

Design and Evaluation of Spatial Interfaces in Virtual Reality

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**VR Interfaces are not
making use of 3D space**

Touch Featured >

All Oculus Touch Titles

Top Selling

Games

Entertainment

Apps

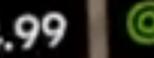
Early Access

Gallery Apps

Browse All

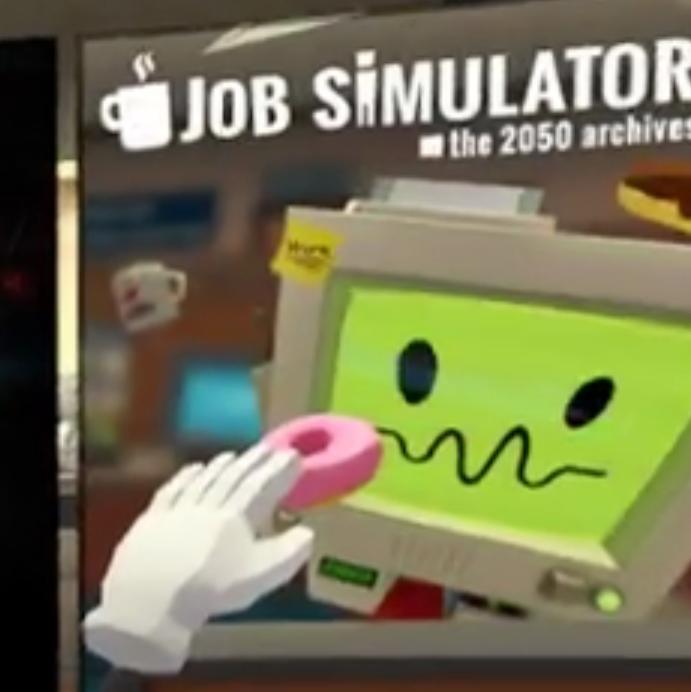
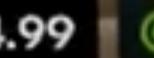


€14.99

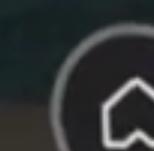


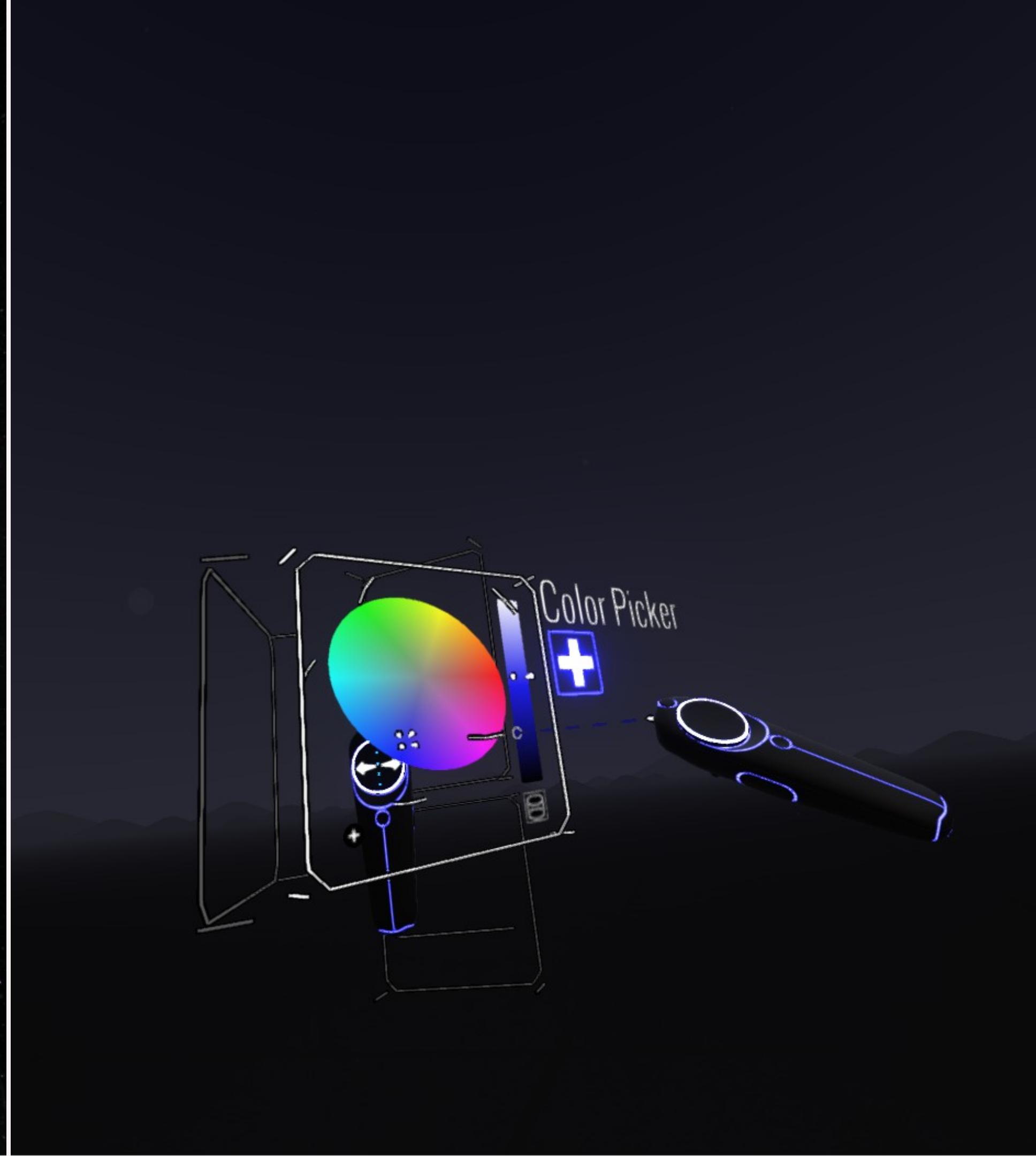
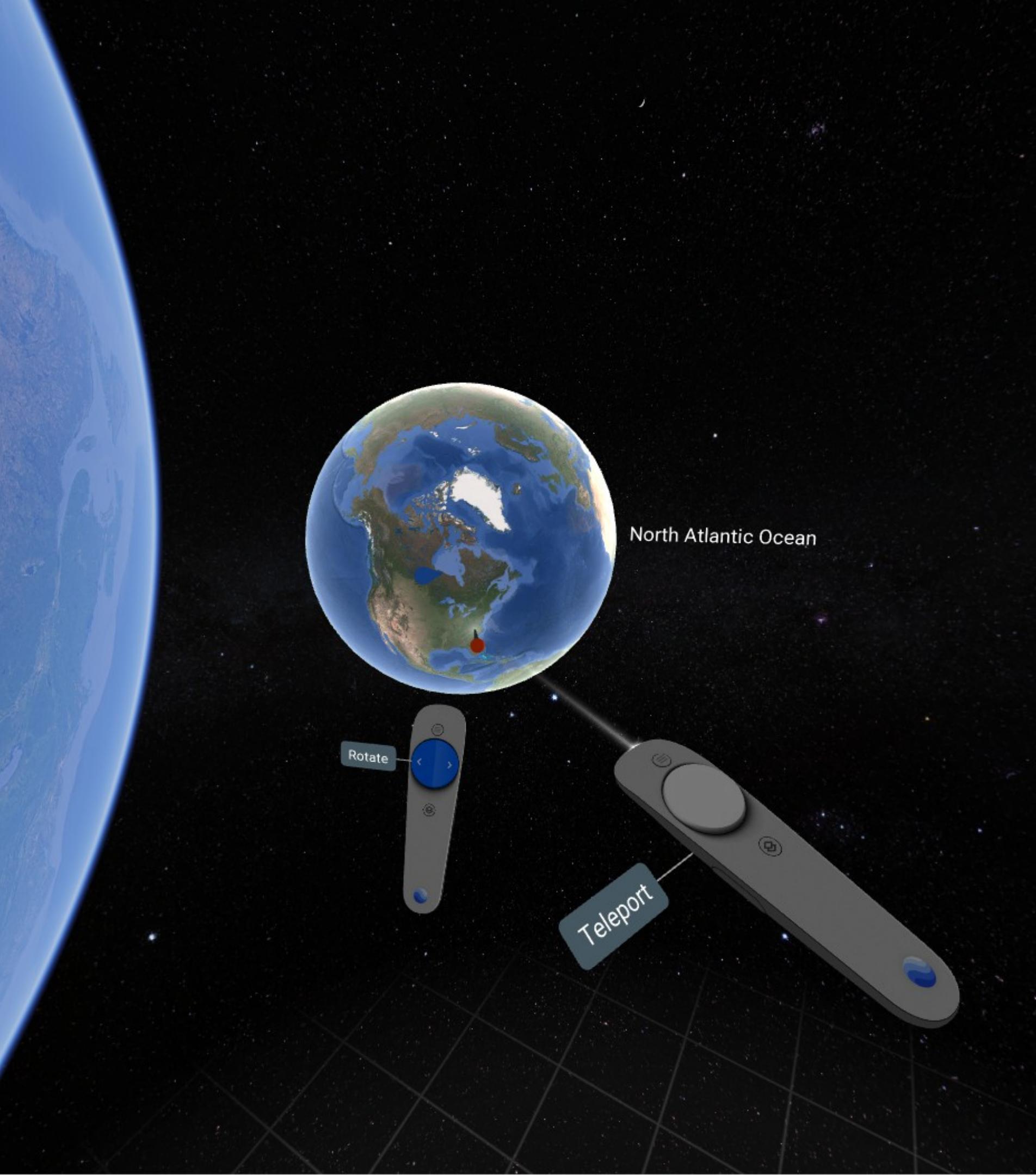
BLUE
EFFECT

