1457,3,9,Medium,Large,Small
Pointing_with_Distractors,18,1458,3,9,Medium,Large,Small
```

Saves the design as a csv trial table that will serve as input for the experiment program

TouchStone 2

next steps

experiment design (TouchStone csv output)

```
DesignName,ParticipantID,TrialID,Block1,Block2,D,A,W
Pointing_with_Distractors,1,1,1,1,Medium,Large,Small
Pointing_with_Distractors,1,2,1,1,Medium,Large,Small
Pointing_with_Distractors,1,3,1,1,Medium,Large,Small
Pointing_with_Distractors,1,4,1,2,Medium,Large,Large
Pointing_with_Distractors,1,5,1,2,Medium,Large,Large
Pointing_with_Distractors,1,6,1,2,Medium,Large,Large
...
Pointing_with_Distractors,18,1456,3,9,Medium,Large,Small
Pointing_with_Distractors,18,1457,3,9,Medium,Large,Small
Pointing_with_Distractors,18,1458,3,9,Medium,Large,Small
```

↓

experiment program

↓

log file (csv file for your statistical analyses)

```
DesignName,ParticipantID,TrialID,Block1,Block2,D,A,W,PointingTime,ErrorCount
Pointing_with_Distractors,1,1,1,1,Medium,Large,Small,1632,0
Pointing_with_Distractors,1,2,1,1,Medium,Large,Small,1552,1
