

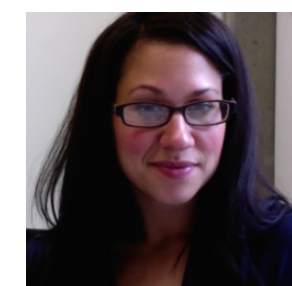
Iterated learning optimizes for simplicity

Jon W. Carr

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School of Philosophy, Psychology and Language Sciences

University of Edinburgh

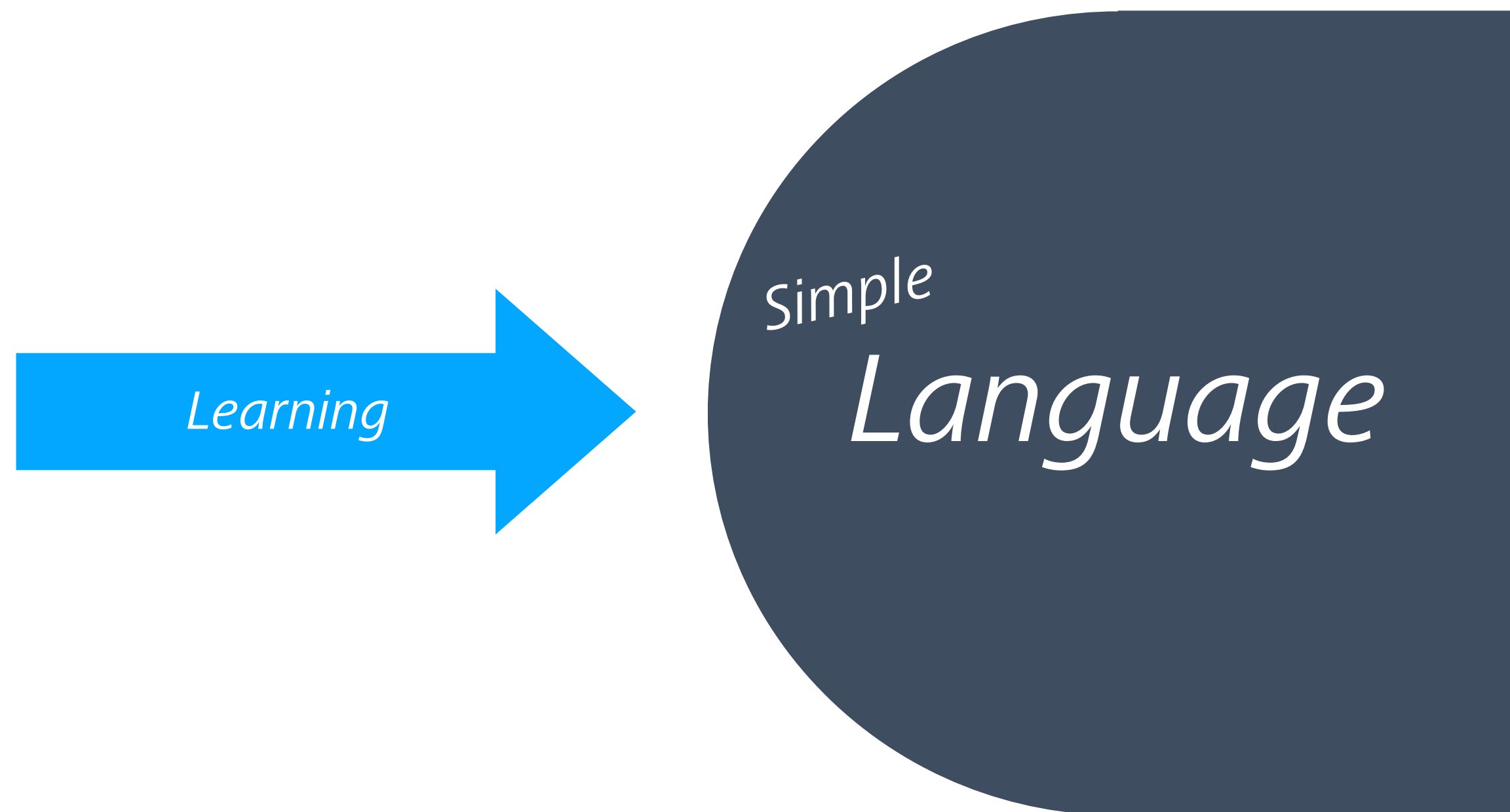


Pressures shaping language

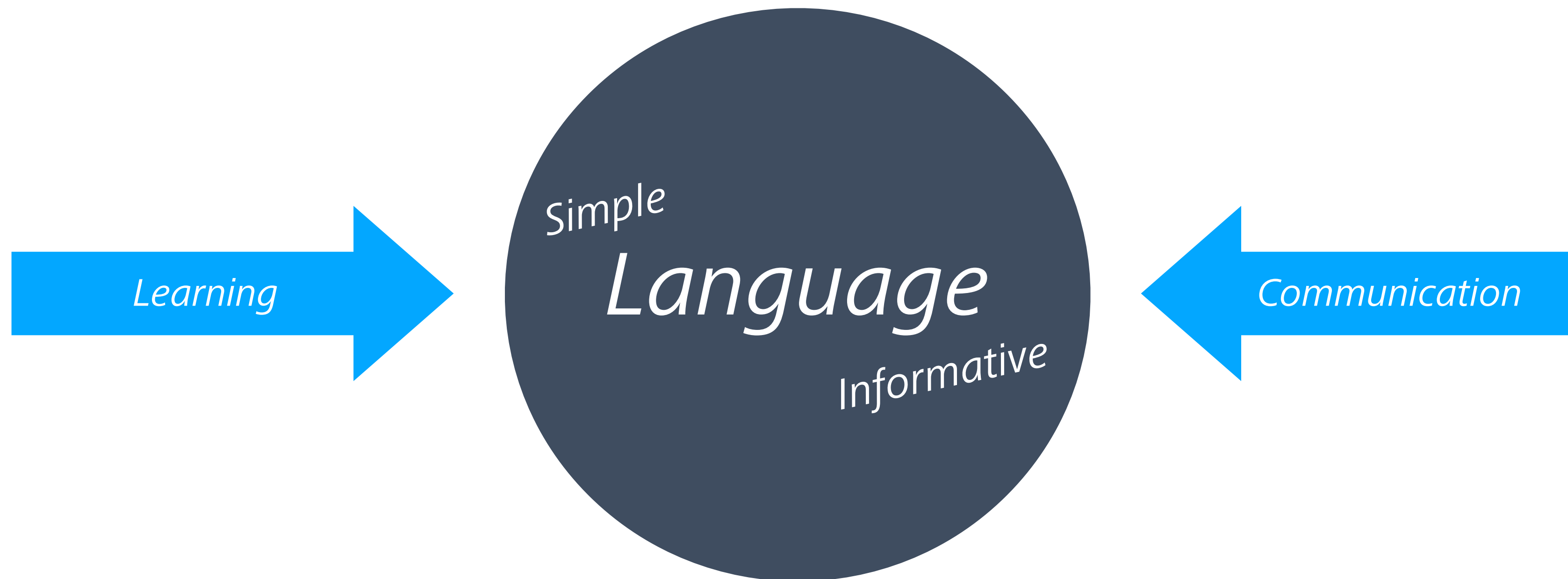


Language

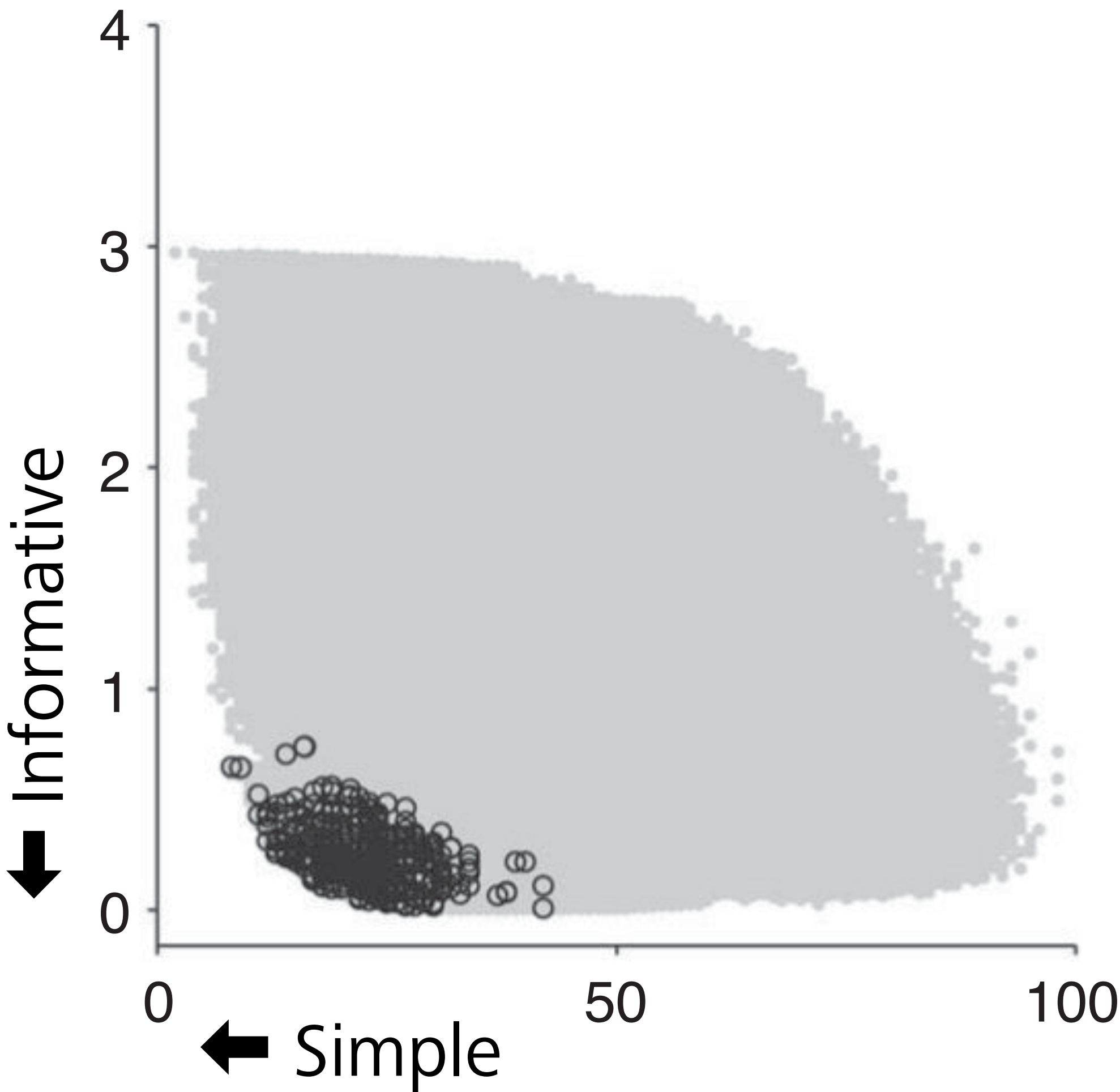
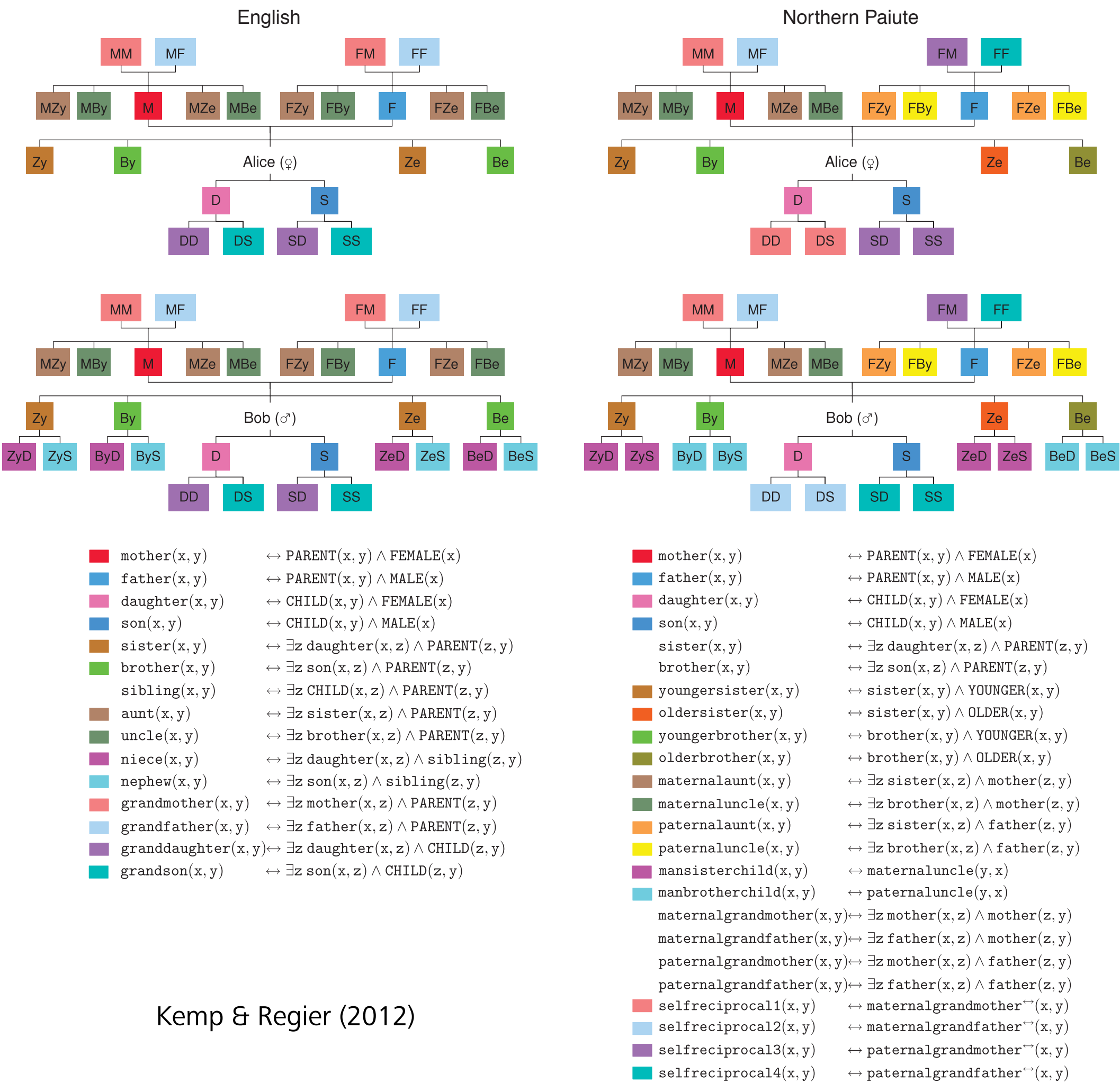
Pressures shaping language



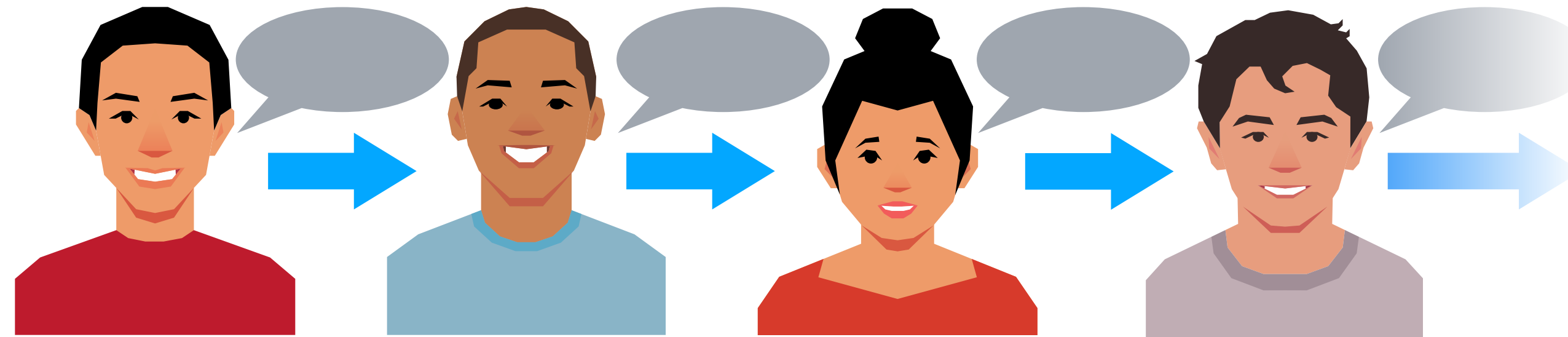
Pressures shaping language



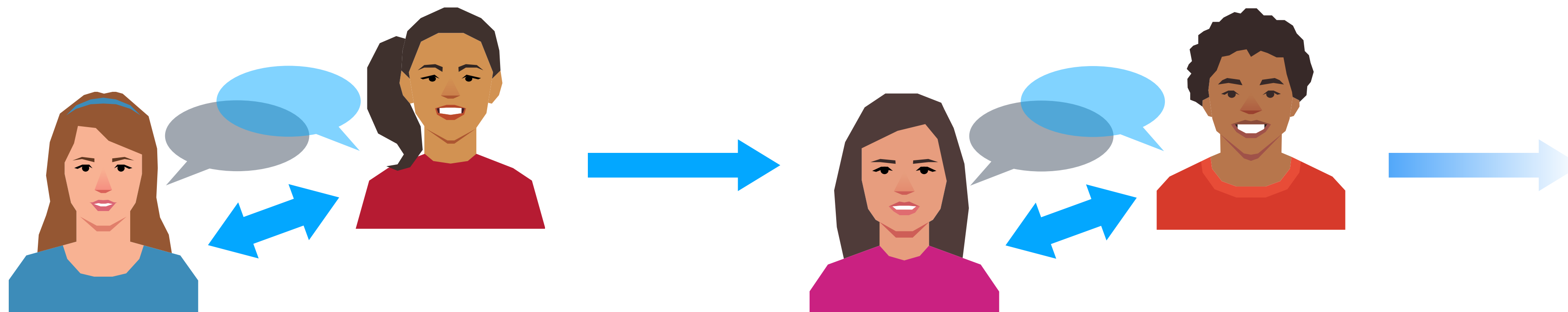
Kinship terms are simple and informative