€14.99



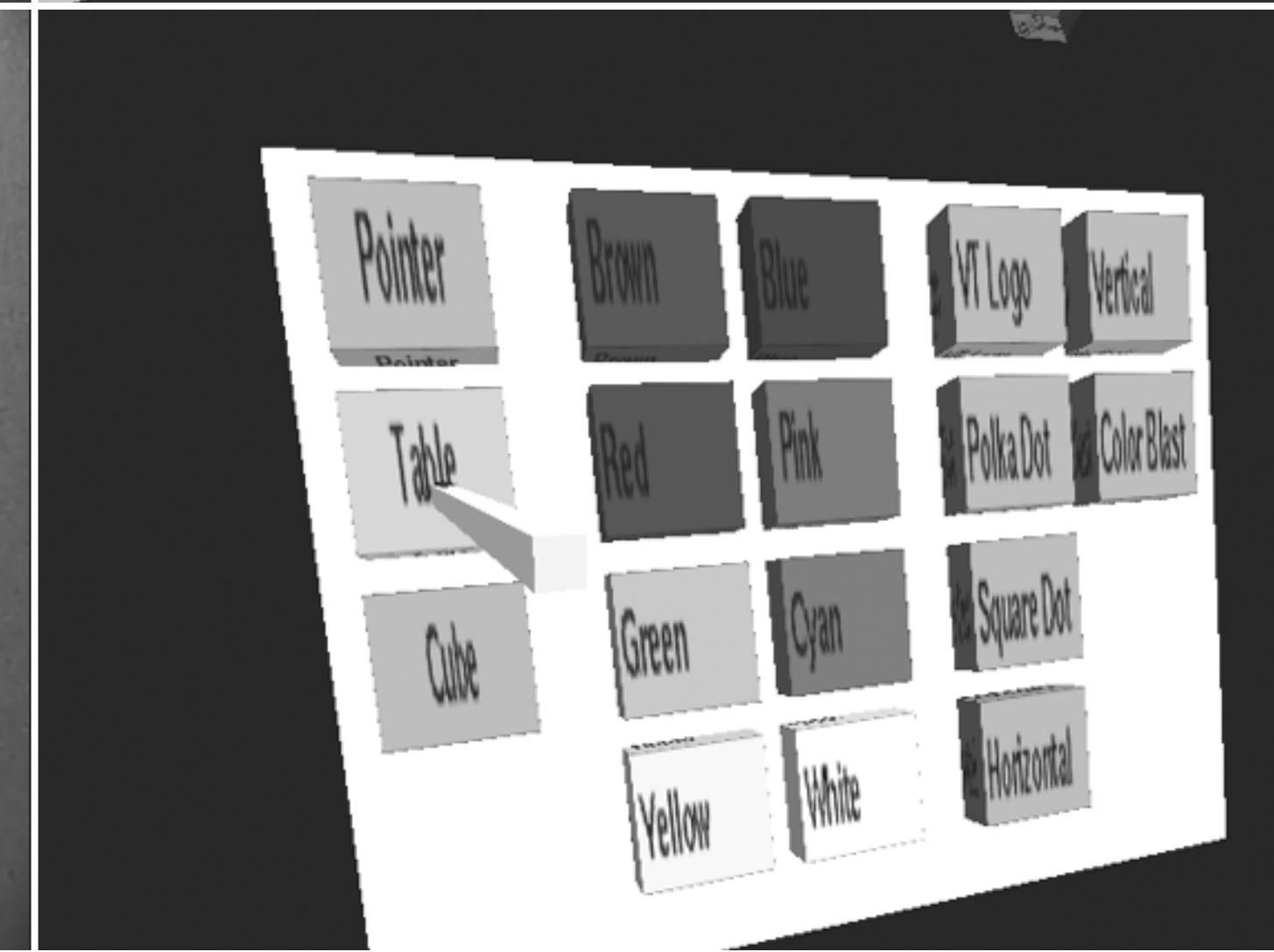
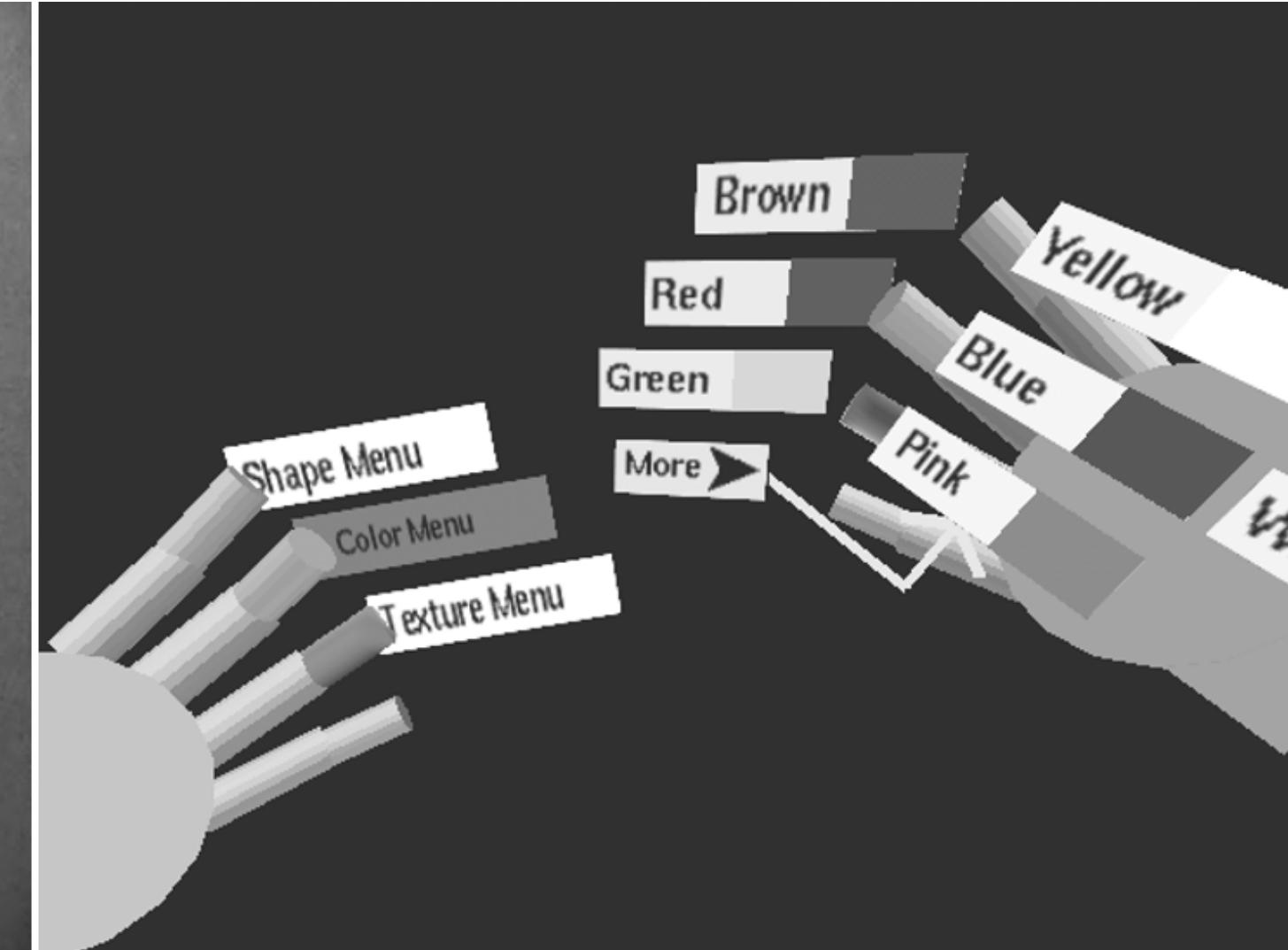
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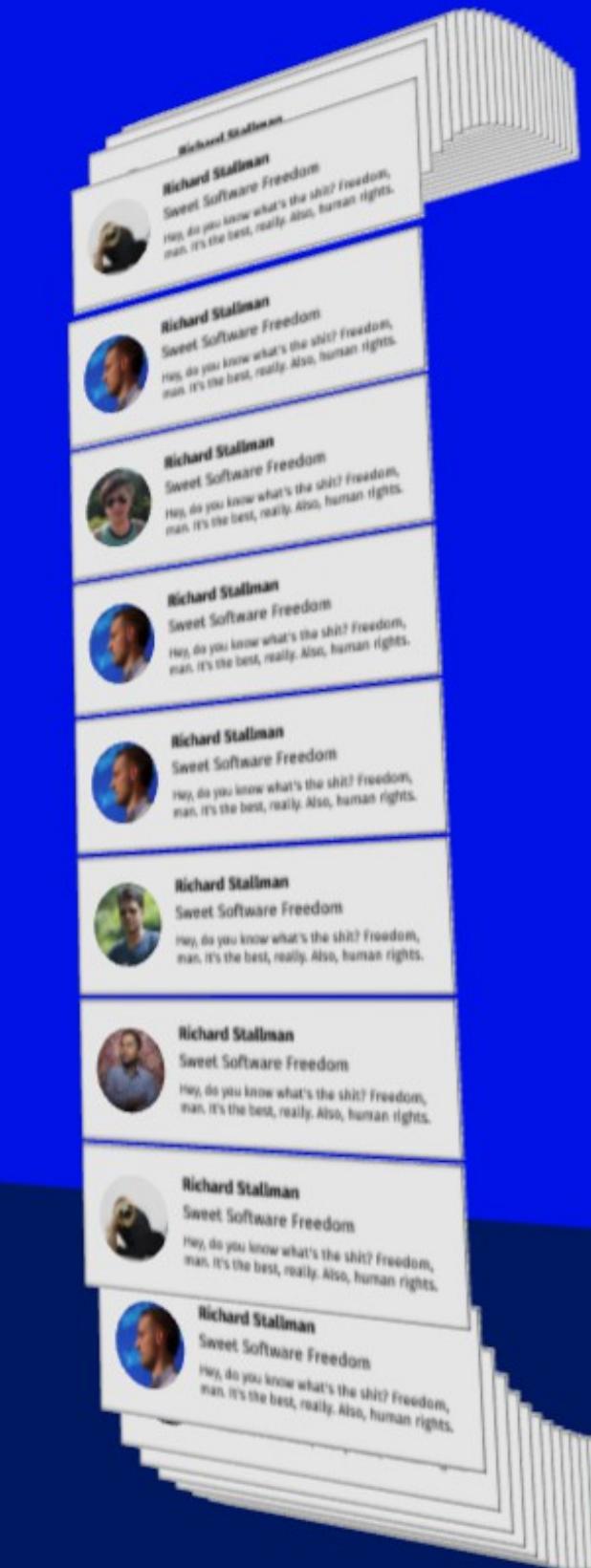


Prior Work

Bowman & Wingrave, 2001



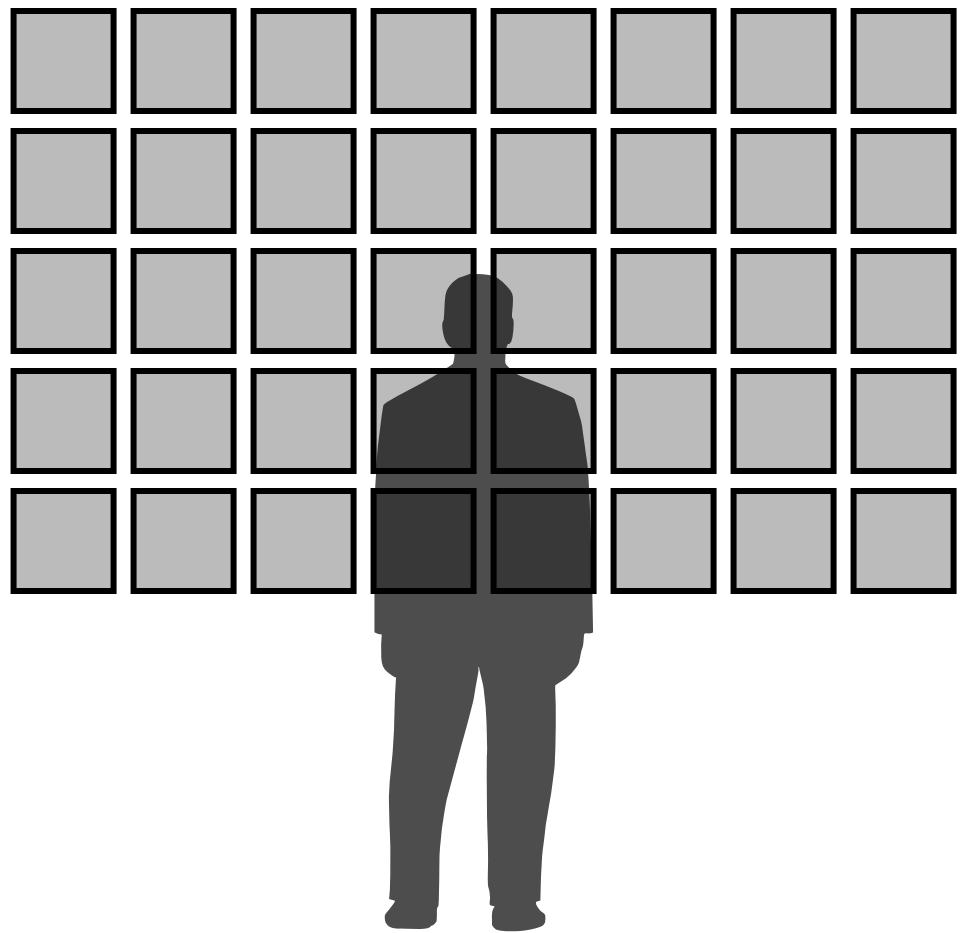
Prototypes





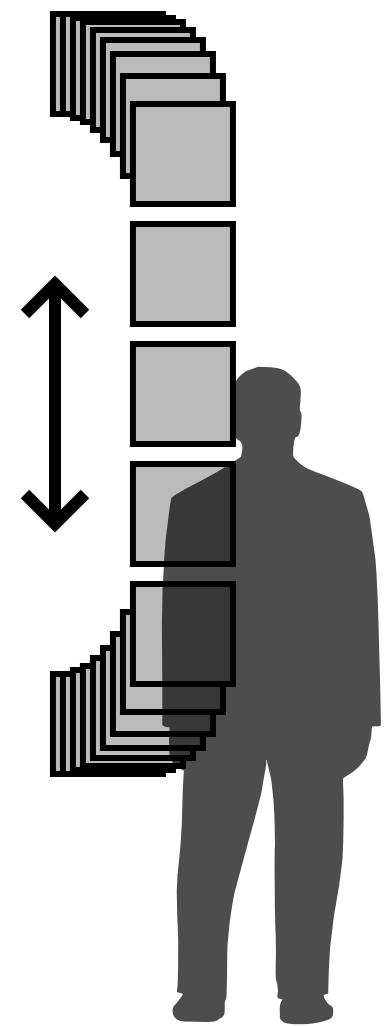
**Can we improve usability
by making use of 3D space?**

Spatial



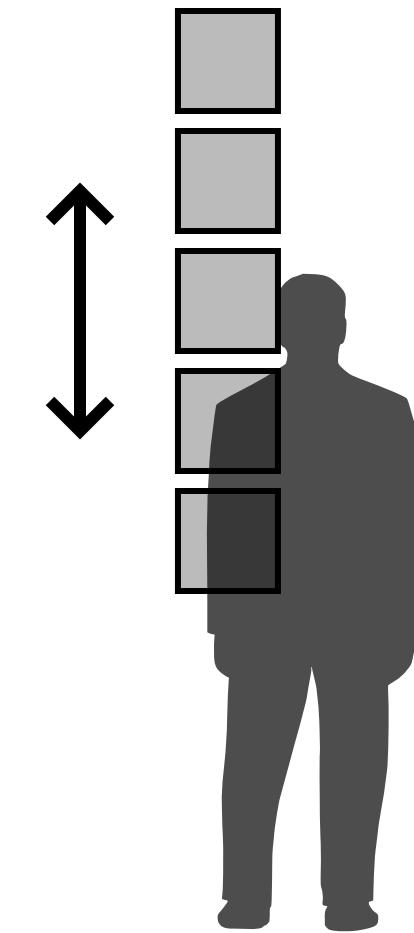
use head movement

Stacked



use z-dimension

Clipped



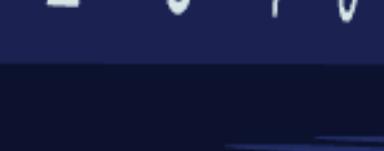
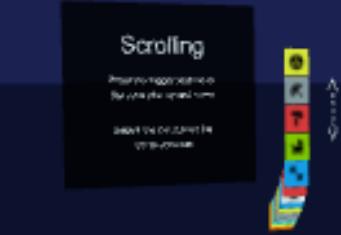
control

