CSC2524 L0101—TOPICS IN INTERACTIVE COMPUTING: INFORMATION VISUALISATION

VISUAL PERCEPTION

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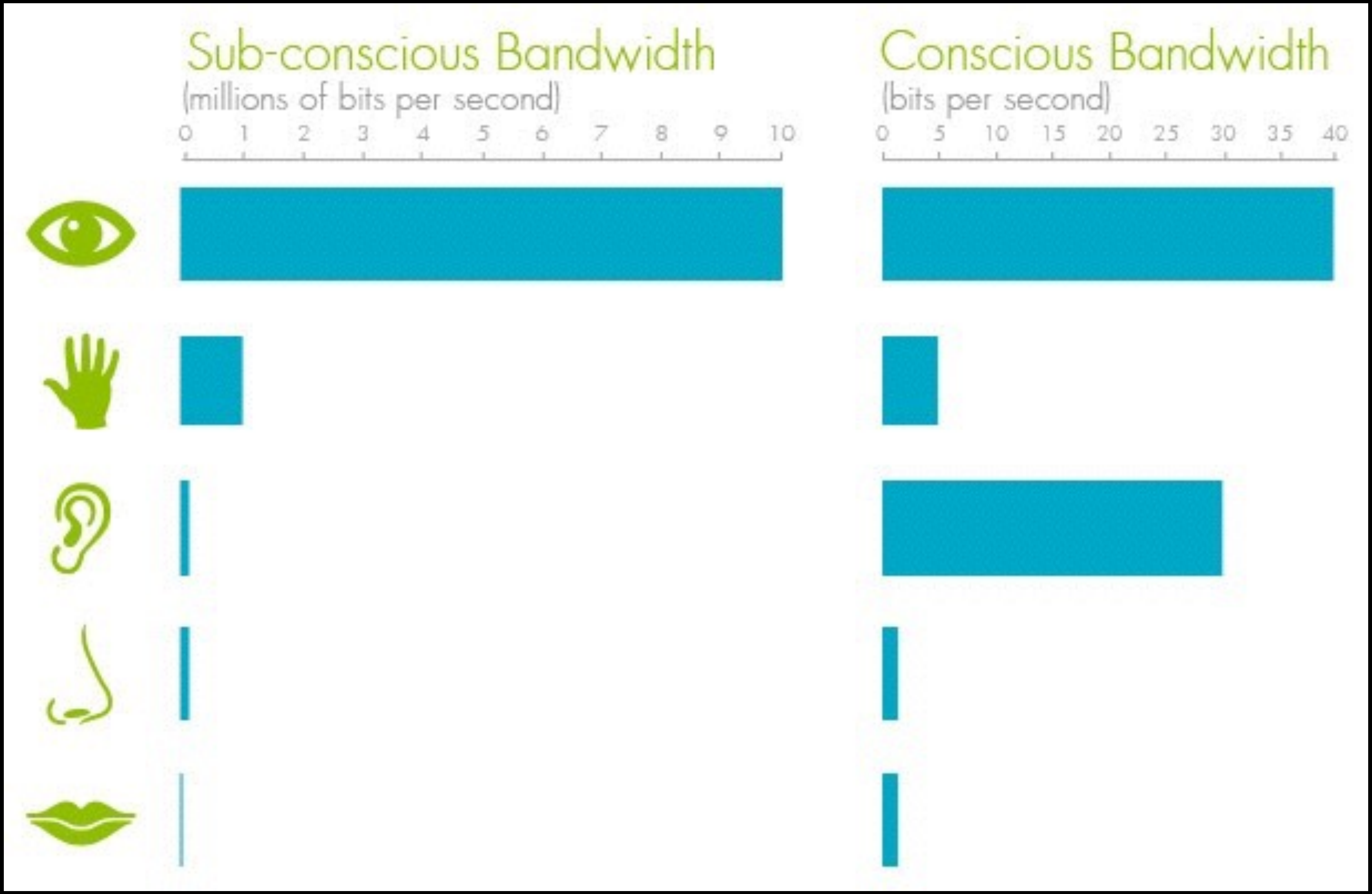
Inria