Lab experiments

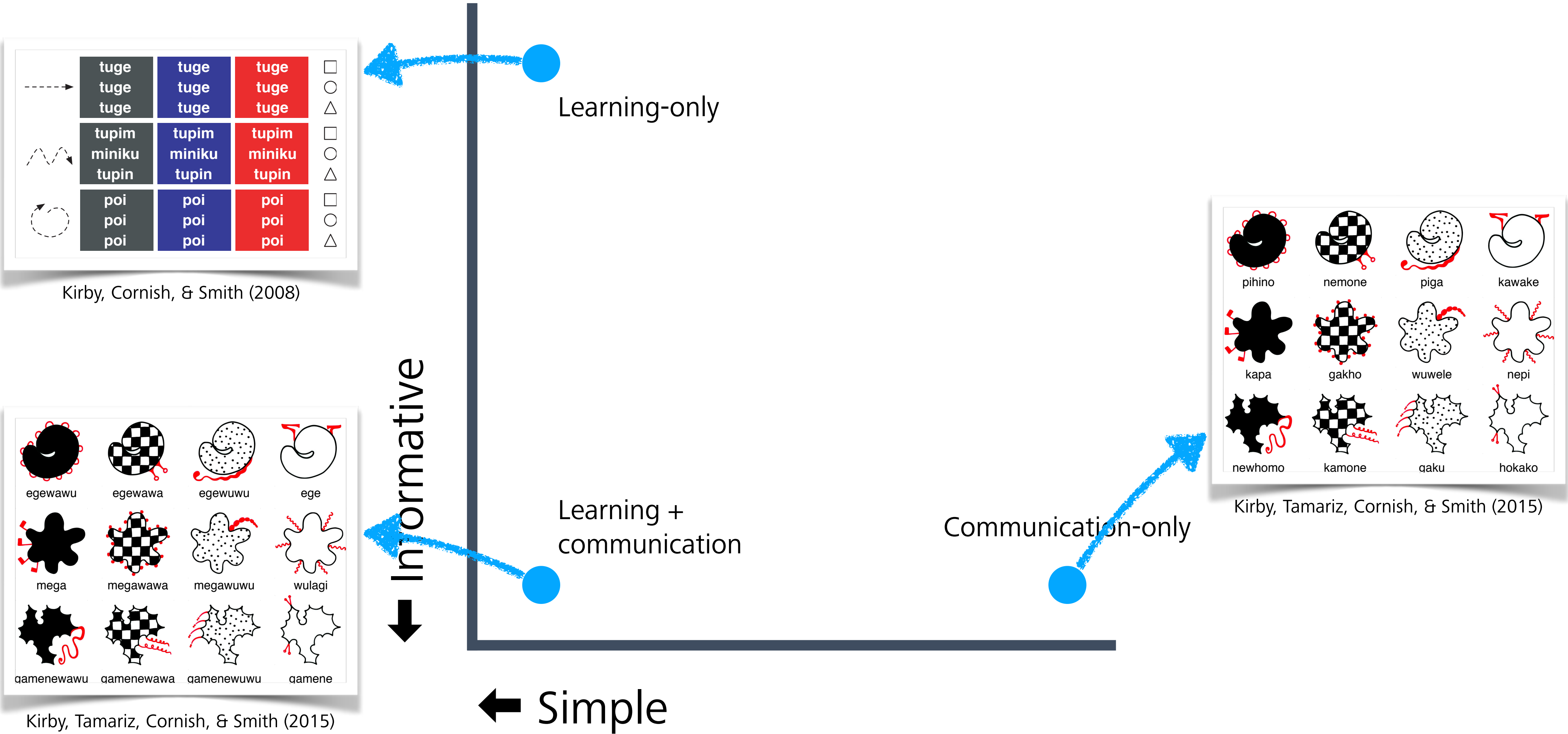


Learning-only



Learning + Communication

Learning and communication pressures

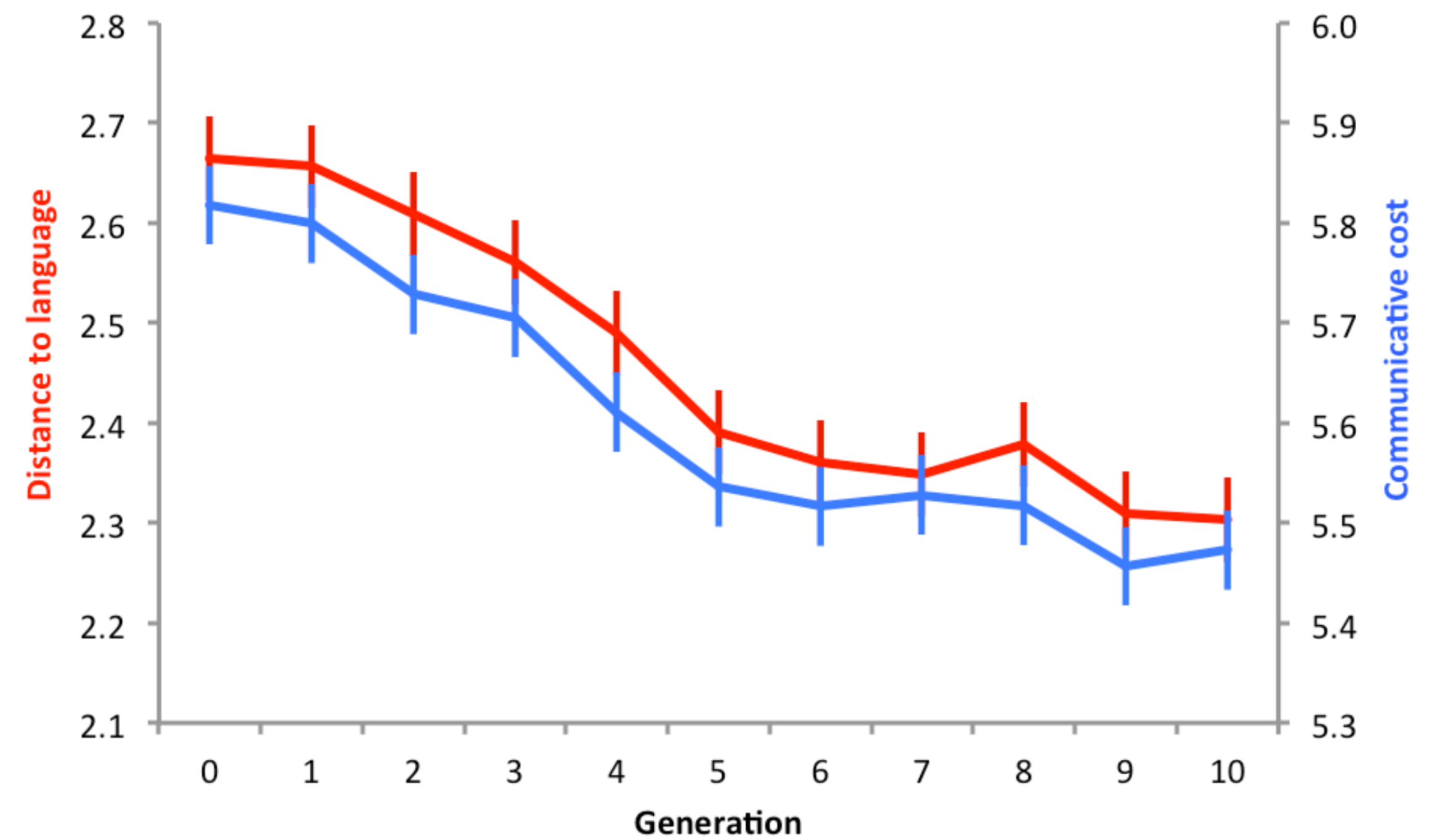
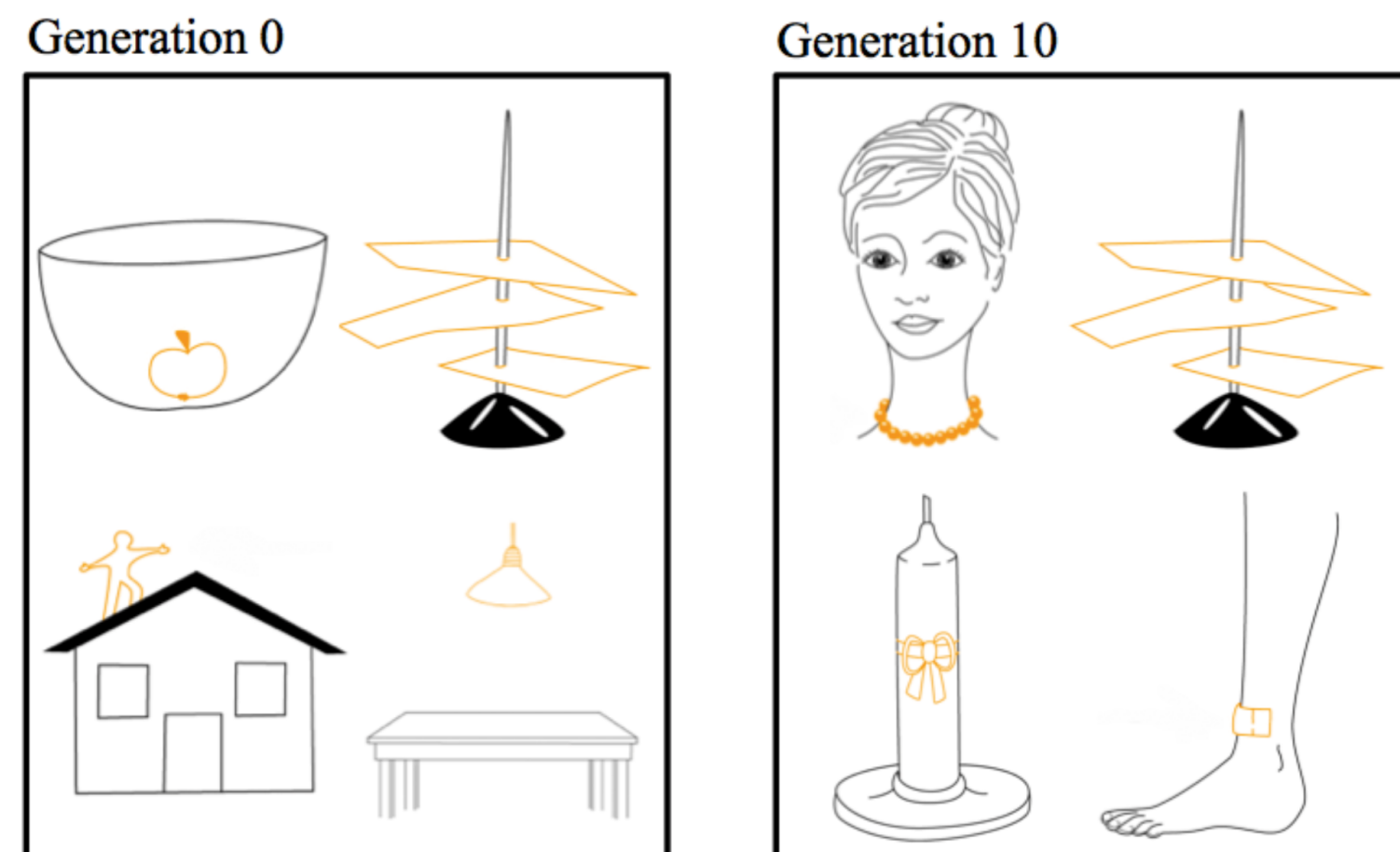
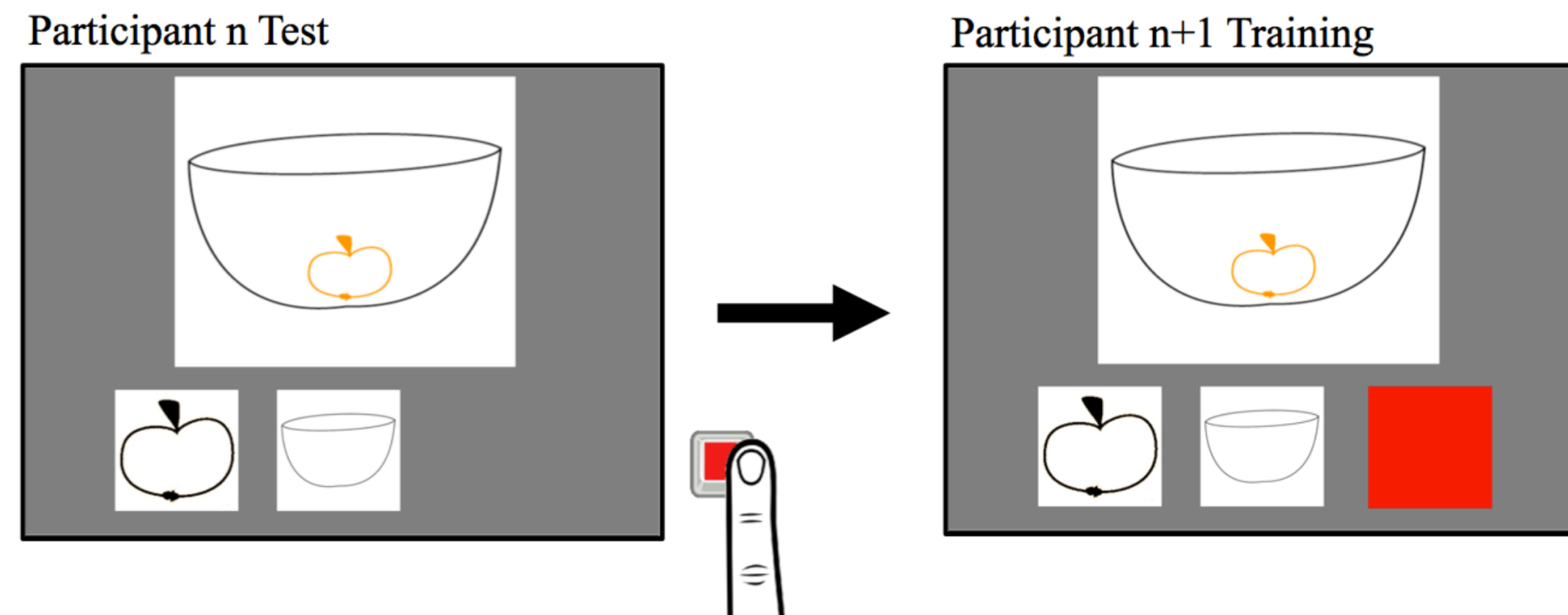


Kirby, Cornish, & Smith (2008)

Kirby, Tamariz, Cornish, & Smith (2015)

Kirby, Tamariz, Cornish, & Smith (2015)

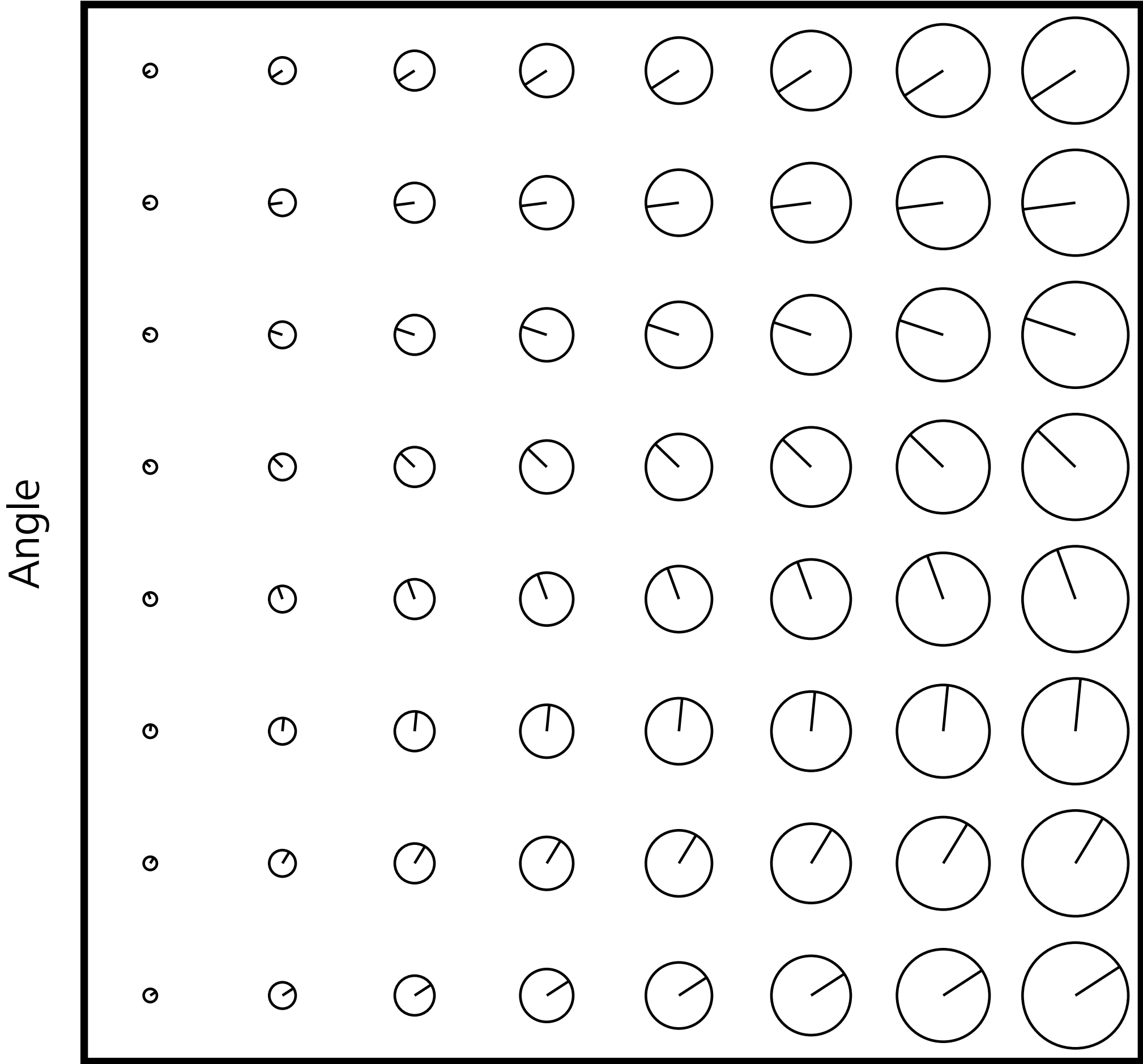
Iterated learning gives rise to informative spatial terms



Carstensen, Xu, Smith, Regier (2015)

