DST GROUP

DEFENCE INNOVATION NETWORK
To go far, go together

NSW RURAL FIRE SERVICE

WESTERN SYDNEY UNIVERSITY

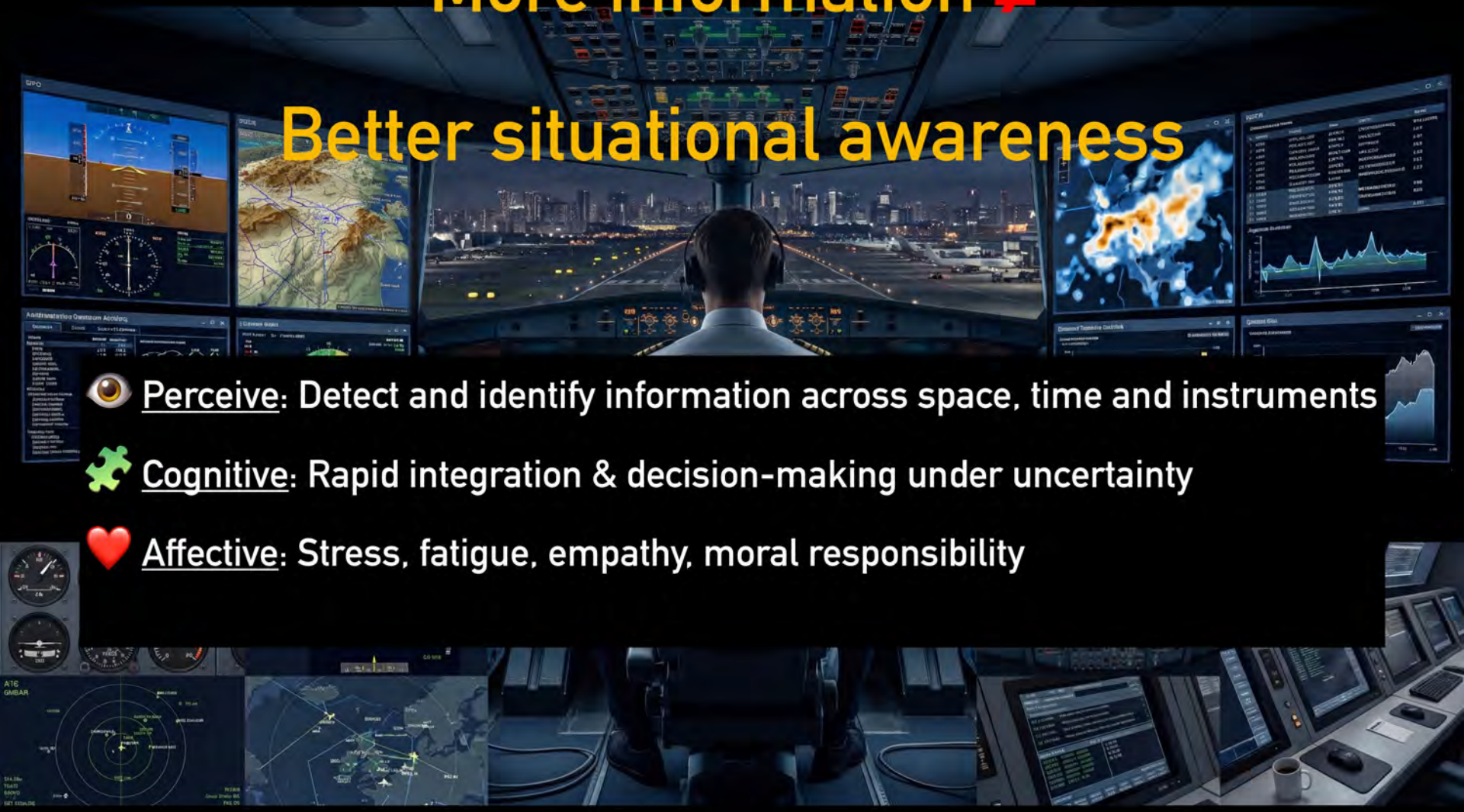
OPTIMISING THE HUMAN FACTORS IN ADVANCED AIR MOBILITY

Designing aerospace interfaces around the human nervous system

John Cass, Kate Stevens, Chris Stanton, Manuel Varlet

More information ≠

Better situational awareness



👁️ Perceive: Detect and identify information across space, time and instruments

🧩 Cognitive: Rapid integration & decision-making under uncertainty

❤️ Affective: Stress, fatigue, empathy, moral responsibility

Associate Professor John Cass | Western Sydney University

The biological design space



WHAT?

Does it signify the intended information?

WHERE?

Can it be resolved and individuated?

HOW MUCH?

How much information can be integrated and evaluated?



WHAT ELSE?

Cognitive load

What other operations compete for resources?



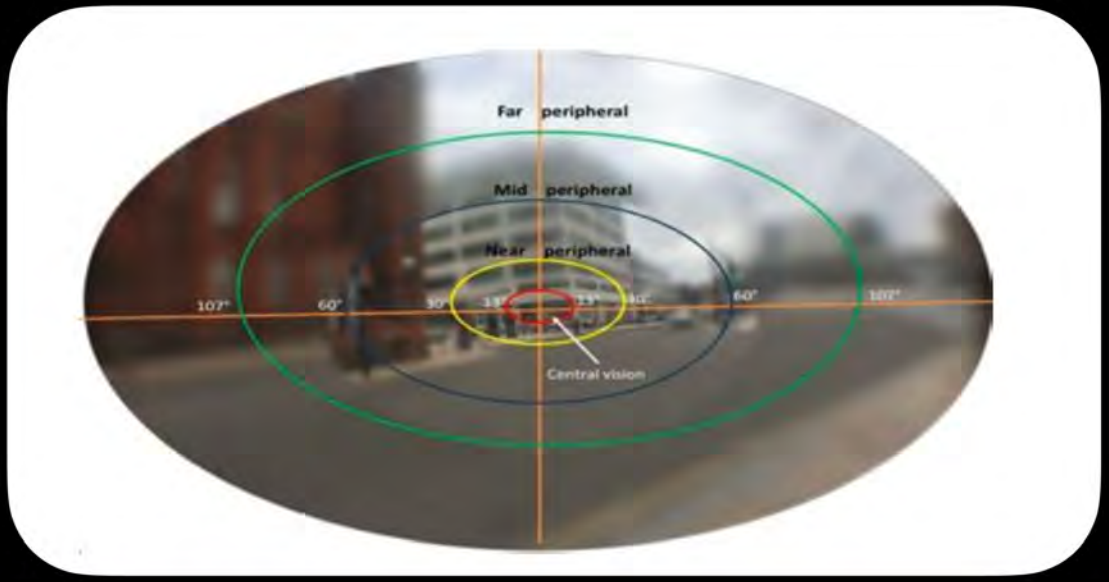
WHAT MATTERS NOW?

