Experimental design and analysis
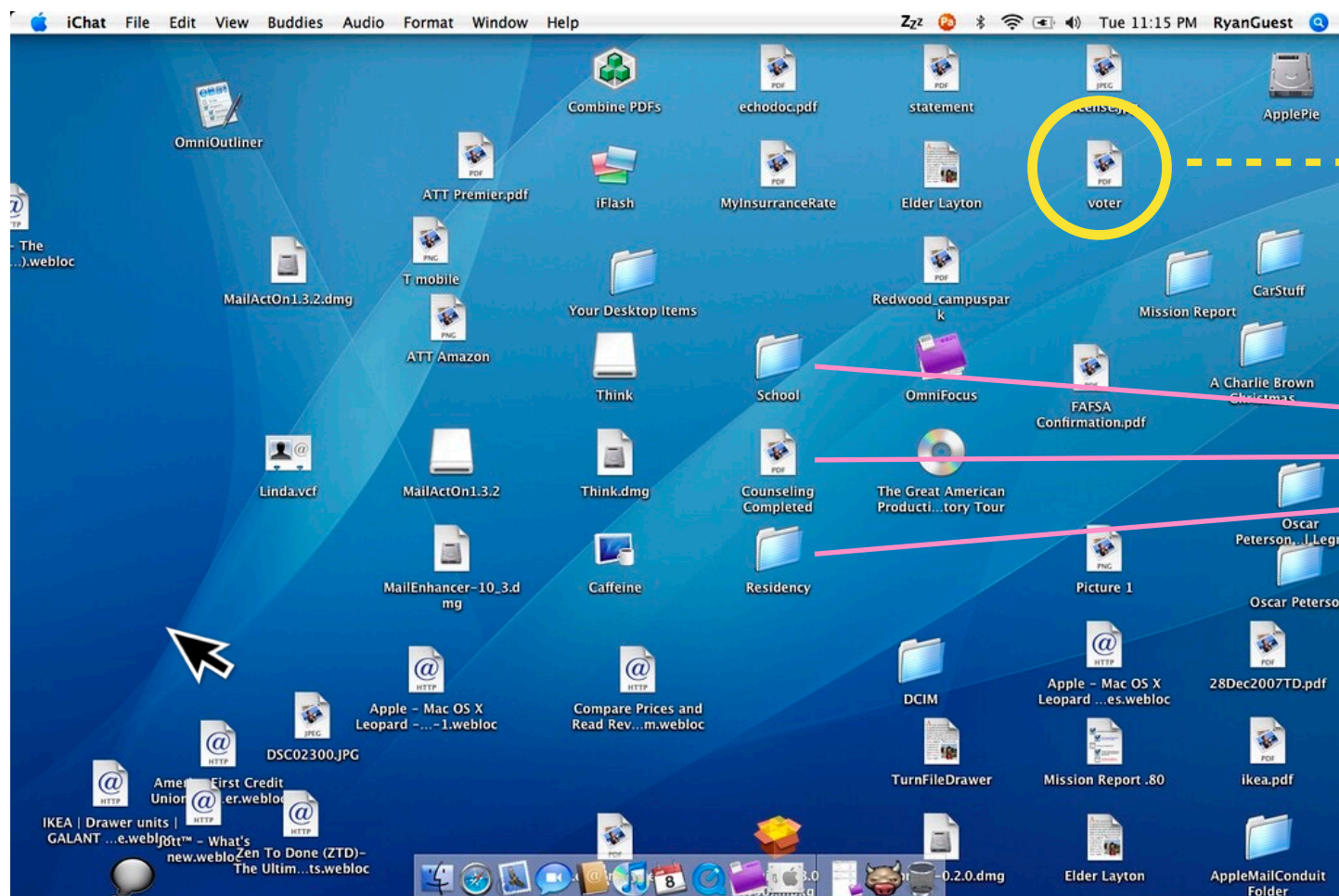
Hands-on approach to experimental design