Experiment I

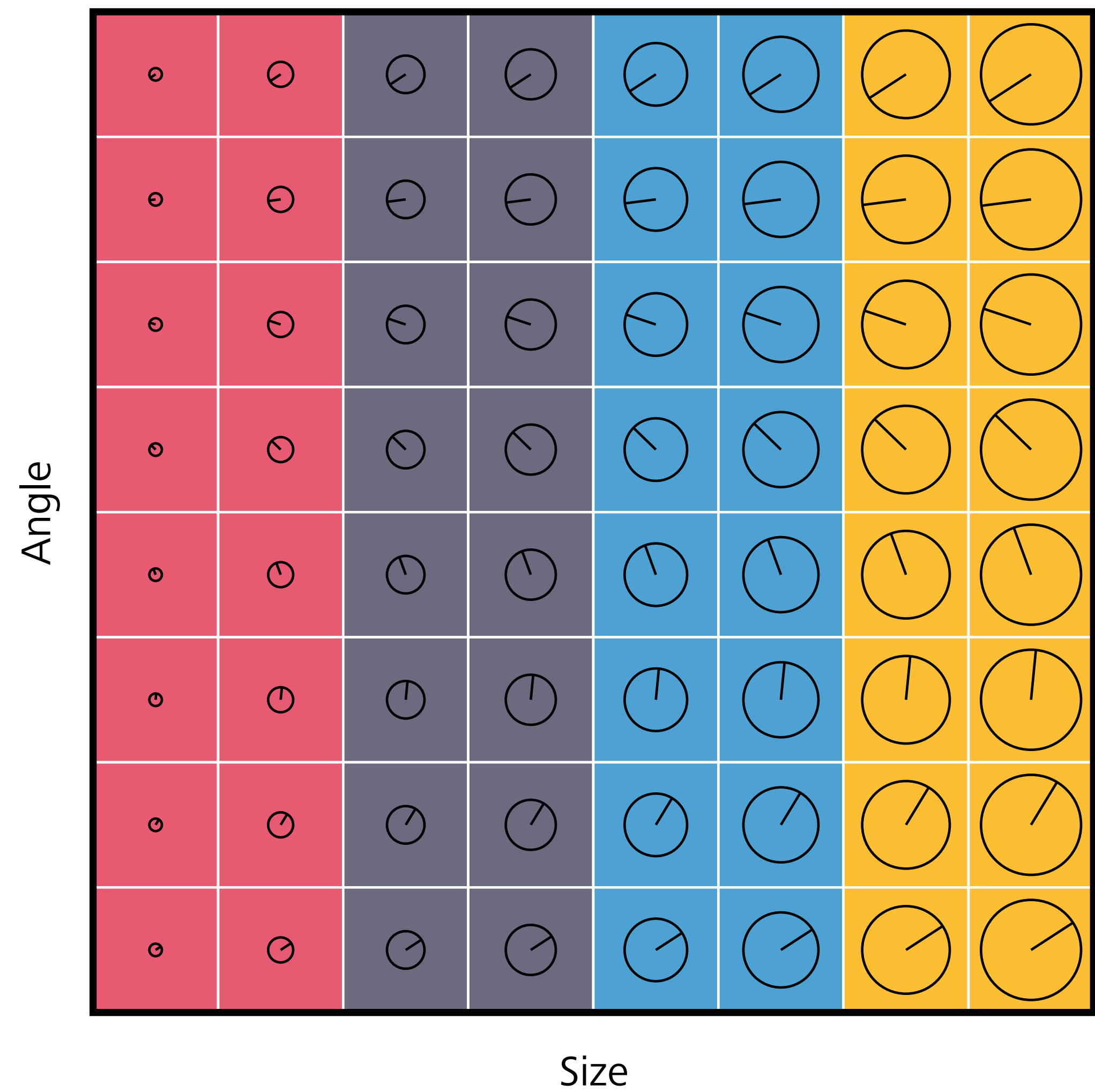
Stimuli



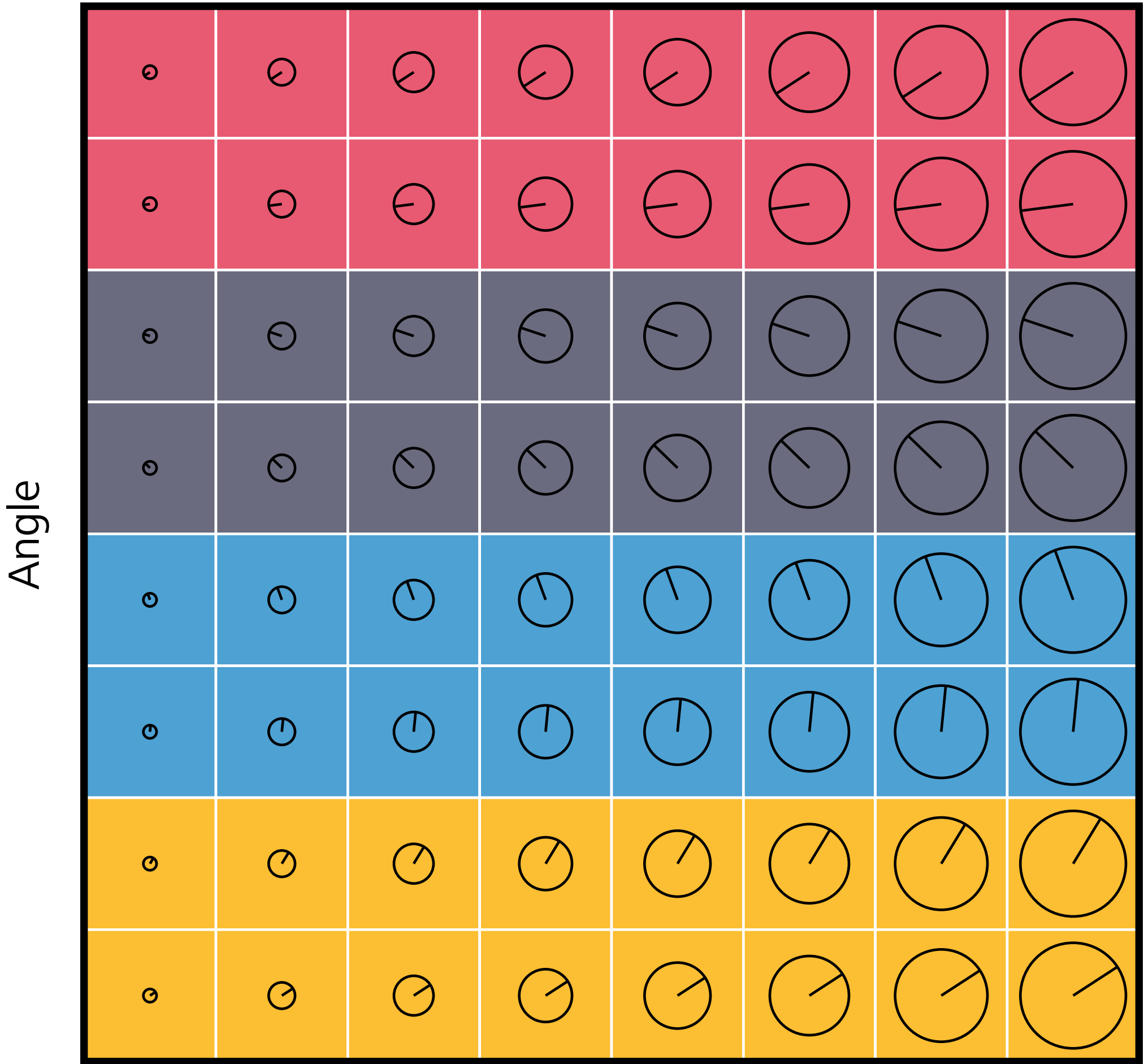
Angle

Size

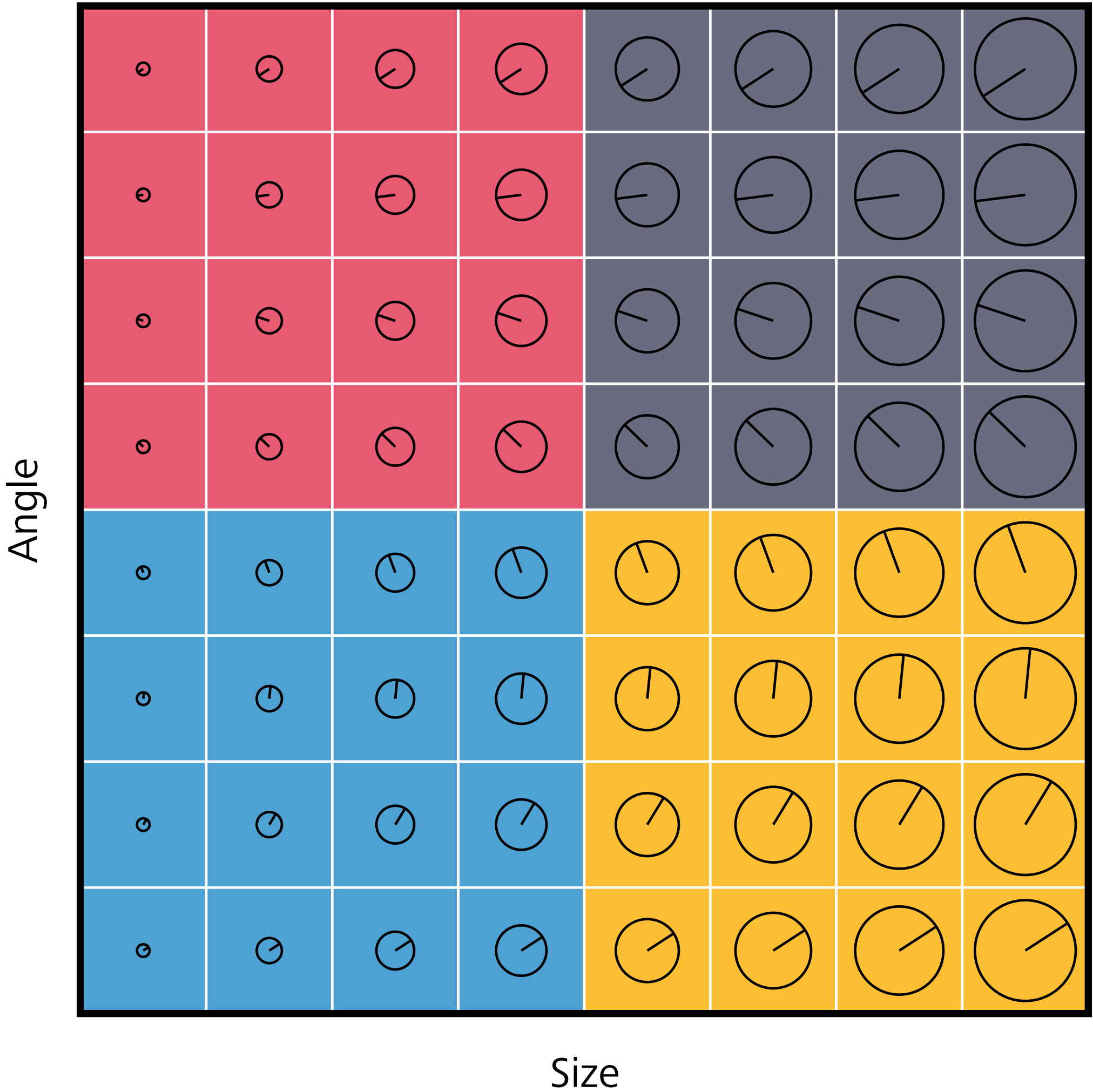
Stimuli



Stimuli

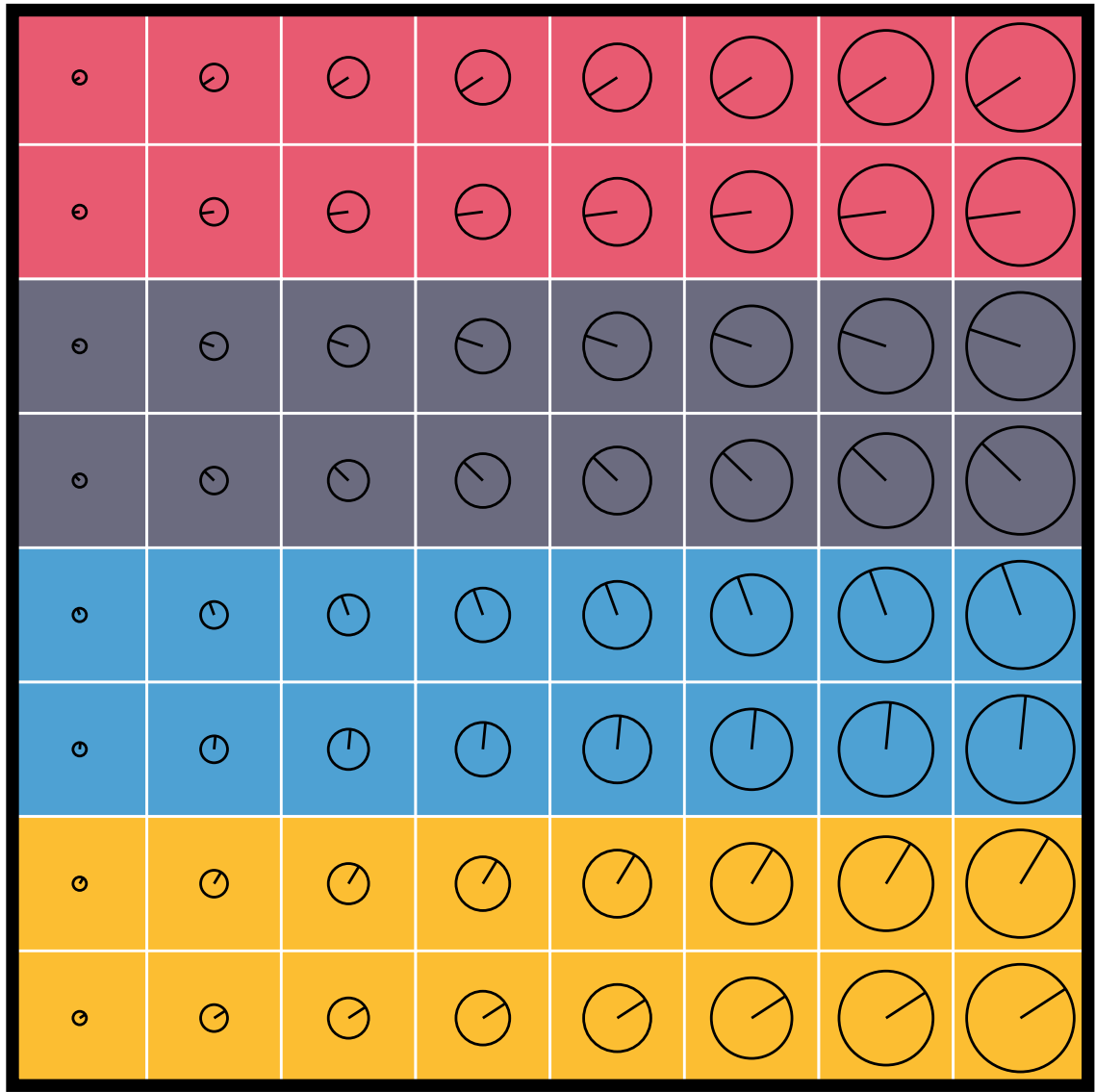


Stimuli



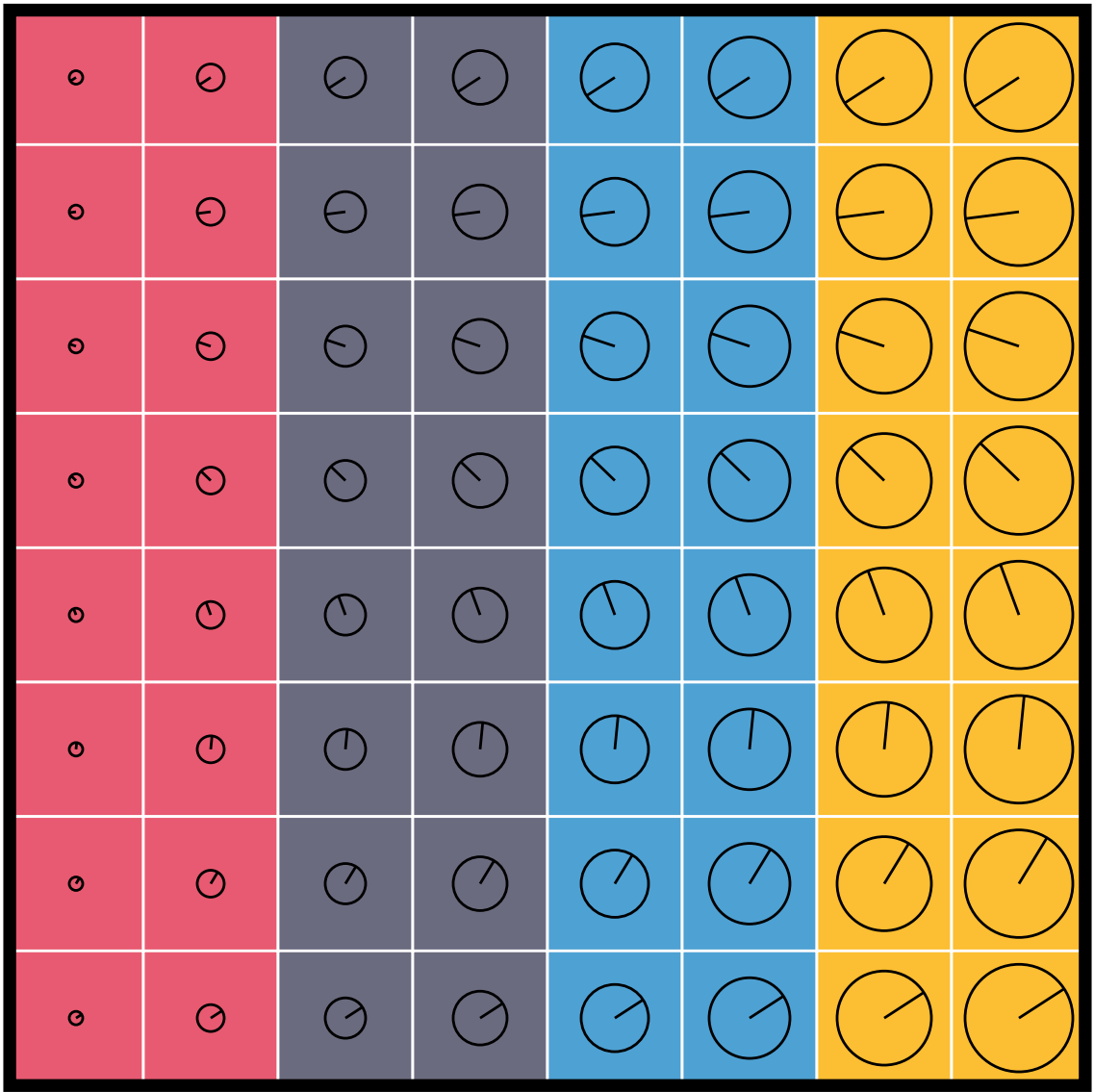
Conditions

Angle-only

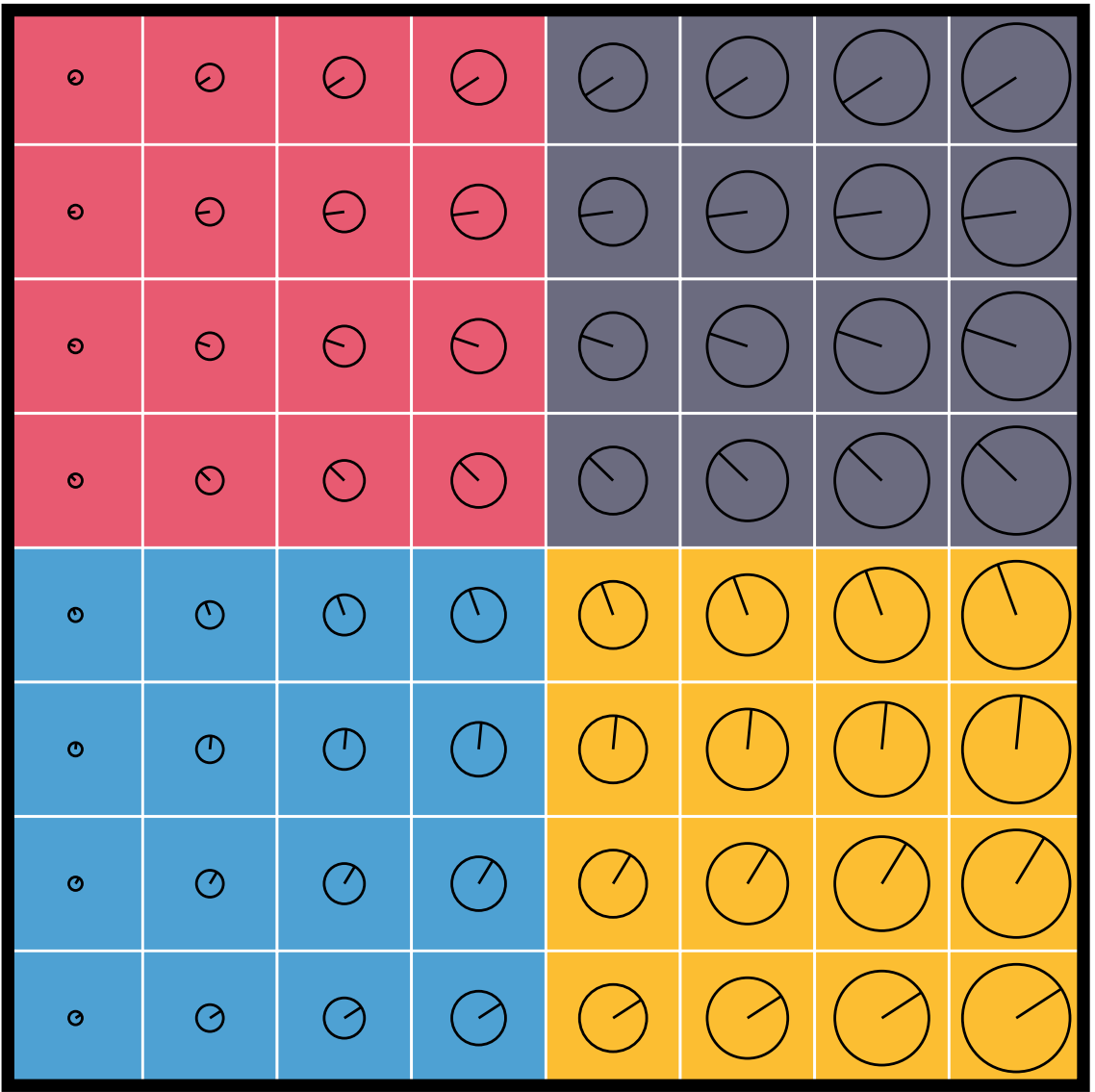


Easy to learn but low informativeness

Size-only

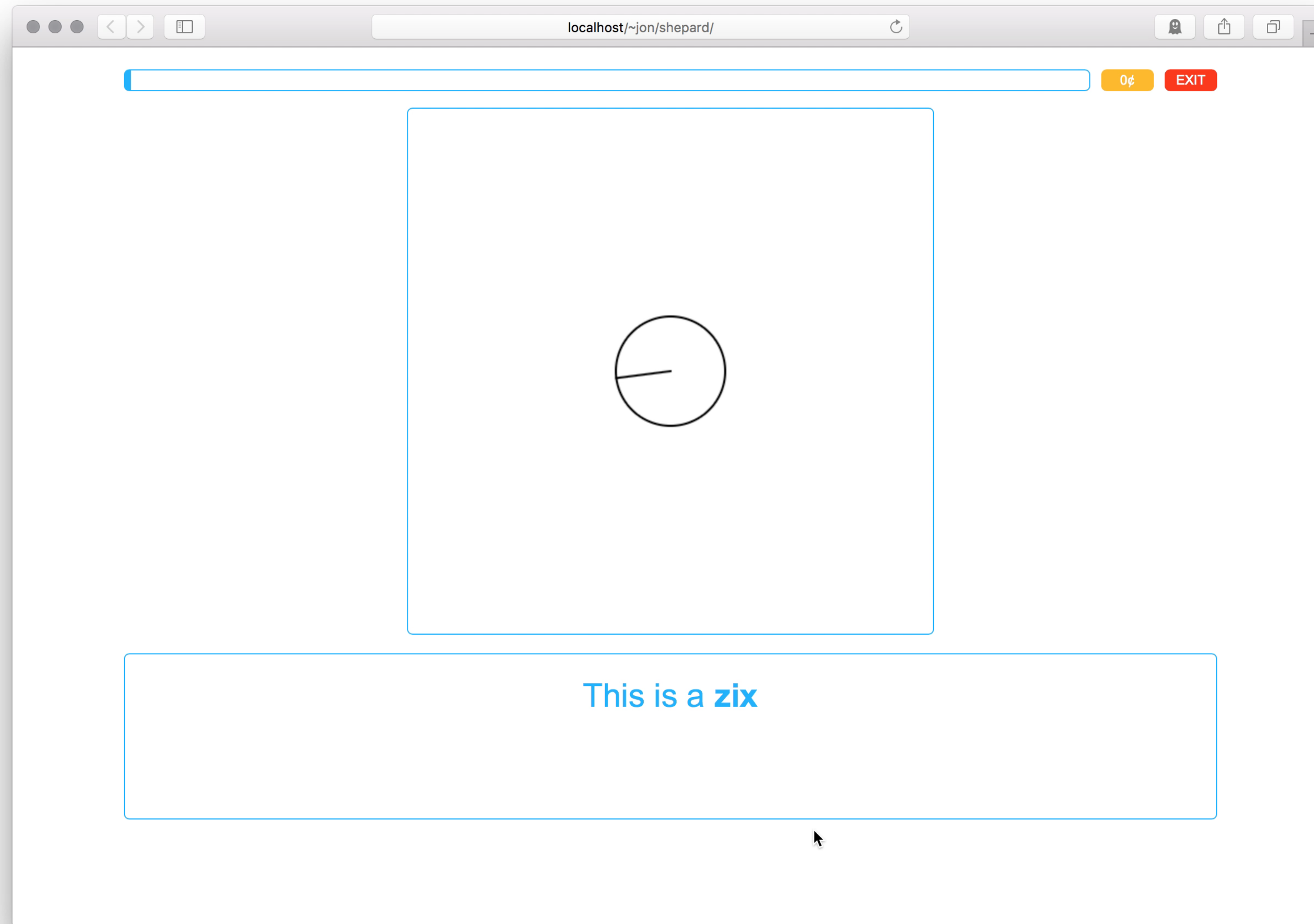


Angle & Size

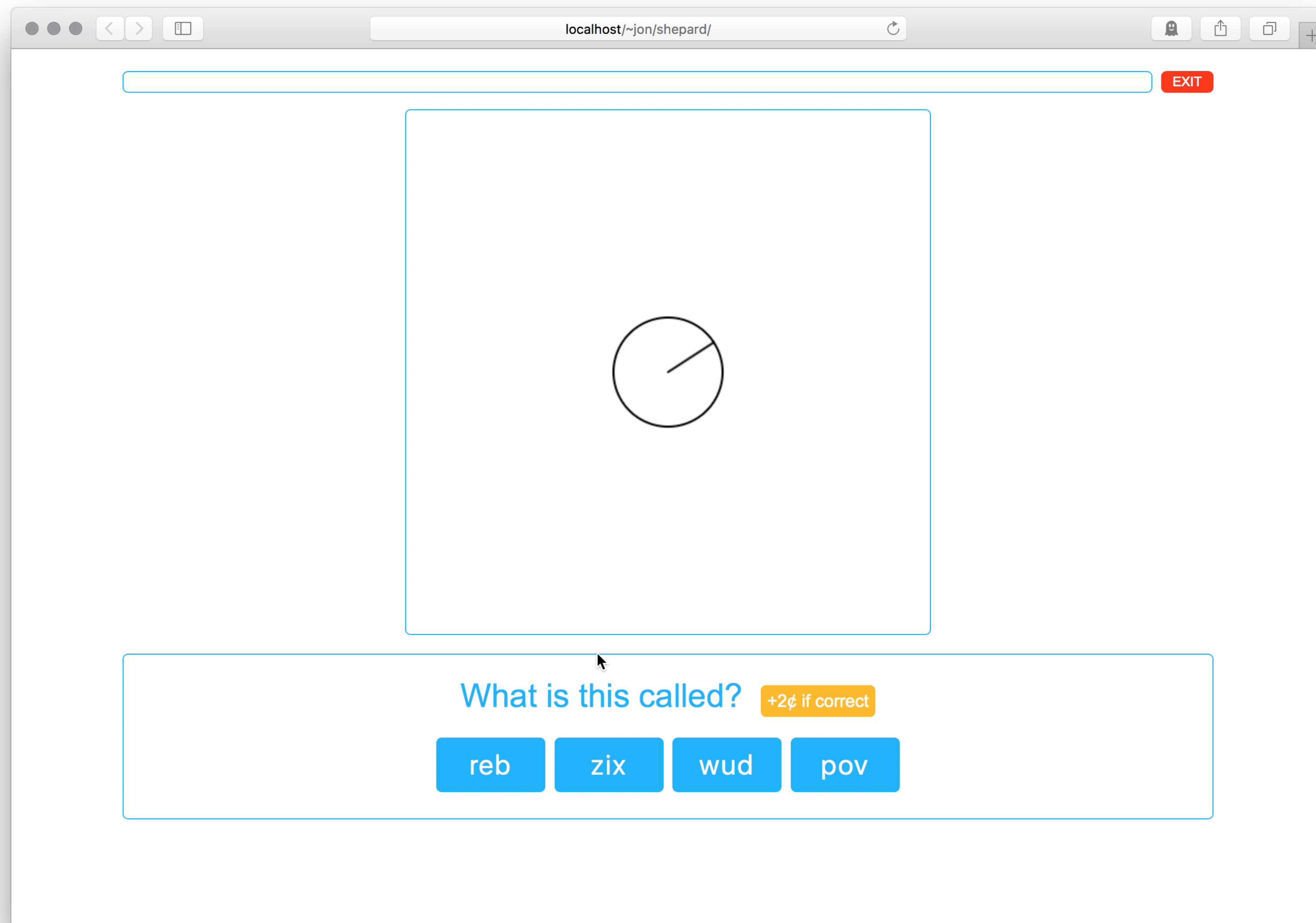


Informative but hard to learn

Training phase

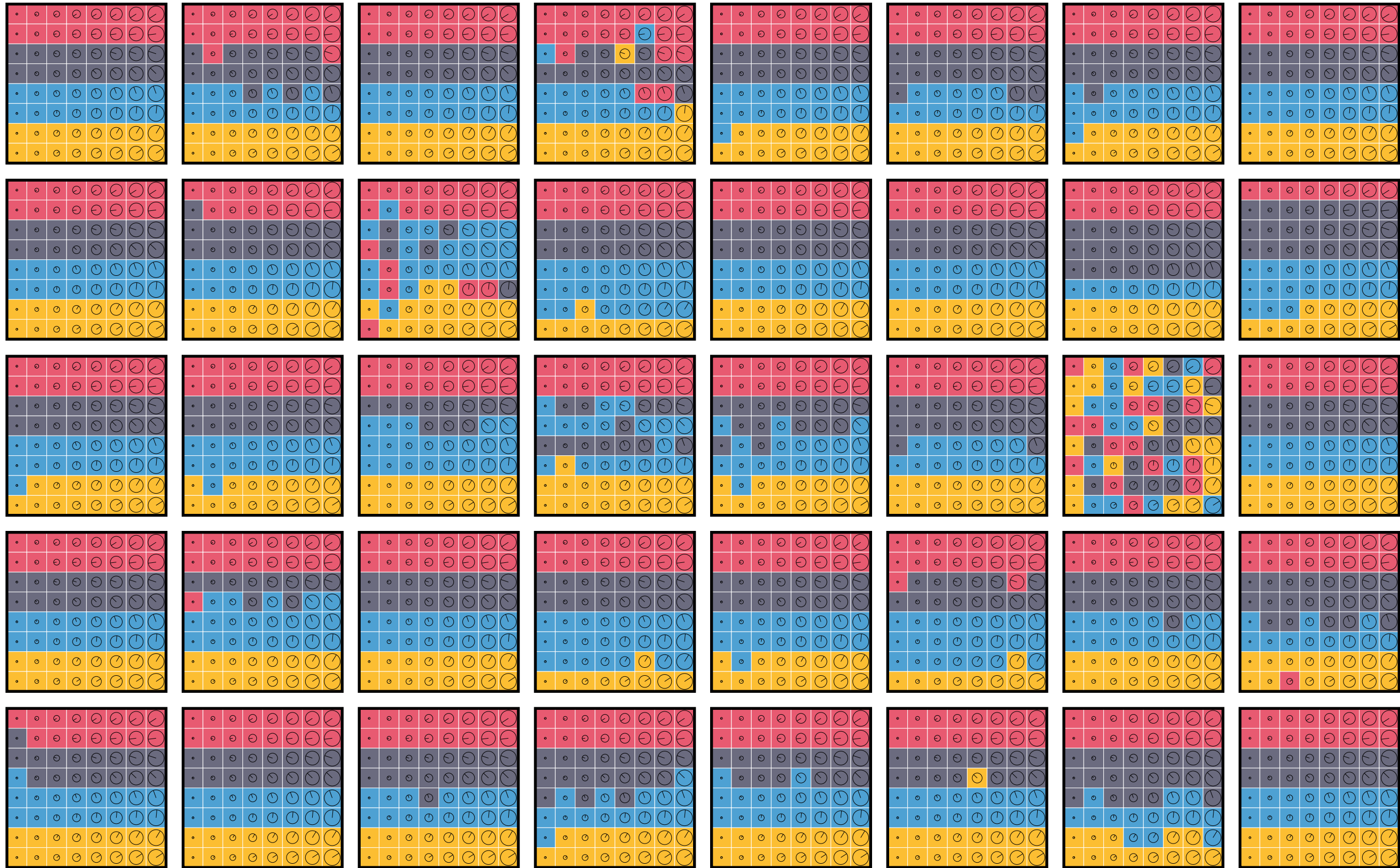
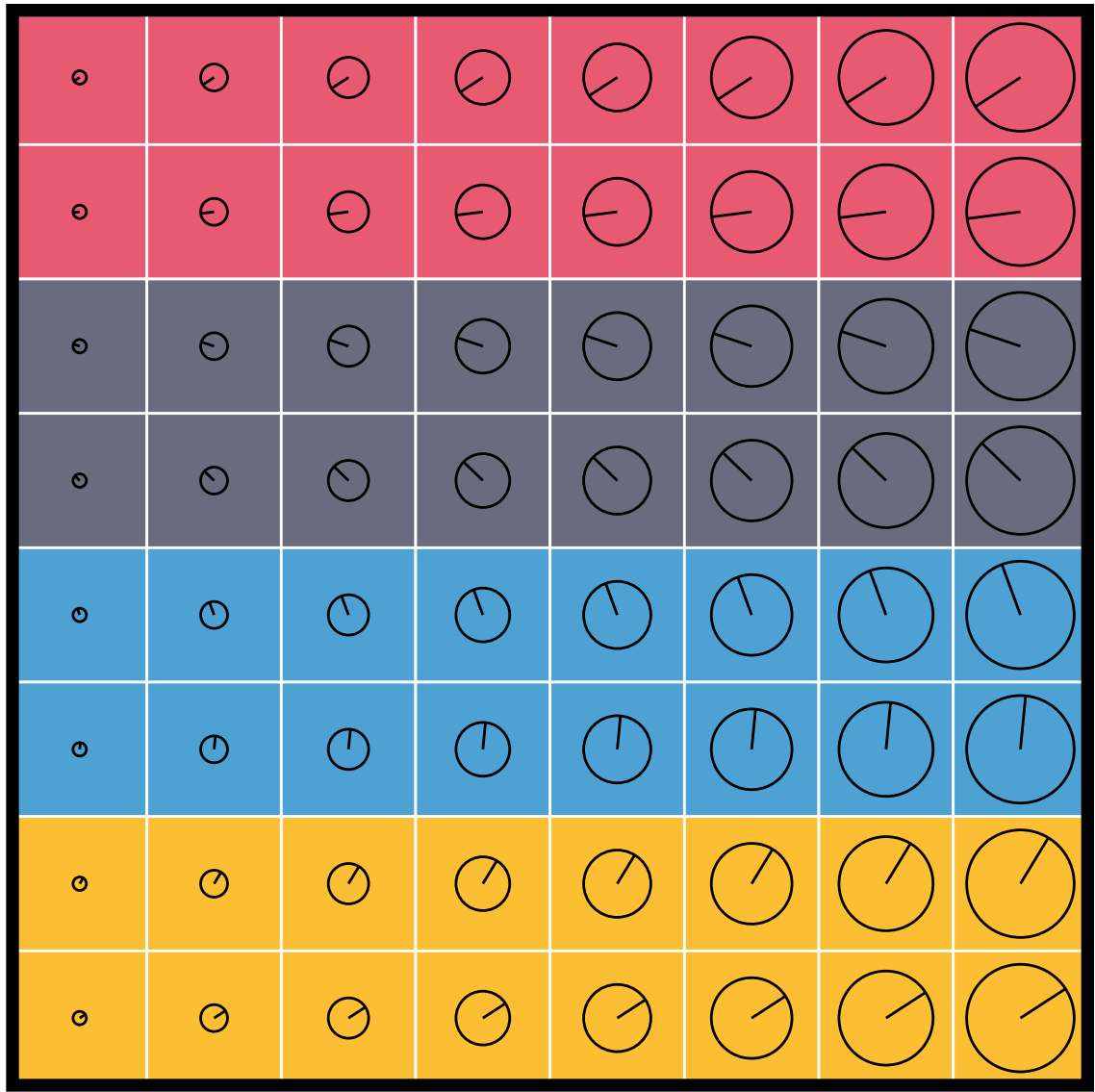