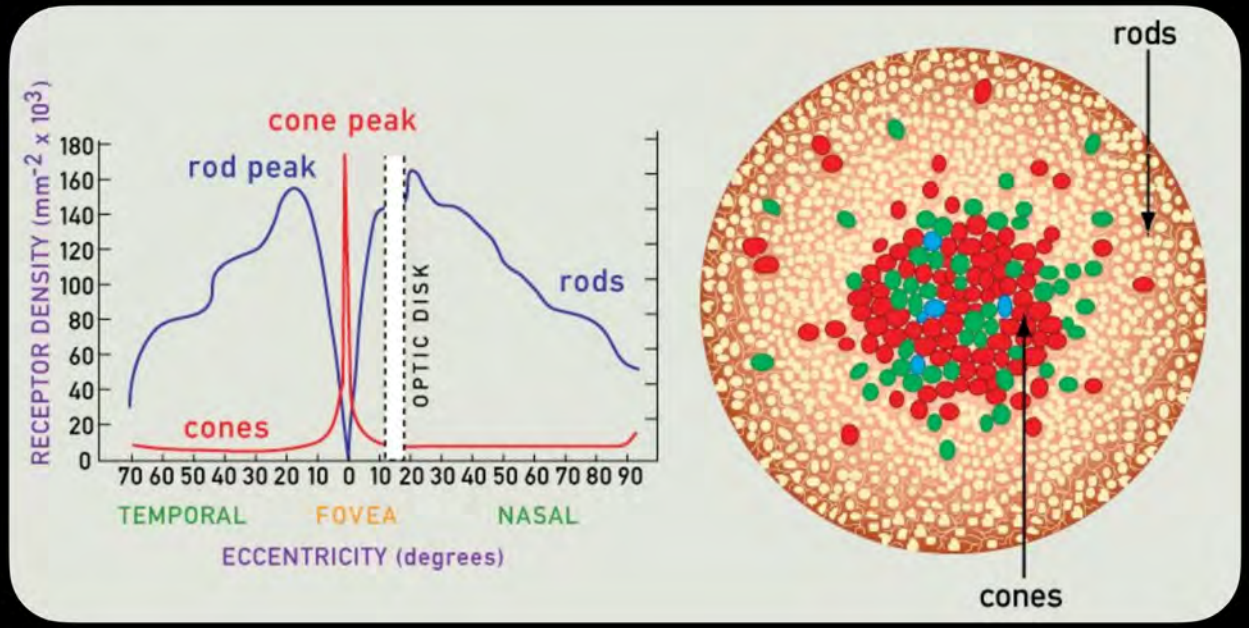
How does consequence alter resource allocation?



Each can be measured parametrically. Each becomes a design variable

WHERE? Vision is not a camera





Visual crowding: Clutter

A

+

Fixate here

N

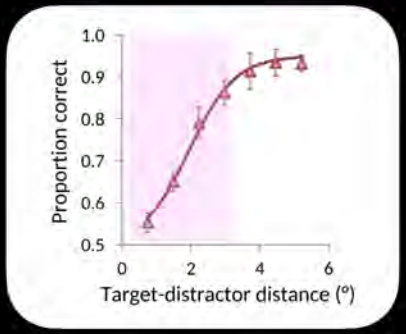
Y A W

V

Interference zone

Disrupts object identification, not detection

"*Something* is happening here but you don't know *what* it is" - Bob Dylan



Visual crowding: Clutter



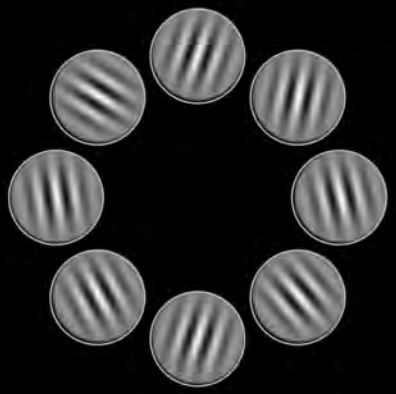
HOW MUCH?

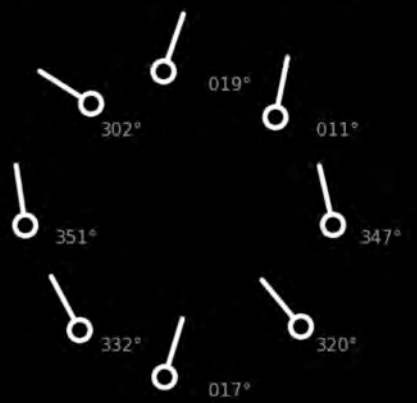
Visual averaging task

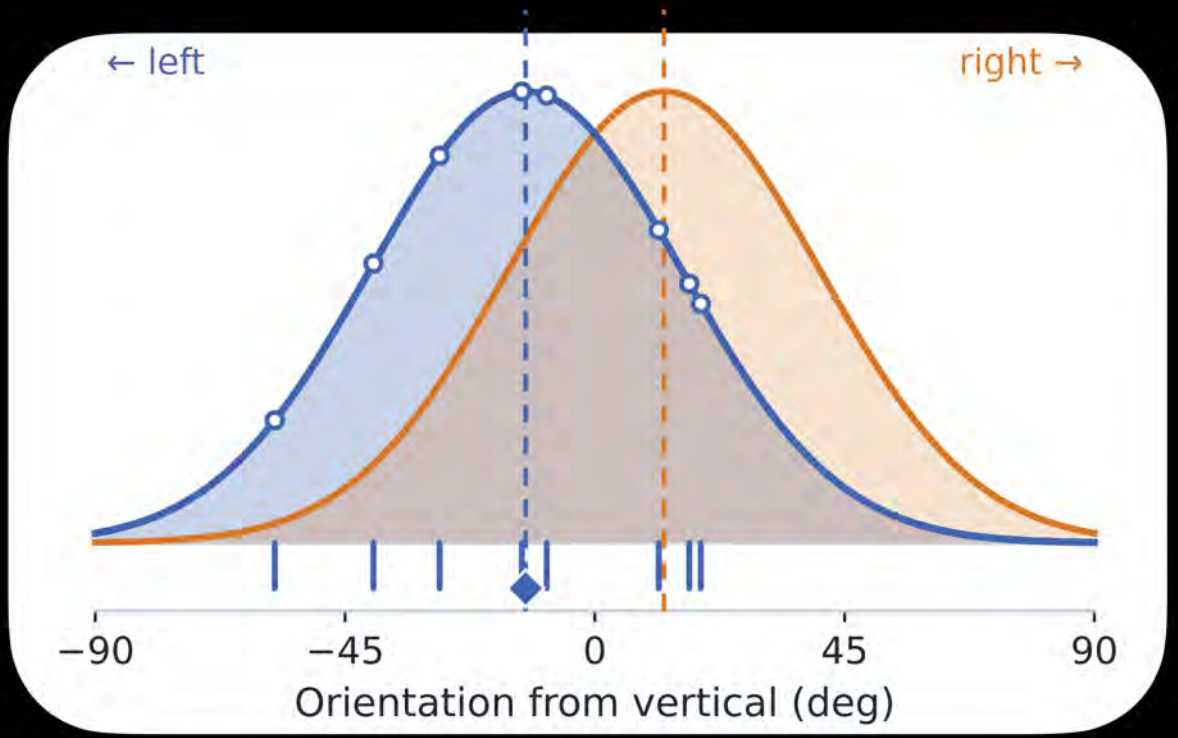
Anticlockwise or clockwise re. vertical?