Apparatus

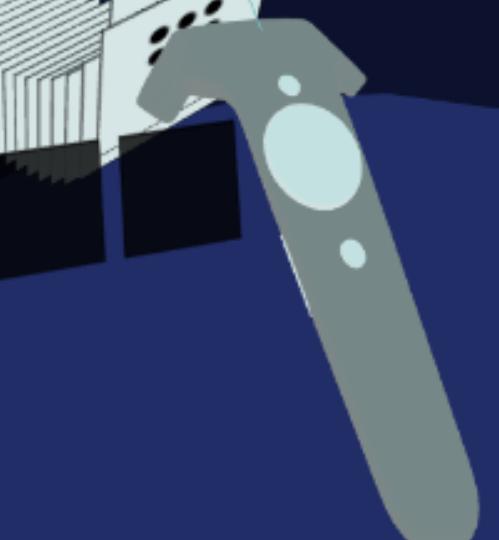
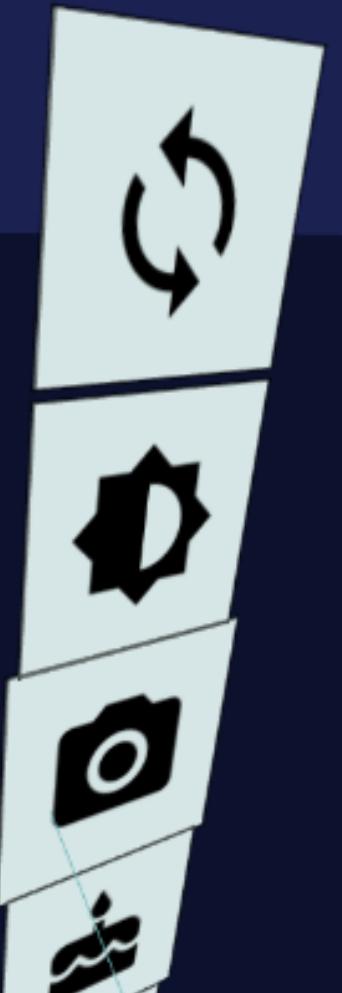


Tutorial Examples

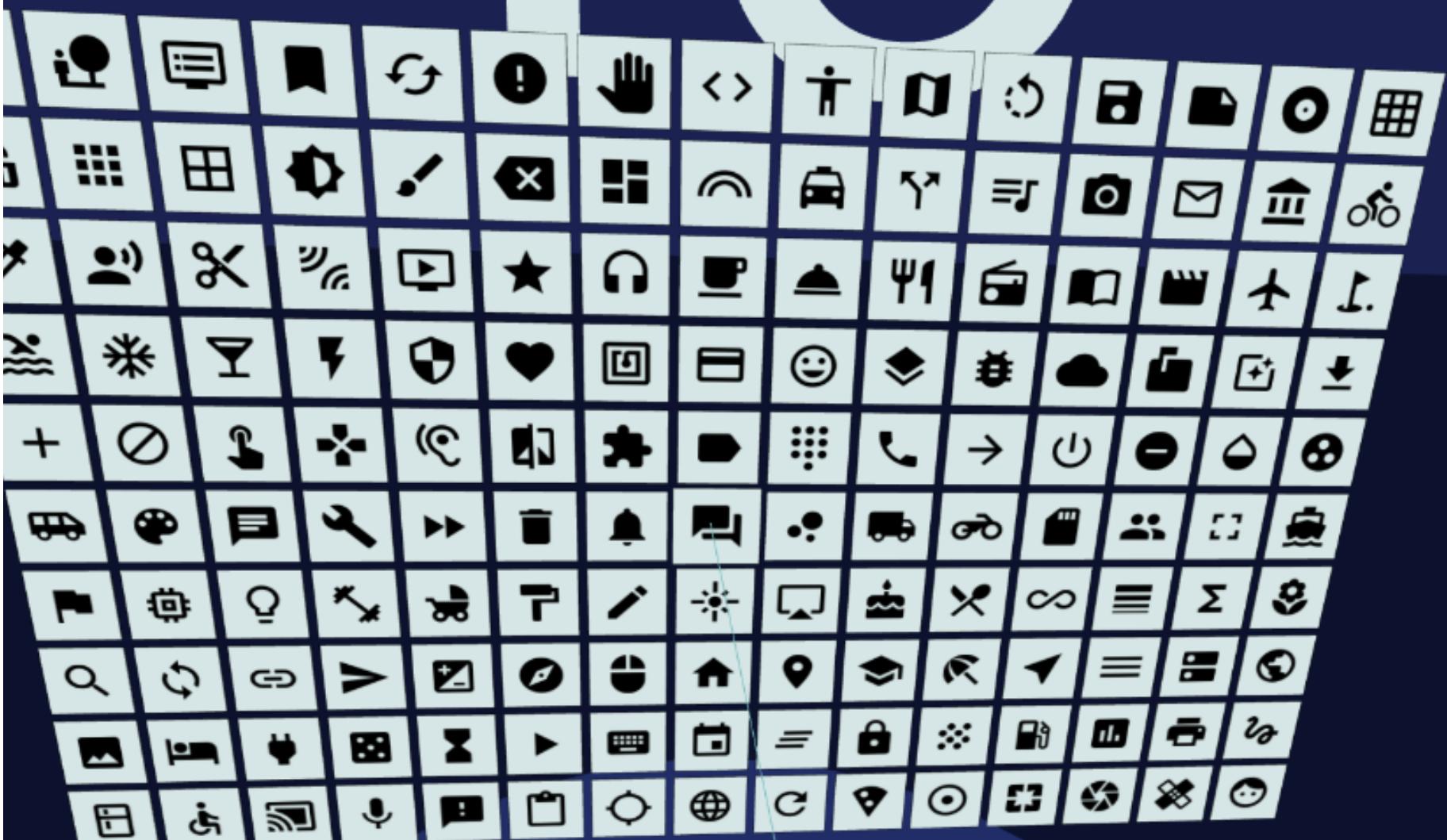
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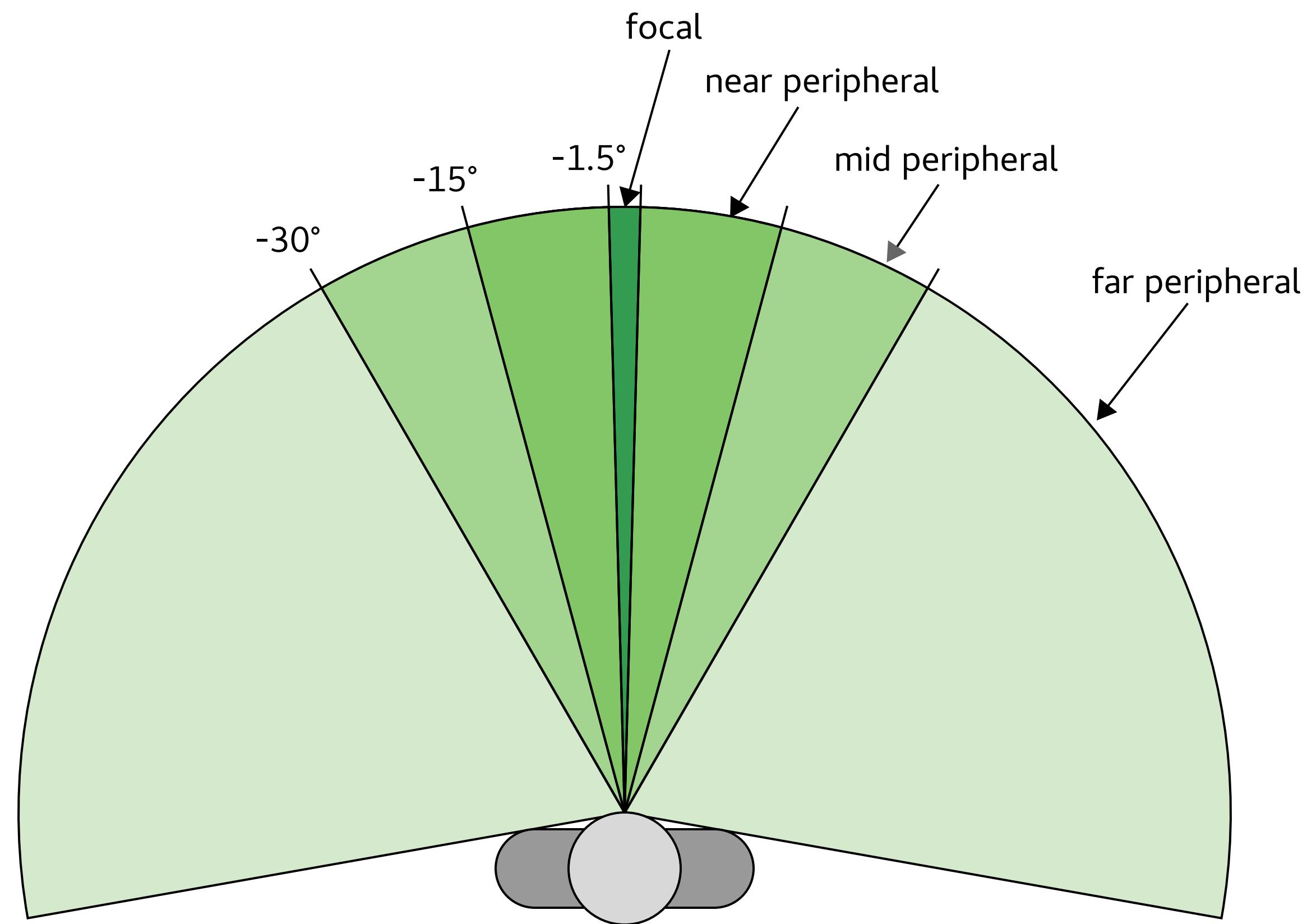