Test phase



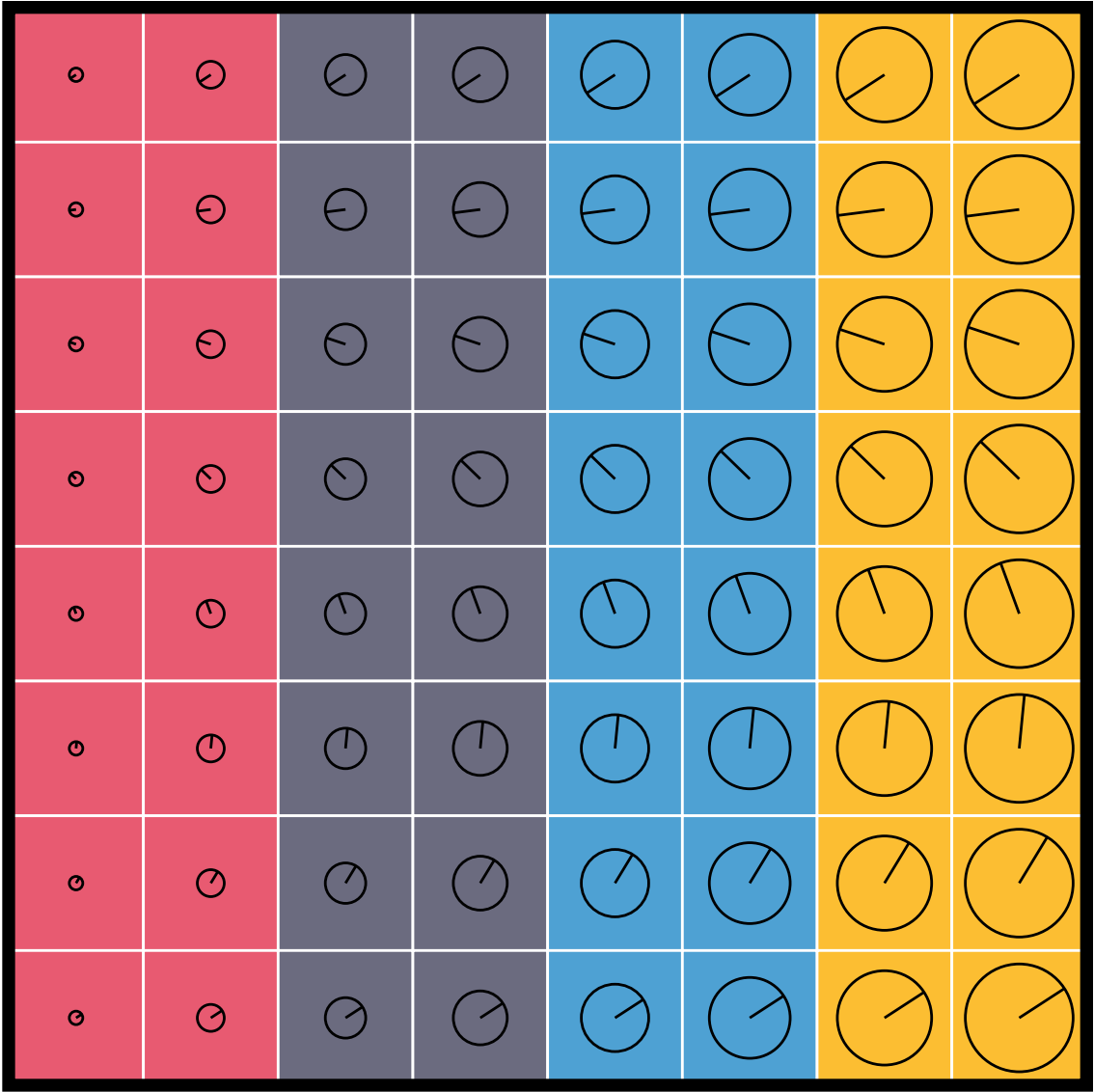
Results

Angle-only



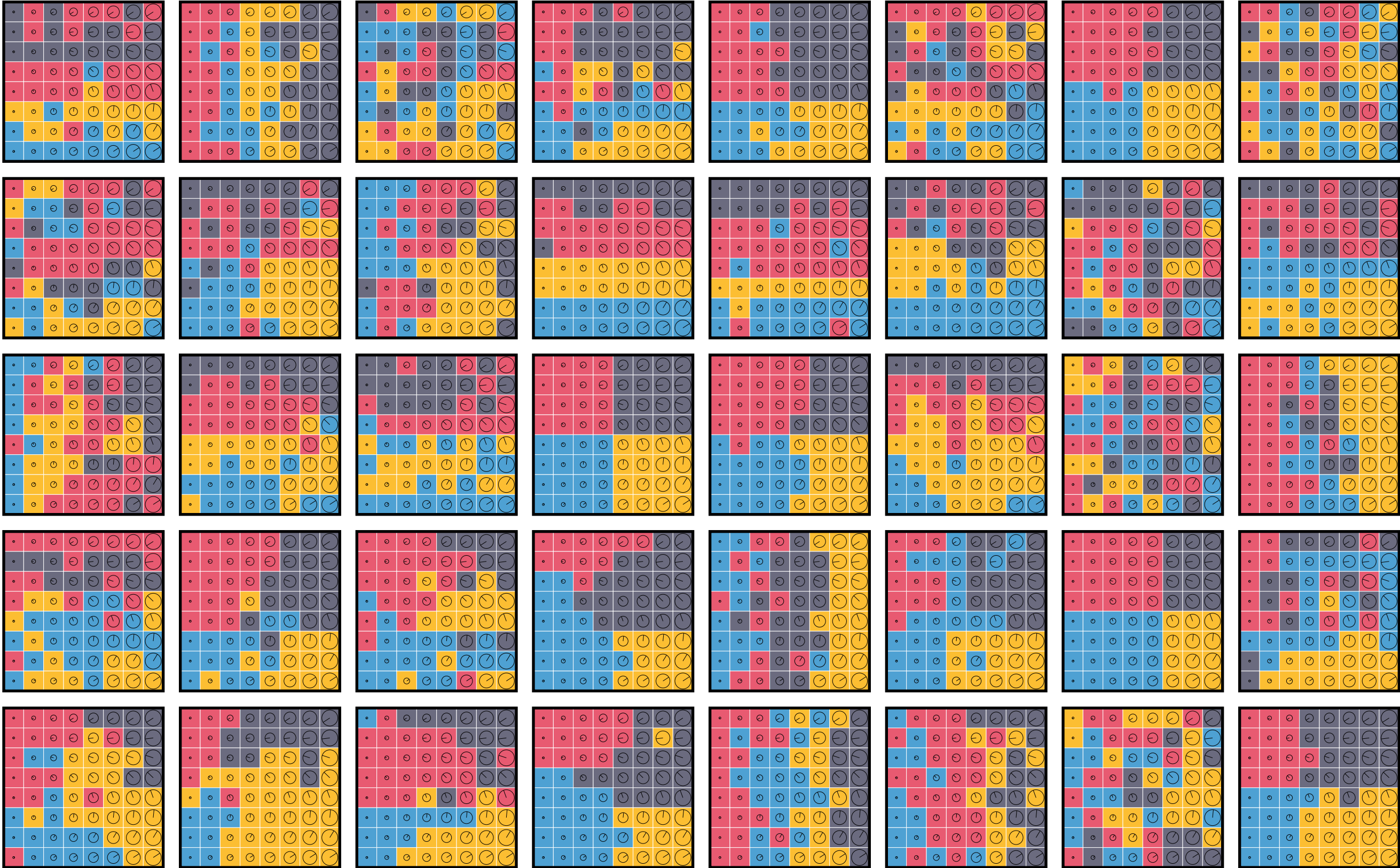
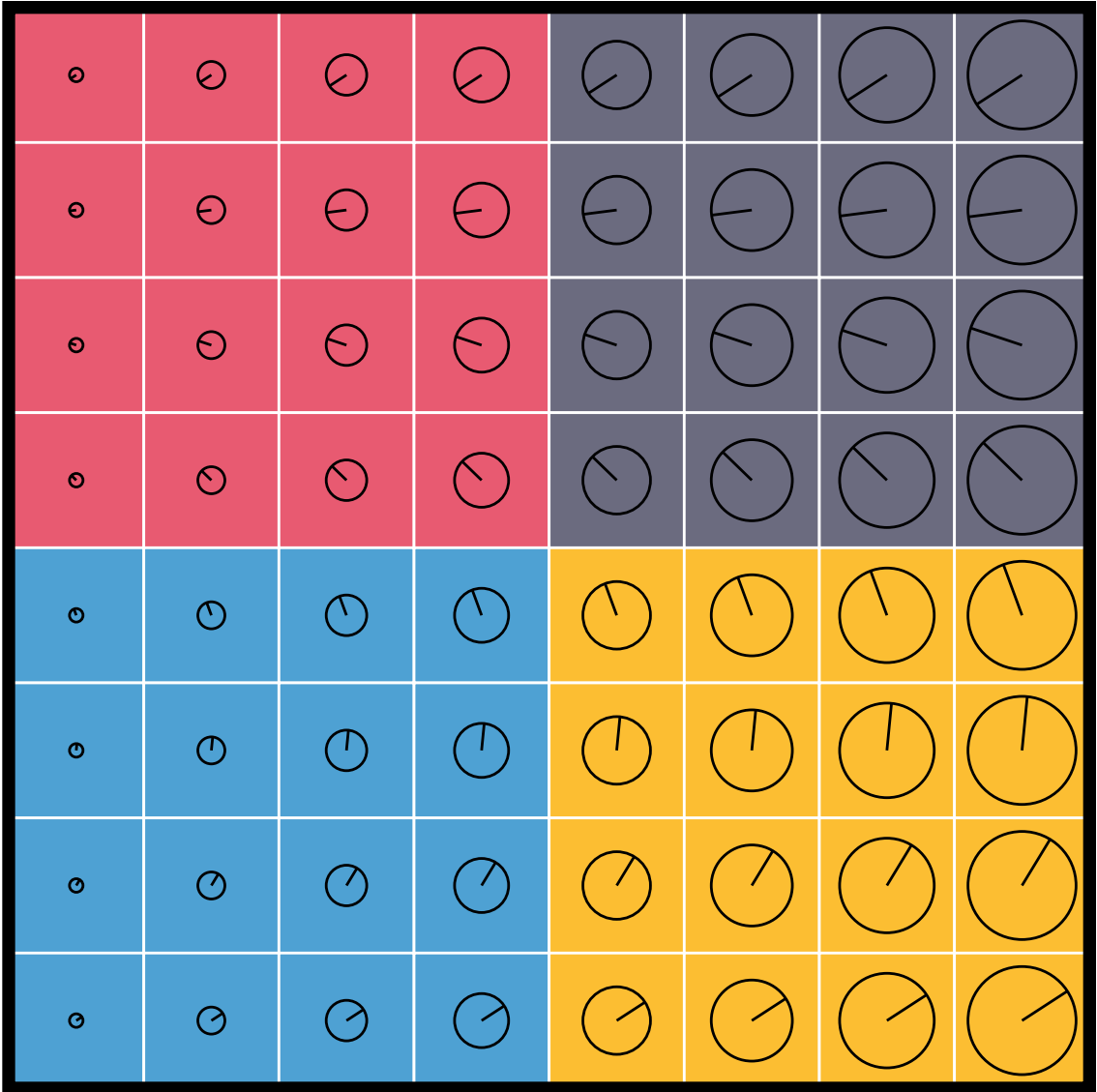
Results

Size-only

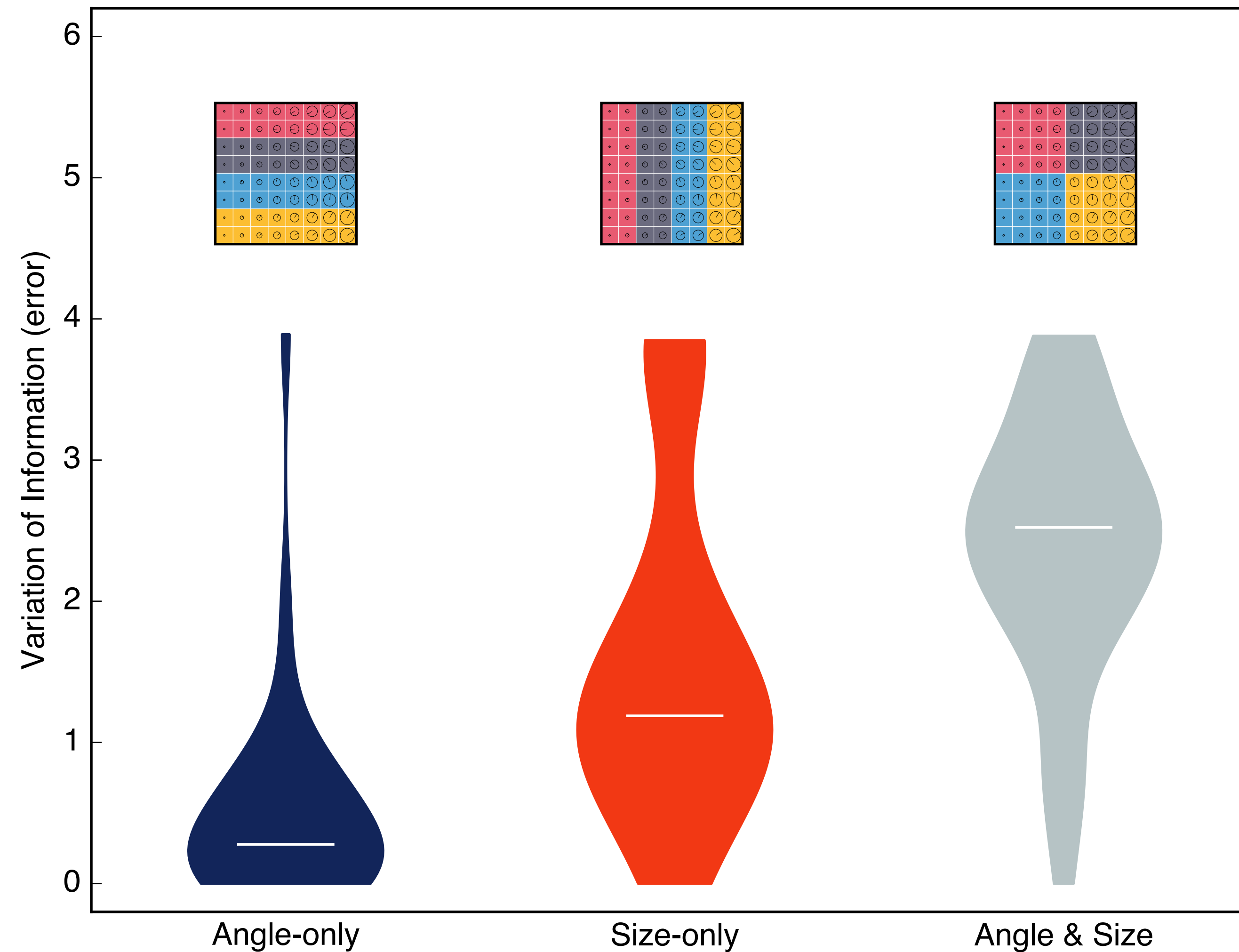


Results

Angle & Size

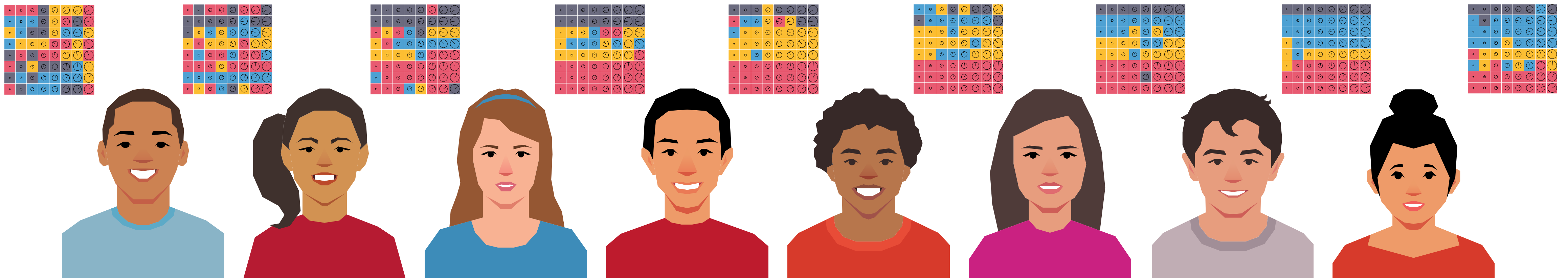


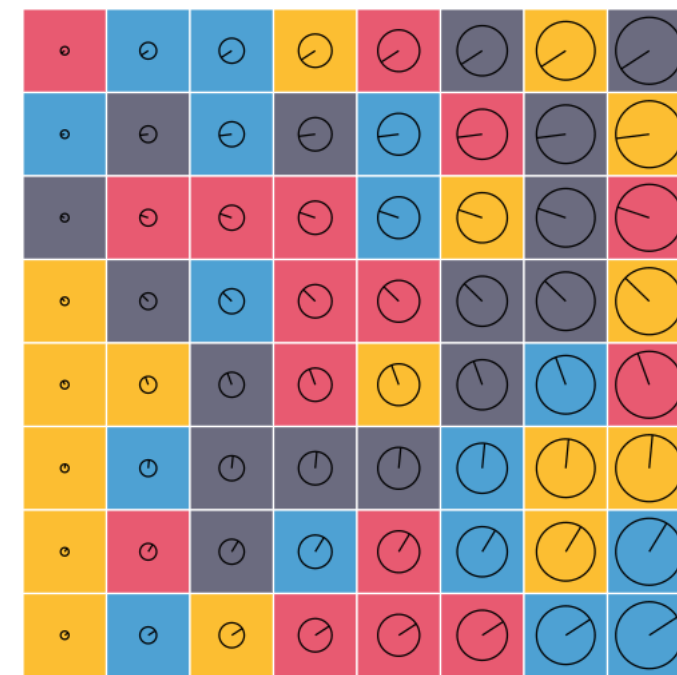
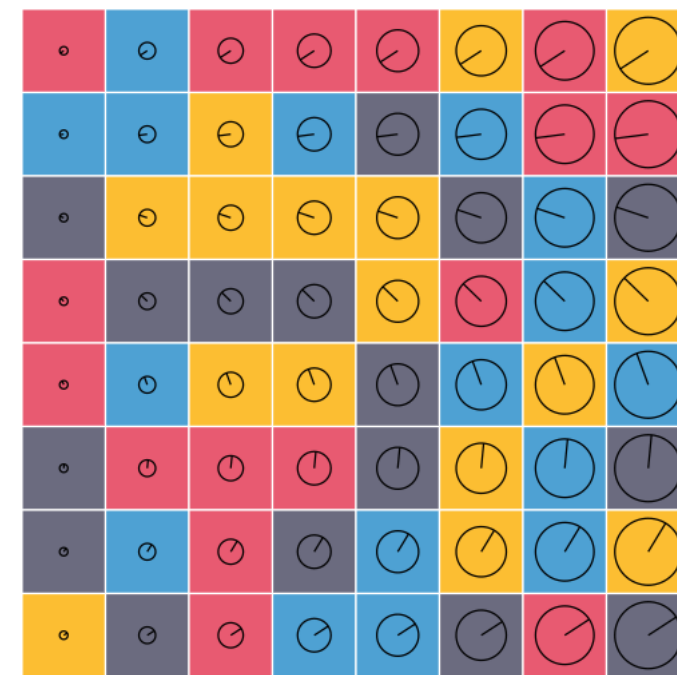
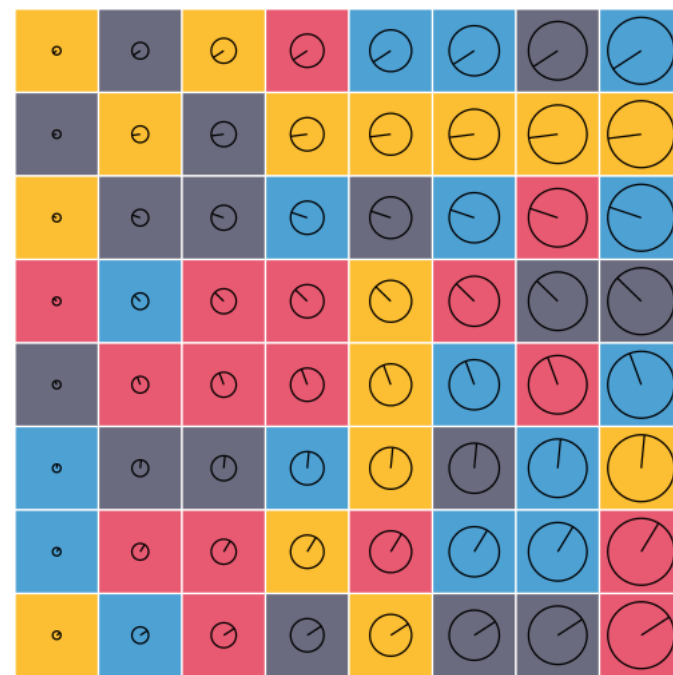
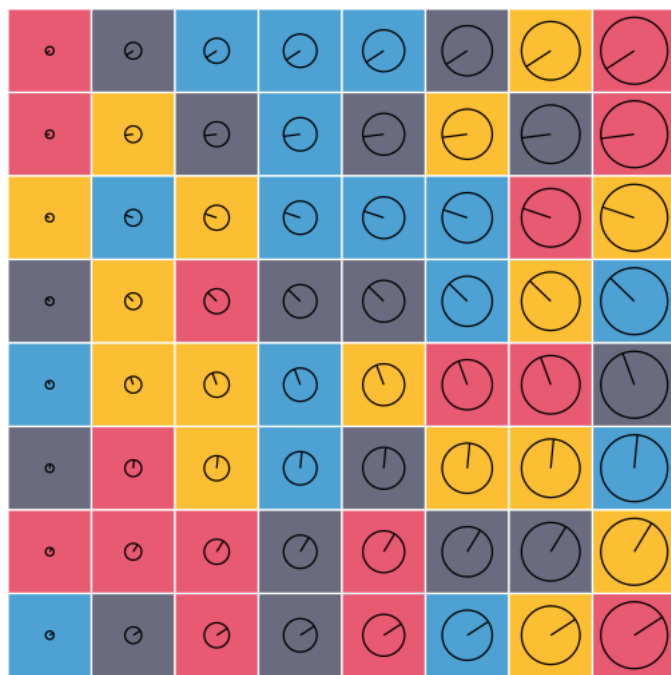
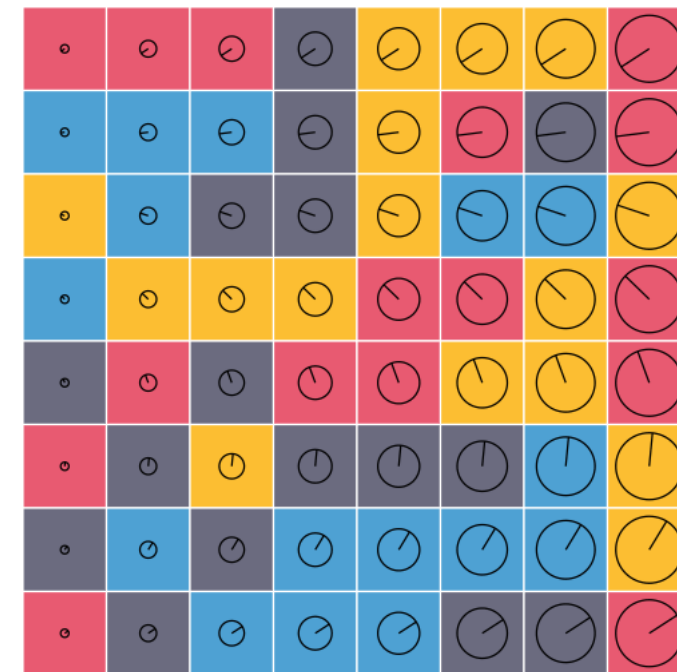
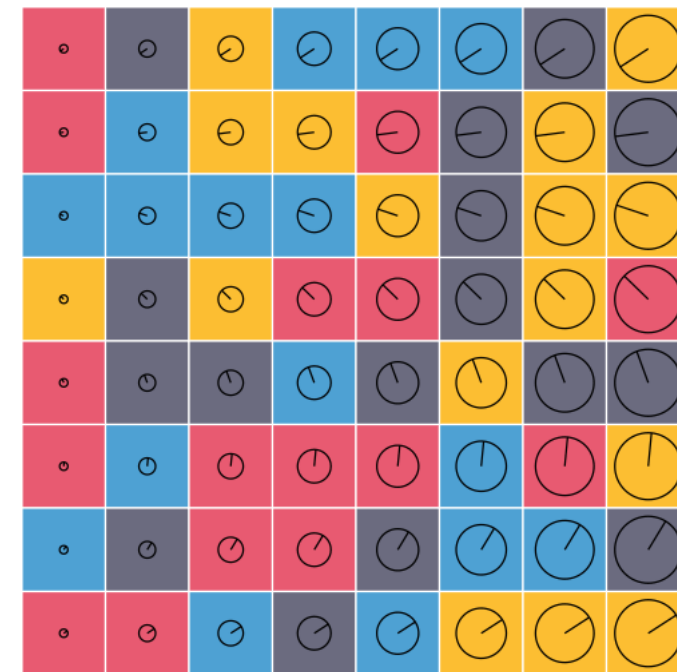
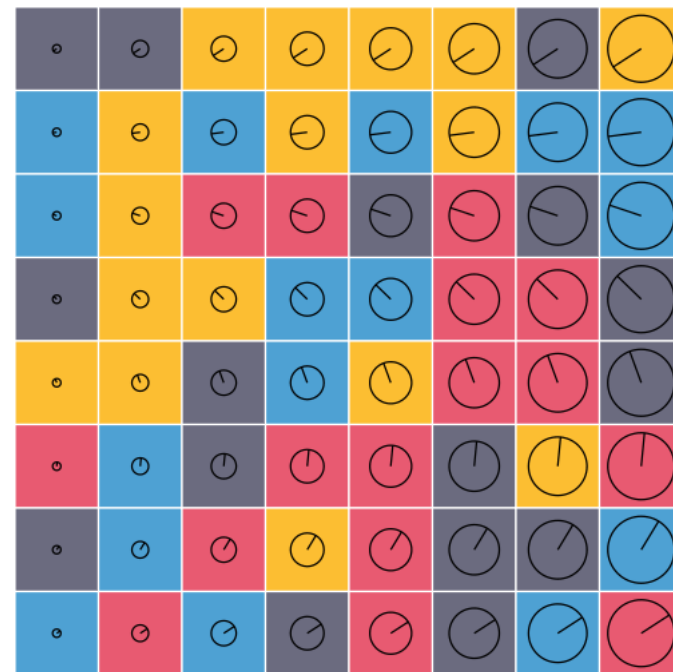
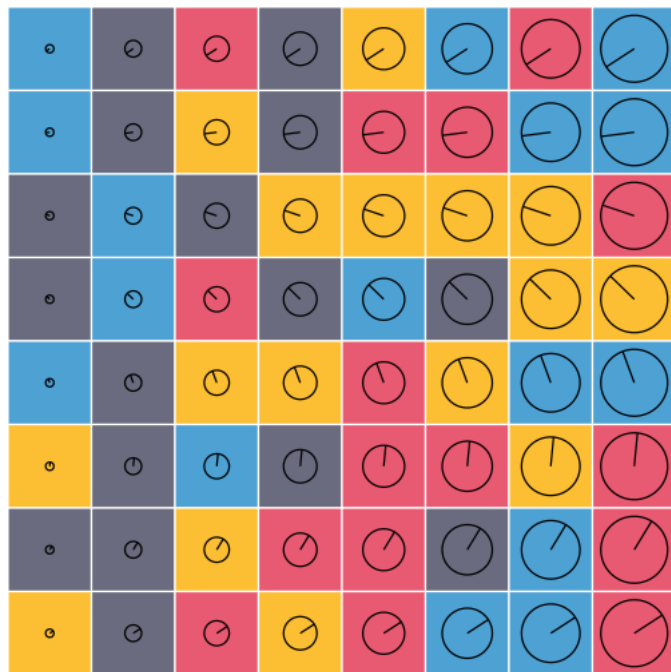
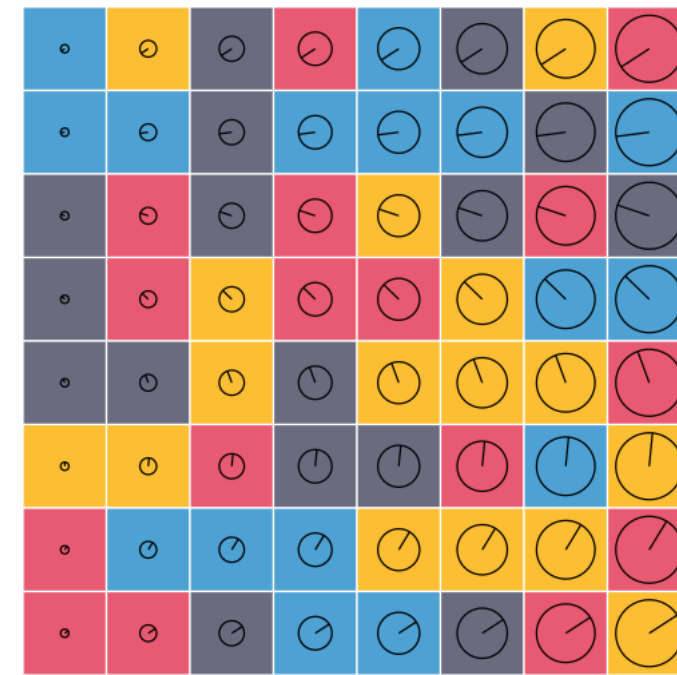
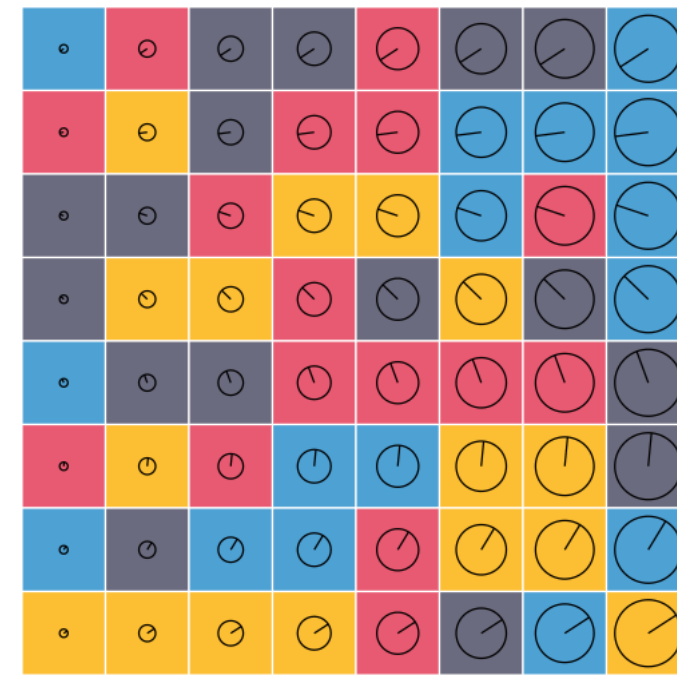
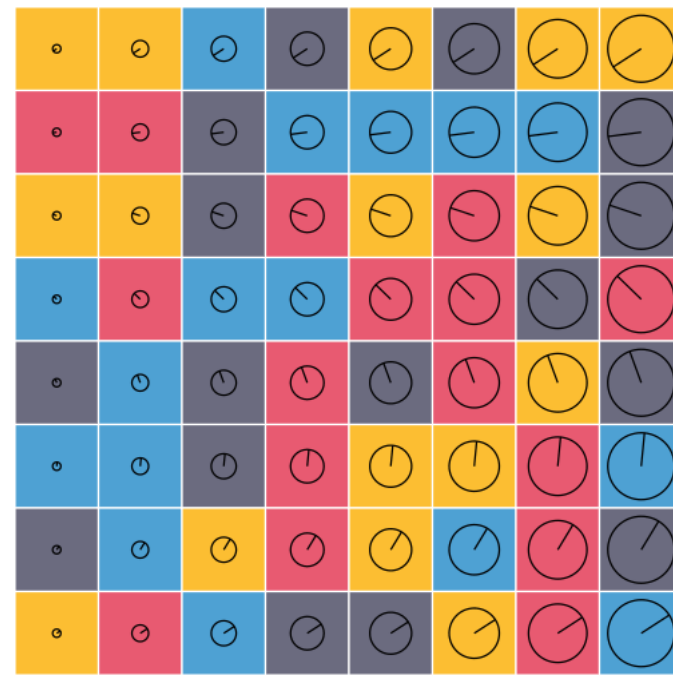
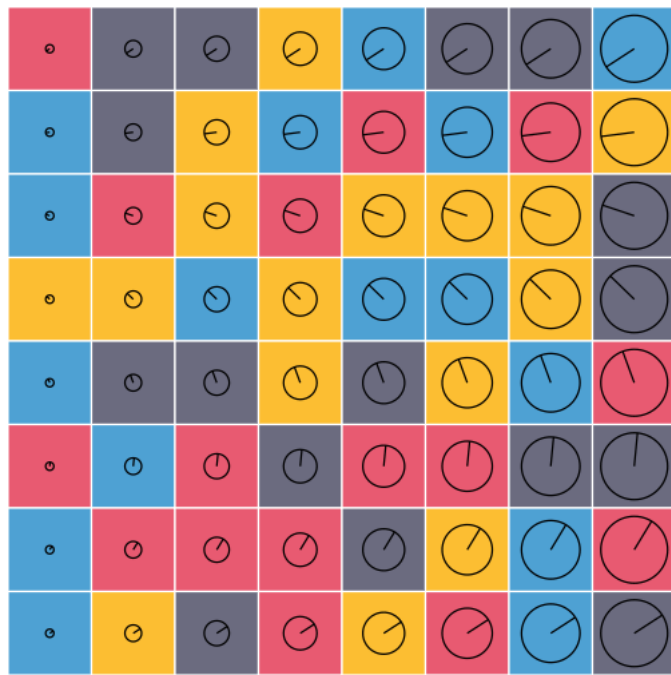
Result: Learnability advantage for the less informative systems