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

Caroline Appert

Operationalizing in practice

State your hypothesis

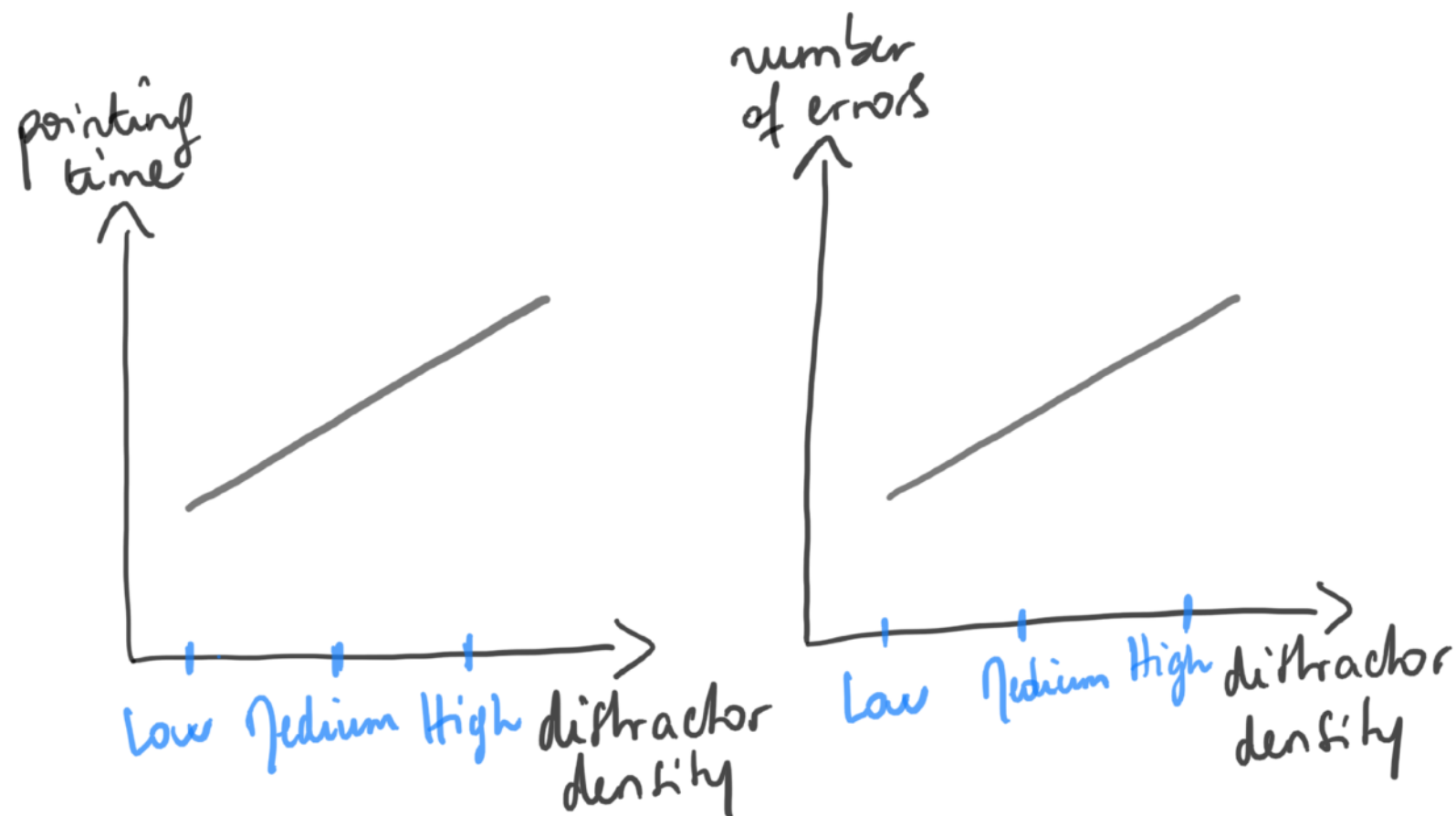*H: The number of distractors