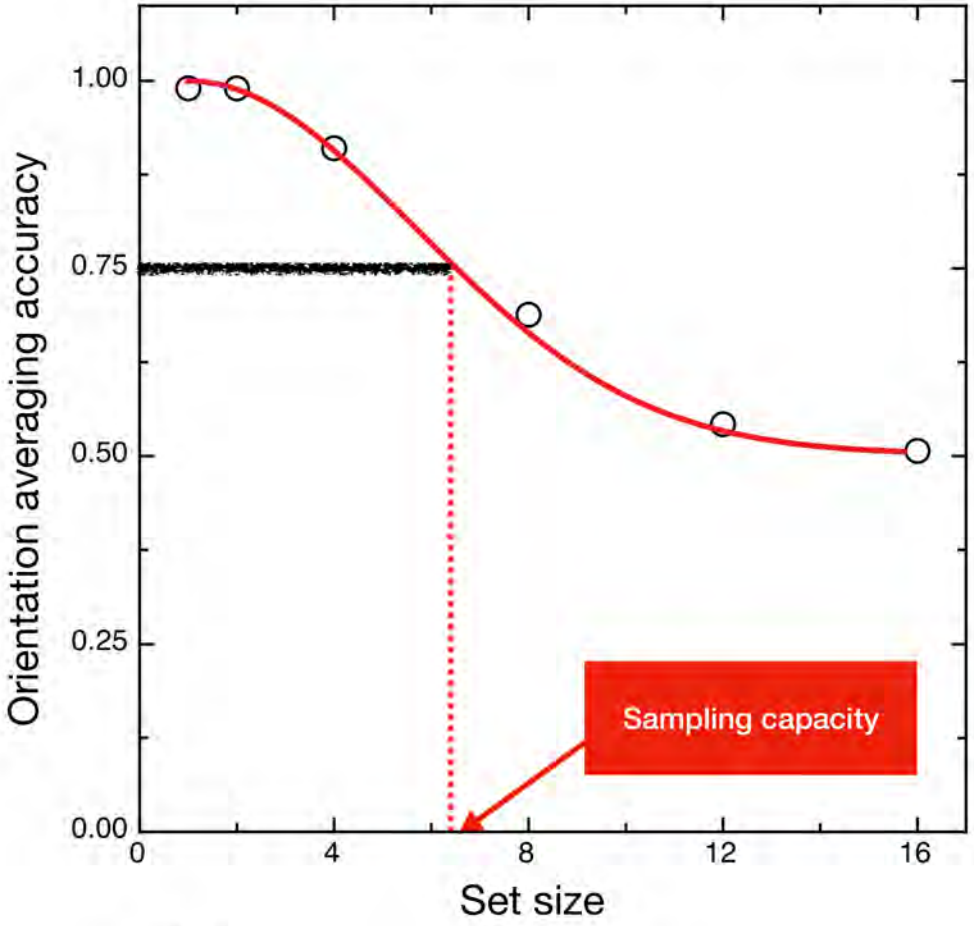
Fixed $\mu = \pm 12.46°$

Fixed $\sigma \approx 28°$

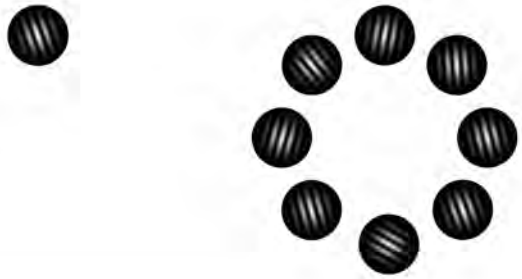






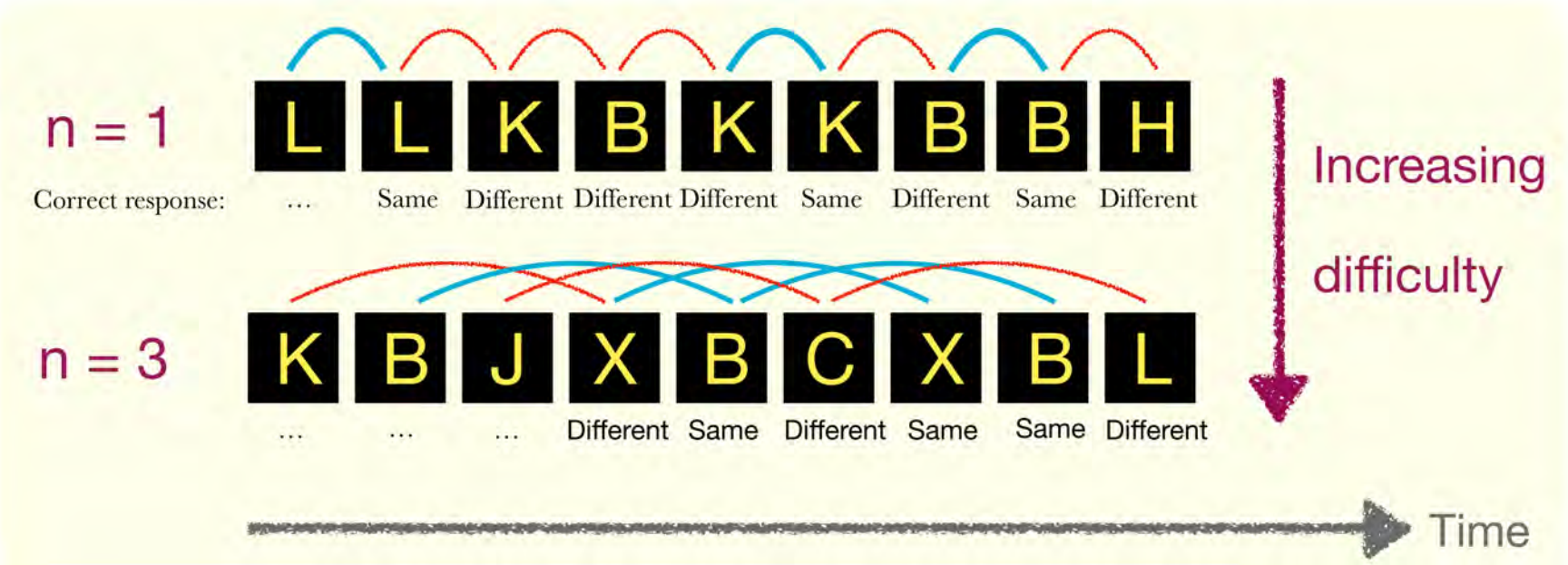

Orientation averaging accuracy
1.00
0.75
0.50
0.25
0.00
0
4
8
12
16
Set size
Sampling capacity