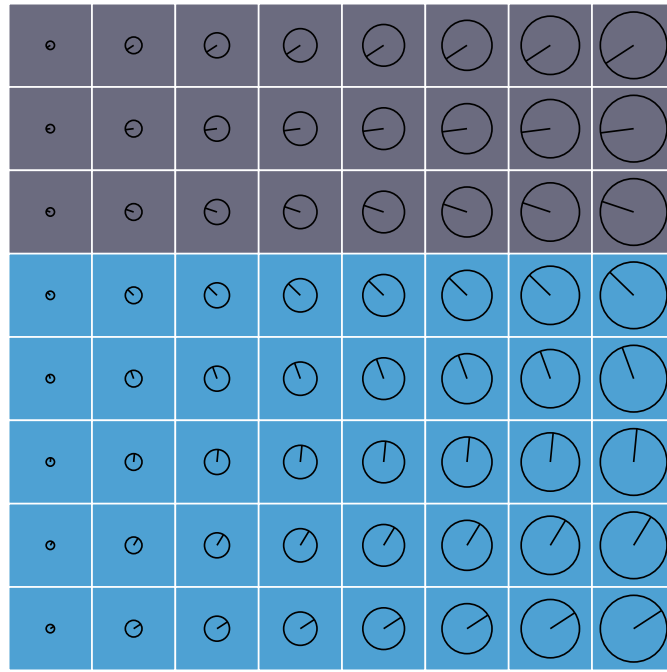
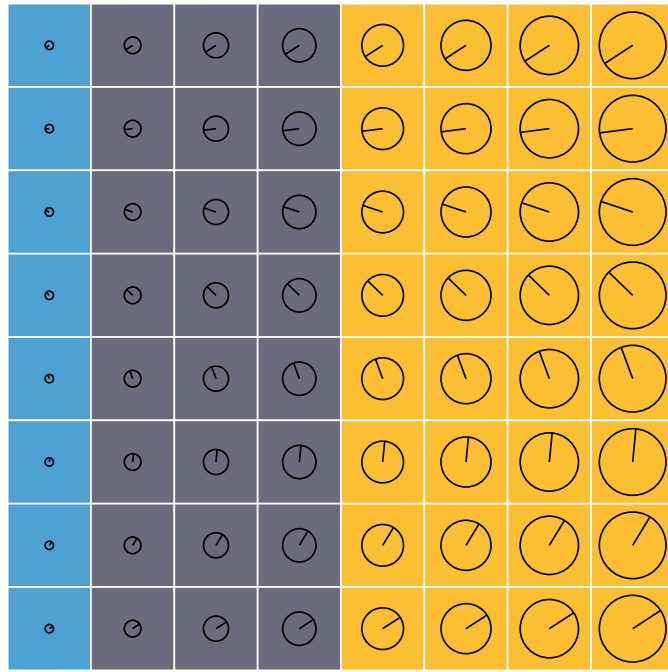
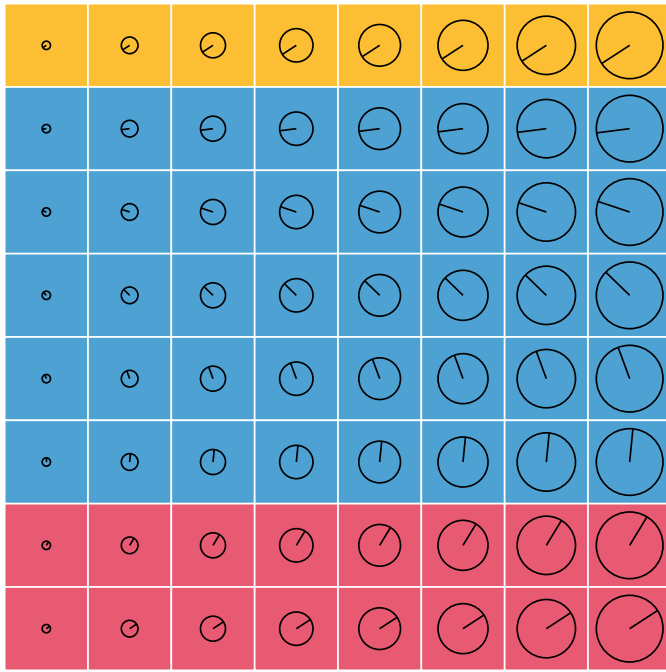
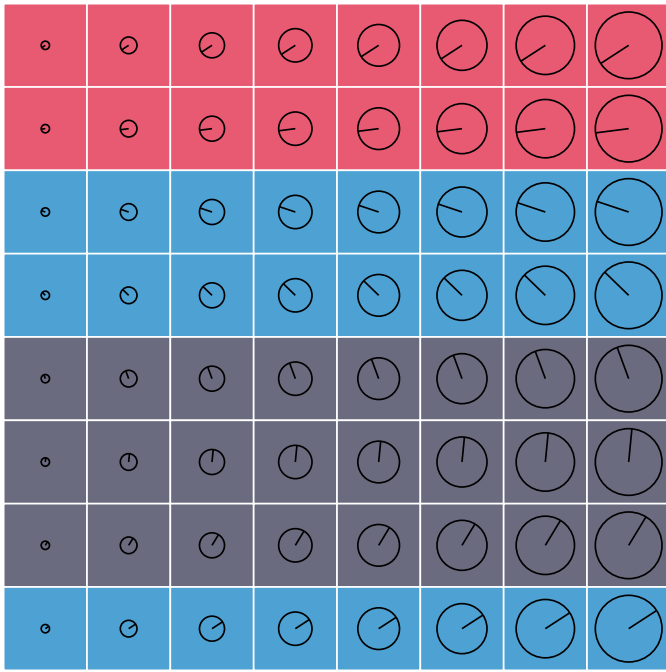
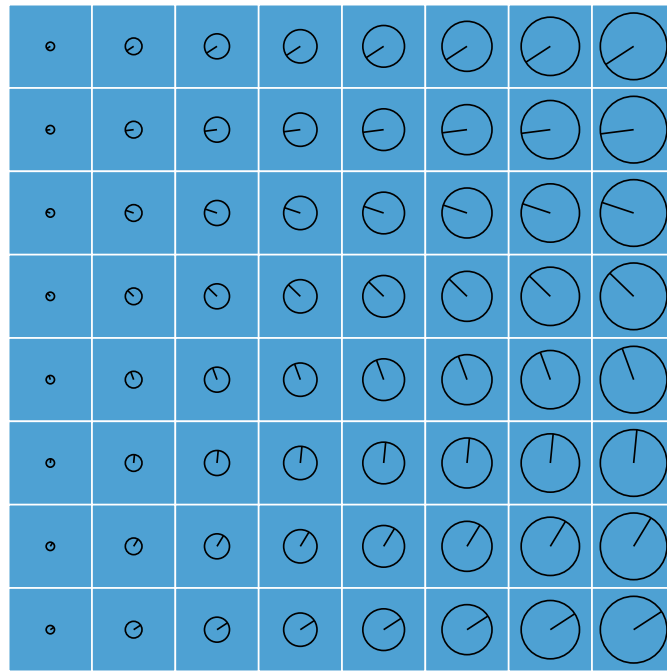
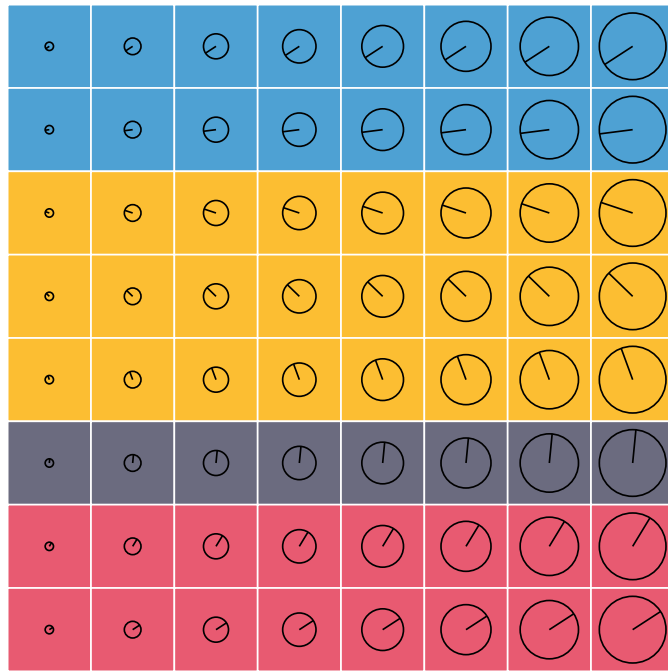
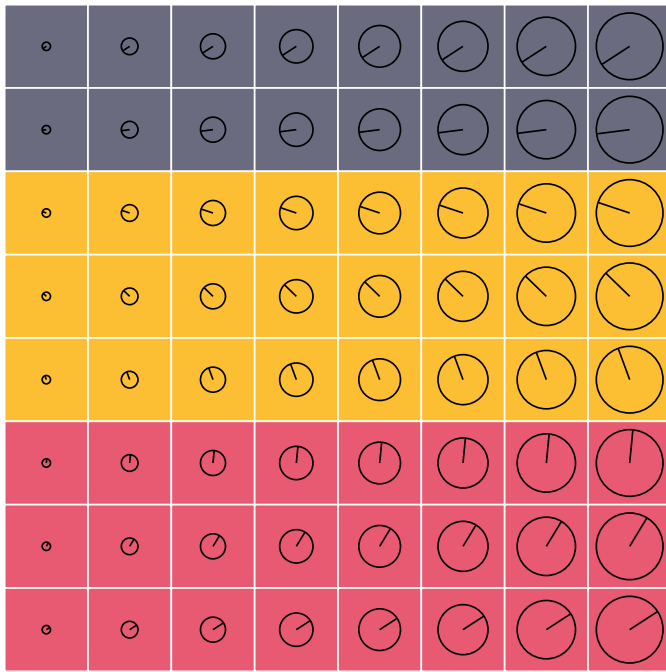
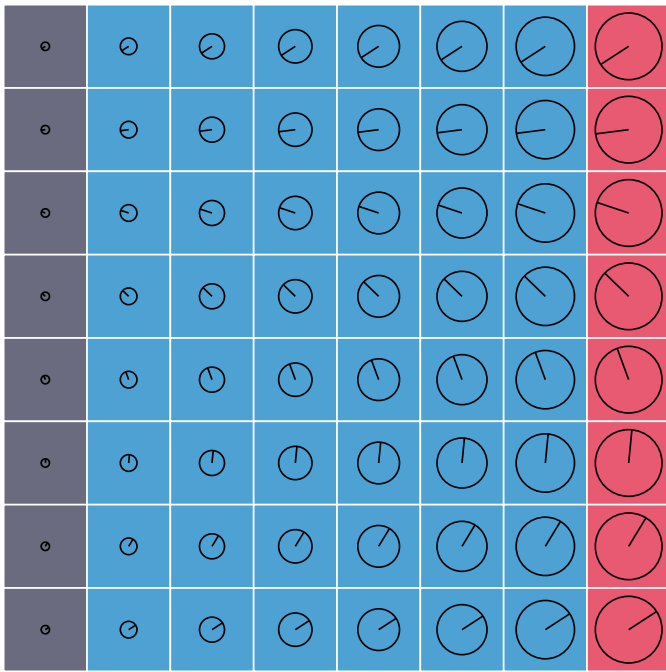
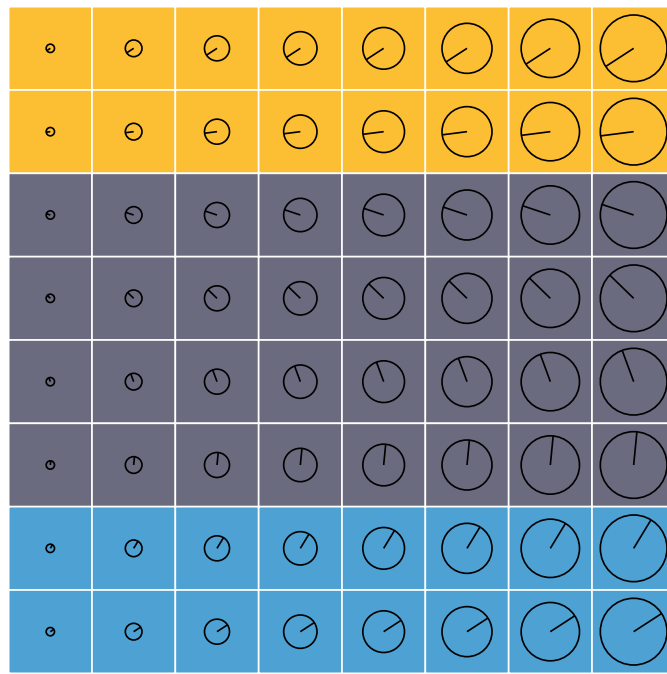
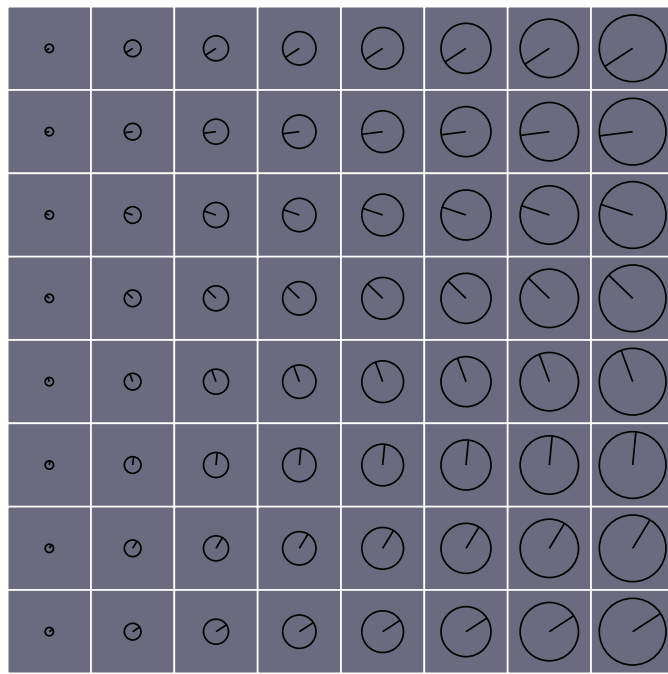
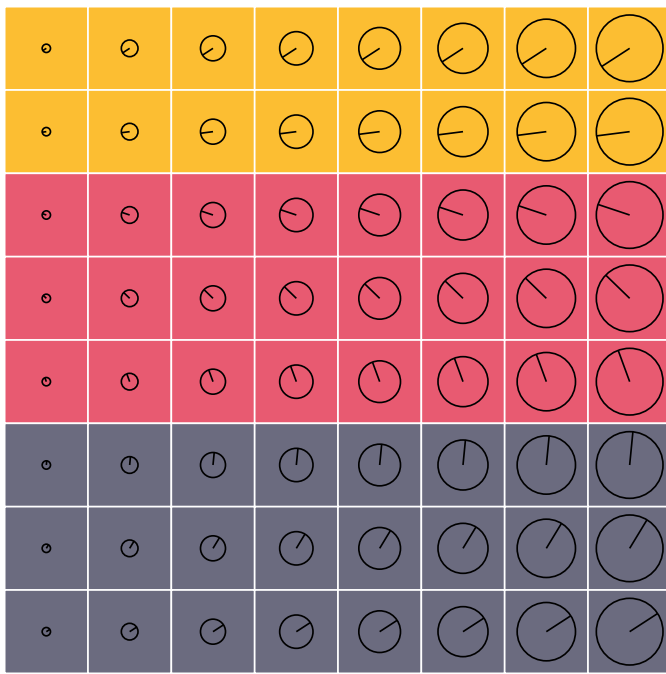
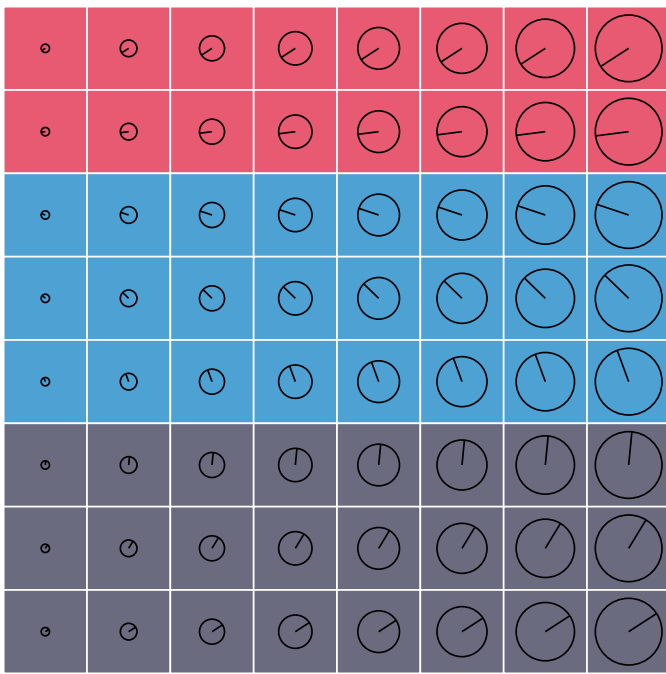