has an impact on pointing performance*

Target icon that the user wants to point at

distractors (other visual objects on screen)
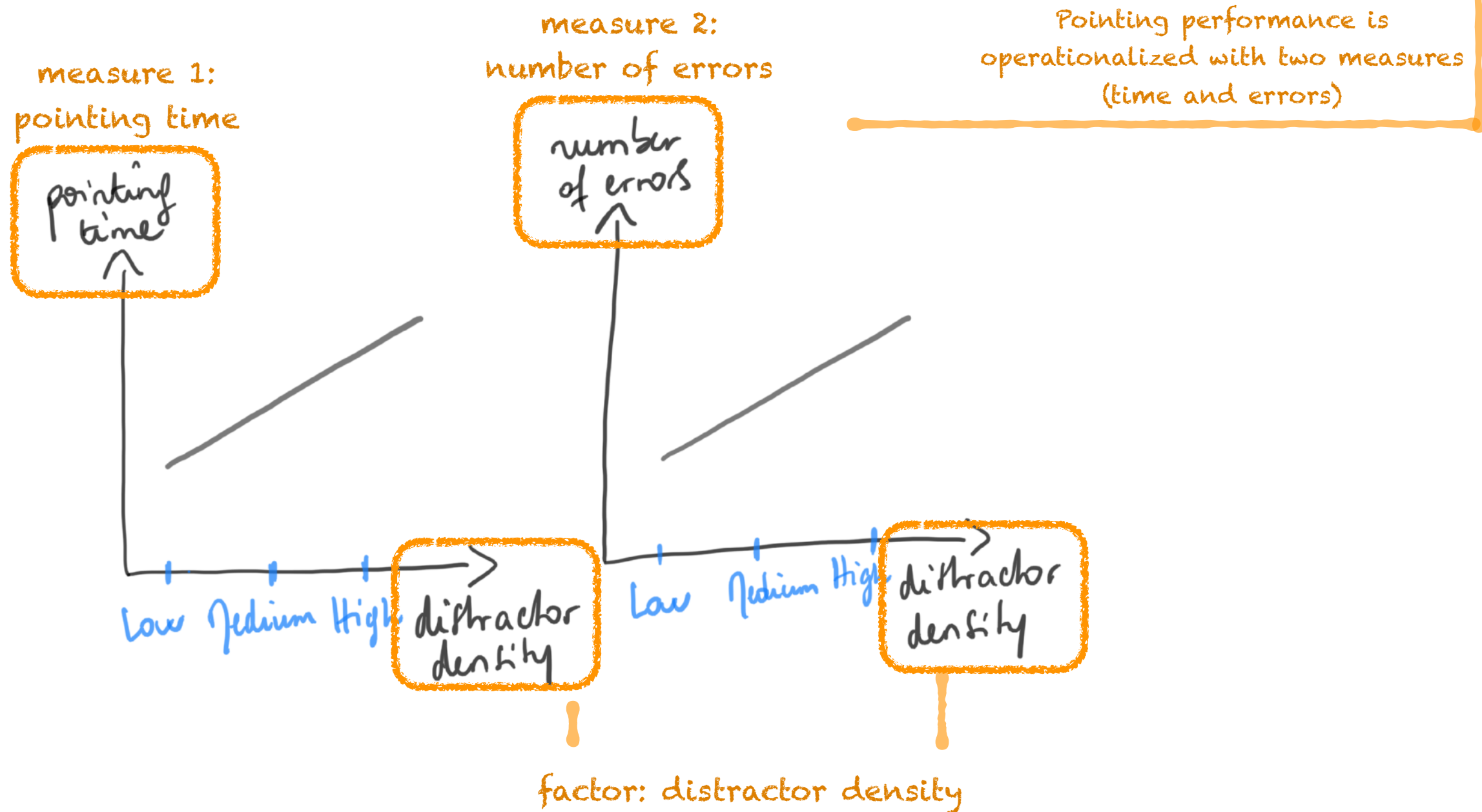
Operationalize