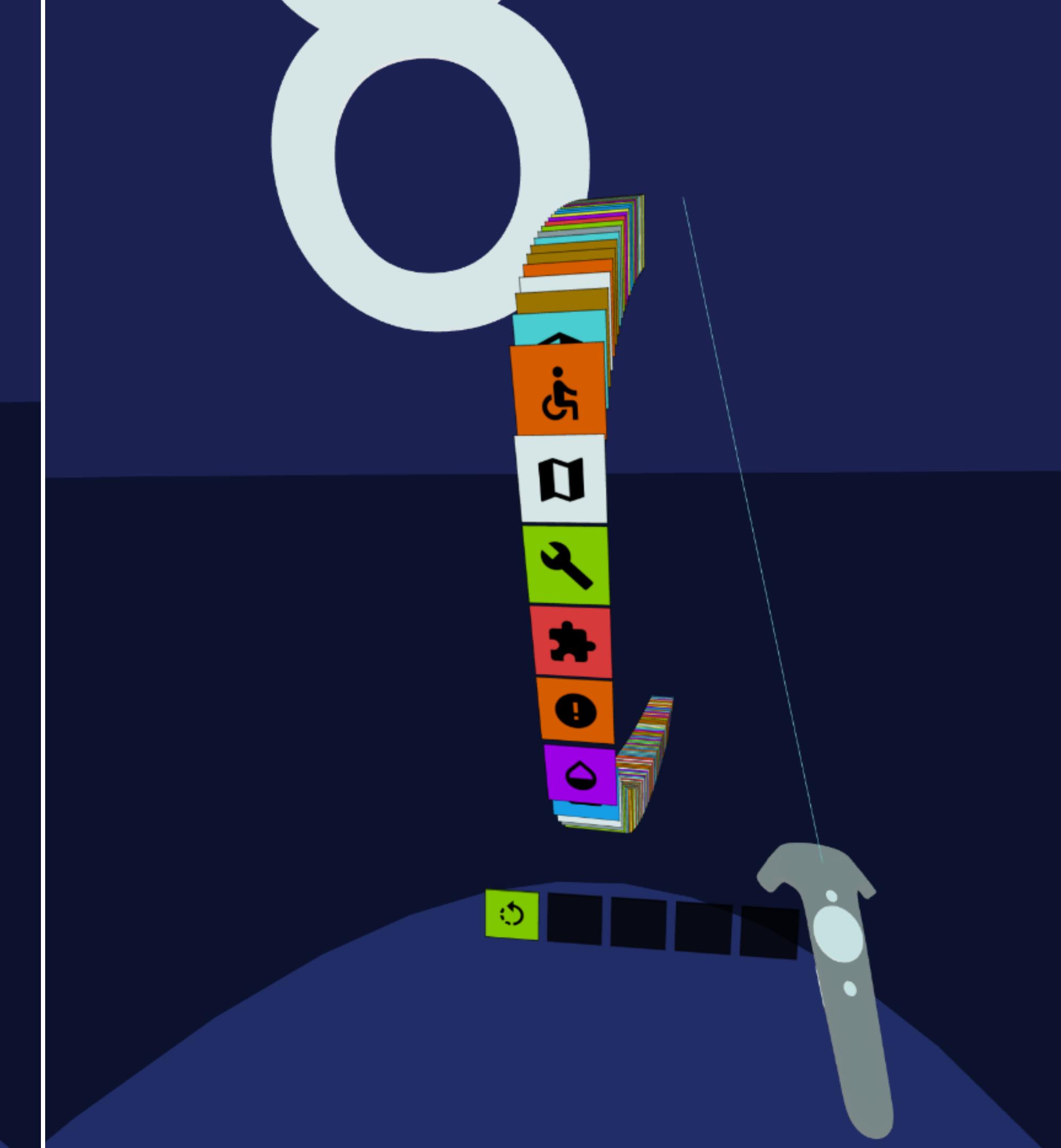
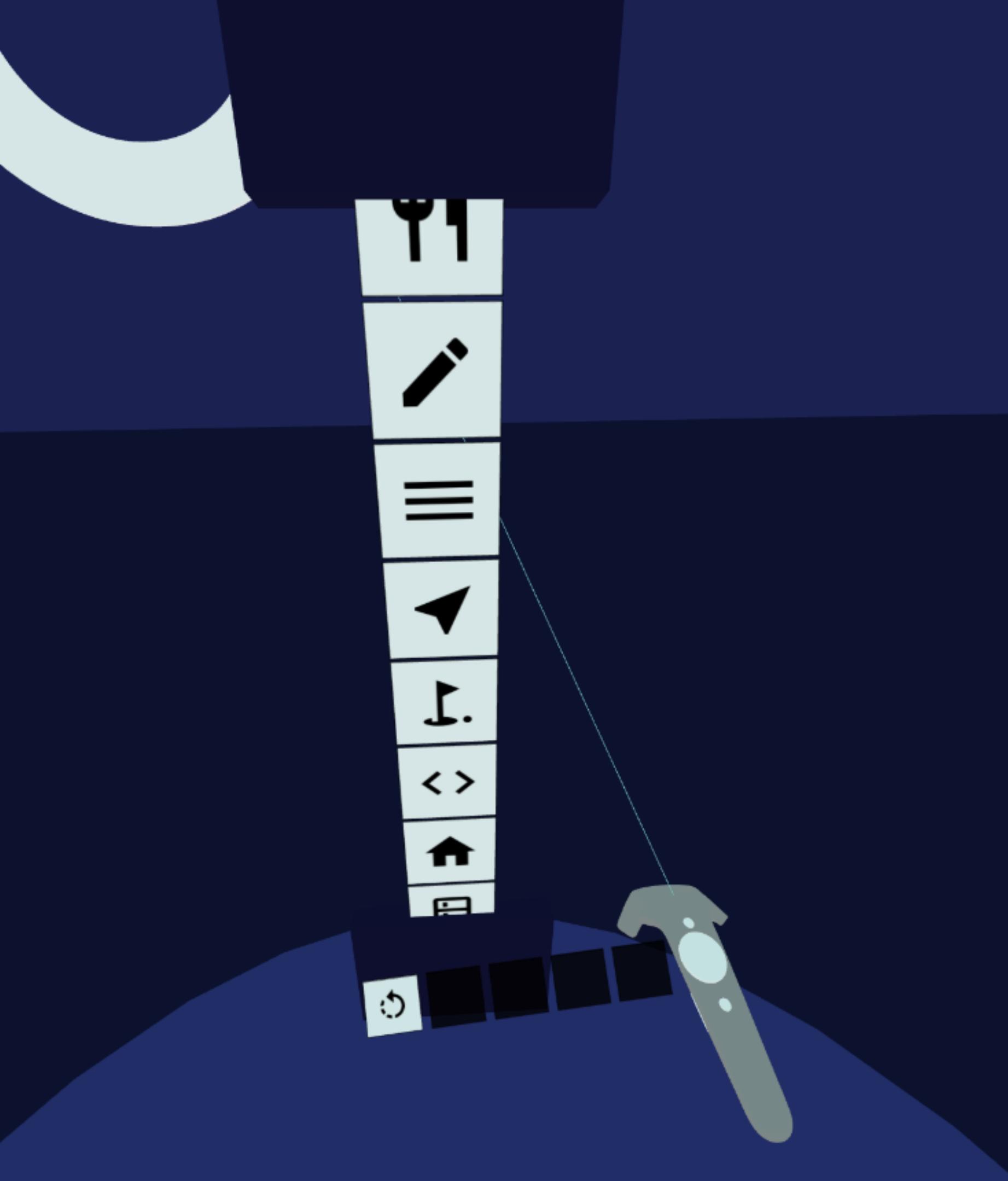
8