Pointing_with_Distractors,1,3,1,1,Medium,Large,Small,1402,0
Pointing_with_Distractors,1,4,1,2,Medium,Large,Large,1272,1
Pointing_with_Distractors,1,5,1,2,Medium,Large,Large,1153,0
Pointing_with_Distractors,1,6,1,2,Medium,Large,Large,1202,0
...
```

Our project :)

Project

We will design, run and analyze an experiment whose goal is test whether two visual variables (or graphical attributes) are preattentive or not.

Preattentive processing

Things that “pop out” from their surroundings

A thing that will be much likely noticed after a very brief exposure (no need for sequential scanning)

e.g., find the 3

8795745256259407594037509697950427695402760594765994404064764527892494037509697950427

sequential scanning

8795745256259407594037509697950427695402760594765994404064764527892494037509697950427

pop out

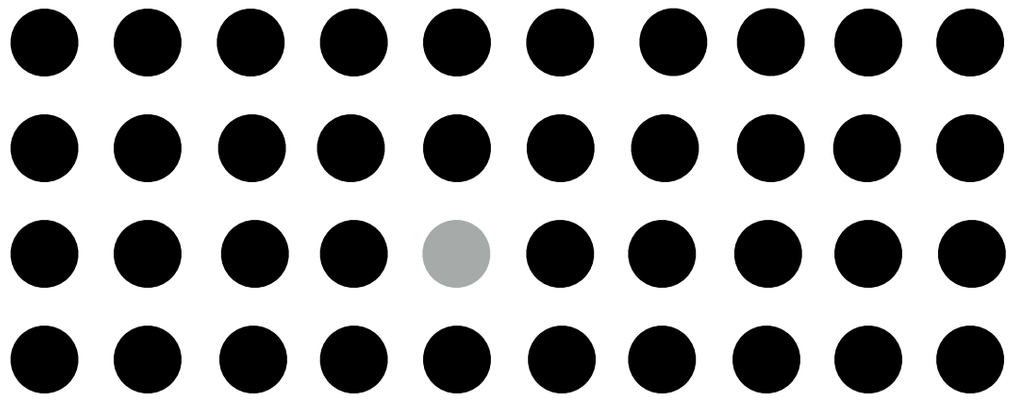
(Color is preattentive)

Preattention is a complex phenomenon

All preattentive variables cannot be easily combined

Only Color

visual variable: color



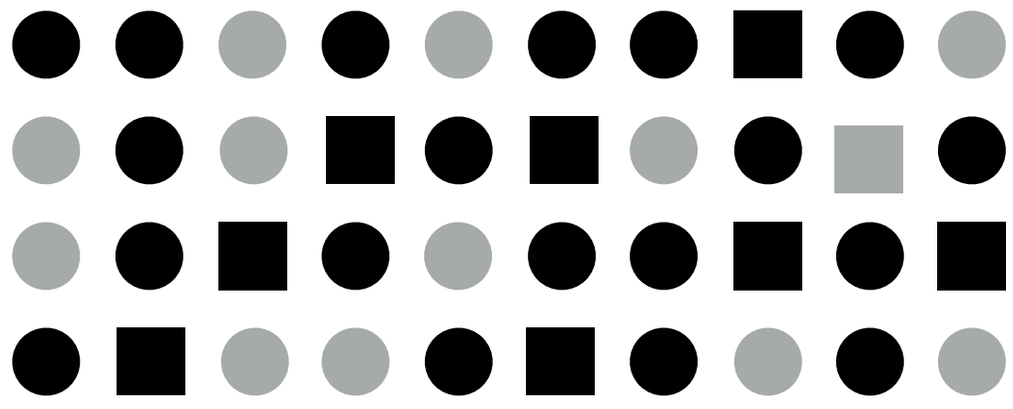
The gray circle pops out

Color and Shape combined

visual variable: color