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)
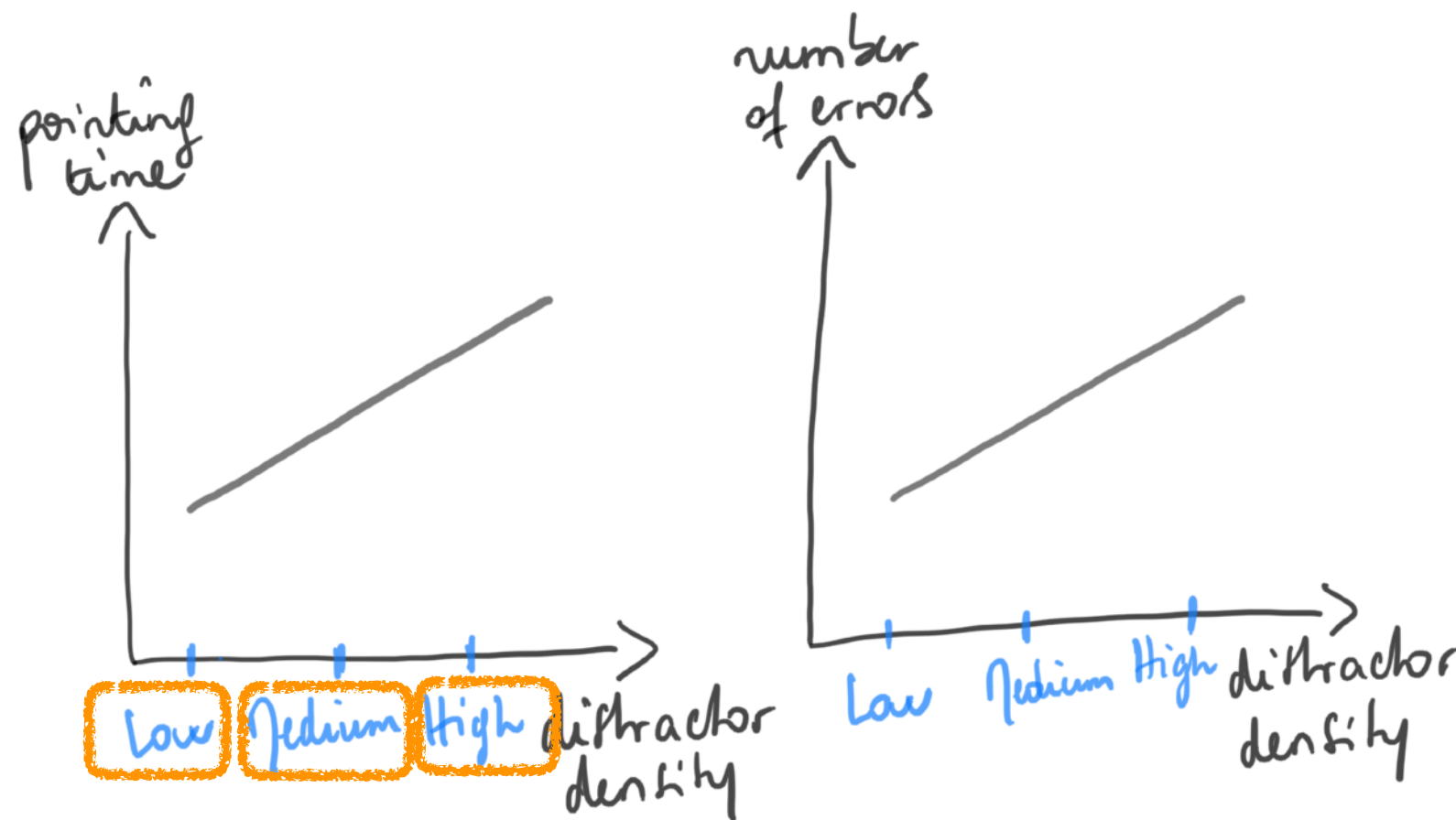
Operationalize

