

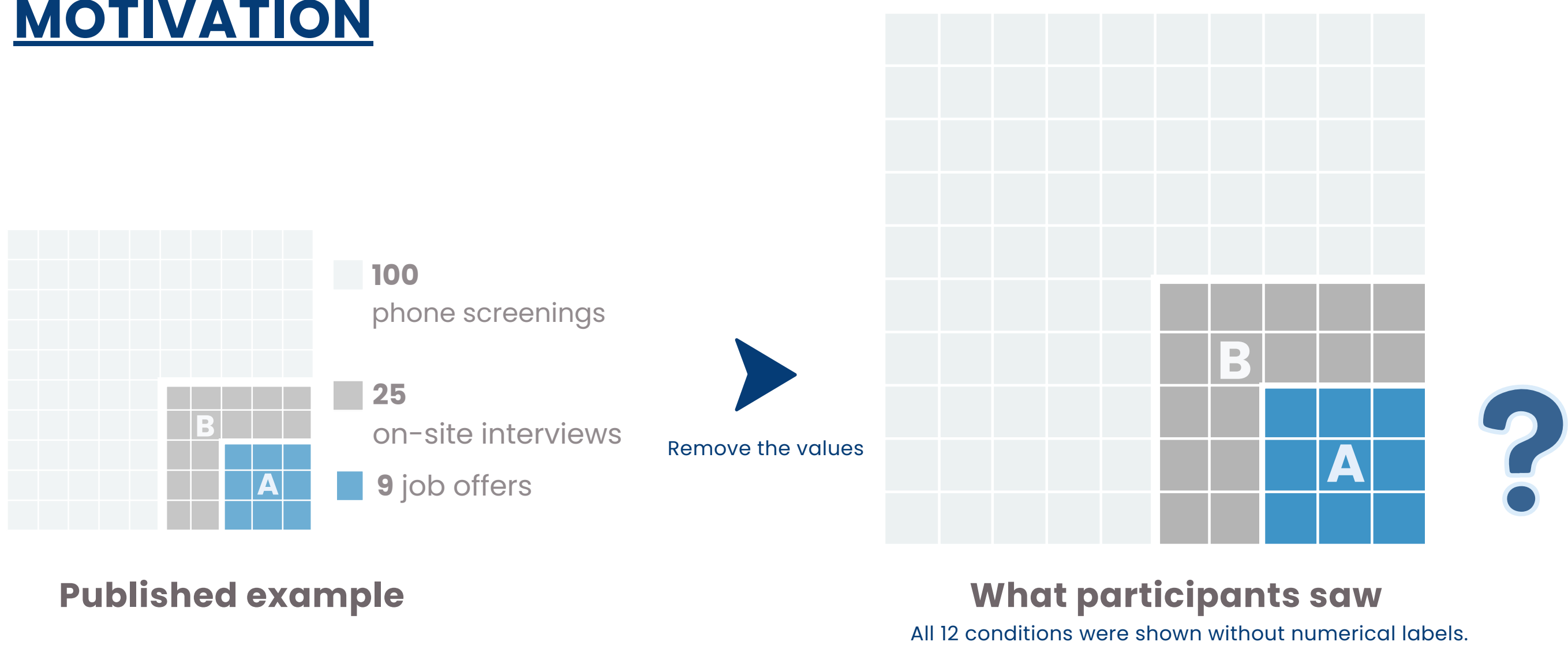
The Effect of Visual Mark Arrangement on Value Estimation Accuracy in Waffle Charts

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Data grouping affected estimation accuracy more than visual mark arrangement or color ordering.
The smaller contained value was estimated more accurately than the larger containing value.