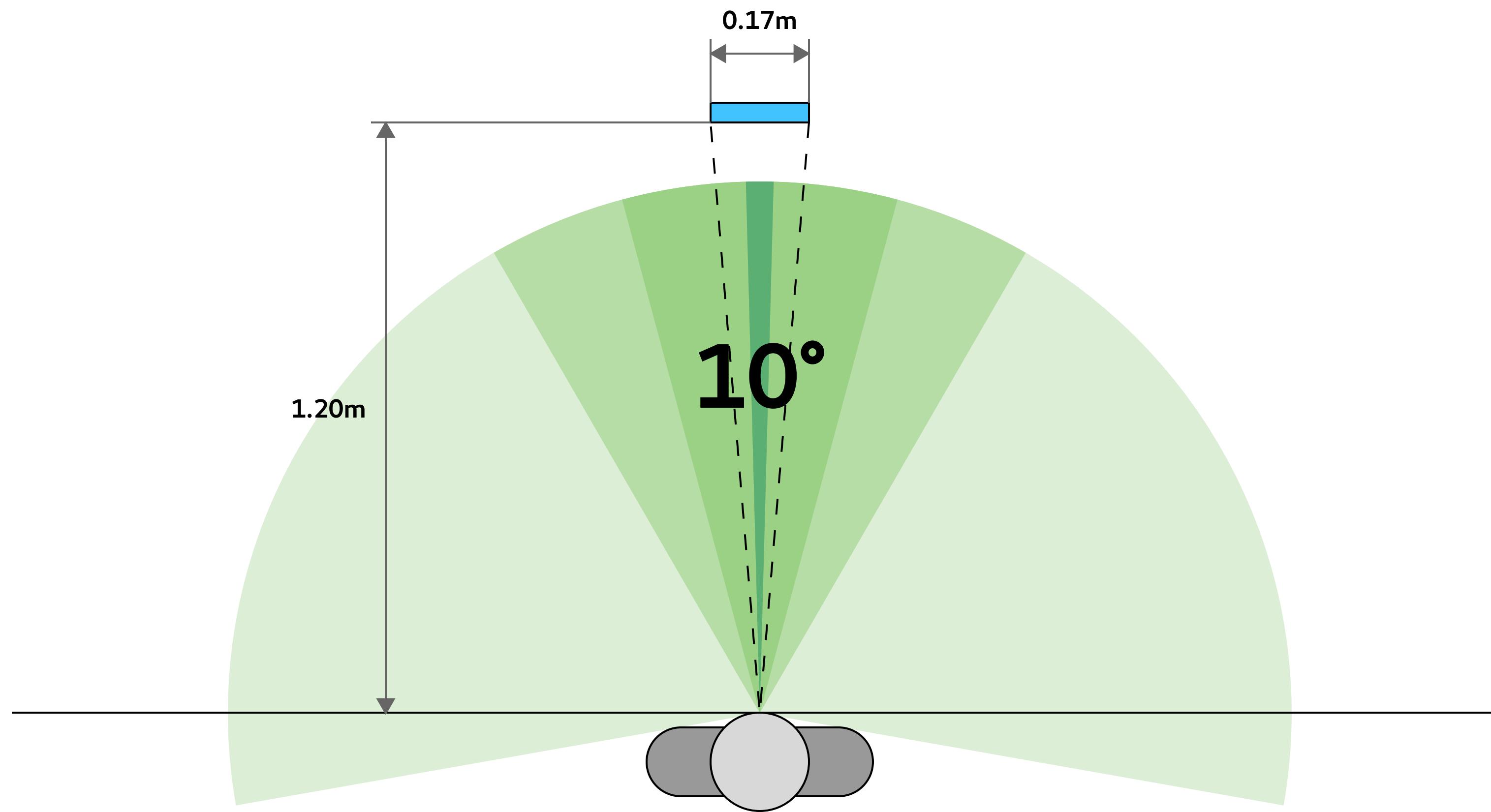


1
8





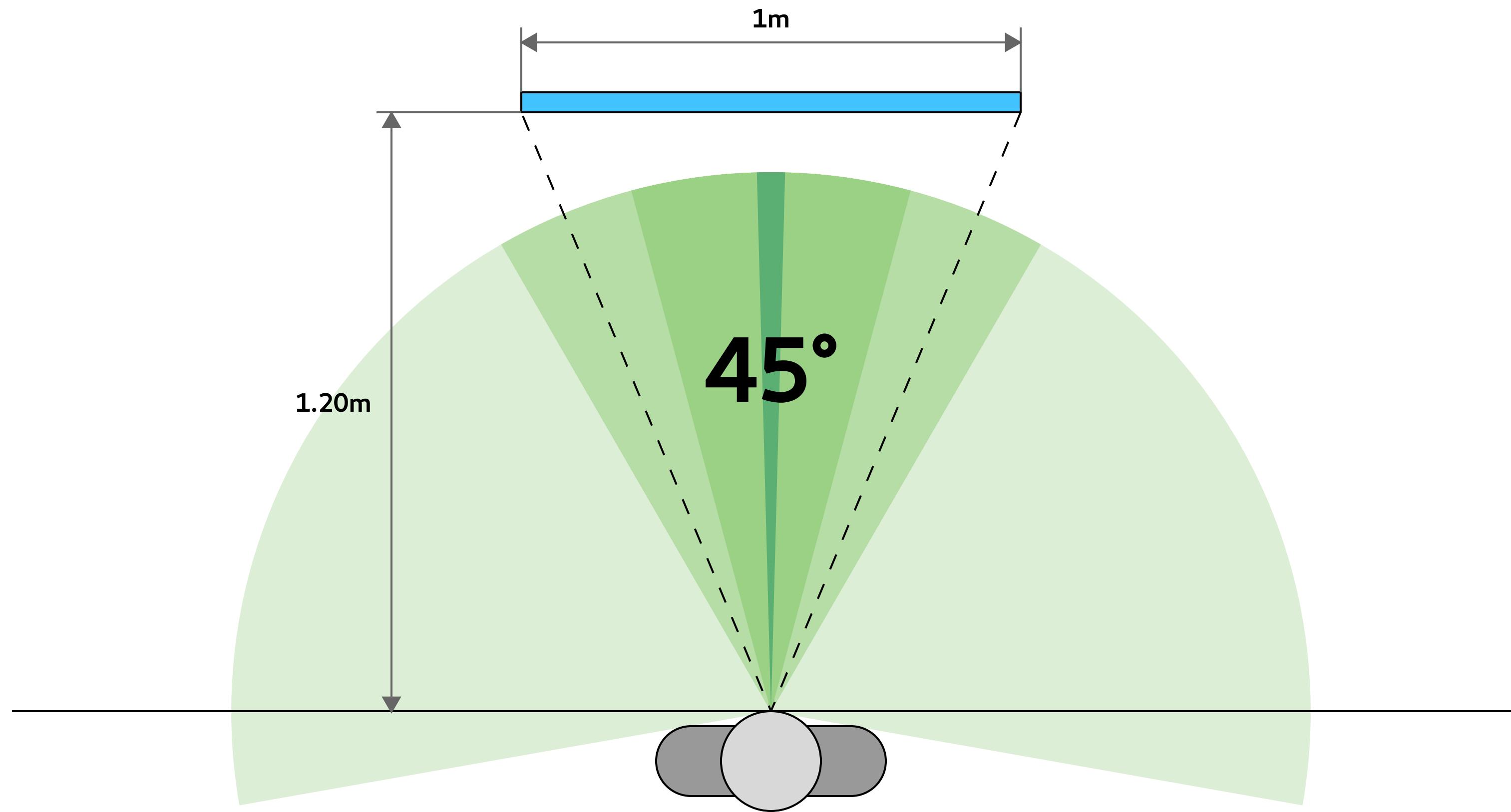




Clipped, Stacked

3

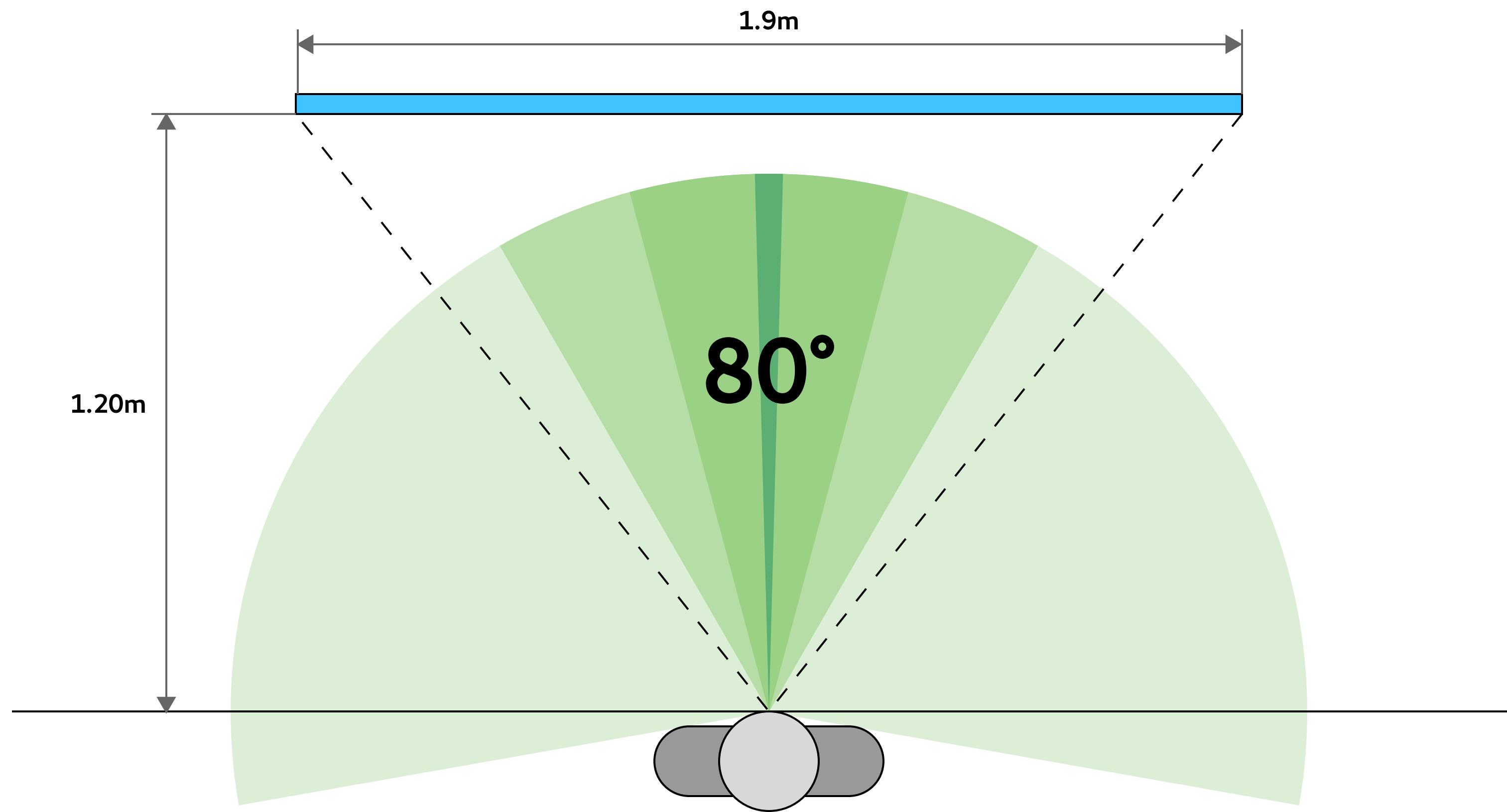




Spatial 20

6





Spatial 50

10



2.8m

100°

1.20m

Spatial 150

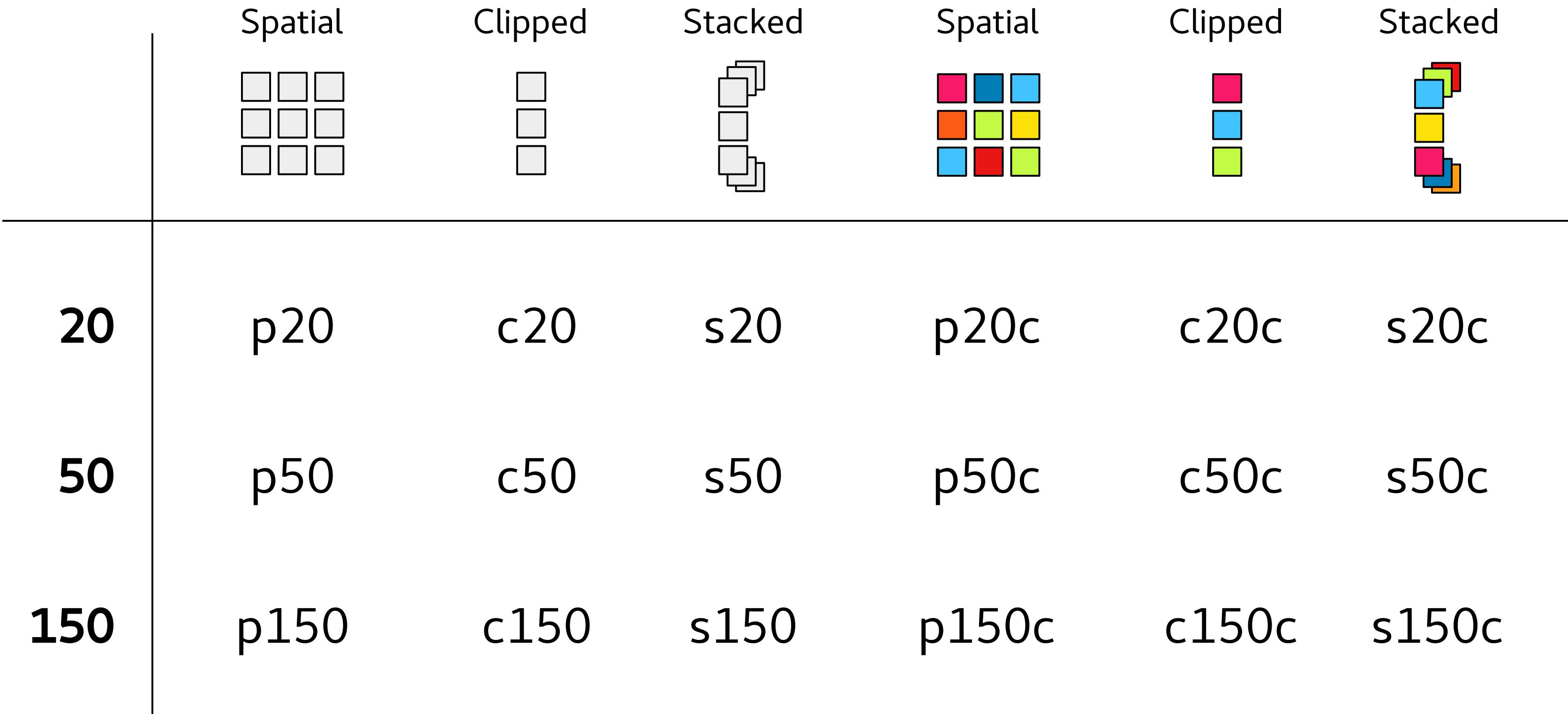
Experimental Design

Independent variables

Type: Spatial / Stacked / Clipped

Size: 20 / 50 / 150

Colored: Color / Black & White



Dependent variables

Time selecting each icon (milliseconds)

Errors (integer)

Controller movement (meters)

Scrolling distance (meters)

Qualitative Data

After each condition:

4 questions (7-point Likert scale, 7=strongly agree)

After the experiment:

Rate each type + color combination (7-point Likert scale, 7=very positively)

Hypotheses

H1 Spatial > Clipped, Stacked

H2 Repeat > Initial

H3 Initial: Clipped == Stacked

H4 Repeat: Spatial > Stacked > Clipped

H5 Color > Black/White

Participants

15 participants (4 female)

19 - 48 years (MDN = 24 years)

display workers ($M = 5.8$ hours / day, $SD = 2.35$)

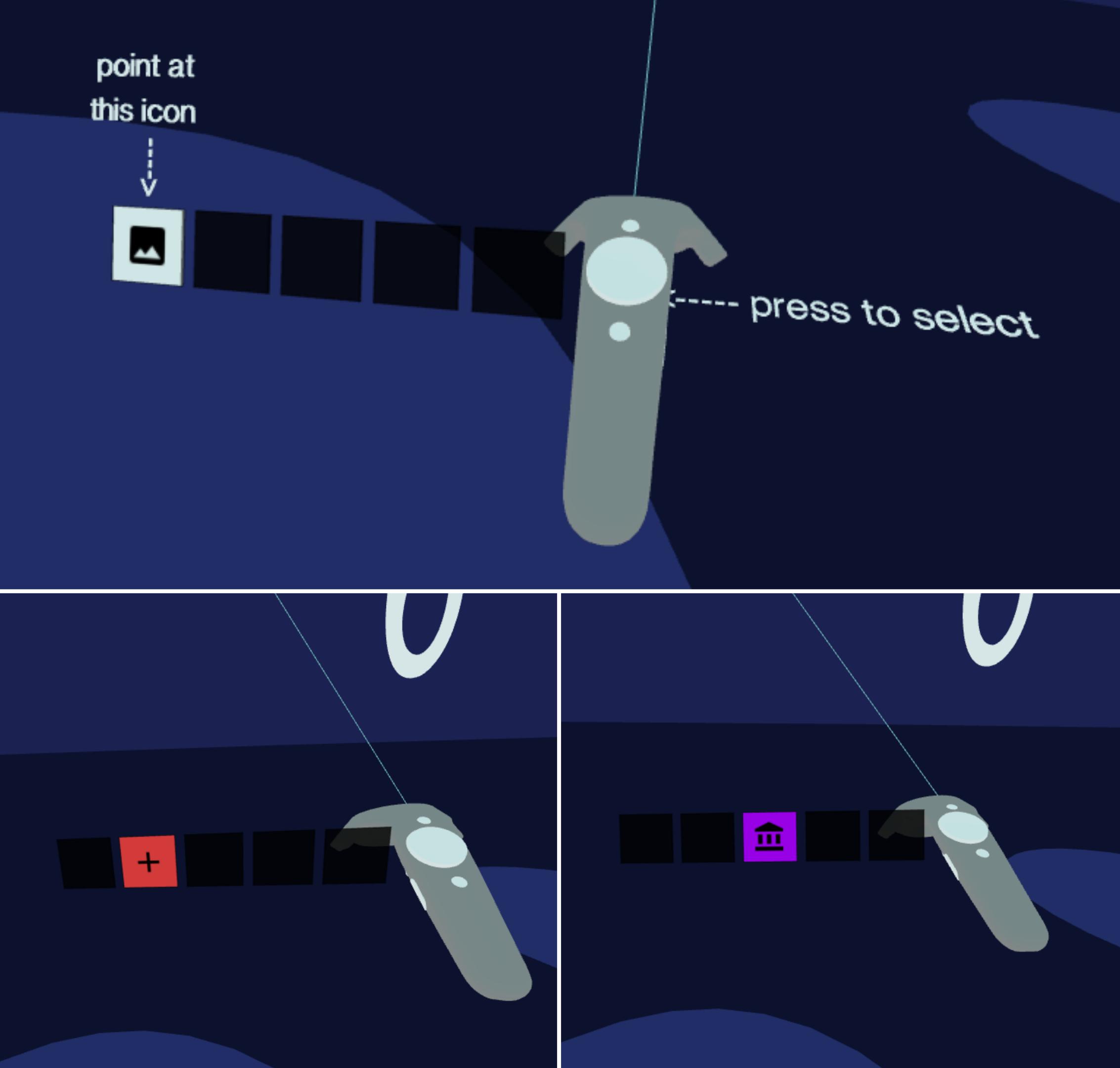
some experience with VR

Tasks

18 conditions

2 x 5 icons each

about 30min



Results

H1

Spatial > Clipped, Stacked



One-way ANOVA ($\alpha=.05$)