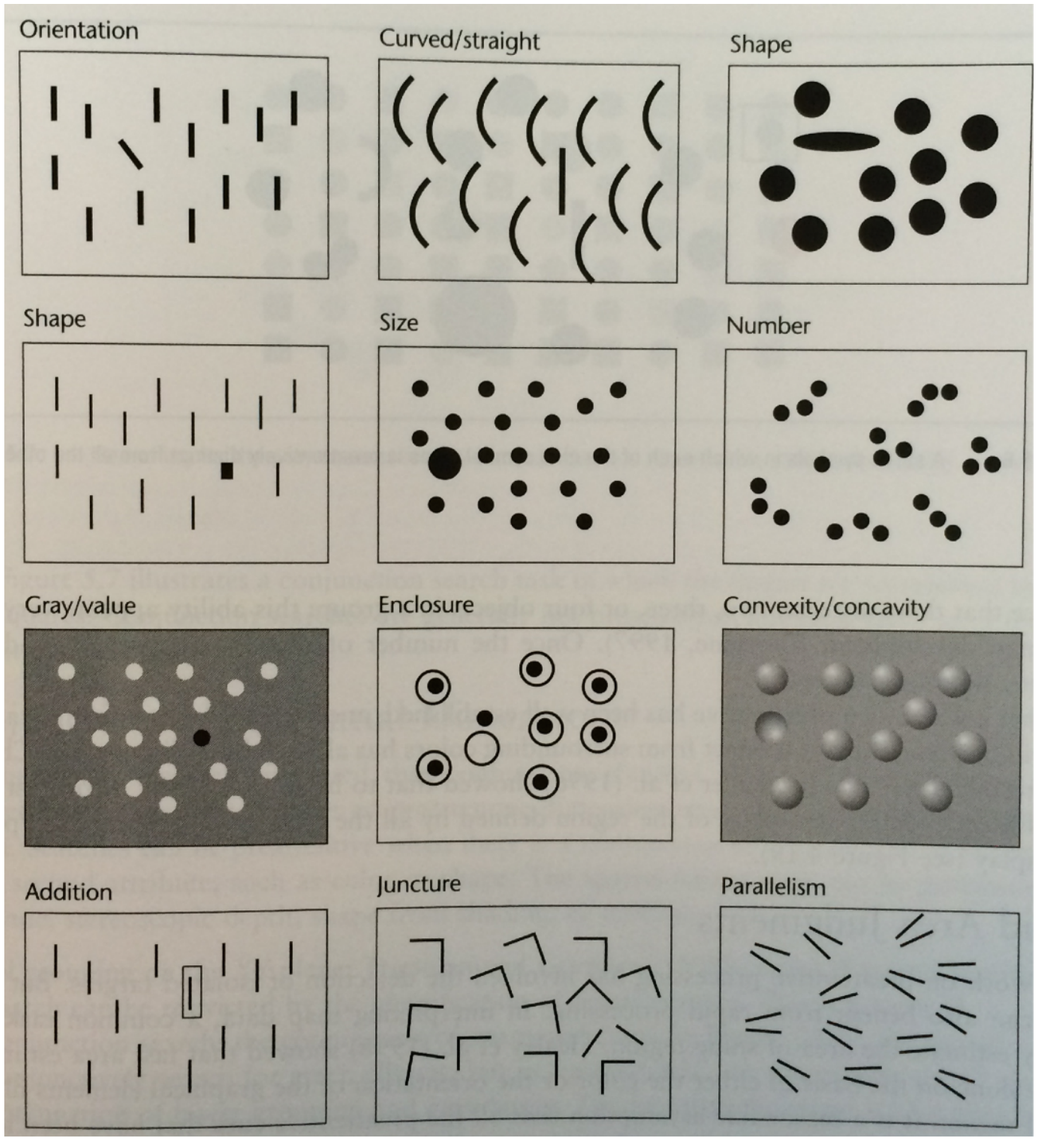
+

visual variable: shape



It takes time to find the gray square

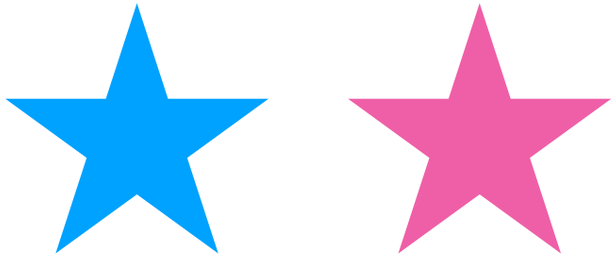
Example of low-level visual variables



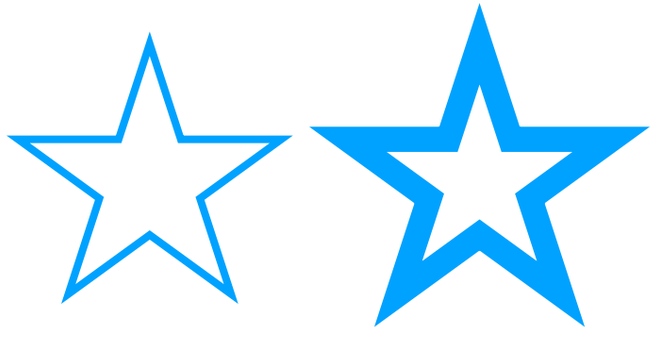
source: book *Information Visualization: Perception for Design* -- author *Colin Ware*

Example of graphical attributes

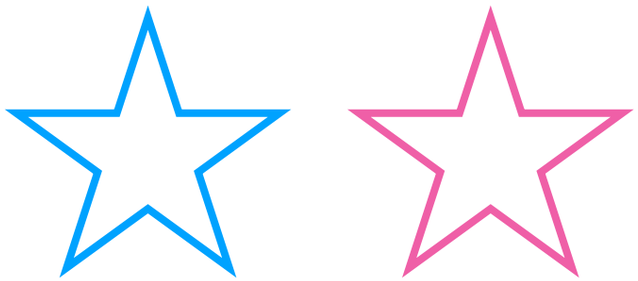
Fill color



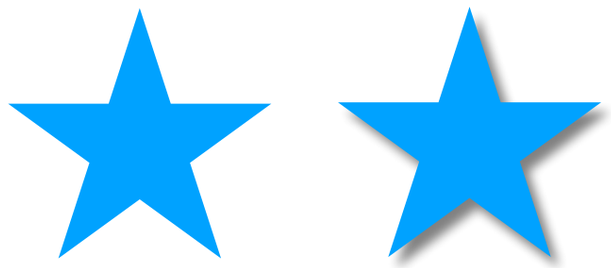
Stroke thickness



Stroke color

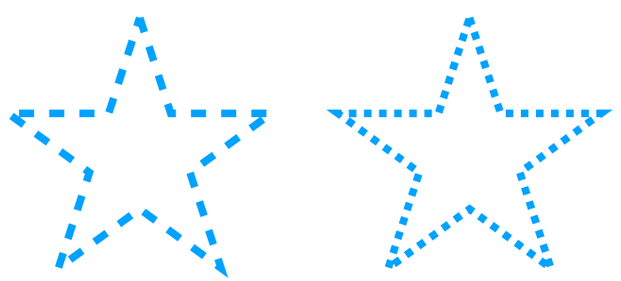


Shadow



Opacity

Dotted pattern



etc.

Project: hypotheses to test

Pick two visual variables (or graphical attributes) of your choice (e.g., color, size, shape, shadow, etc.). Let's call them VV1 and VV2.

Research hypotheses to test:

H_1: VV1 is preattentive

Example: A difference in color is preattentive

H_2: VV2 is preattentive

Example: A difference in shape is preattentive

H_3: VV1 and VV2 combined are less preattentive than VV1 or VV2 in isolation

Example: Spotting a difference in both color and shape takes more time that spotting a difference in color only or in shape only