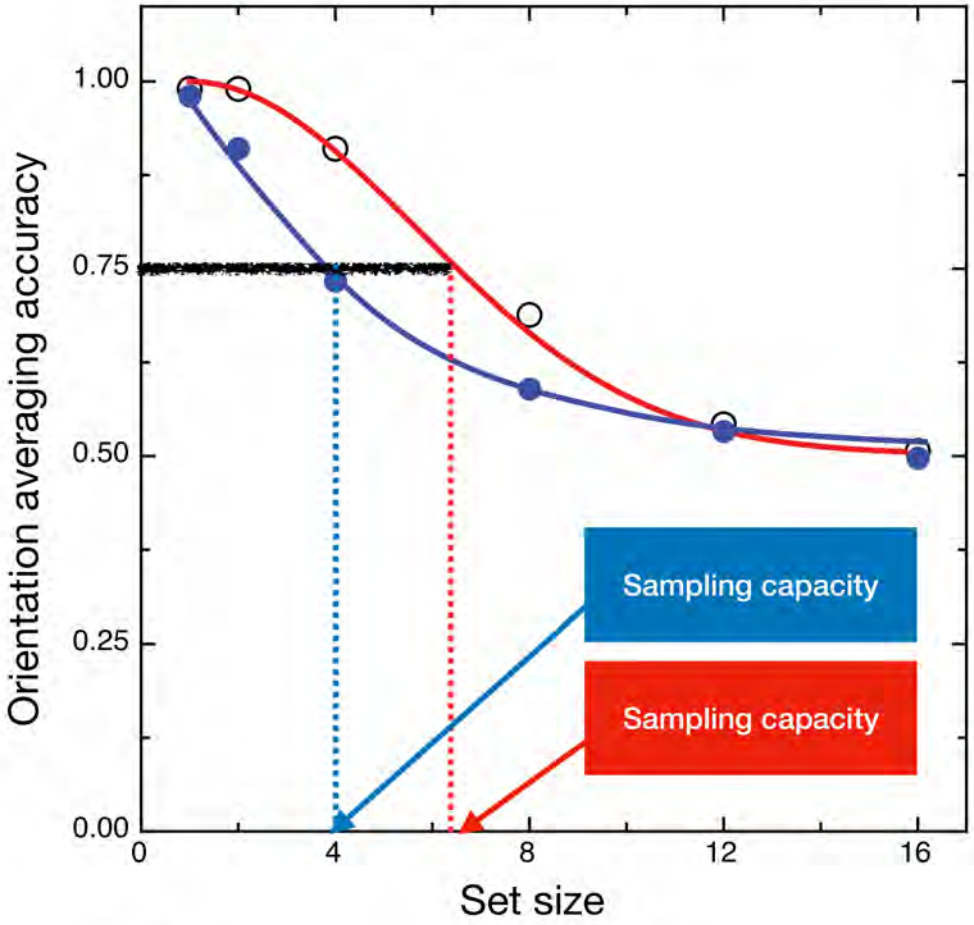
No load



WHAT ELSE?

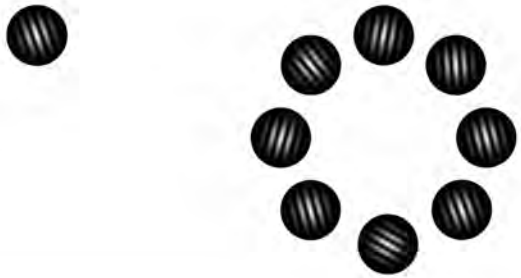
Concurrent working memory task





No load

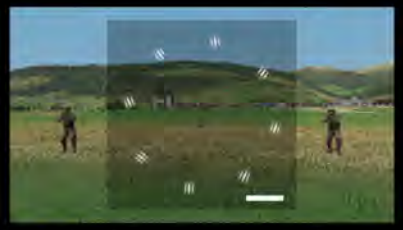
Working Memory load



Perceptual task

Cognitive task

Perceptual task error -> Shock



Task: Average orientation
(Enemy Left vs Right?)

Shooting response

Correct

Incorrect

Shock

N-back task

Task: Single letter
(Current Same or different?)