Spatial vs. Clipped ✓

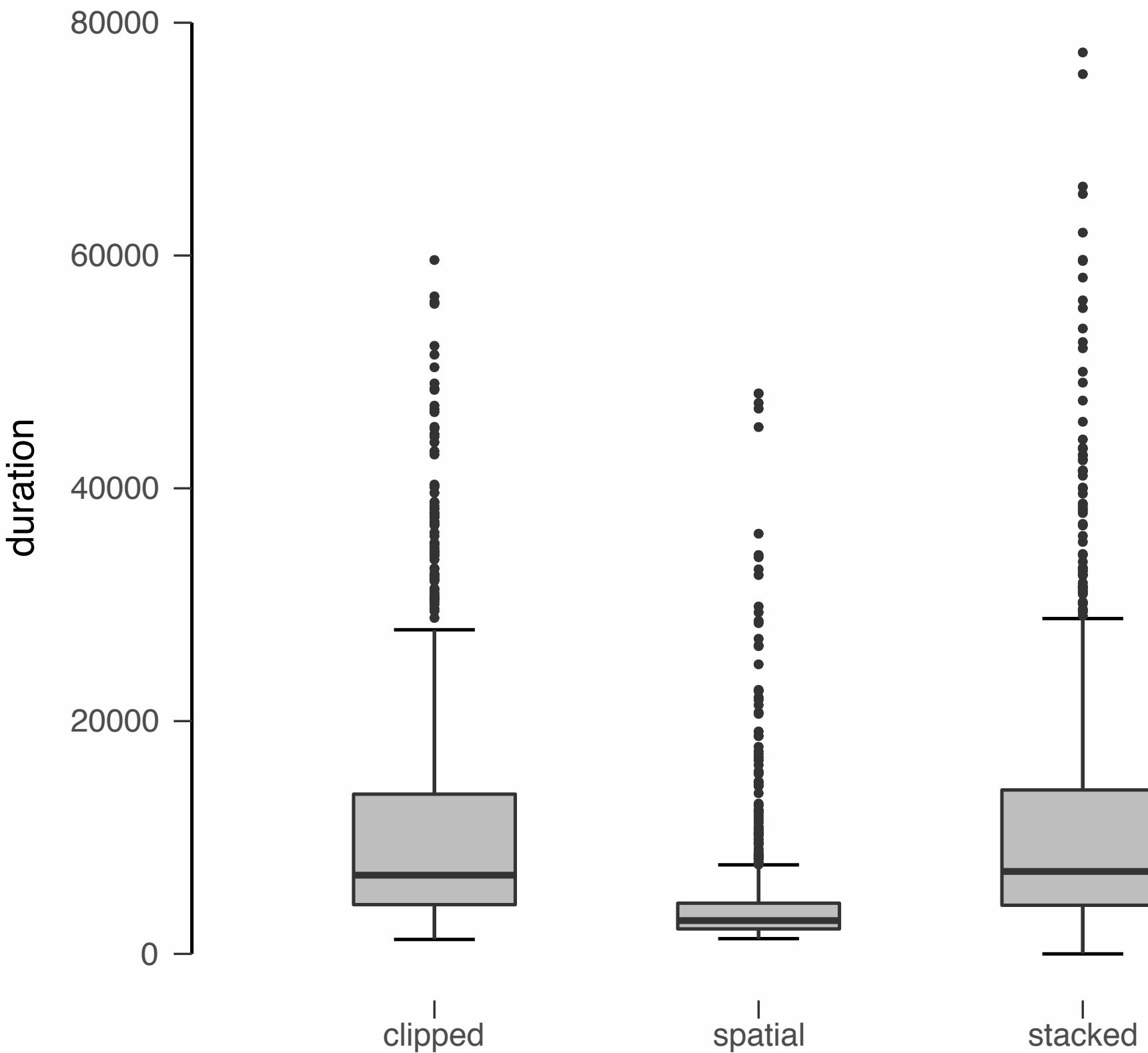
Mean Difference: 6356ms

SE: 320ms, $p < .001$

Spatial vs. Stacked ✓

Mean Difference: 6581ms

SE: 320ms, $p < .001$



H2

Repeat > Initial

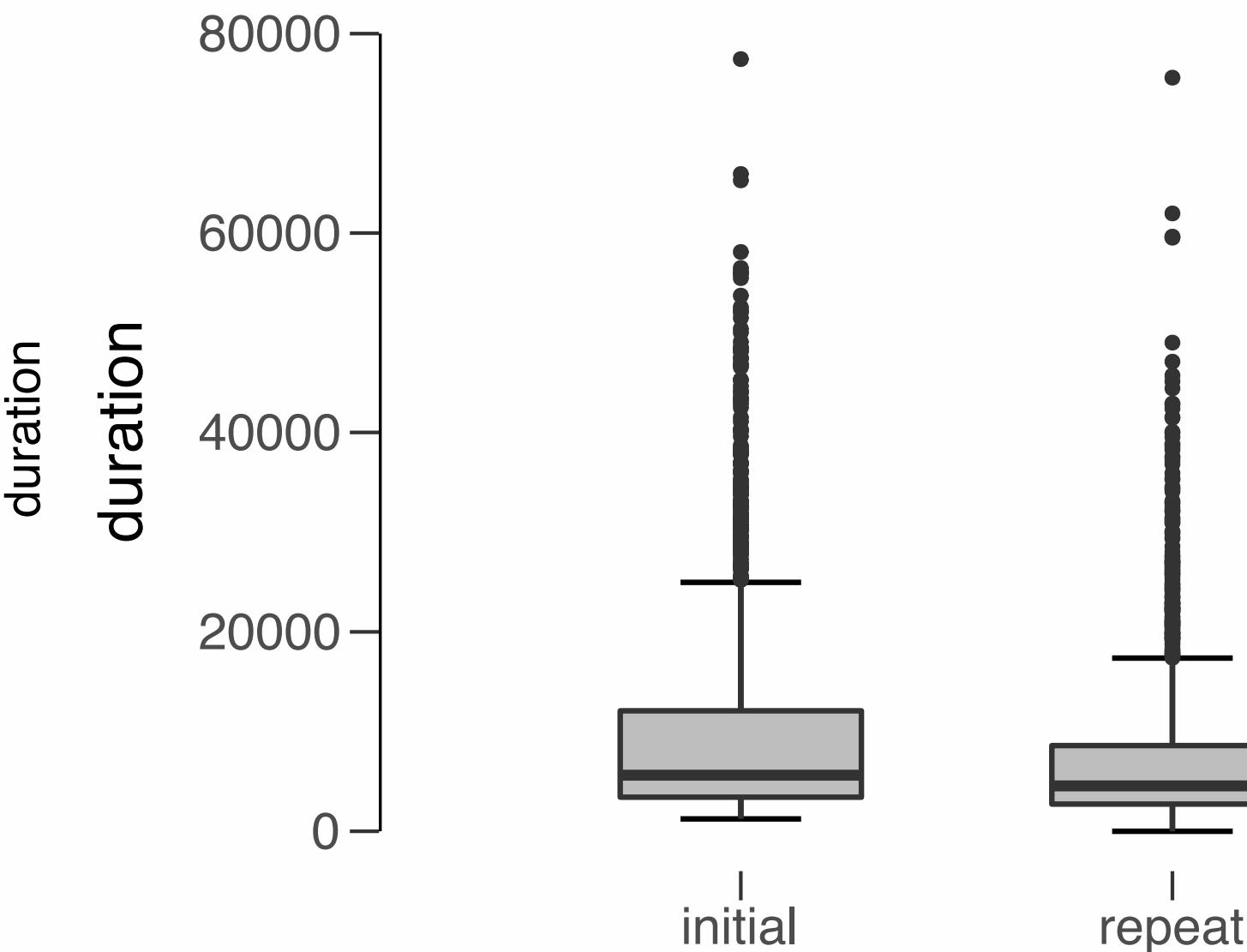


One-way ANOVA ($\alpha=.05$)

Initial vs. Repeat 

Mean Difference: 2397ms

SE: 377ms, $p < .001$



H3

Initial

Clipped == Stacked

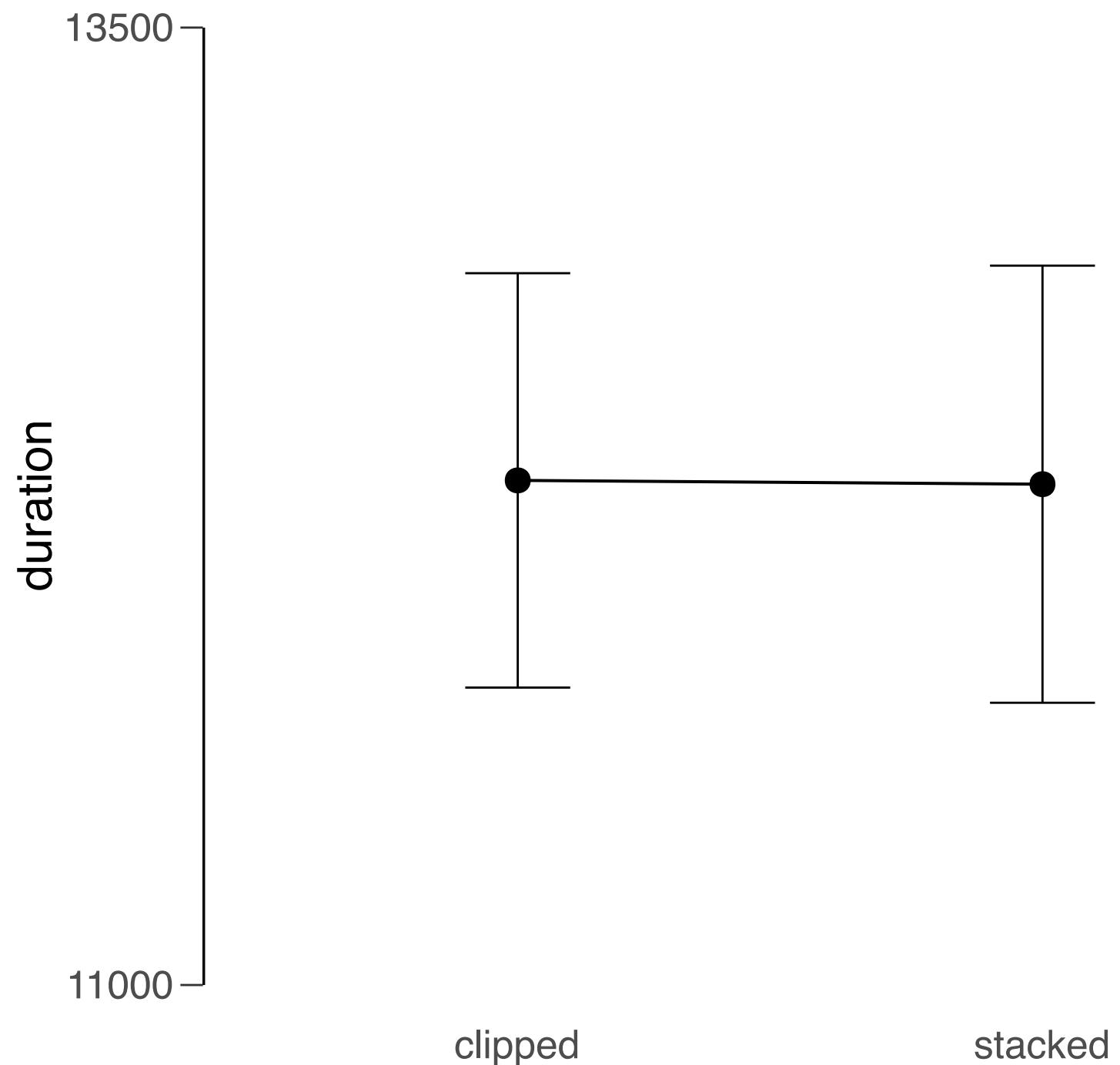


One-way ANOVA ($\alpha=.05$)

Clipped vs. Stacked ✗

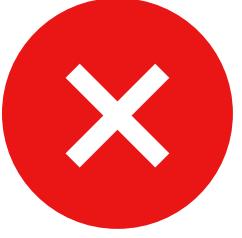
Mean Difference: 9.89ms

SE: 377ms, p: .99



H4

Repeat

Spatial > Stacked > Clipped 

One-way ANOVA ($\alpha=.05$)