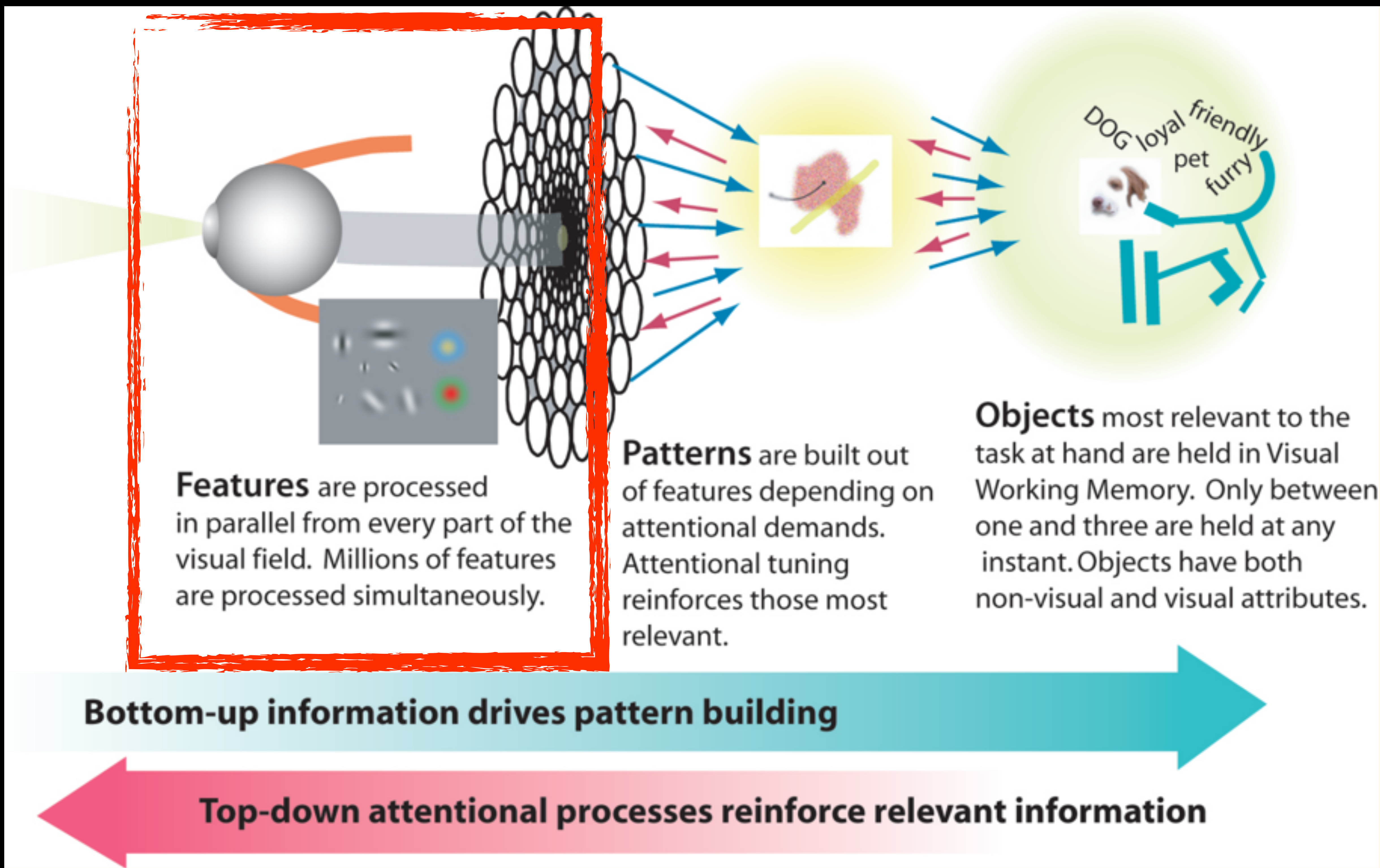
VISUAL PERCEPTION & COGNITION

KNOWING HOW WE PERCEIVE … TO BETTER REPRESENT



[Source: http://www.creativebloq.com/design/science-behind-data-visualisation-8135496]

MODEL OF PERCEPTUAL PROCESSING



[Source: Ware et al.]

VISION: PERCEPTUAL CONSTRAINTS

Temporal perception

- reaction time: 200ms to initiate a conscious observation
- stimuli <100ms apart are not perceived