2. Clearly name factors and measures

Pointing performance is
operationalized with two measures
(time and errors)

measure 1:
pointing time

measure 2:
number of errors

number
of errors

pointing
time

Low Medium High distractor
density

Low Medium High distractor
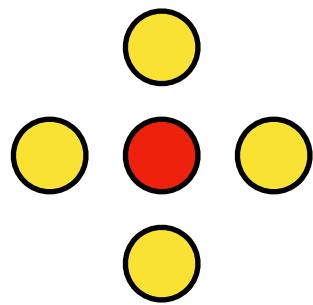density

factor: distractor density

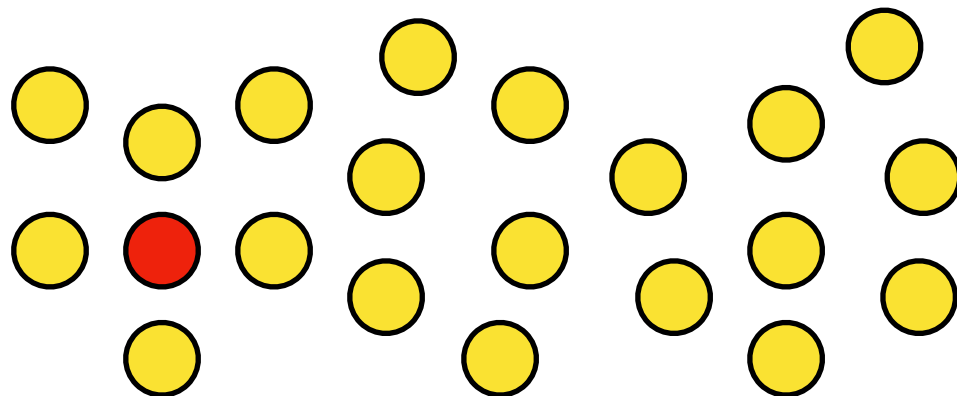# Operationalize

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
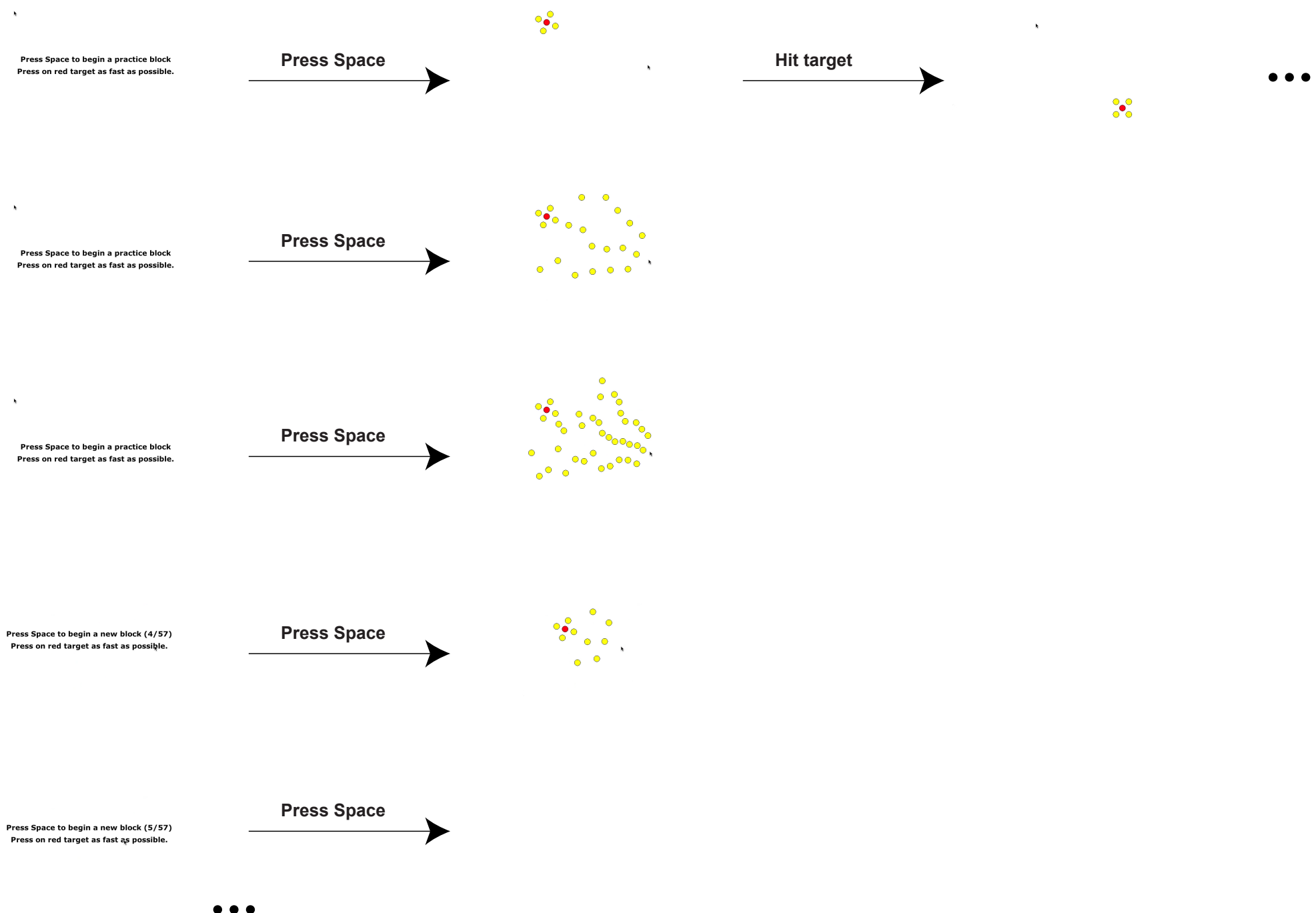
Operationalize