Spatial vs. Clipped

Mean Difference: 6241ms

SE: 532ms, $p < .001$

Spatial vs. Stacked

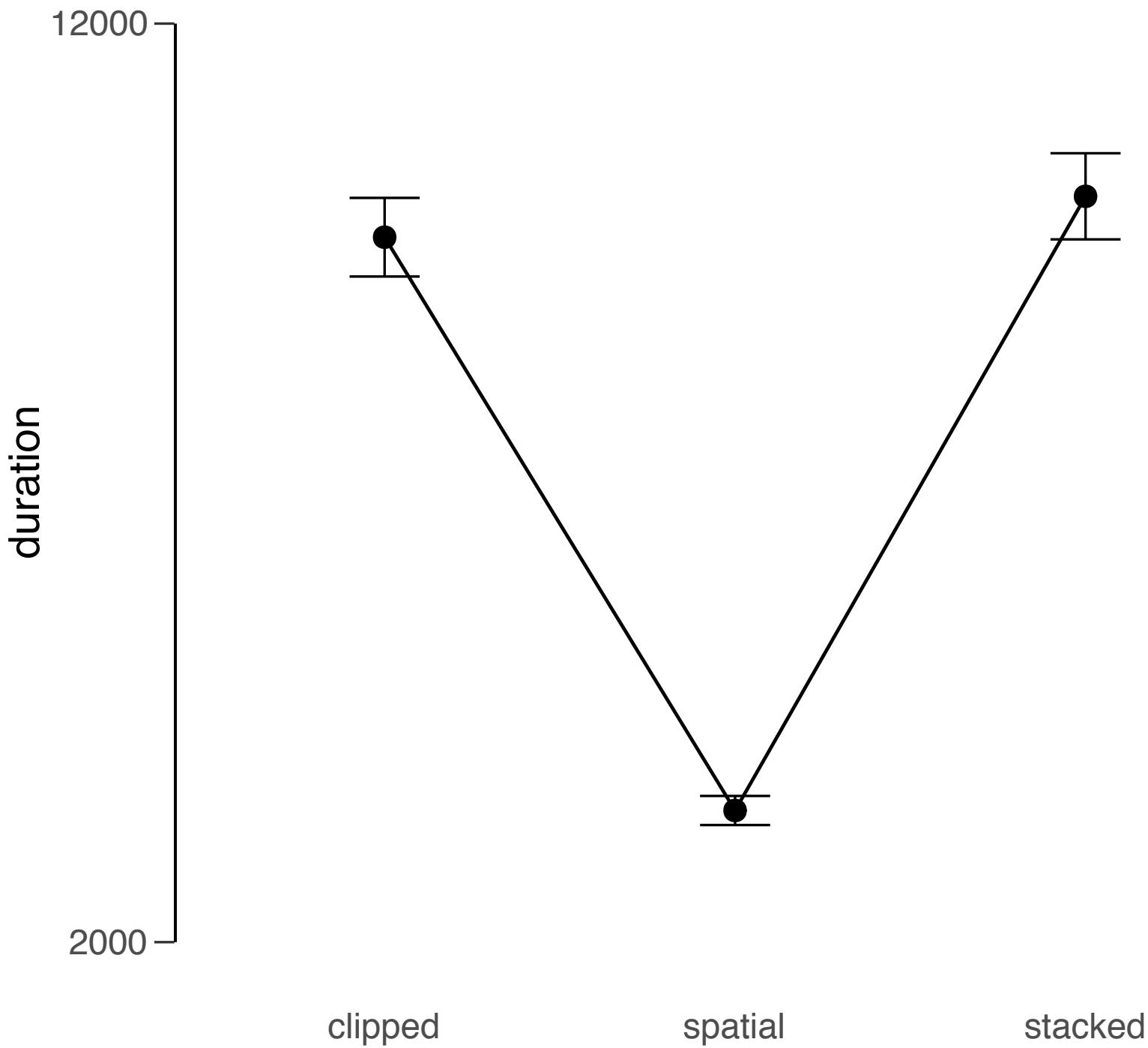
Mean Difference: 6686ms

SE: 532ms, $p < .001$

Clipped vs. Stacked

Mean Difference: 445ms

SE: 533ms, $p: .682$



H5

Color > Black/White

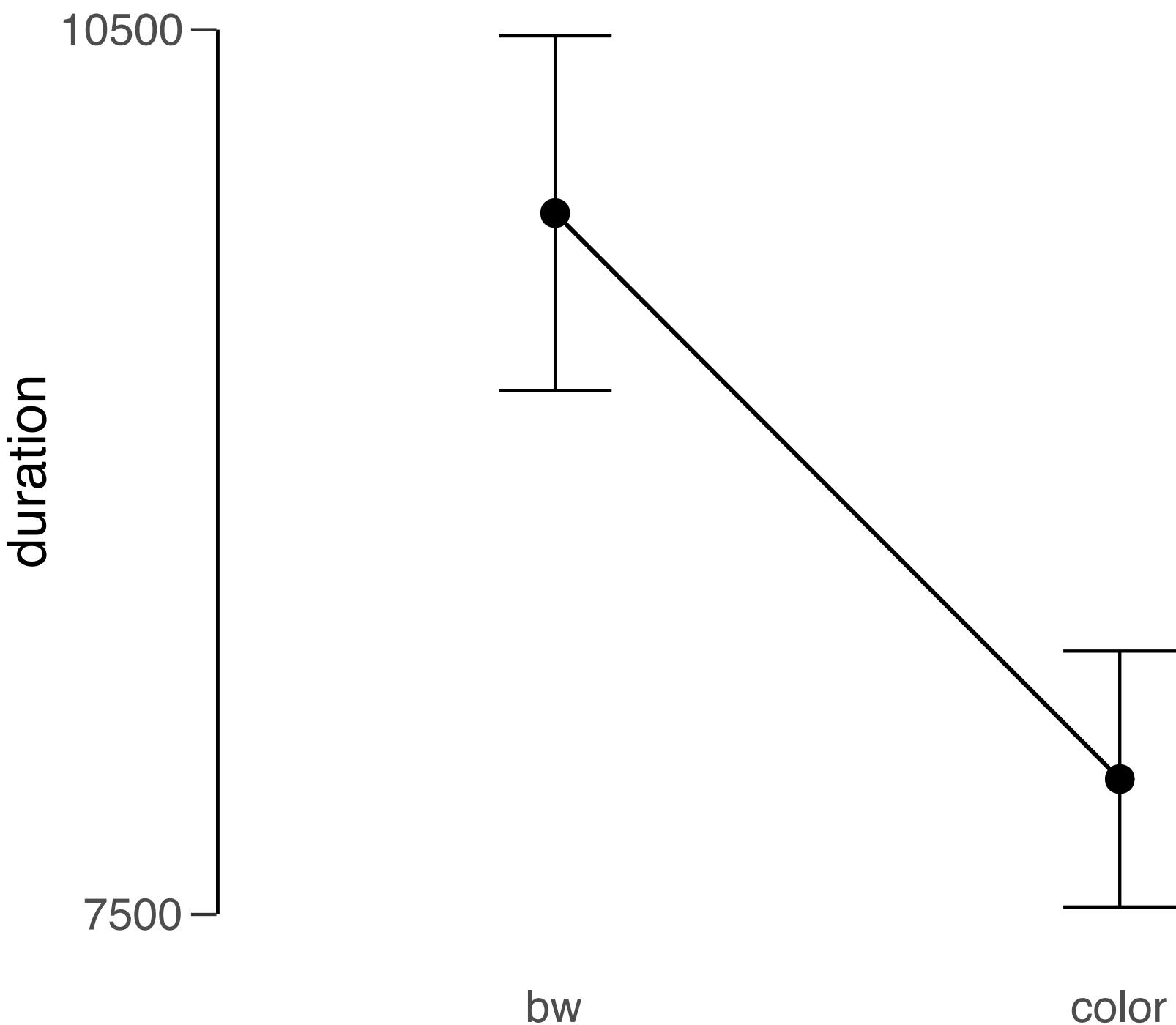


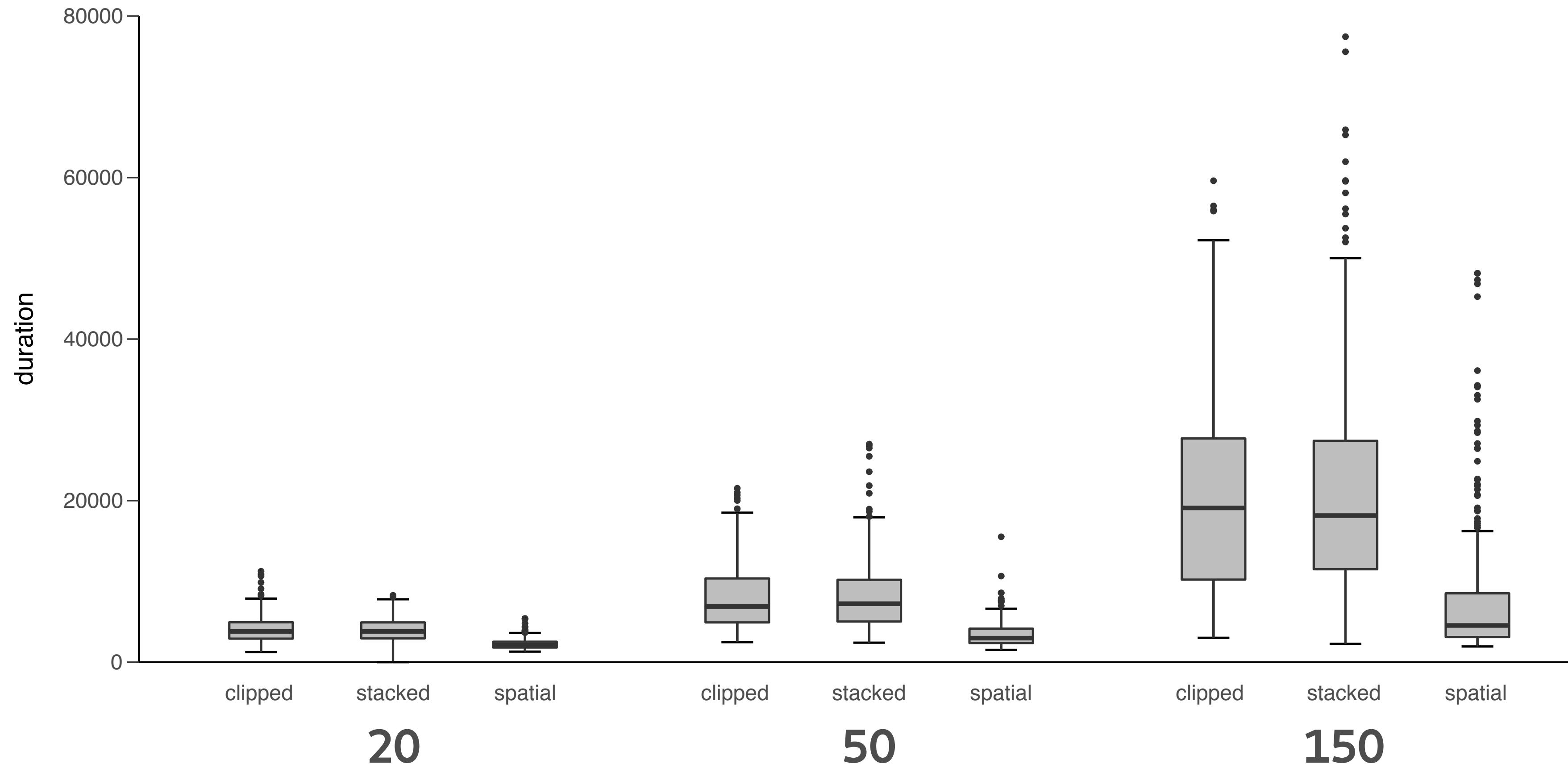
One-way ANOVA ($\alpha=.05$)

Black/White vs. Color 

Mean Difference: 1919ms

SE: 377.8ms, $p < .001$





Qualitative Results

Questions after each condition

Likert Scale 1-7, 7=very true

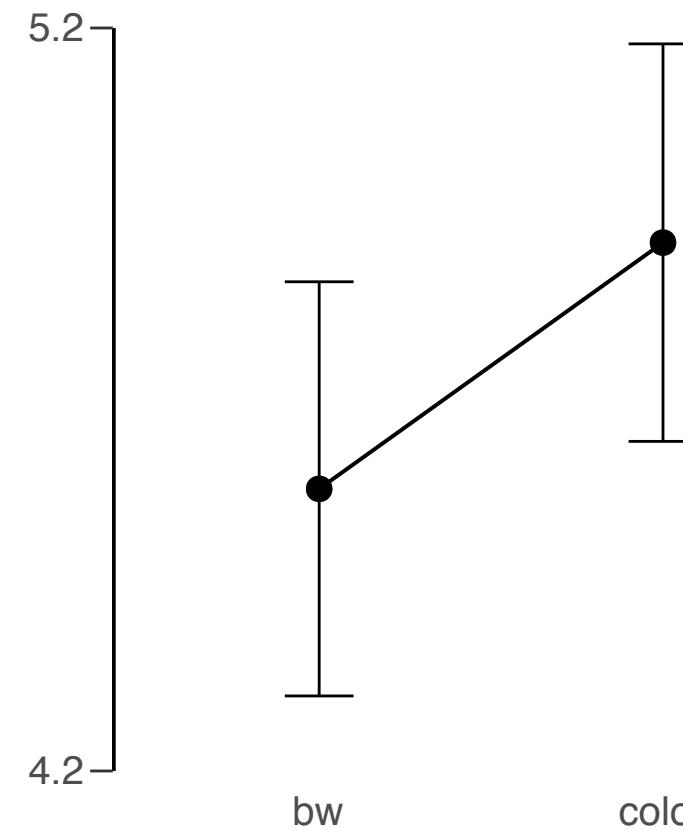
I could memorize the position of the items.

I was overwhelmed by the number of items.

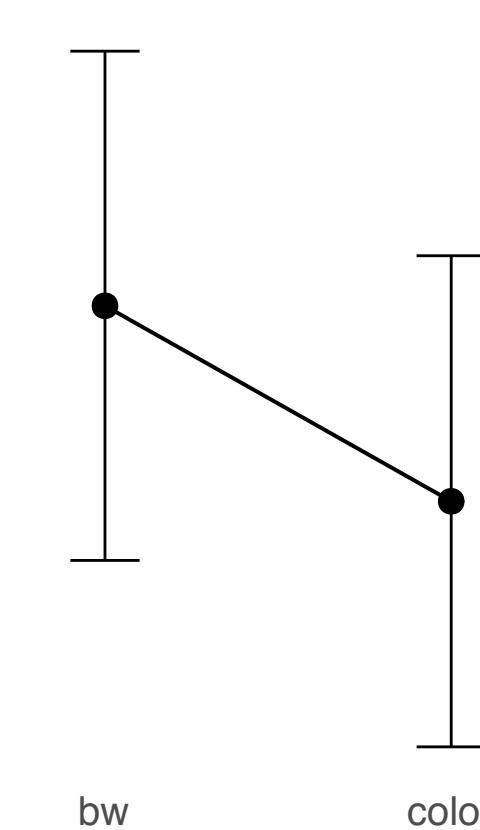
I found the layout efficient to navigate.