Experiment 2

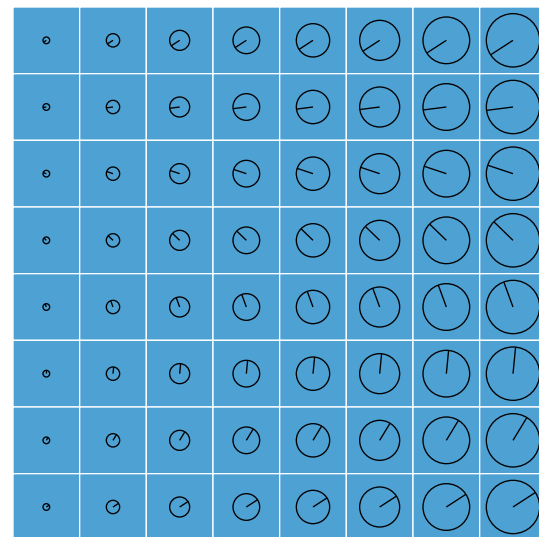
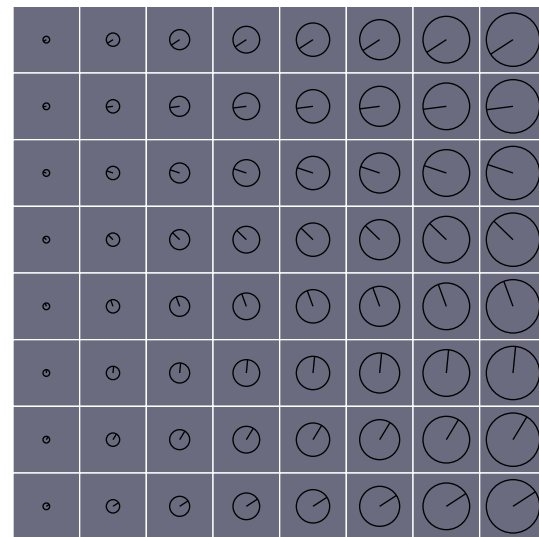
Iterated learning



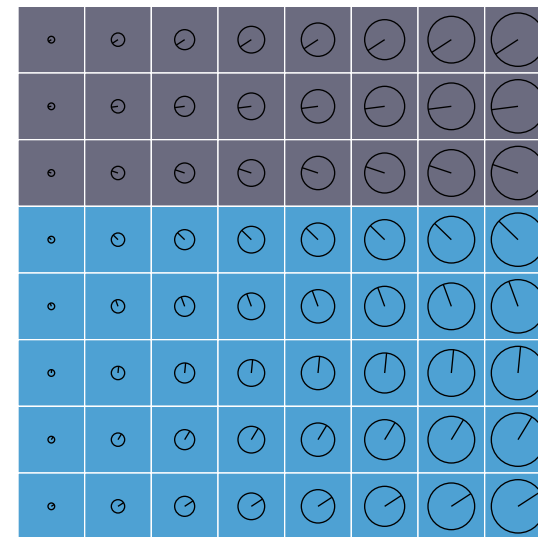




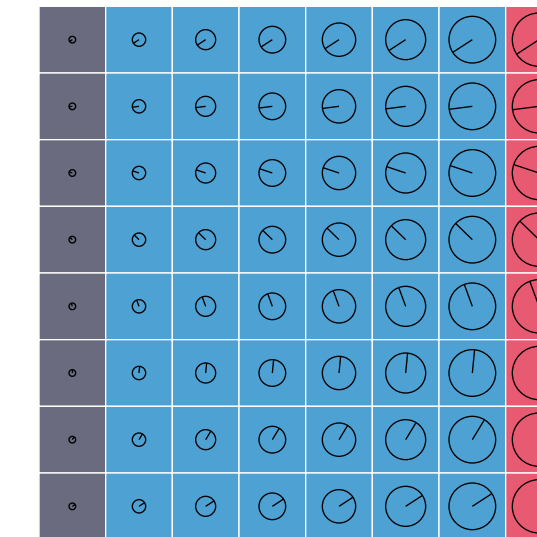
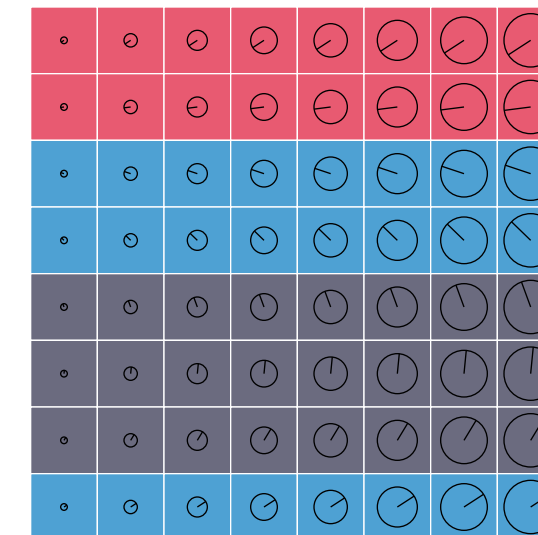
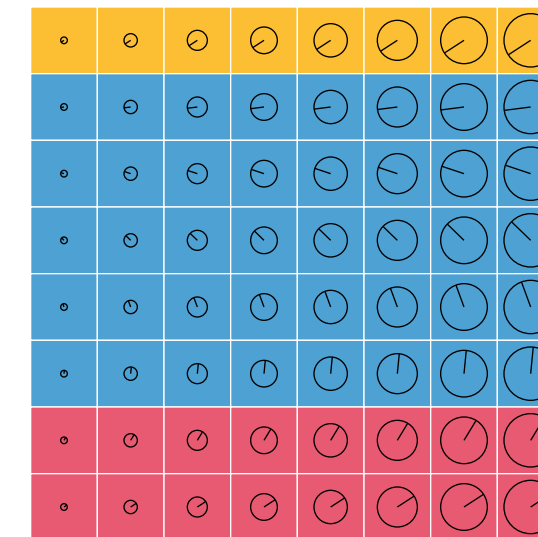
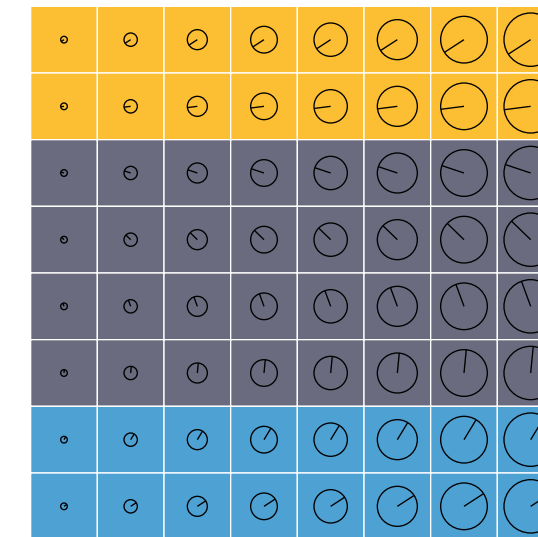
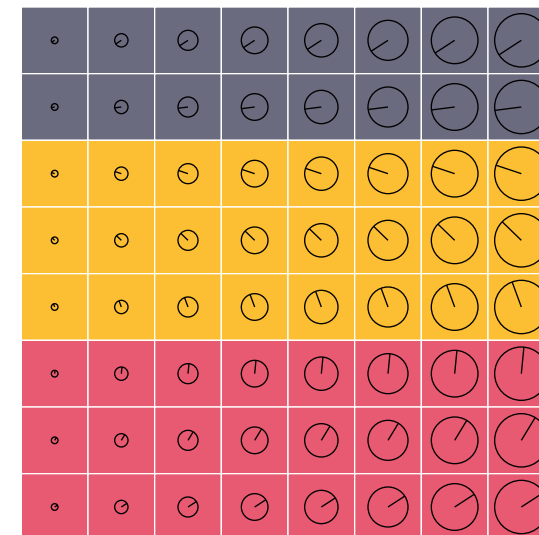
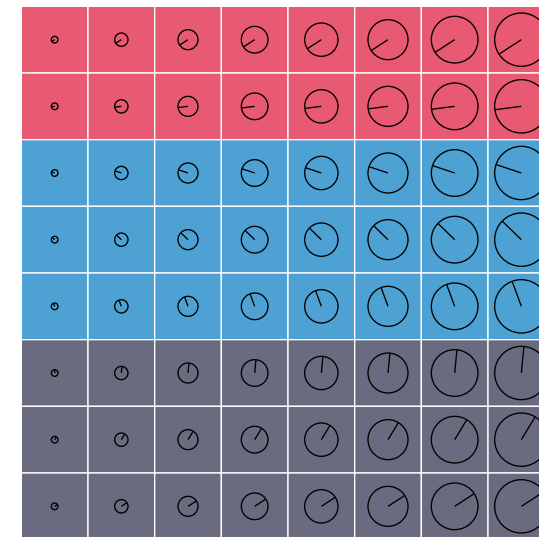
1 category



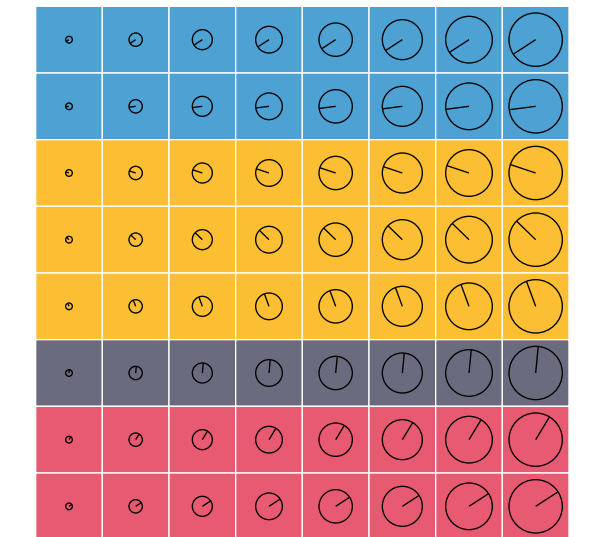
2 categories



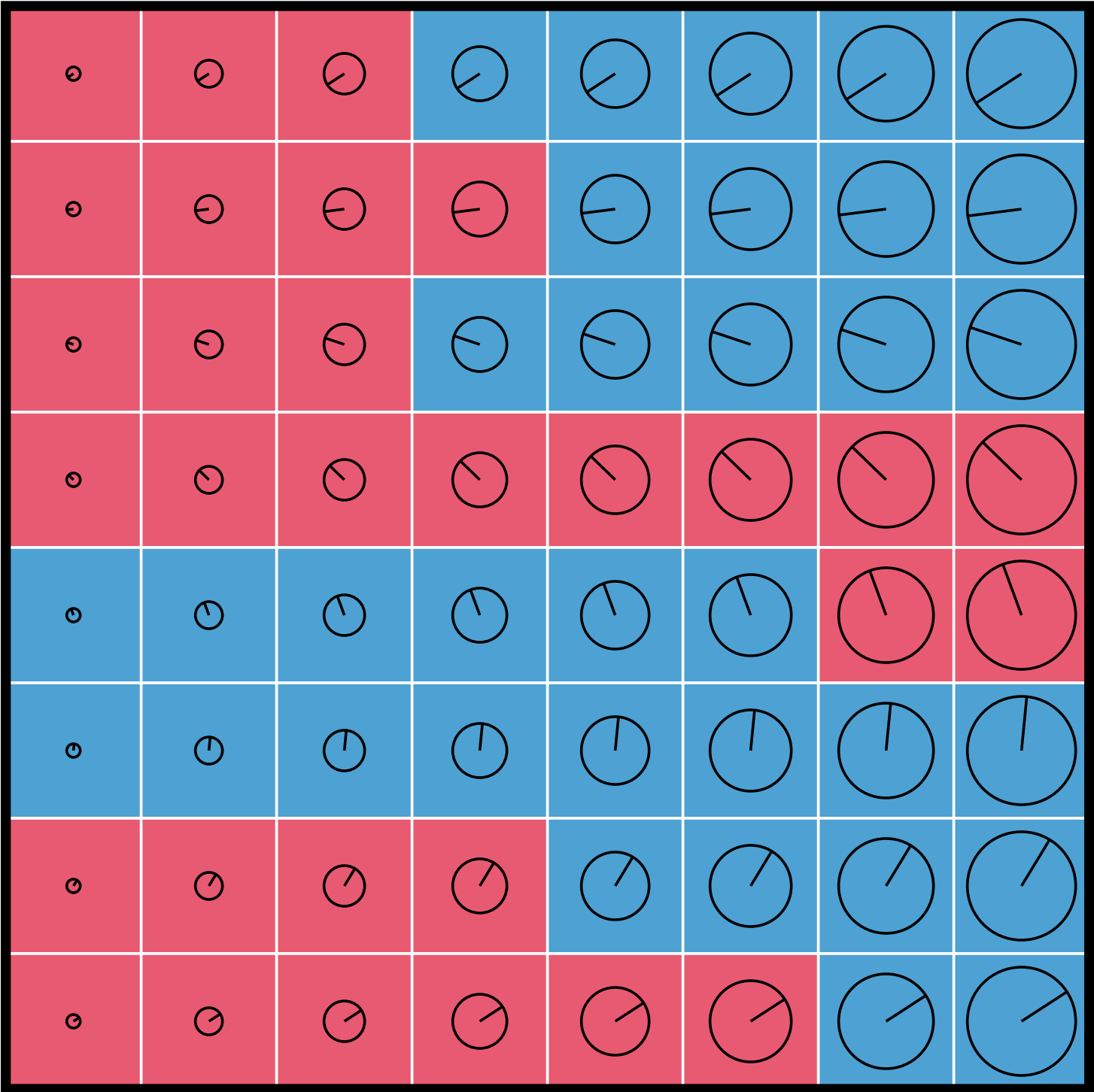
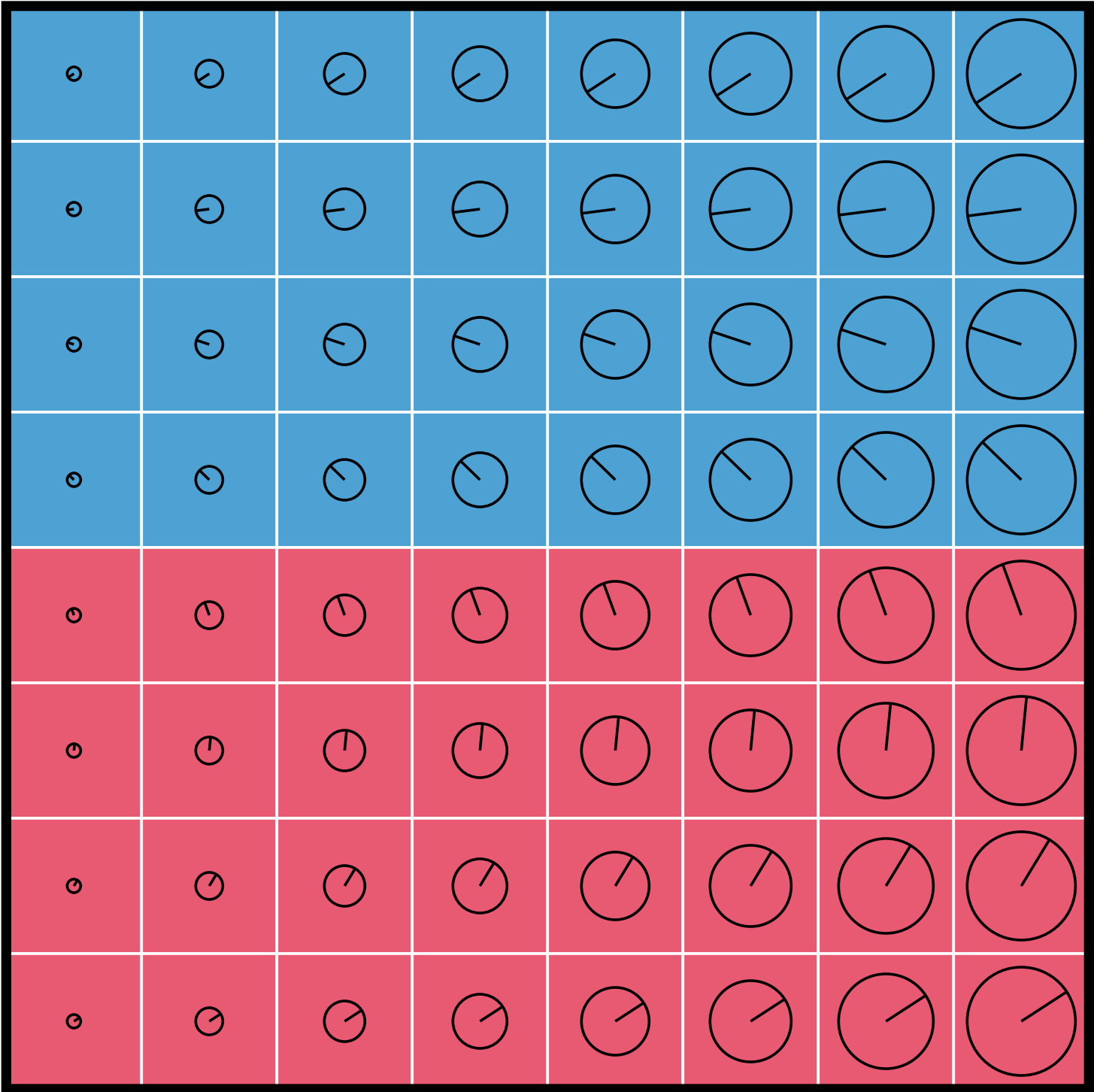
3 categories



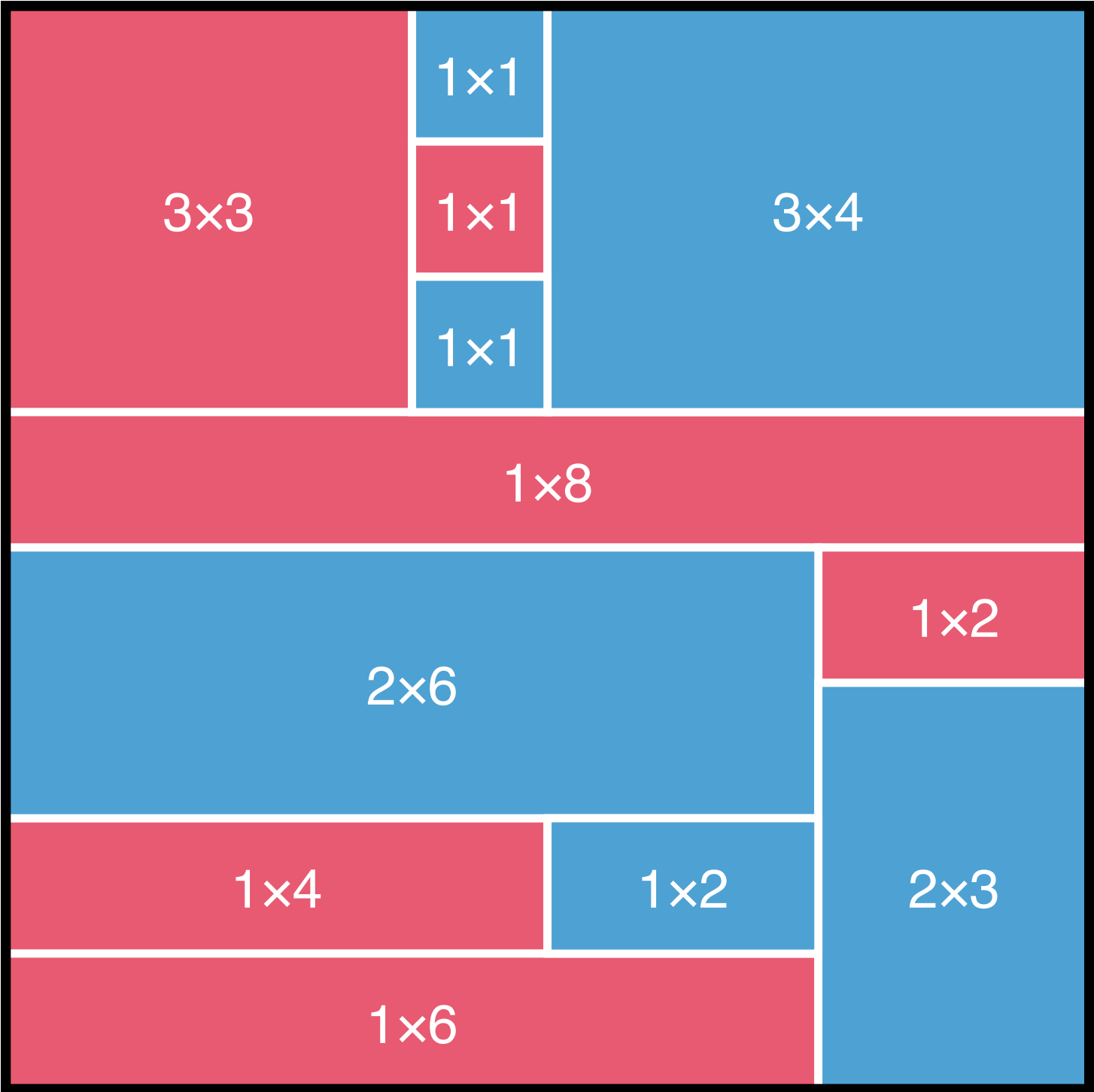
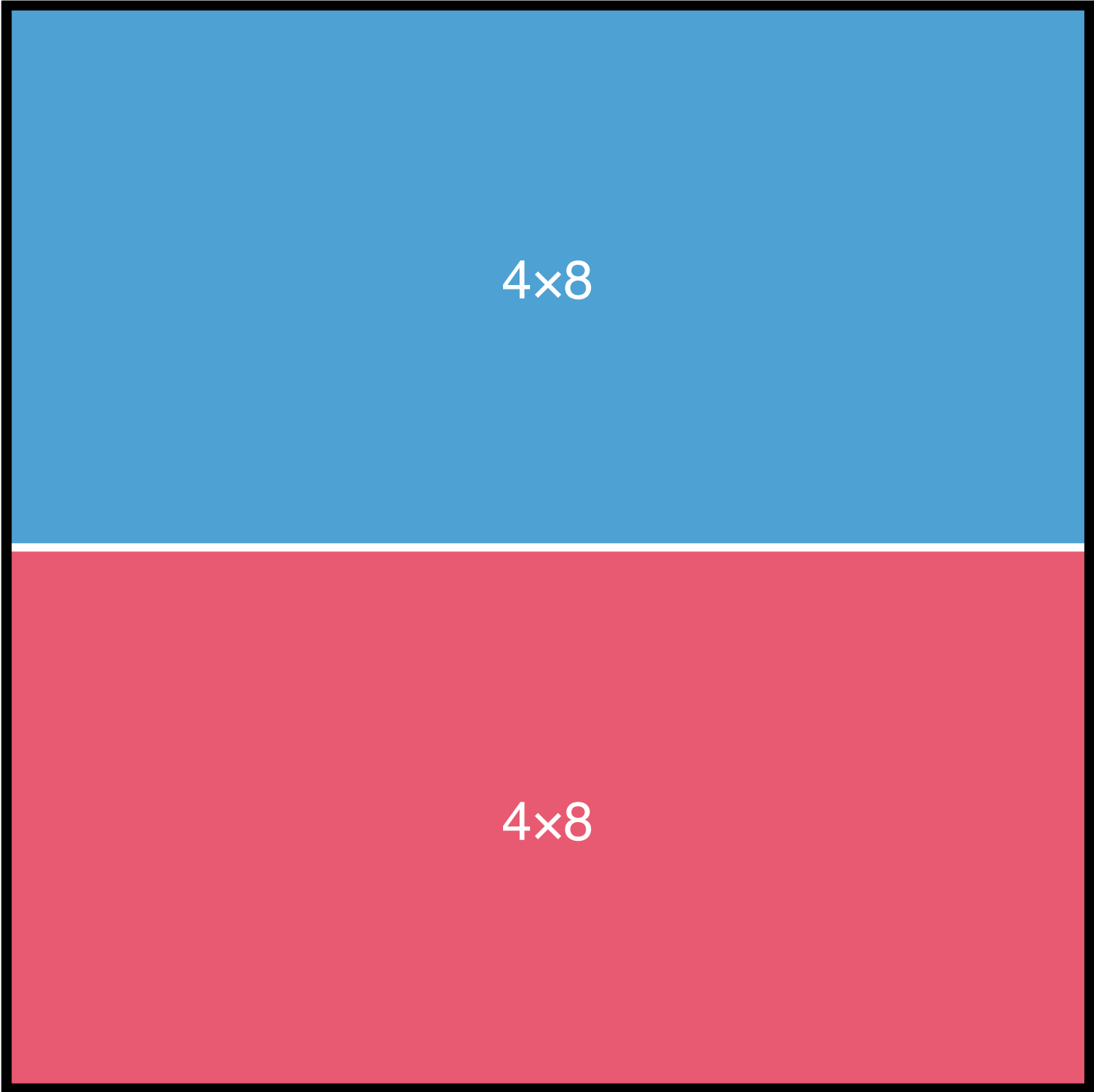
4 categories