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.
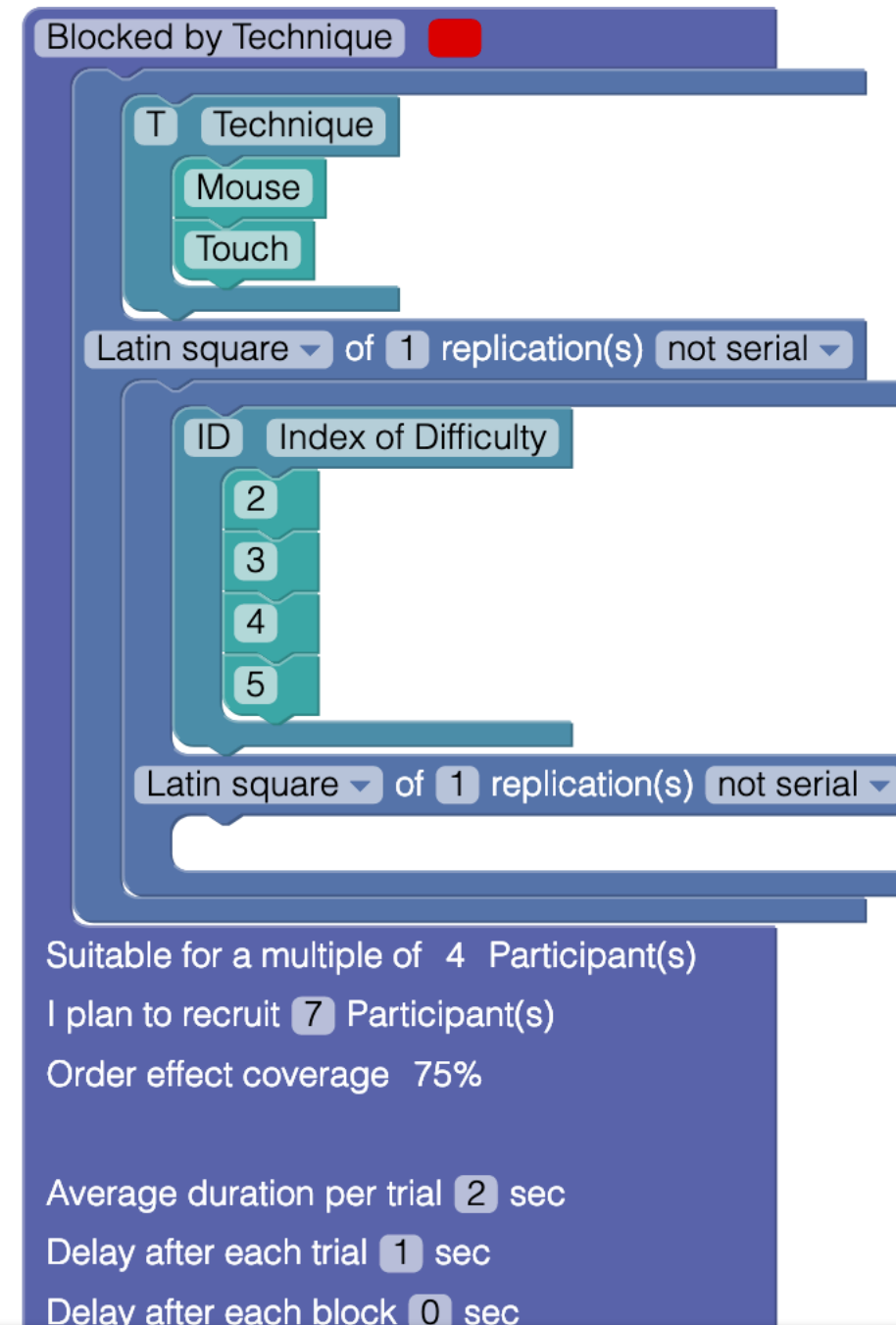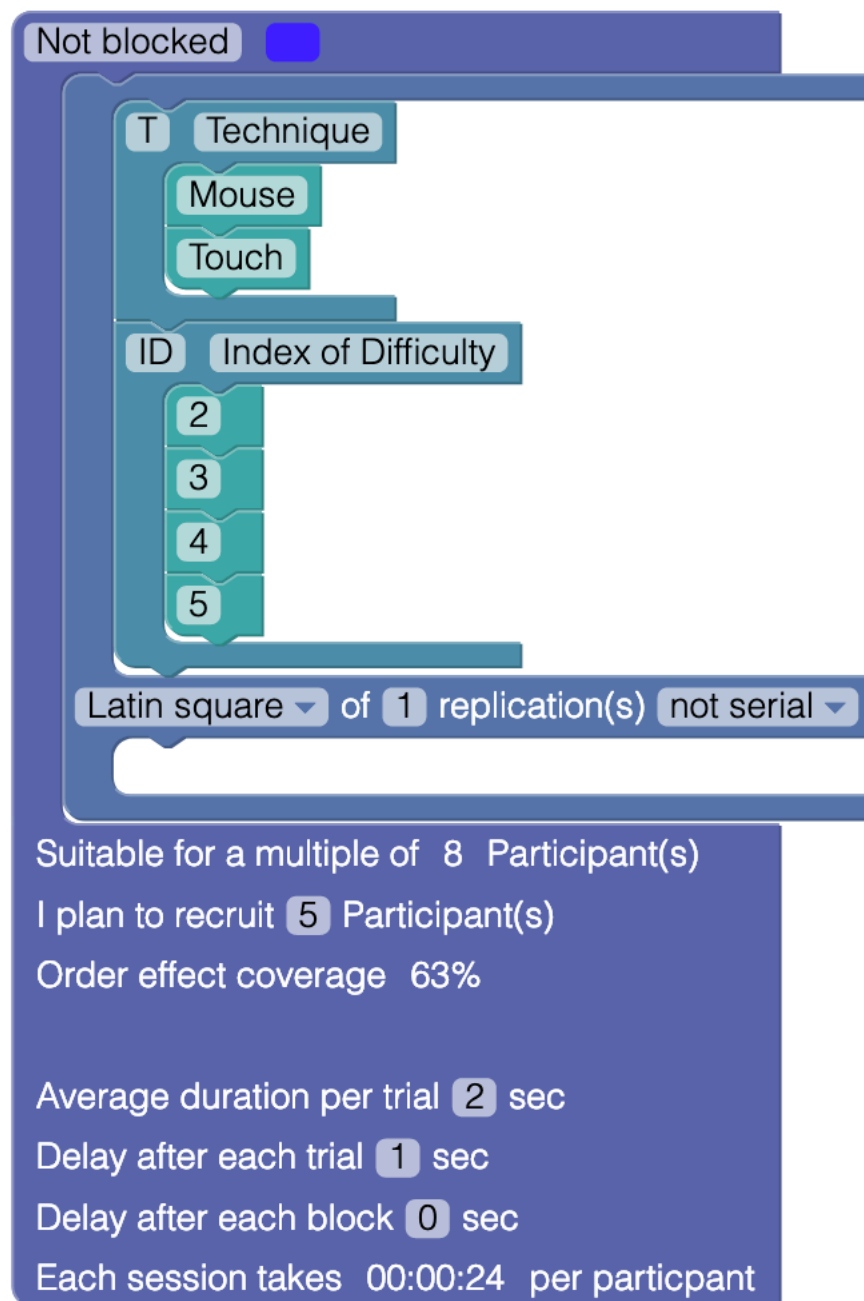
Experiment storyboard