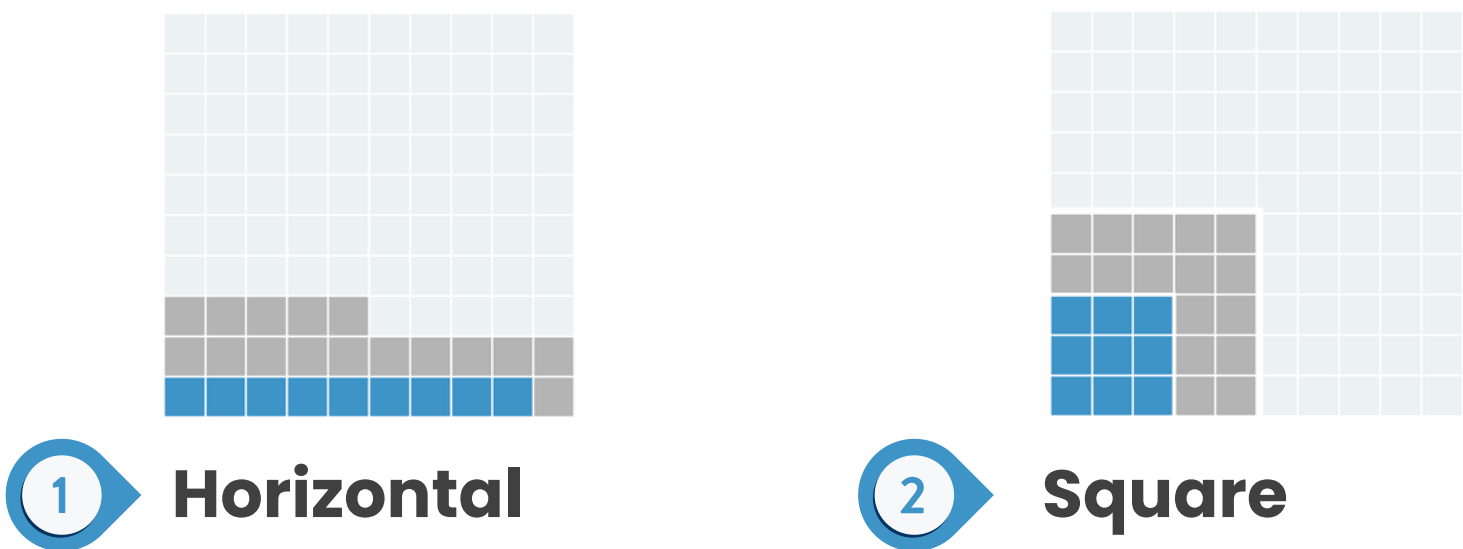
MOTIVATION



Can viewers estimate both nested quantities without numerical labels – and does the arrangement of filled cells make it easier?

RESEARCH FOCUS

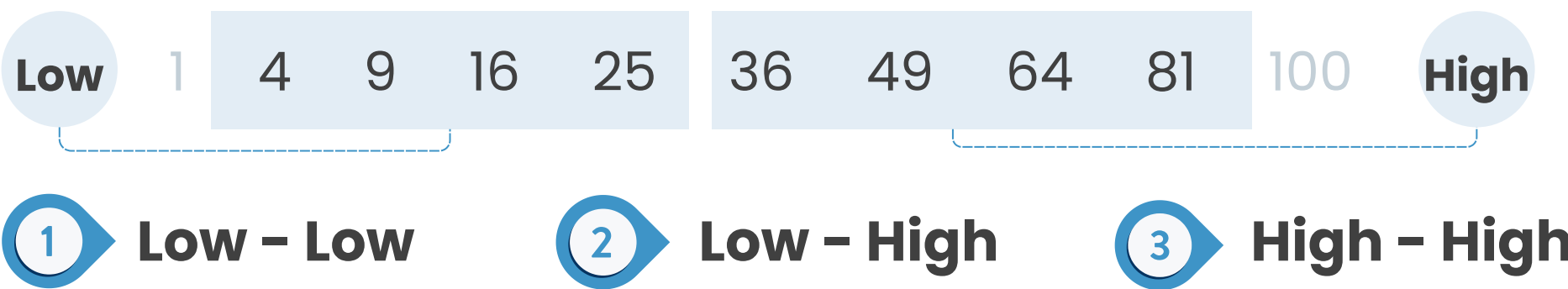
01 Visual Mark Arrangement



02 Color Ordering



03 Data Grouping



STUDY DESIGN

Visual mark Arrangement	Light-to-dark			Dark-to-light		
	Low-low	Low-high	High-high	Low-low	Low-high	High-high
Horizontal	1	2	3	4	5	6
Square	7	8	9	10	11	12

73
Participants

12
Conditions

10 x 10

±10%

- Latin Square counterbalancing
- Response categories:
CC (correct-correct) **CN** (A correct, B not)
NC (A not, B correct) **NN** (neither correct)
- Mixed-effects multinomial logistic regression
- Generalized estimating equations as a robustness check

Study configuration & stimuli:
github.com/Dheerissara/Study/tree/main/public/waffle-chart-study