I could easily find the item I was looking for.

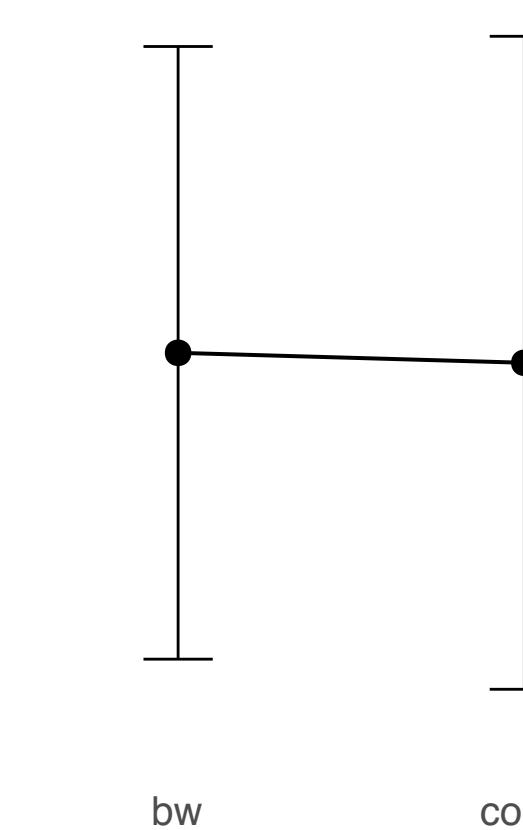
Easy to find



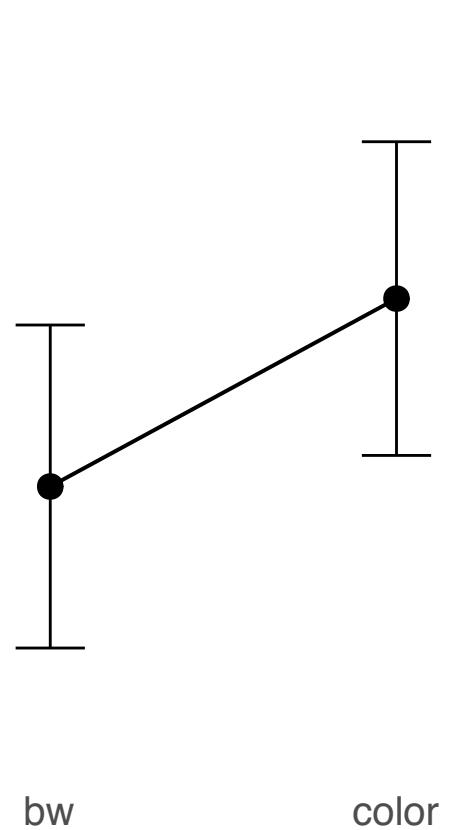
Overwhelmed



Memorize



Efficient

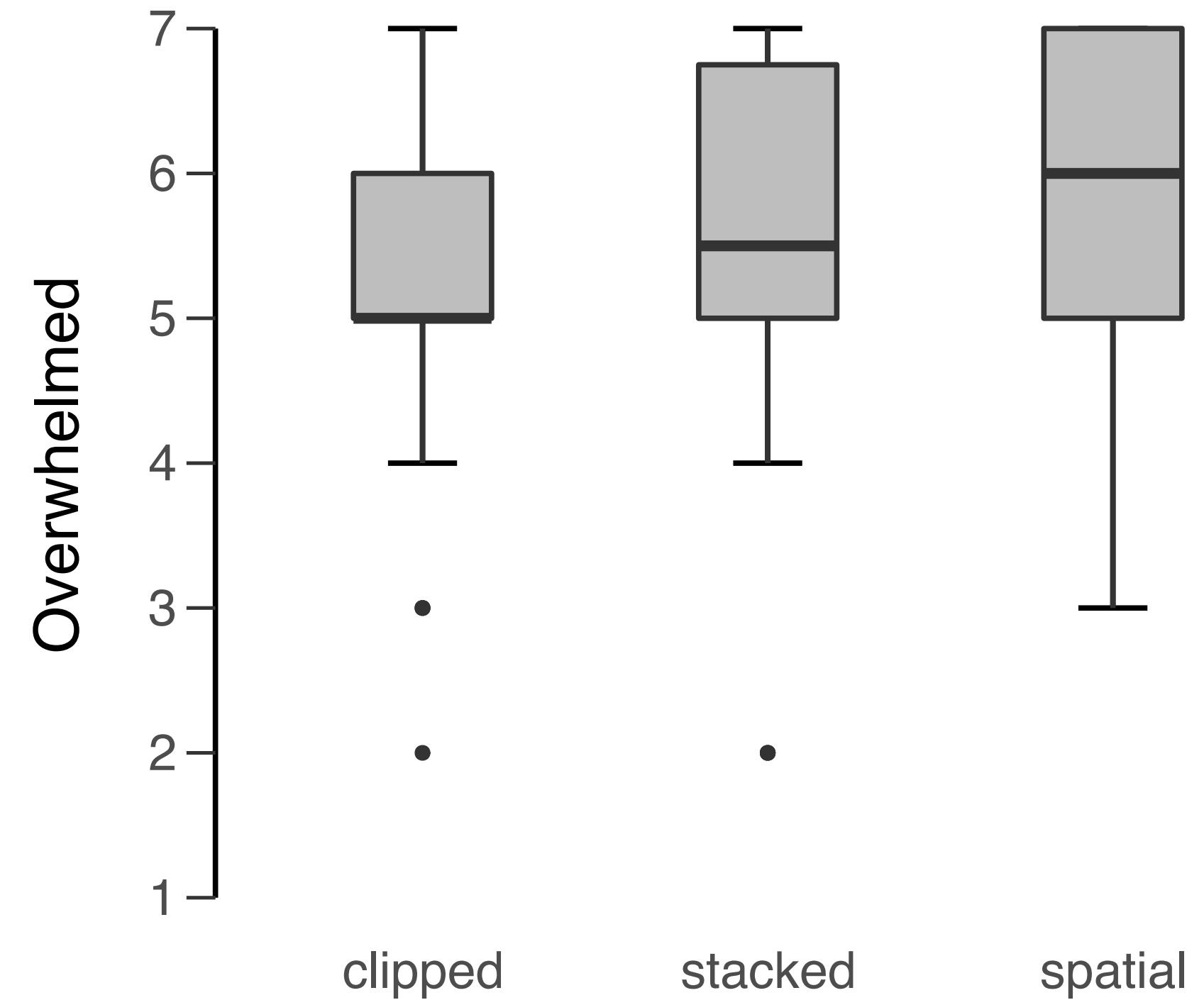


Spatial and colored conditions performed better.

No significant differences between stacked and clipped.

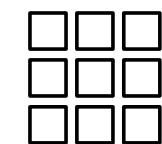
150 items

People were not significantly more overwhelmed by spatial for 150 items

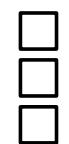


Post-experiment Questionnaire

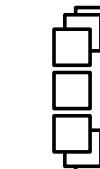
How would you rate the different interfaces?
(1 = very negatively, 7 = very positively)



Spatial



Clipped



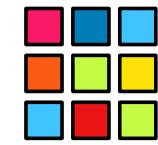
Stacked

Black/white

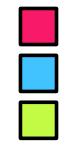
1	2	3	4	5	6	7
---	---	---	---	---	---	---

1	2	3	4	5	6	7
---	---	---	---	---	---	---

1	2	3	4	5	6	7
---	---	---	---	---	---	---



Spatial



Clipped



Stacked

Color

1	2	3	4	5	6	7
---	---	---	---	---	---	---

1	2	3	4	5	6	7
---	---	---	---	---	---	---

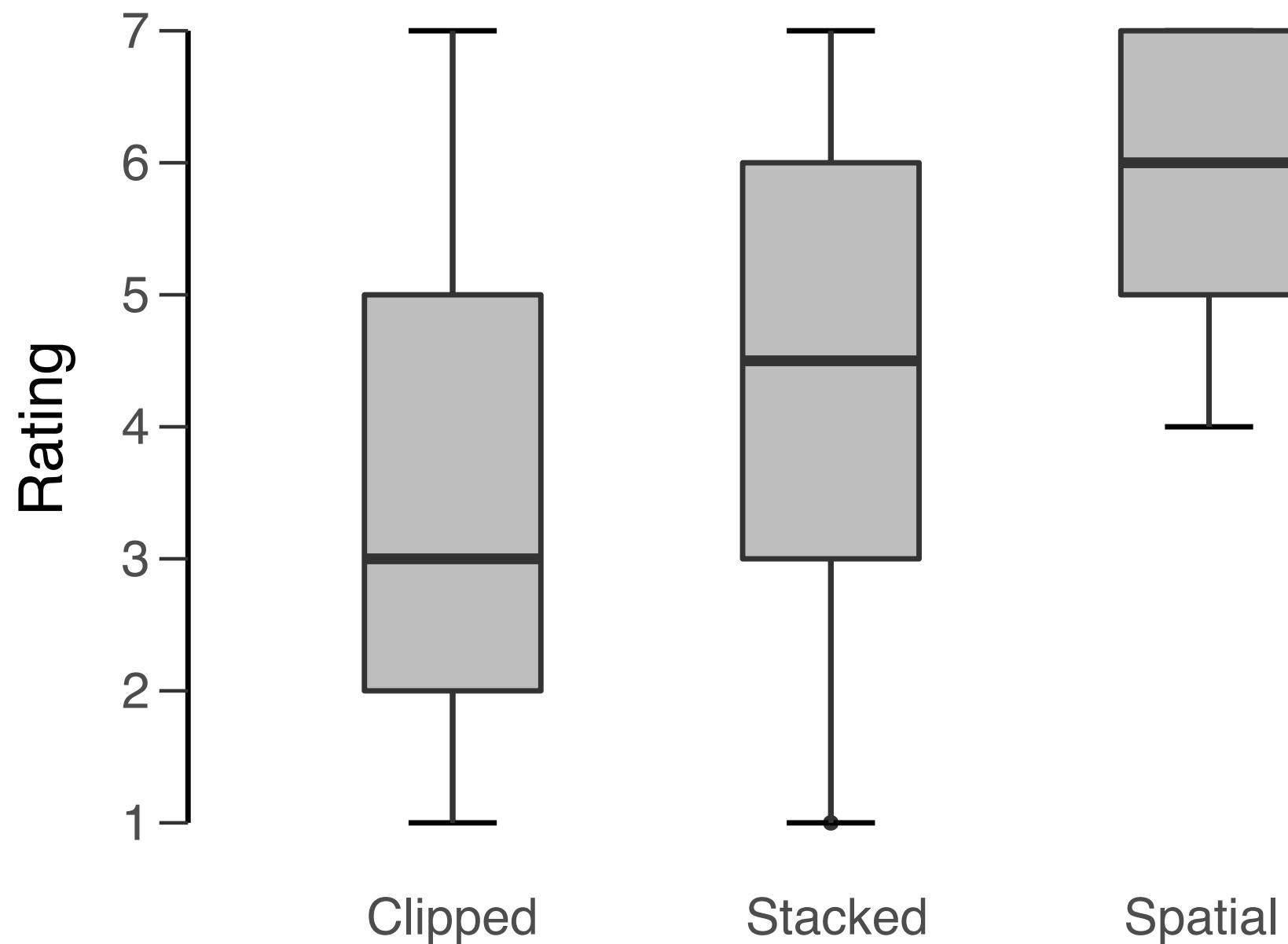
1	2	3	4	5	6	7
---	---	---	---	---	---	---

One-way ANOVA ($\alpha=.05$)

Clipped vs. Stacked ✓

Mean Difference: .9

SE: .34, p: .025



"Color helps find icons easily (even if you don't remember the location)"

"Clipped gives no indication where in the list I am"

"In the colored clipped ones, I searched more using my memory compared to the colored stacked ones. There I looked more for color rather than using my memory."

Other considerations

Some participants reported spatial being slower and laggier than clipped when scrolling

Some participants experienced problems with clicking items while scrolling (clipped and stacked)

Summary of results

Spatial and colored conditions performed best and were preferred by participants.

Clipped and stacked performed similarly, but **stacked was preferred** by participants.

Implications

It's easier and more efficient for people to **look around rather than interact** to search for items.

This is true even when there is a lot of information, displayed on a large physical surface.

Implications

Linear lists are less efficient for random-access scanning than two-dimensional grids.

Hiding elements when they are out of view **doesn't impact performance**, but people don't like it.

Limitations and Future Work

WebVR performance problems

More sophisticated implementation of stacked

Pagination

Linear lists with no spatial model

Conclusion

VR enables new ways to navigate information

Spatially arranging information can lead to better performance

Avoid interaction for navigation

Spatial layouts are more pleasant even if not more efficient

Thanks!