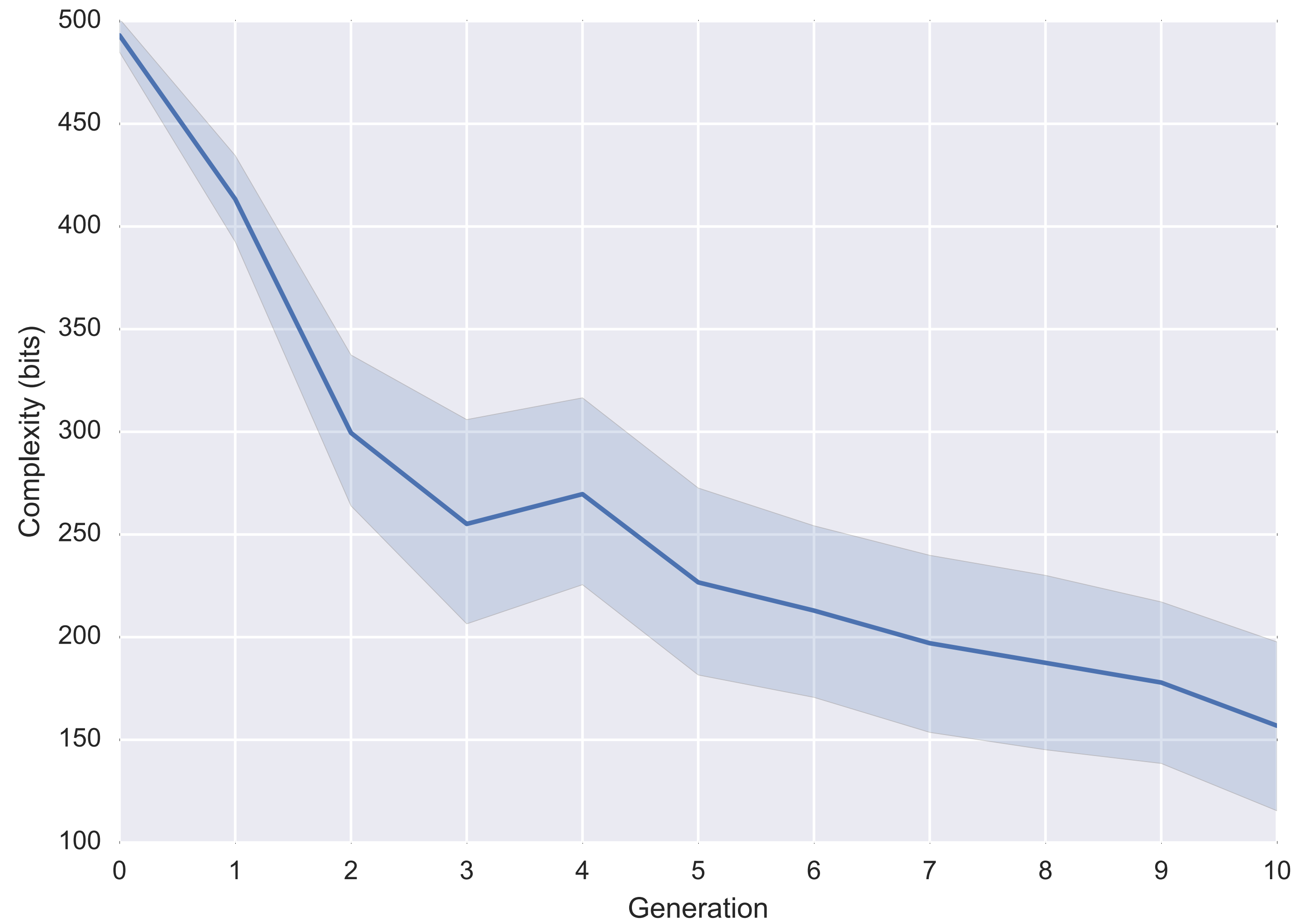
Measuring simplicity



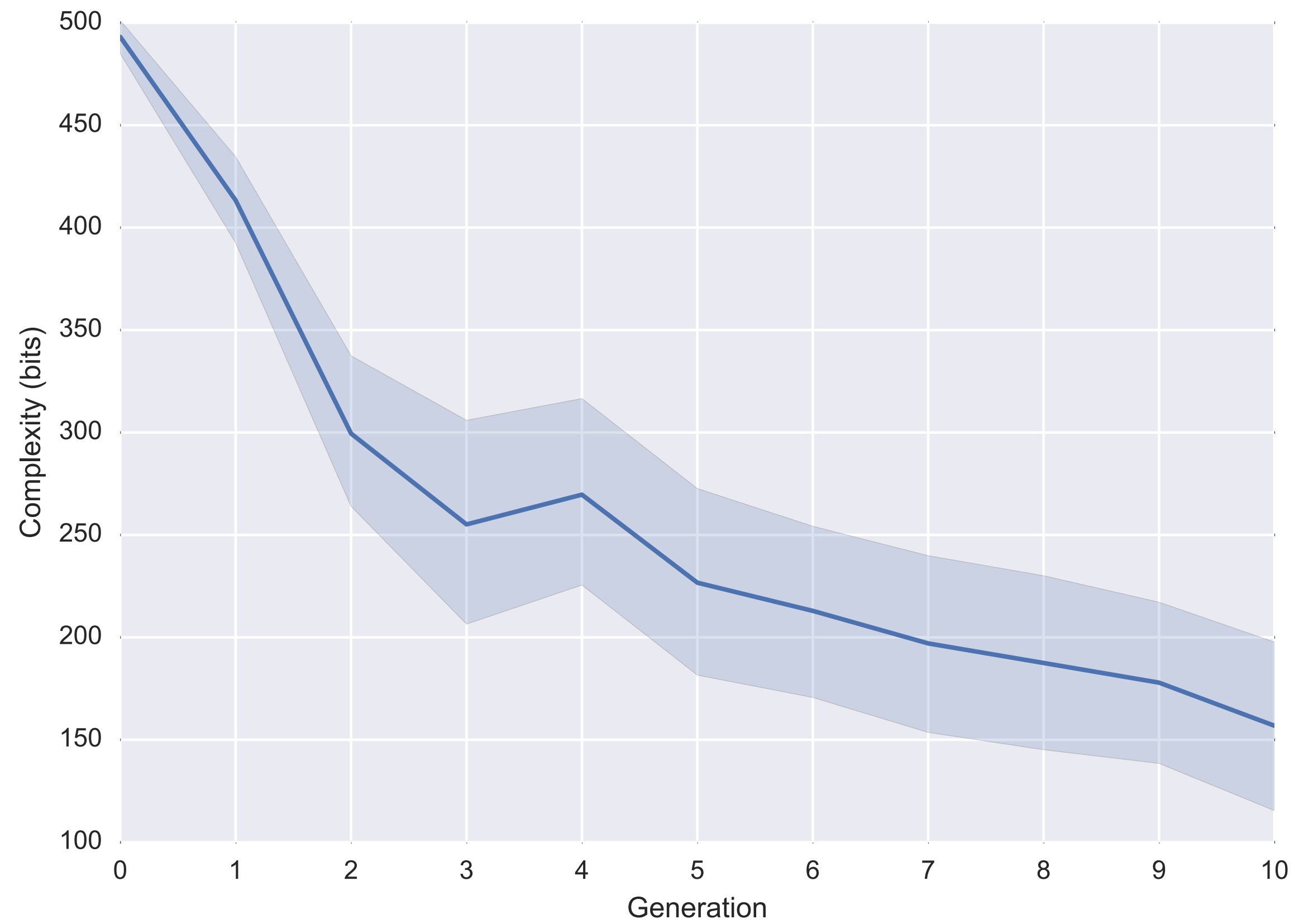
Measuring simplicity



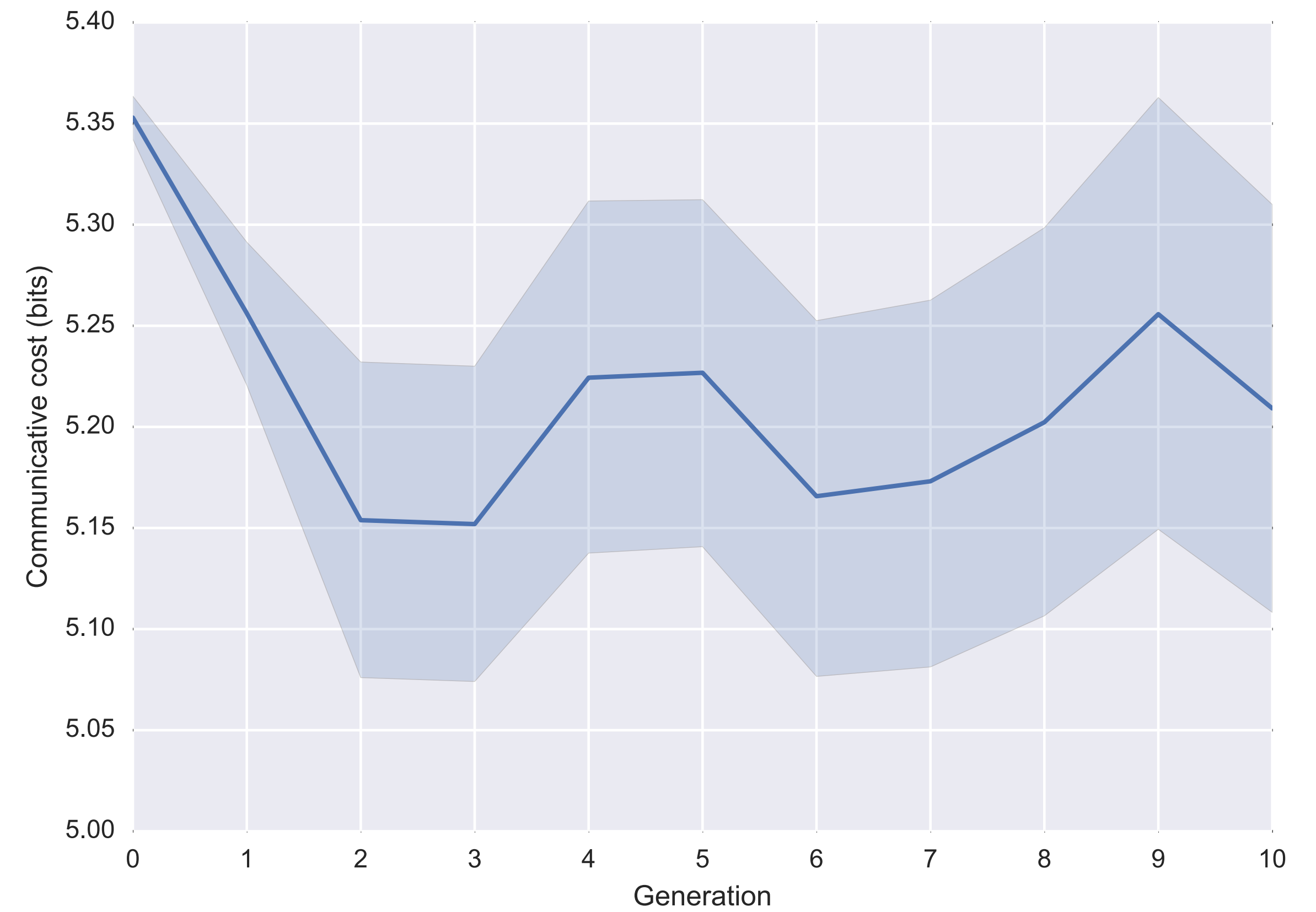
Simplicity



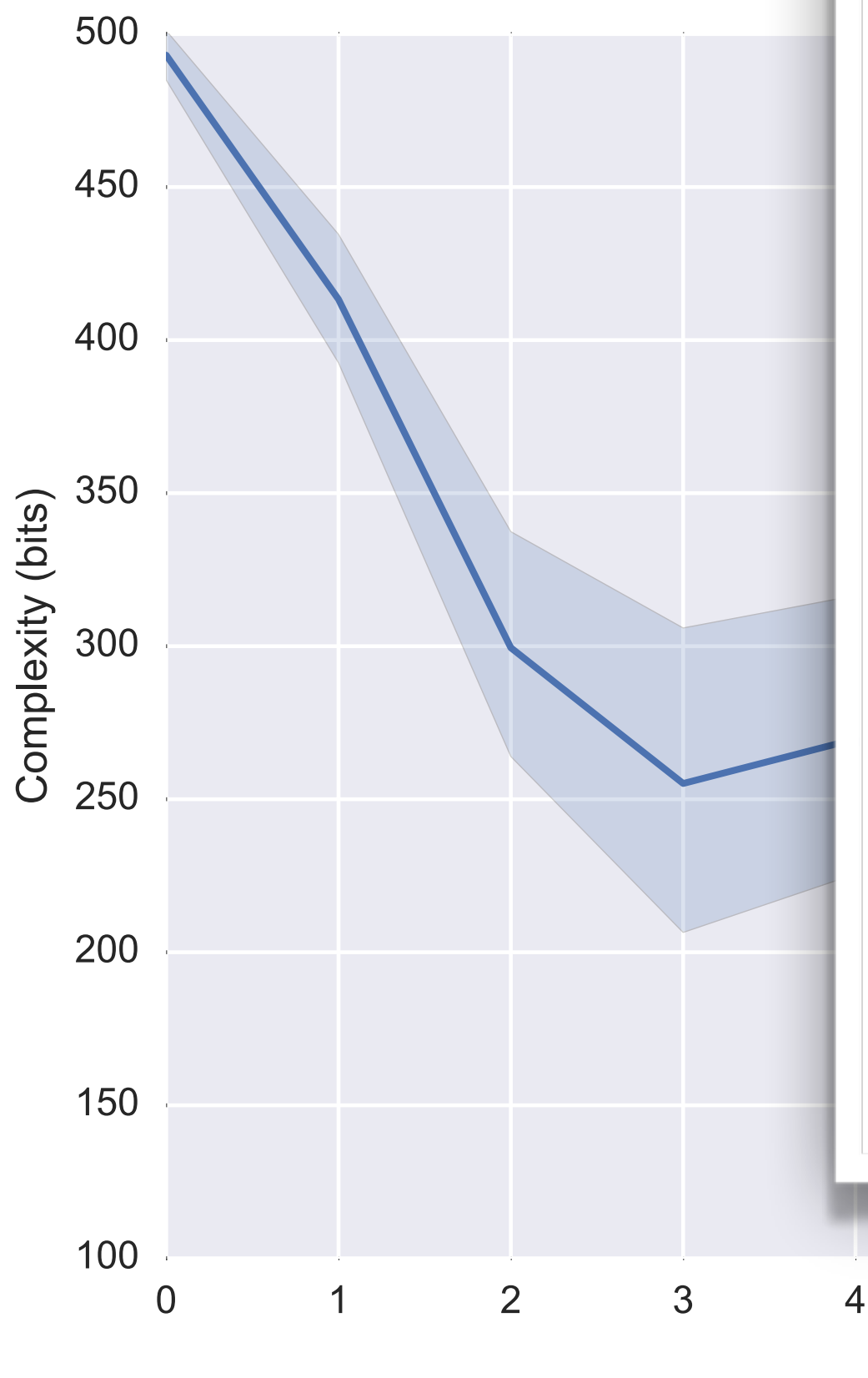
Simplicity



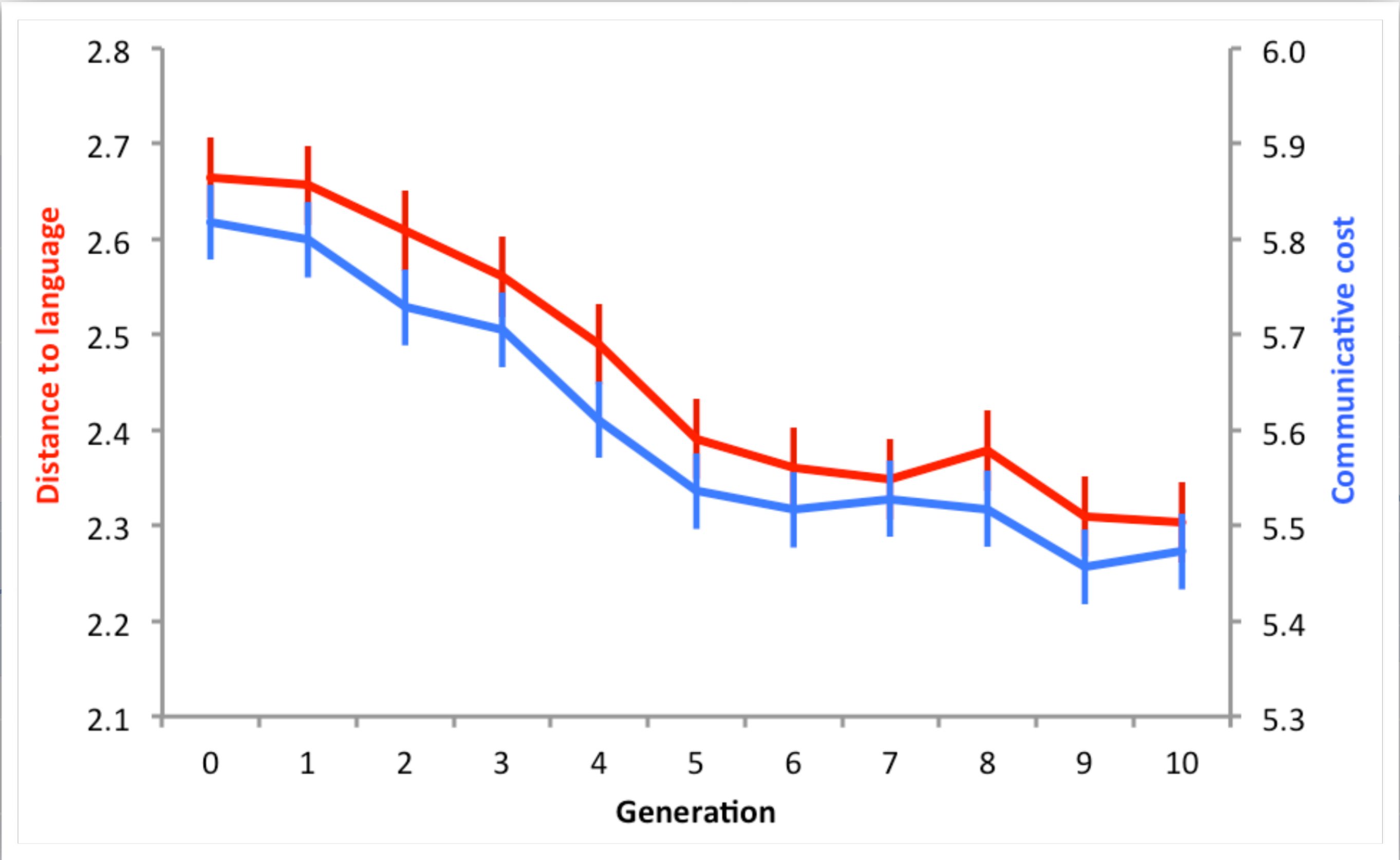
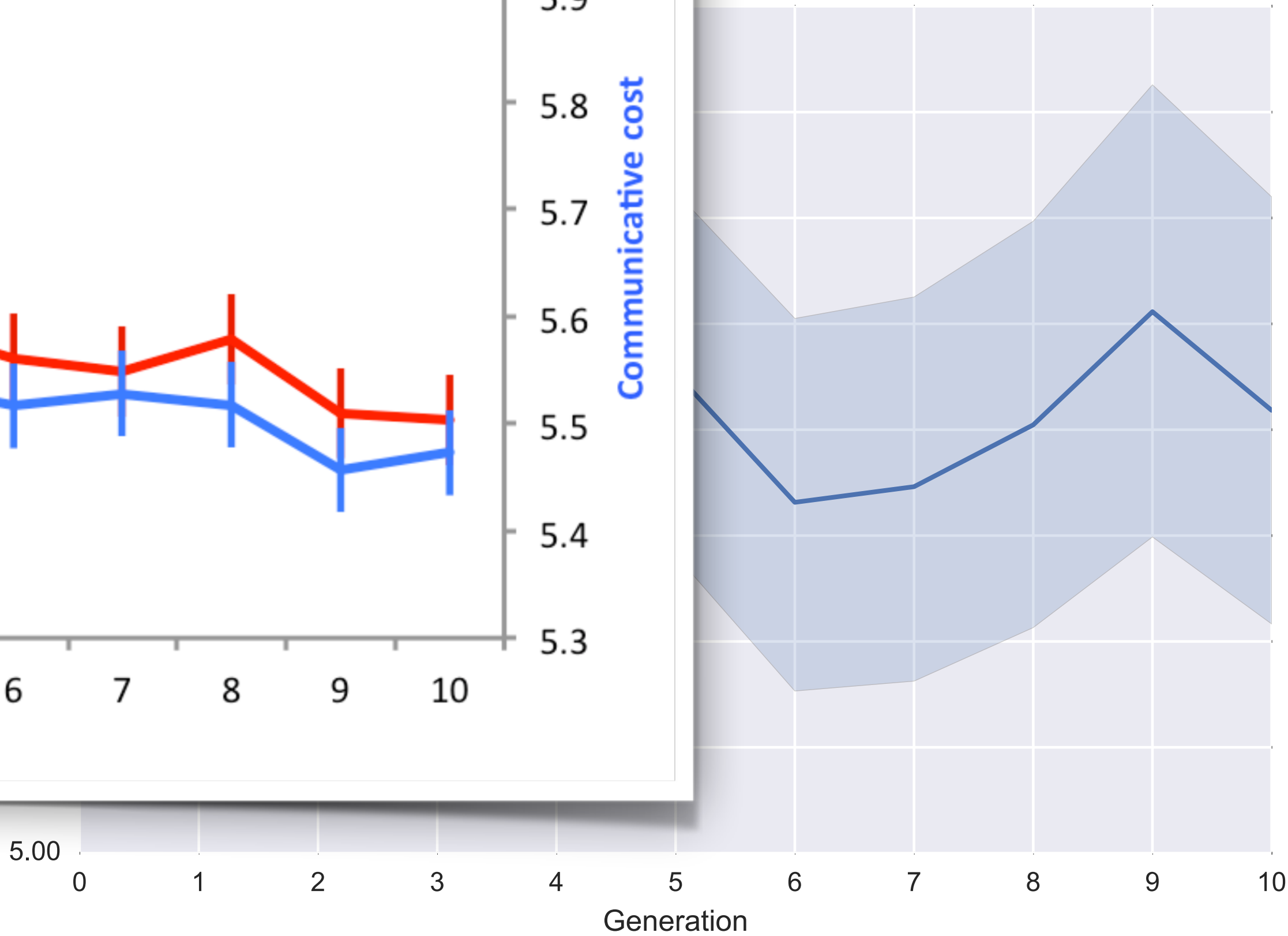
Informativeness