RESULTS

65%
CN
A Correct, B not

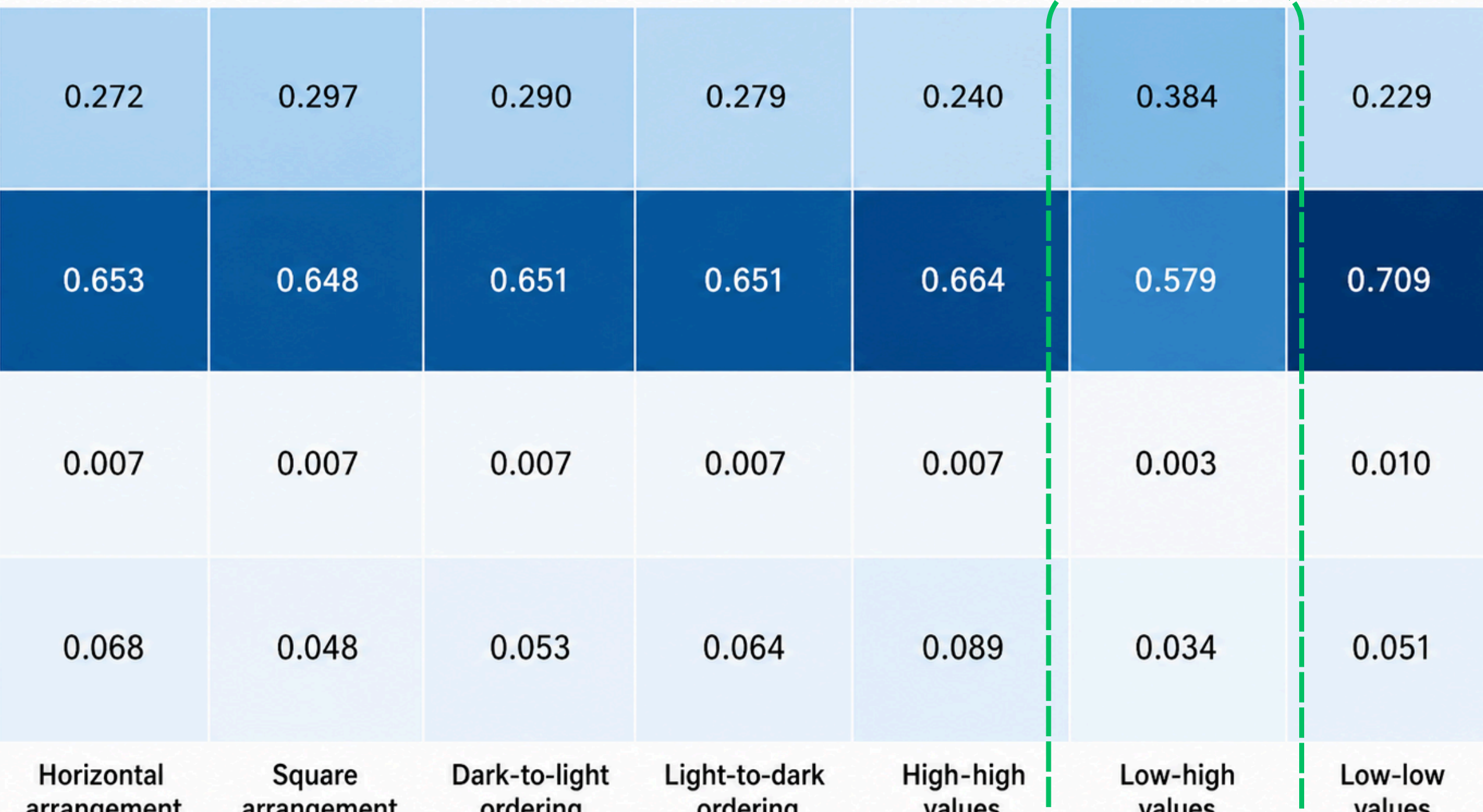
28%
CC
Both correct

OR = 0.25
p < .001
(Low-high vs high-high)

OR = 0.09
p < .001
(Low-high vs high-high)

95% CI
[0.14, 0.44]

95% CI
[0.03, 0.24]

Joint Accuracy by Experimental Factor							
Joint Accuracy Categories							
	Horizontal arrangement	Square arrangement	Dark-to-light ordering	Light-to-dark ordering	High-high values	Low-high values	
	Low-low values	Low-high values	High-high values	Low-low values	Low-high values	High-high values	
	CC	0.272	0.297	0.290	0.279	0.240	0.384
	CN	0.653	0.648	0.651	0.651	0.664	0.579
NC	0.007	0.007	0.007	0.007	0.007	0.003	
NN	0.068	0.048	0.053	0.064	0.089	0.034	
Condition Summaries							

Statistical Significance (α = .05)		
	Visual Mark Arrangement	Not significant (all p ≥ .07)
	Color Ordering	Not significant (all p ≥ .27)
	Data Grouping	Significant (p < .001)

Data grouping had a significant effect on estimation accuracy. Arrangement and color ordering did not.

CONCLUSION

- Visual mark arrangement and color ordering did not significantly affect estimation accuracy under the tested conditions.
- Data grouping was the only significant factor; participants estimated both values more accurately when the quantities differed substantially.
- The smaller contained value was estimated more accurately than the larger containing value.
- Numerical labels are recommended when precise estimation of both values is required, especially when the two quantities are similar.



LIMITATIONS

- All stimulus values were perfect squares, which lets the square arrangement be read by counting one side.
- Accuracy was scored as a binary ±10% outcome, which treats small and large deviations alike and is stricter for low values than for high ones.
- Only 12 trials per participant, with no practice or attention-check trials.
- Participants were recruited through convenience and snowball sampling; screen size, resolution, and demographics were not recorded.
- Estimation accuracy only – no comparison or overview tasks, response time, or viewing strategies.



FUTURE WORK

- Generalize to other unit-based representations such as icon arrays.
- Test values that are not perfect squares.
- Score accuracy as a continuous deviation from the ground truth.
- Extend to more than two nested values and other grid sizes.
- Investigate boundary cues, spacing, and annotations.
- Examine interaction and real-world tasks.