Button press response

Correct

Incorrect

Cognitive task error -> Shock



Shooting response

Correct

Incorrect

N-back task

Button press response

Correct

Incorrect

Shock

Either task errors -> Shock



Shooting response

Correct

Incorrect

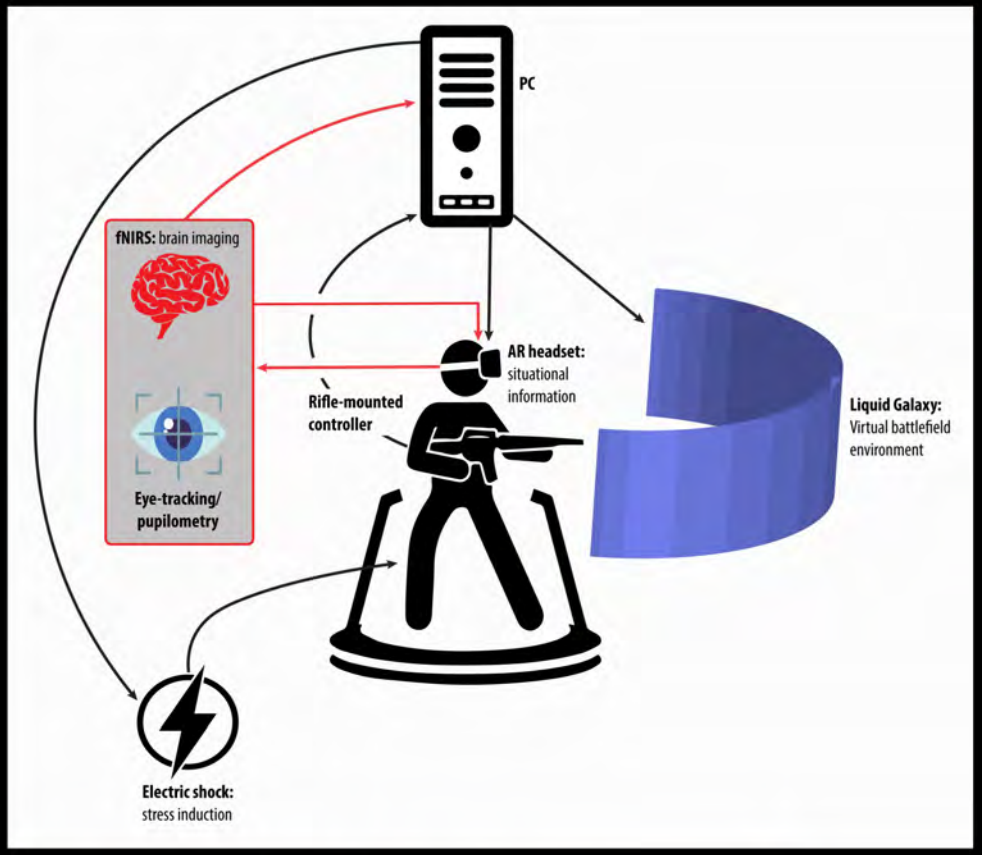
Shock

N-back task

Button press response

Correct

Incorrect

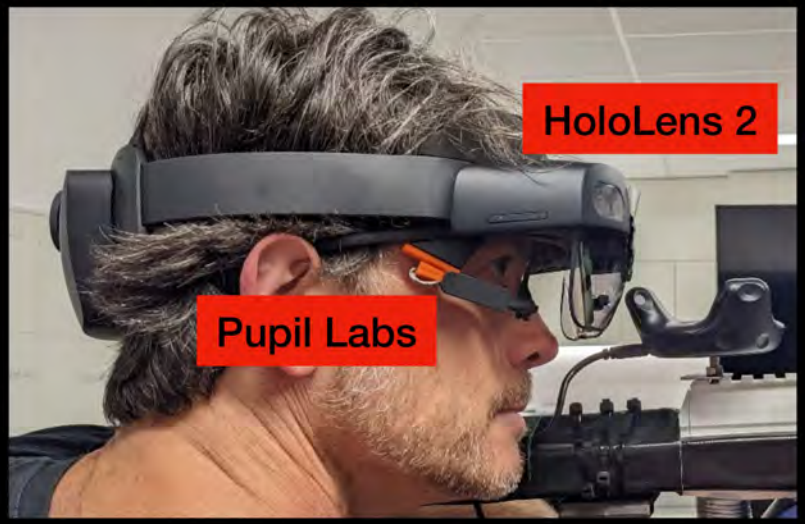


DST GROUP

DEFENCE INNOVATION NETWORK
to go far, go together



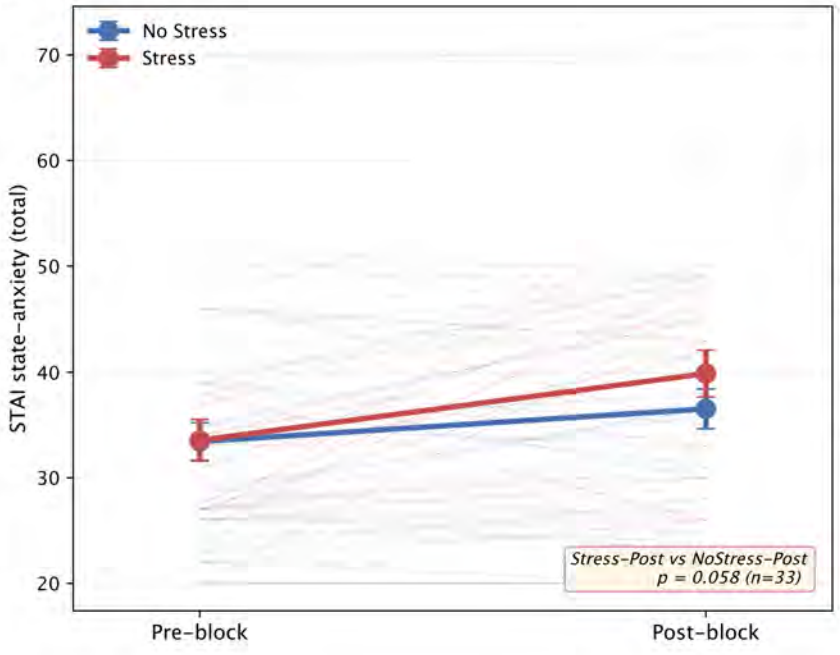