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

Press Space to begin a practice block
Press on red target as fast as possible.

Press Space →

Hit target →

• • •

Press Space to begin a practice block
Press on red target as fast as possible.

Press Space →

Press Space to begin a practice block
Press on red target as fast as possible.

Press Space →

Press Space to begin a new block (4/57)
Press on red target as fast as possible.

Press Space →

Press Space to begin a new block (5/57)
Press on red target as fast as possible.

Press Space →

• • •

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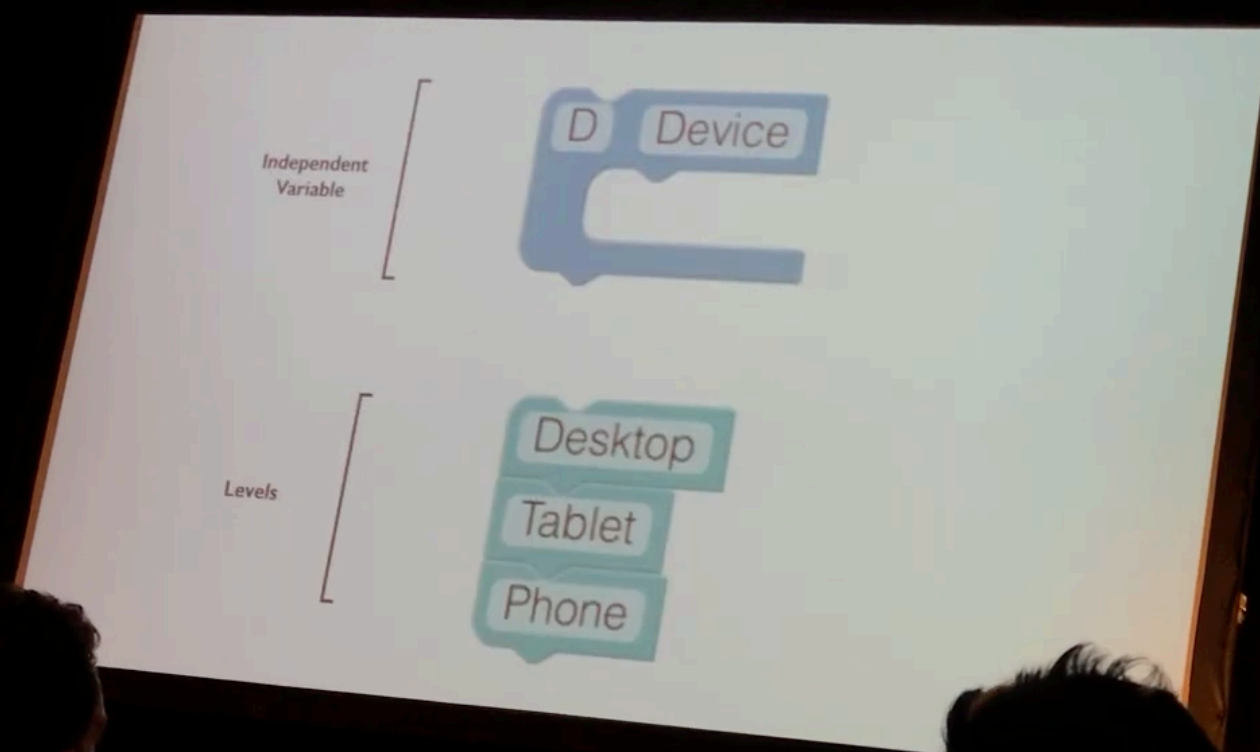
TouchStone 2 [Eiselmayer et al., CHI '19]

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

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

Number of Participants

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

... more

o highlight matching cells)   Toggle Fisheye

vith_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

```
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
...
```
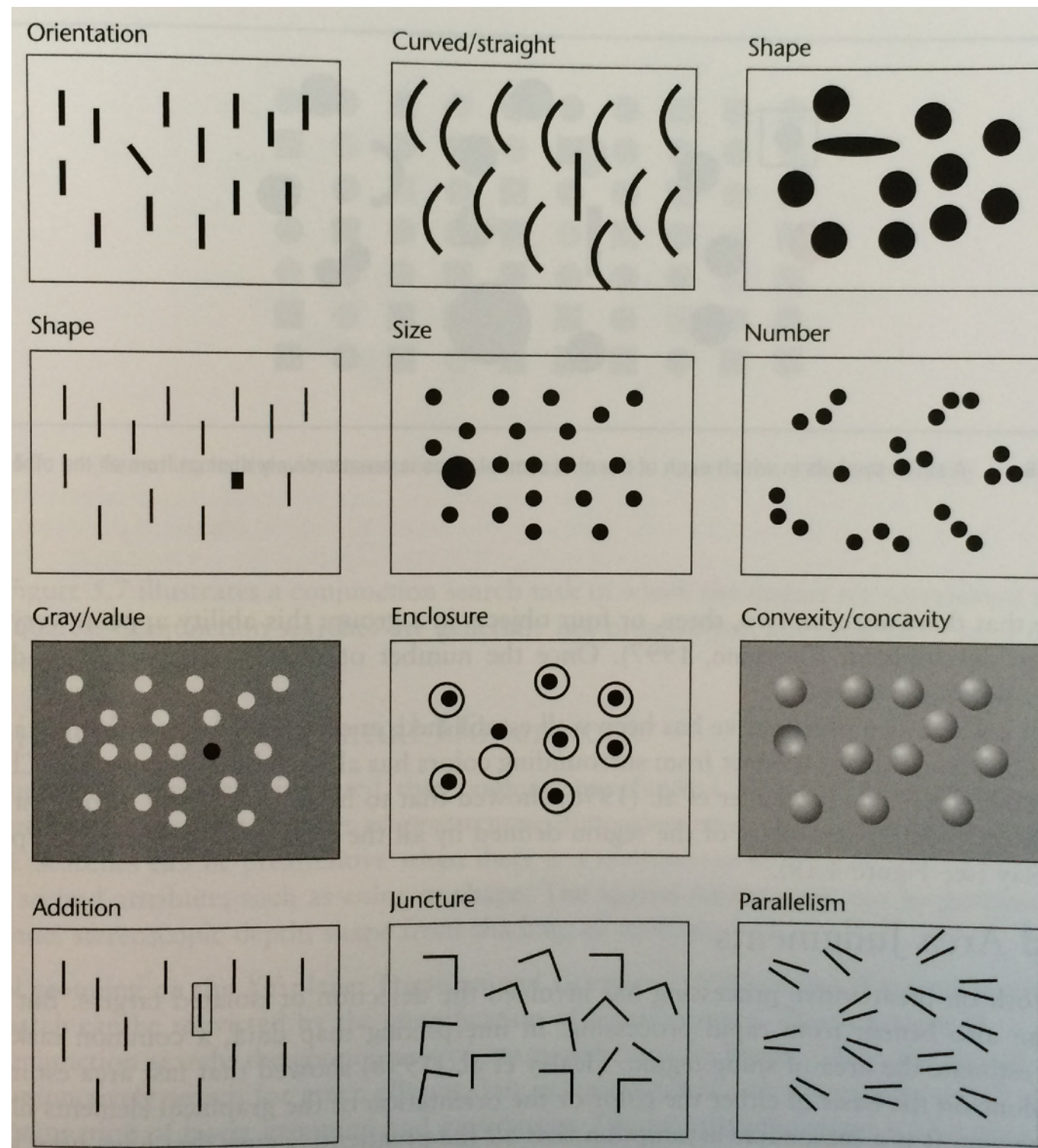
Our project :)