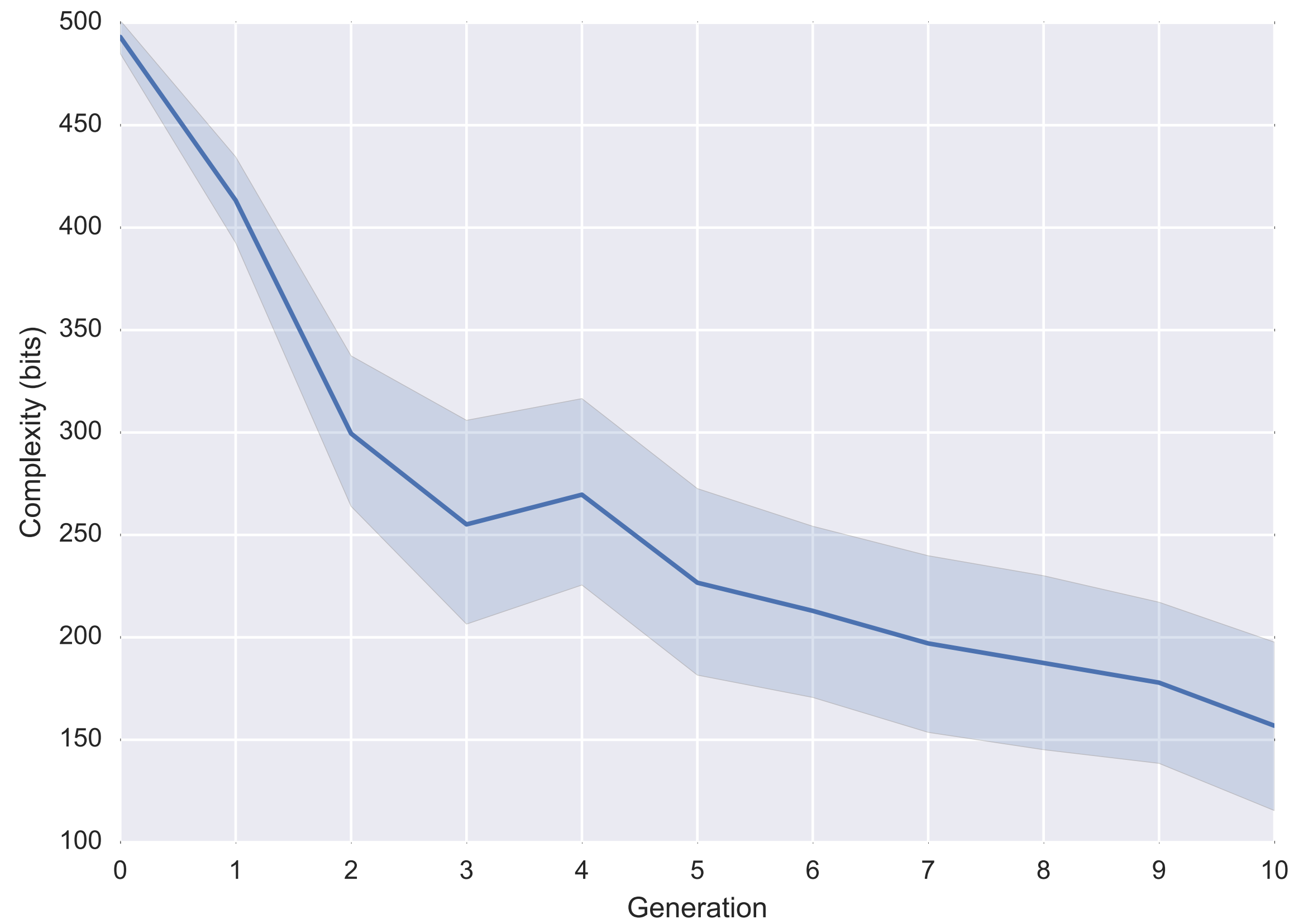
Simplicity



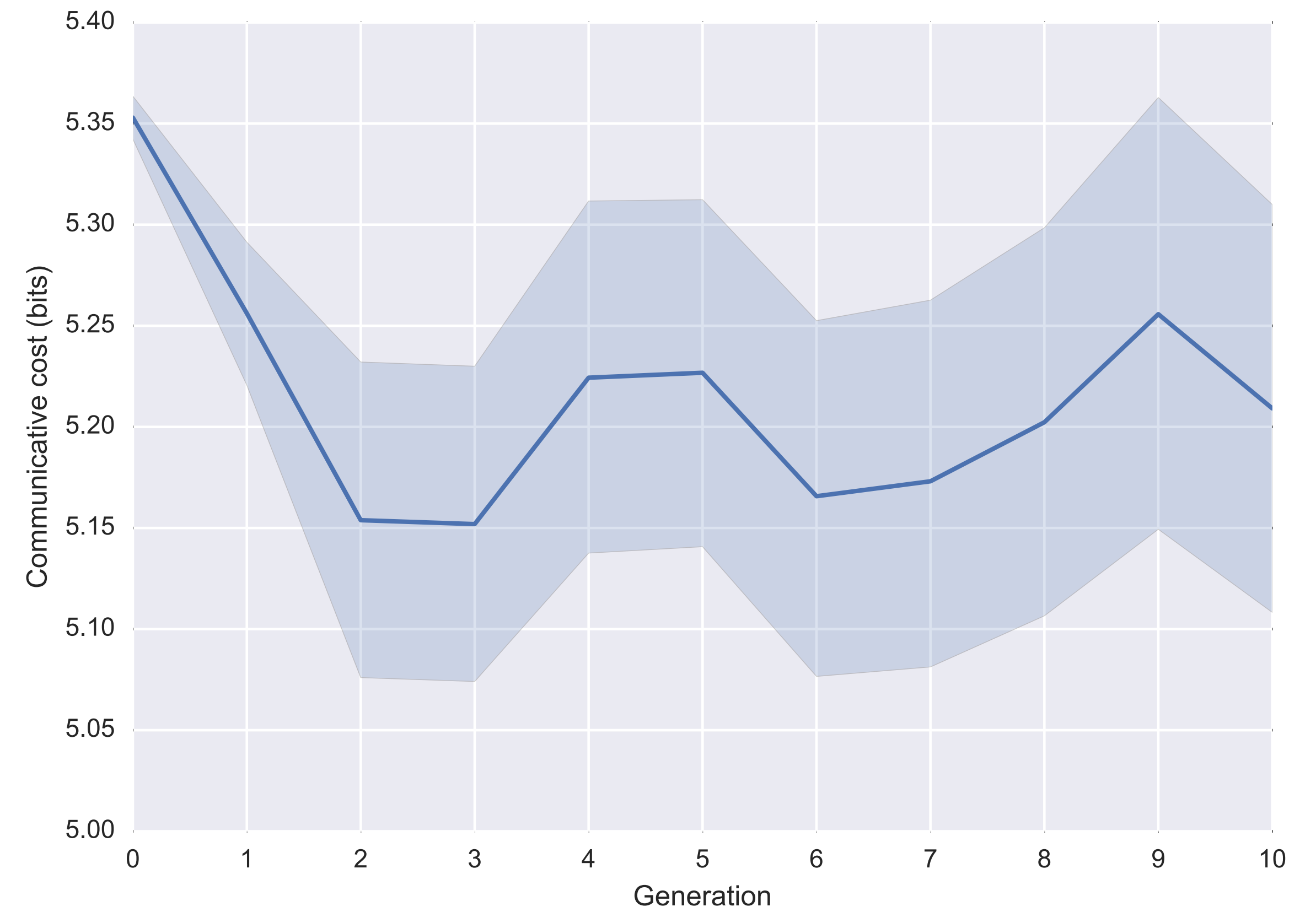
Informativeness



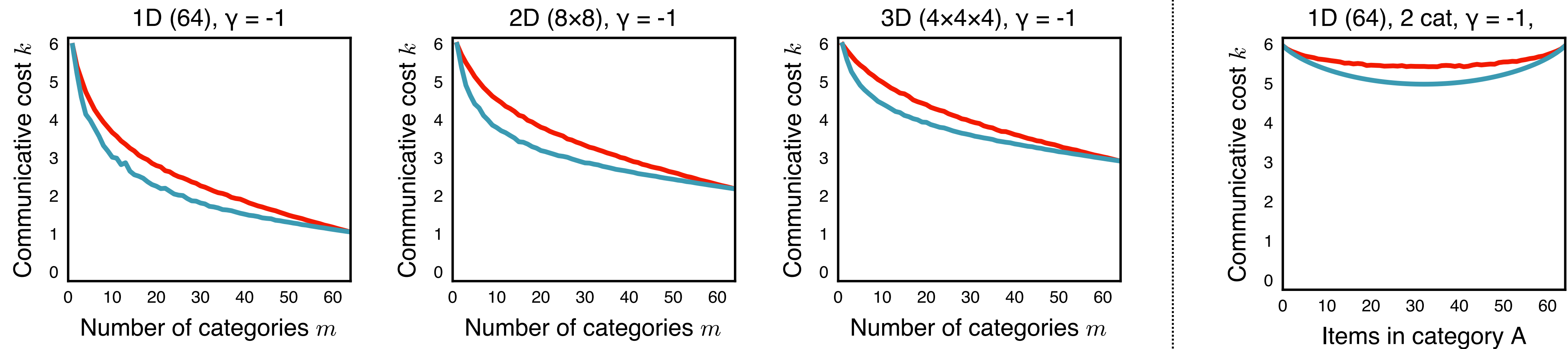
Simplicity



Informativeness



What makes language informative?



Expressivity A system of many categories is more informative than a system of few categories

Balanced categories A system of equally sized categories is more informative than a system of unequally sized categories

Dimensionality A system that uses many dimensions is less (?) informative than a system that uses few dimensions

Convexity A system of convex categories is more informative than a system of nonconvex categories

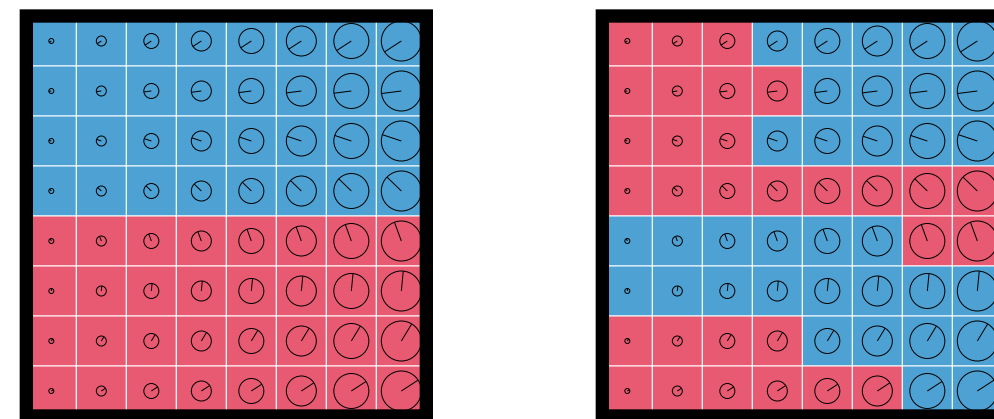
Discreteness A system of discrete categories is more informative than a system of fuzzy categories

Compactness A system of compact categories is more informative than a system of noncompact categories

What makes language informative?

Expressivity A system of many categories is more informative than a system of few categories

Convexity A system of convex categories is more informative than a system of nonconvex categories



Learning

Pressure for simplicity



Communication

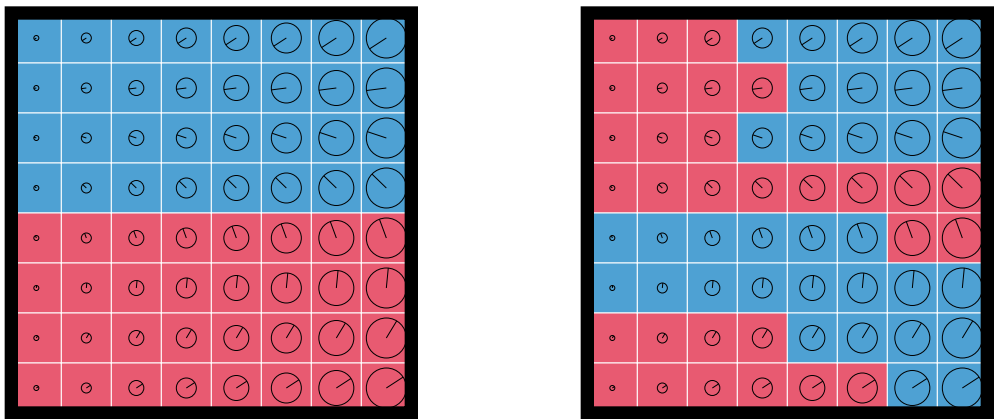
Pressure for informativeness



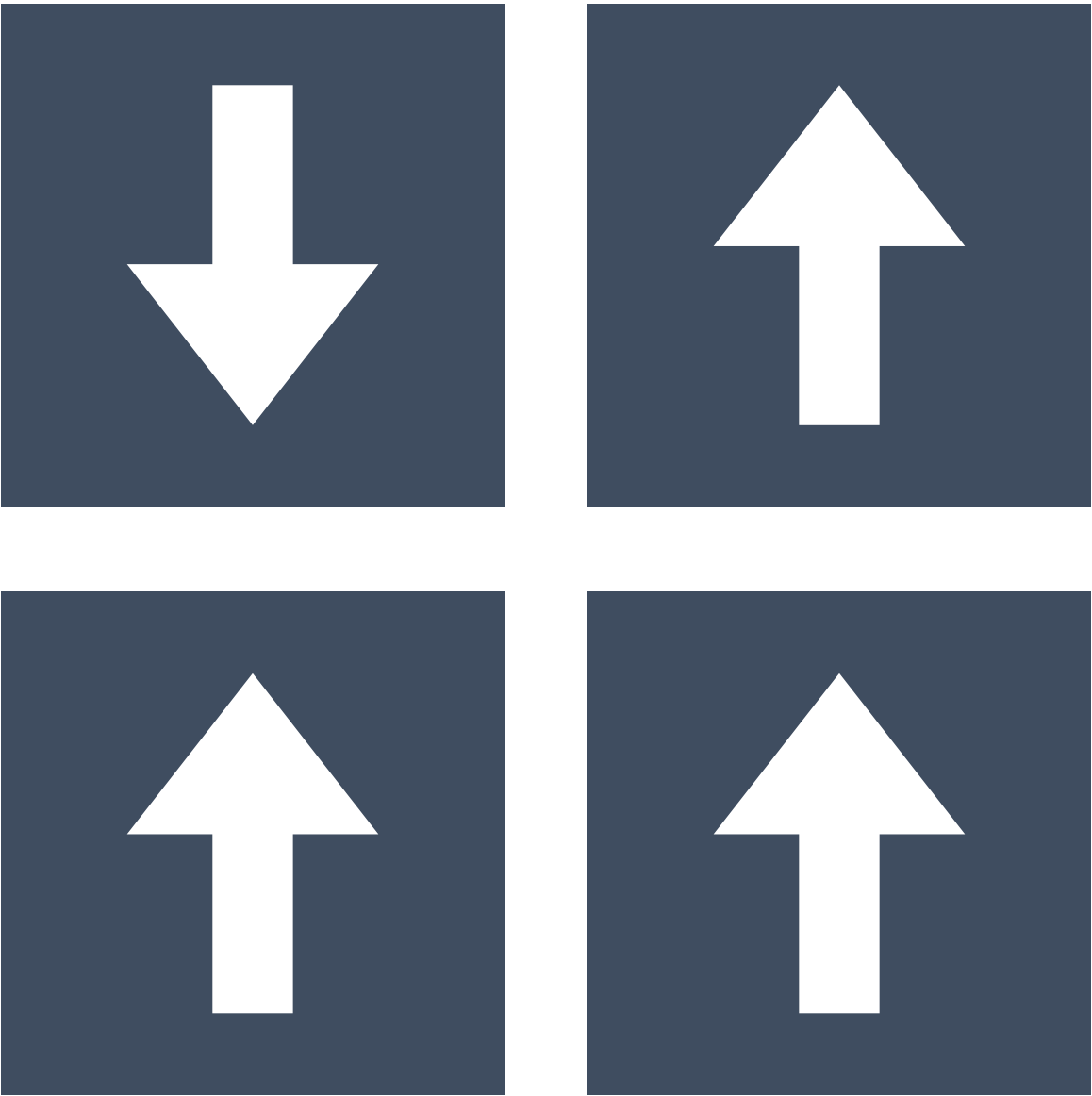
What makes language informative?

Expressivity A system of many categories is more informative than a system of few categories

Convexity A system of convex categories is more informative than a system of nonconvex categories



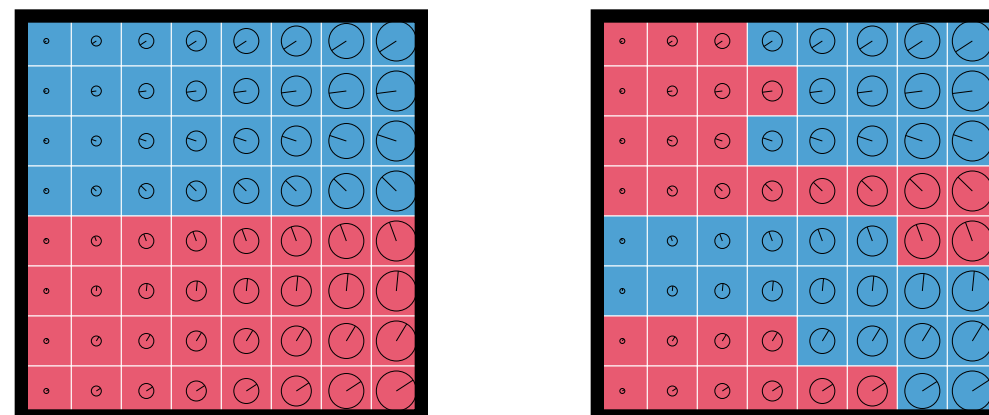
Learning Pressure for simplicity	Communication Pressure for informativeness
--	--



What makes language informative?

Expressivity A system of many categories is more informative than a system of few categories

Convexity A system of convex categories is more informative than a system of nonconvex categories



Learning
Pressure for simplicity



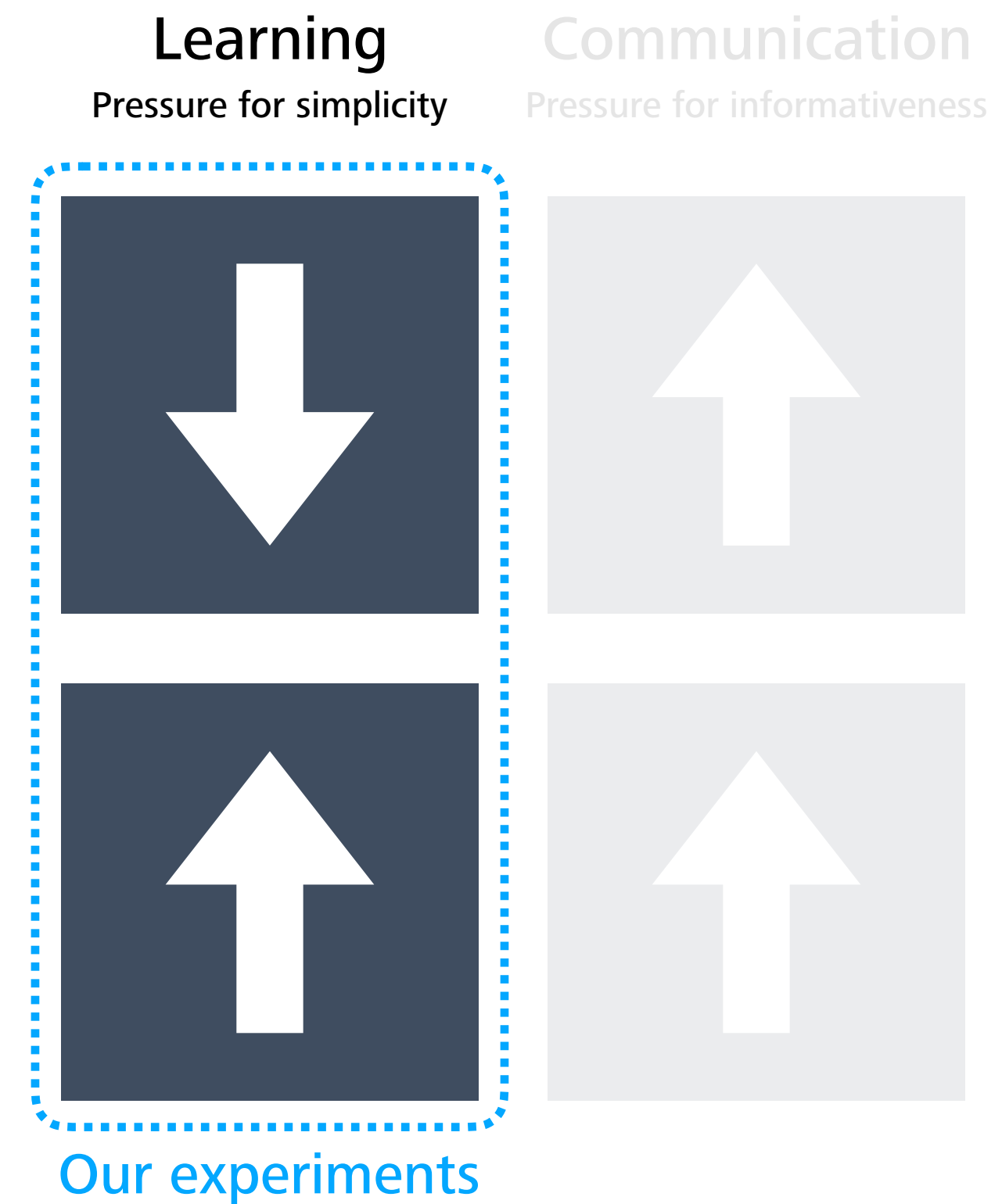
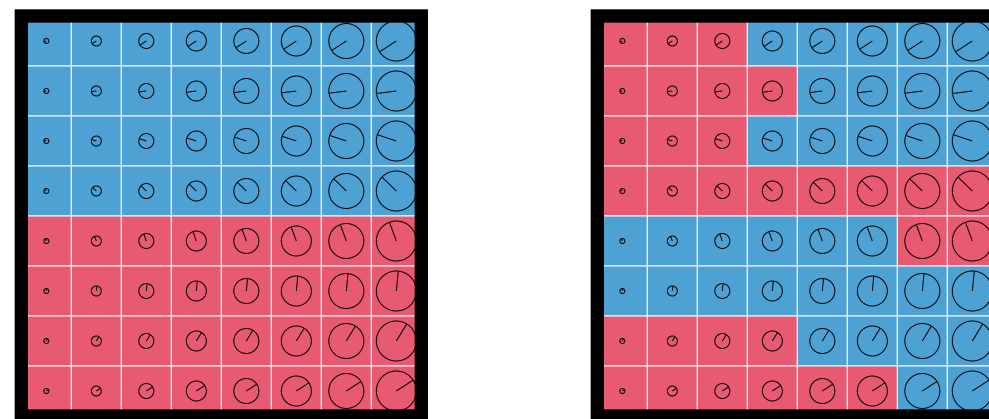
Communication
Pressure for informativeness



What makes language informative?

Expressivity A system of many categories is more informative than a system of few categories

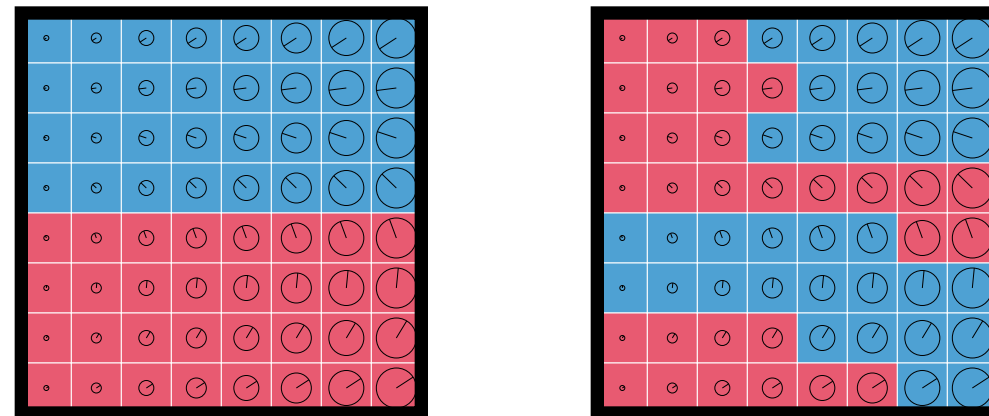
Convexity A system of convex categories is more informative than a system of nonconvex categories



What makes language informative?

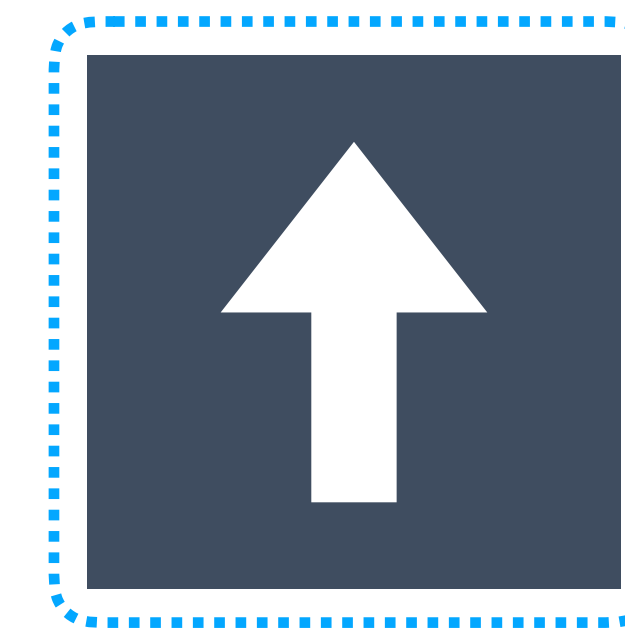
Expressivity A system of many categories is more informative than a system of few categories

Convexity A system of convex categories is more informative than a system of nonconvex categories



Learning
Pressure for simplicity

Communication
Pressure for informativeness



Carstensen et al.



Conclusions

The pressure from learning yields simple languages, but this can manifest itself through multiple semantic properties:

Expressivity Loss of words/categories to aid learning

Convexity Reorganization of the meaning space to aid learning

The pressure from communication has the same effect on convexity as learning does, making it difficult to identify the causal mechanism.

In iterated learning, the pressure for simplicity favours semantic category systems that are convex – informativeness comes along for the ride.

Thanks!