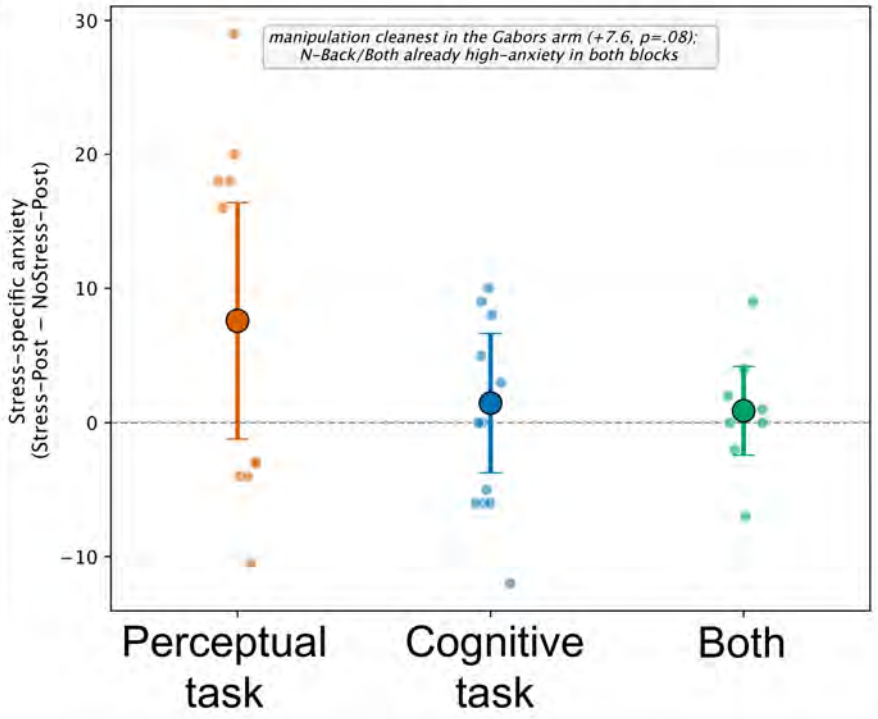




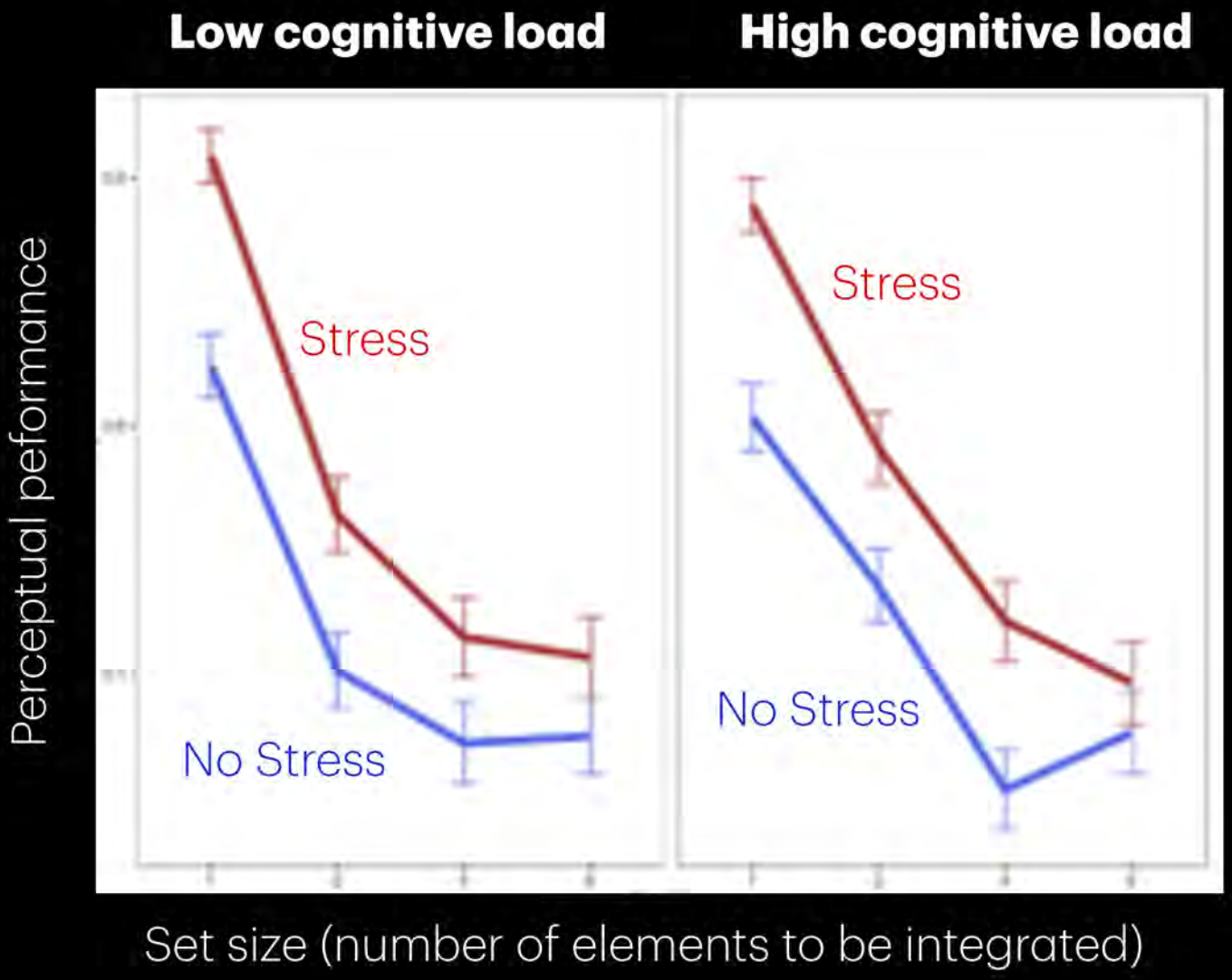


Subjective stress (STAI)

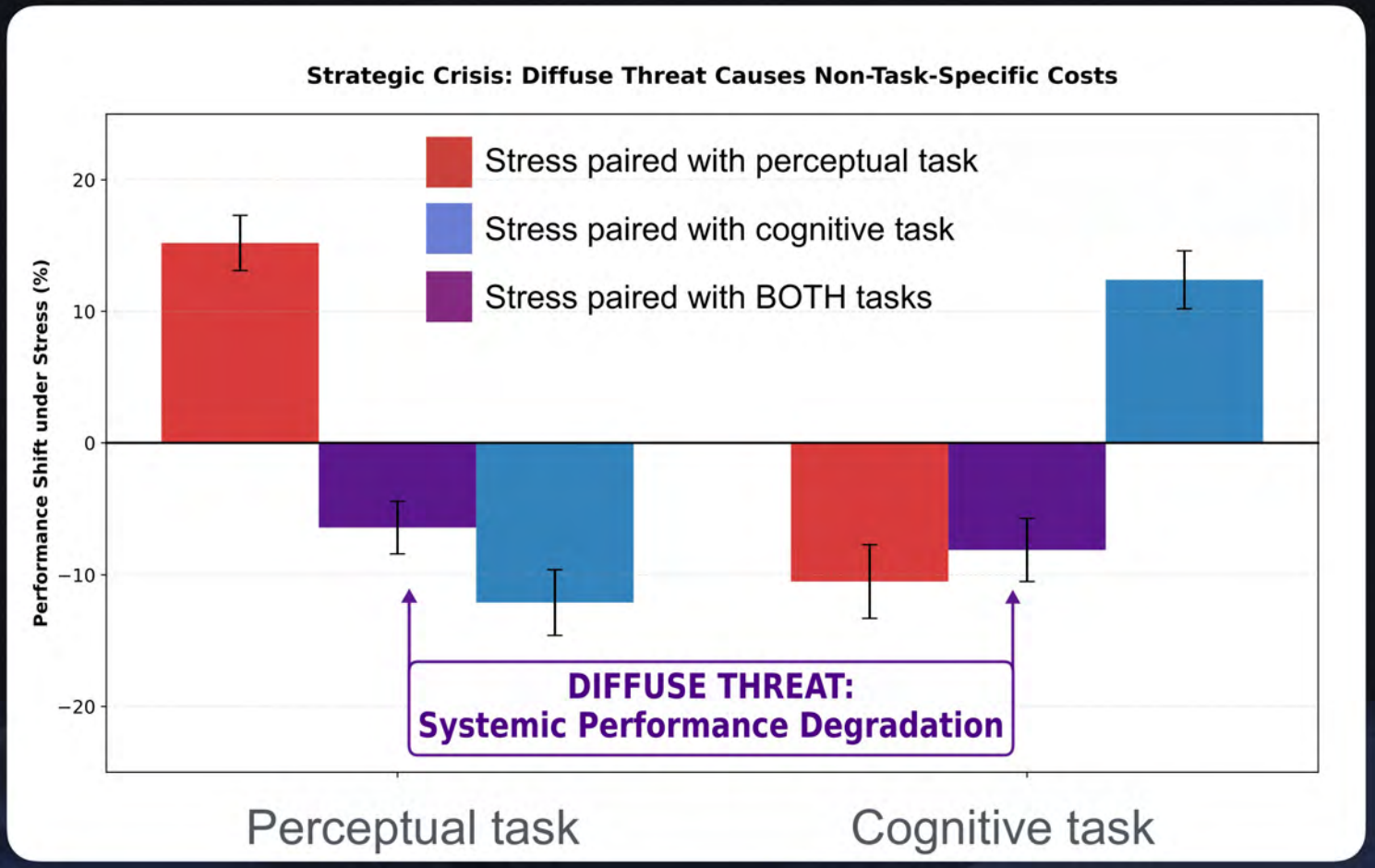




Effects of stress on perceptual performance



Stress: Beyond raw capacity



Under diffuse threat ->

Brain cannot effectively decide what to ignore

Interface design



Problem:

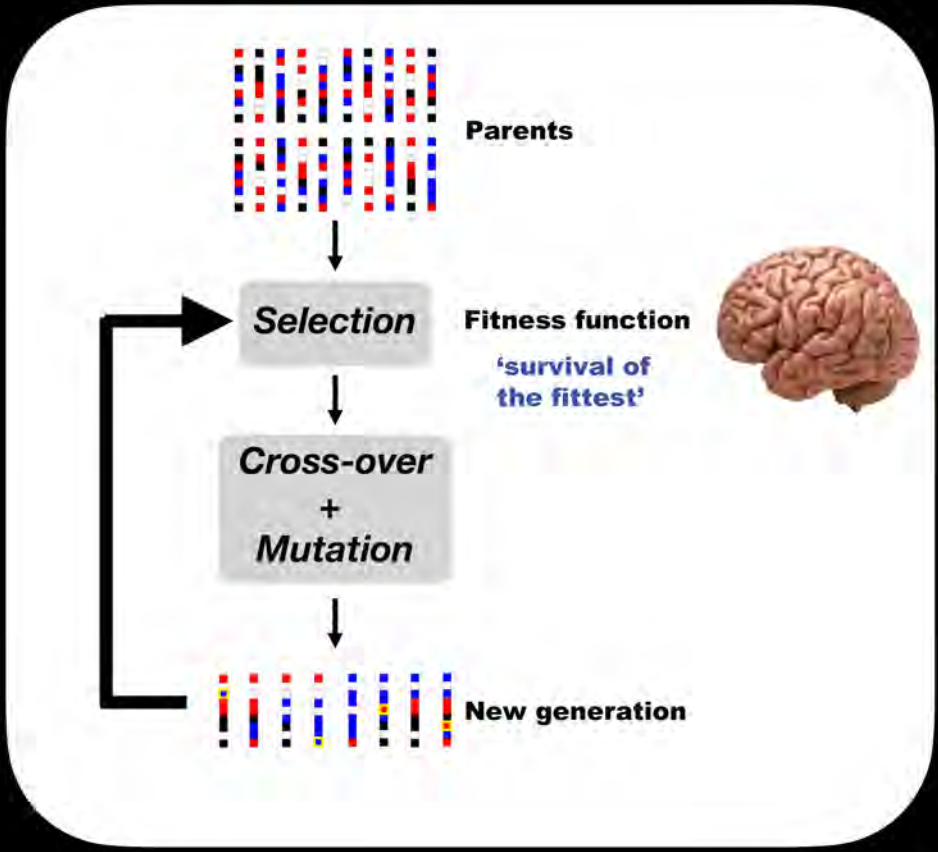
Search space is
astronomically large

Manual intuition, design principles,
neuroscientific models,
and factorial testing can only explore
a tiny fraction