Project

We will design, run and analyze an experiment whose goal is:

Test whether two visual variables are preattentive or not

Examples of visual variables

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

87957452562594075
94037509697950427
69540276059476599
44040647645278924

sequential scanning

87957452562594075
94037509697950427
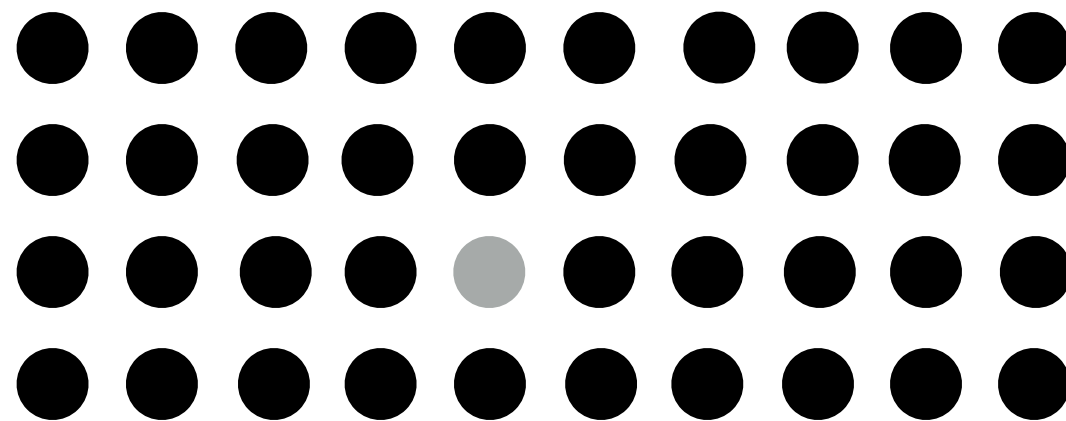69540276059476599
44040647645278924

pop out

(Color is preattentive)

Preattention is a complex phenomenon

In particular, all preattentive variables cannot be easily combined
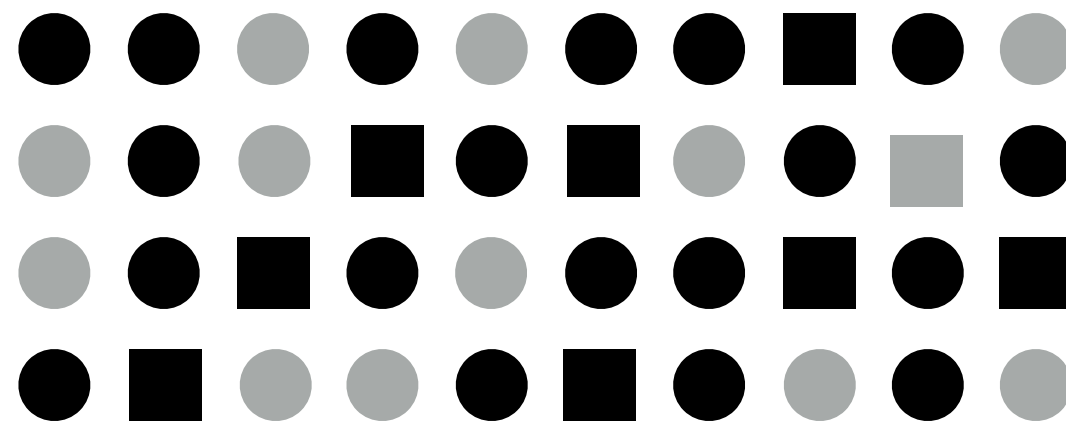
visual variable: color

The gray circle pops out

visual variable: color
+
visual variable: shape

It takes time to find the gray square

Project: hypotheses to test

Pick two visual variables 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