Solution: Evolutionary Design Engine

Process

1. Generate structured populations of stimulus variants.
2. Measure biological performance (RT, accuracy).
3. Apply selection
4. Breed the next generation
5. Iterate across generations

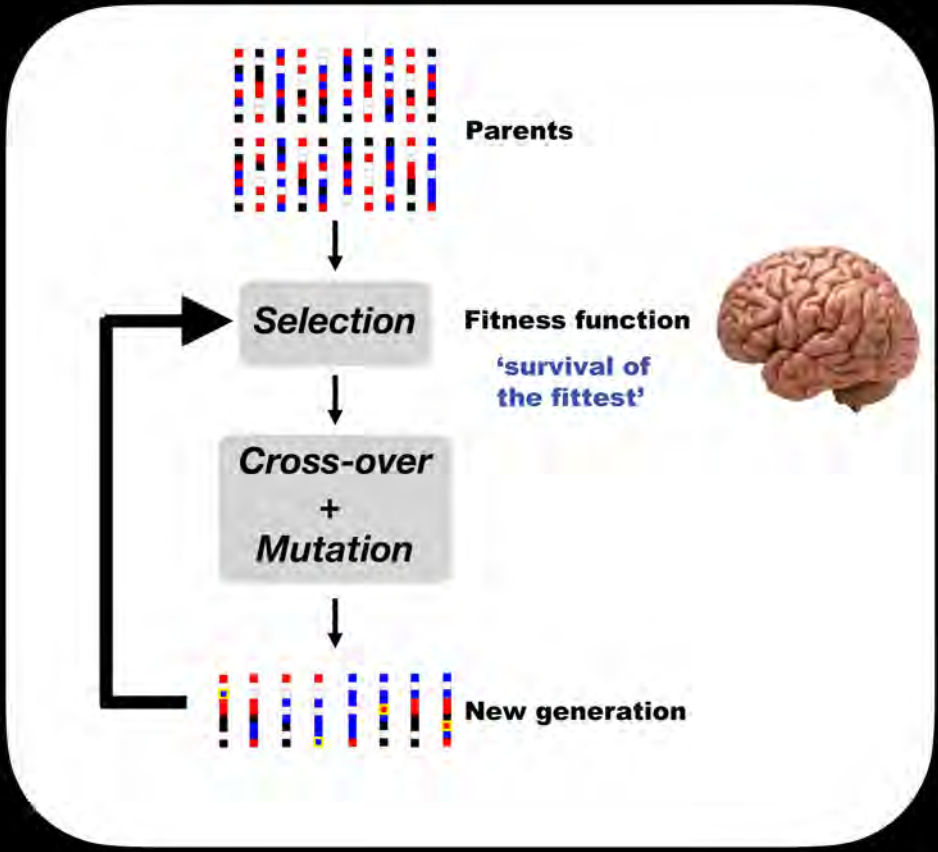


Solution: Evolutionary Design Engine

Efficiently and reliably converges on optimal solutions

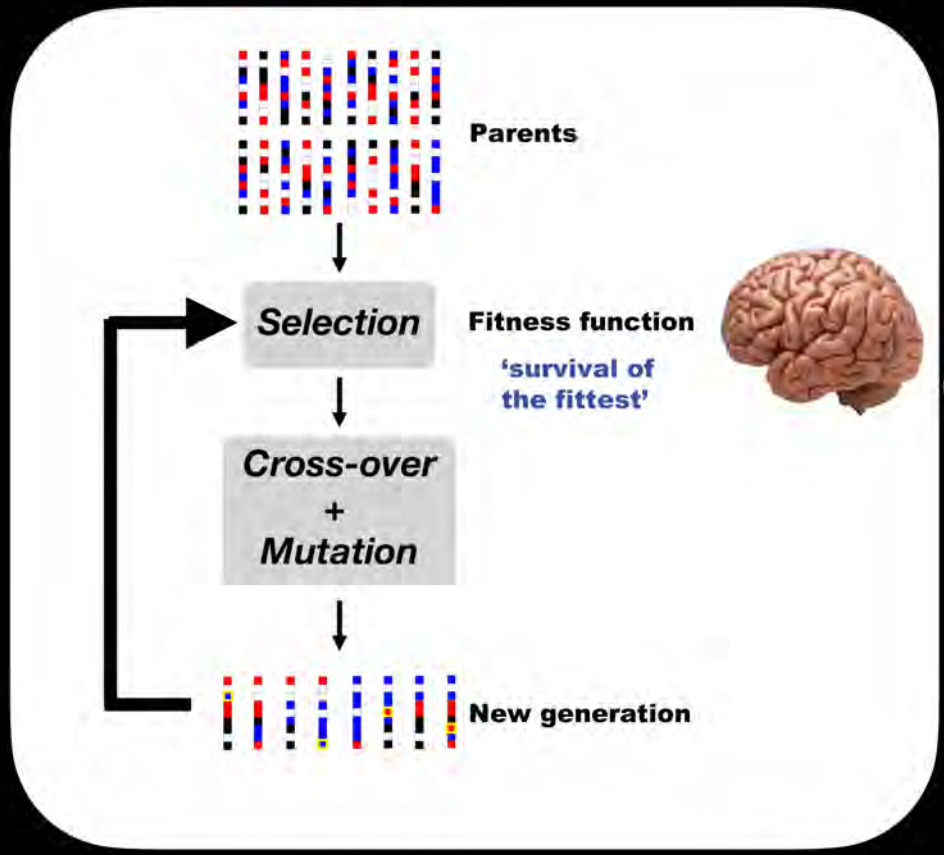
Design driven by performance

What *actually* works



Evolutionary Interface Design Engine

Can be applied to any task(s) with a defined input parameter space & performance outcome



Visual object discrimination

Journal of Experimental Psychology:
Human Perception and Performance

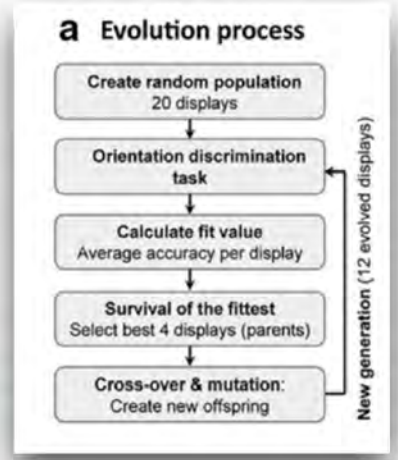
© 2017 American Psychological Association
0096-1523/17/$12.00 http://dx.doi.org/10.1037/xhp0000333

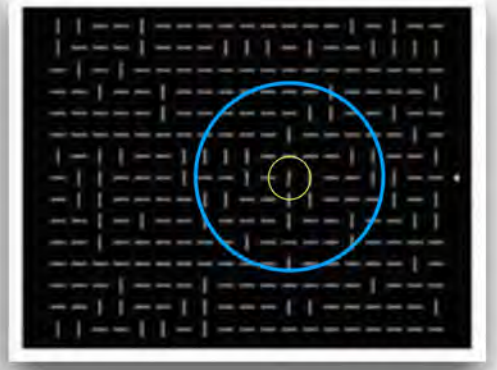
Evolving the Keys to Visual Crowding

Erik Van der Burg
University of Sydney and Vrije Universiteit Amsterdam

Christian N. L. Olivers
Vrije Universiteit Amsterdam

John Cass
Western Sydney University



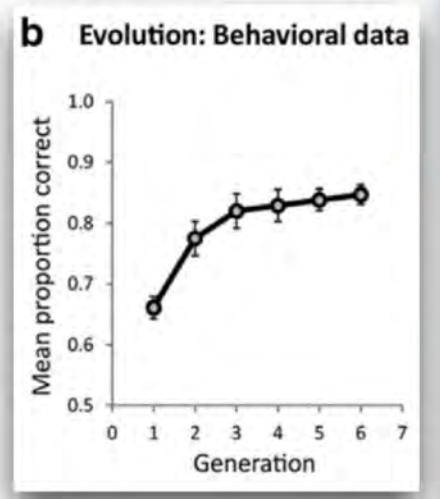


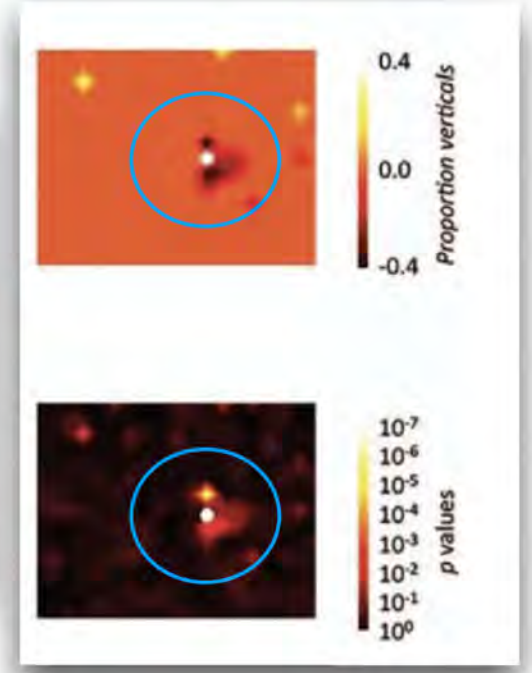
2 orientations, 284 distractors

$2^{284} = 3.108 \times 10^{85}$ possible combinations

10^{82}

Atoms in observable Universe





Visual search: Find

Journal of Vision (2015) 15(2):8, 1–15 http://www.journalofvision.org/content/15/2/8

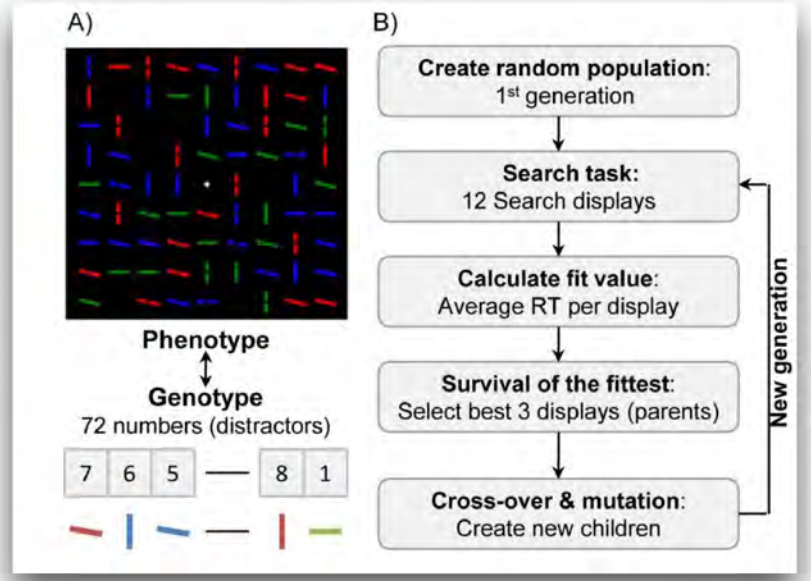
Evolving the stimulus to fit the brain: A genetic algorithm reveals the brain's feature priorities in visual search

Erik Van der Burg University of Sydney, Sydney, Australia; VU University, Amsterdam, the Netherlands

John Cass University of Western Sydney, Sydney, Australia

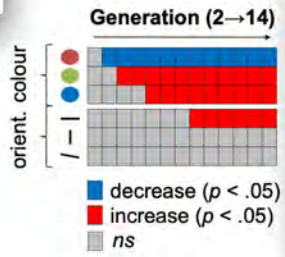
136 distractors: 8 possible orientation x colour combinations

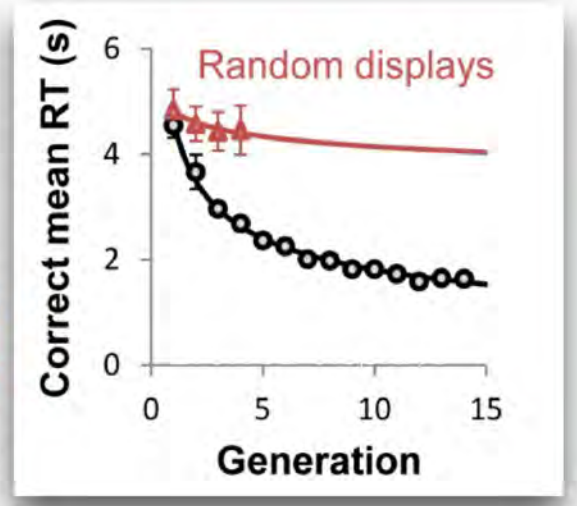
$8^{136} = 6.106 \times 10^{122}$ possible combinations

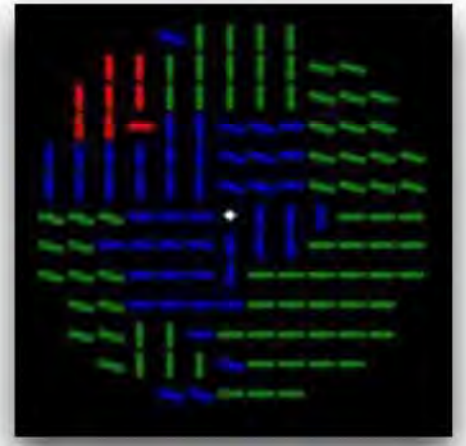


10^{82}

Atoms in observable Universe







Put the human nervous system inside the design loop