Visual acuity

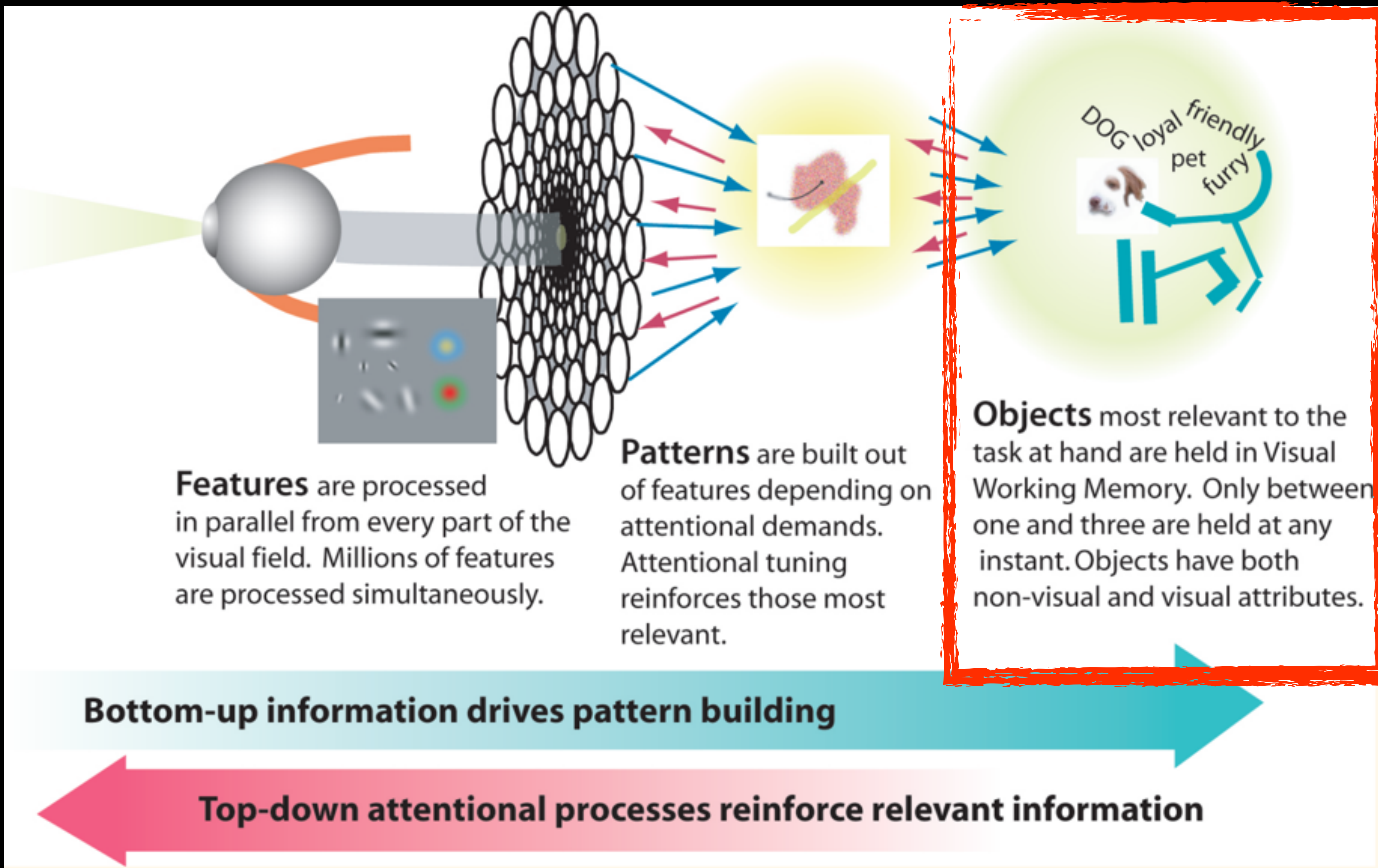
- Lines can be detected from 0.5″
- Distance between two lines from 30″ to 1′

Implications for Information Visualisation

- Animations should have cycles > 1/10° seconds
- Large datasets: guarantee that the data displayed remains above limits

arcminute (′) = 1/60 of one degree. arcsecond (″) : 1/60 of one arcminute

MODEL OF PERCEPTUAL PROCESSING

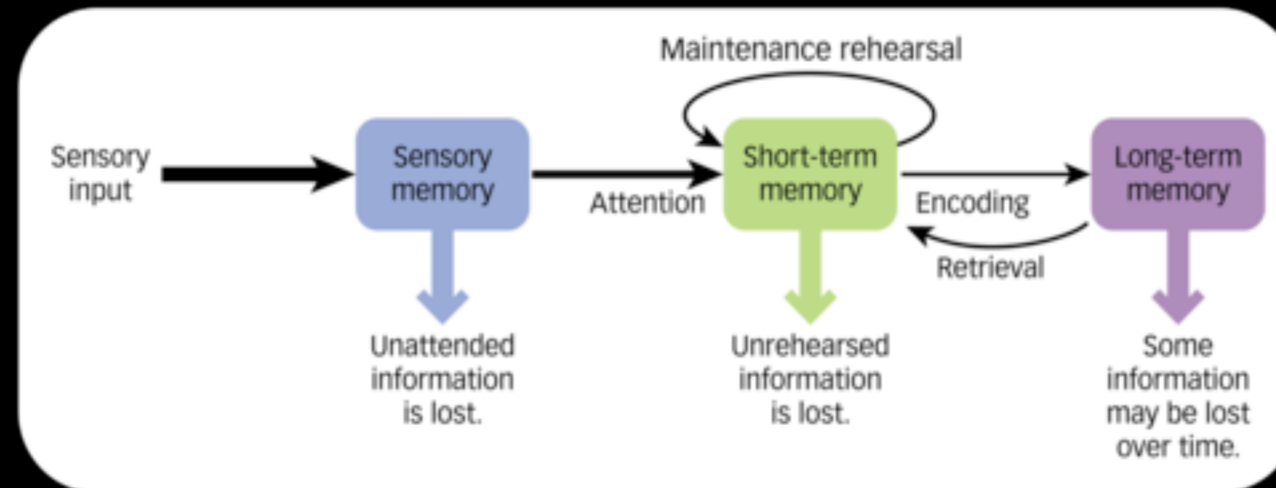


[Source: Ware et al.]

COGNITION & VISION: COGNITIVE LOAD

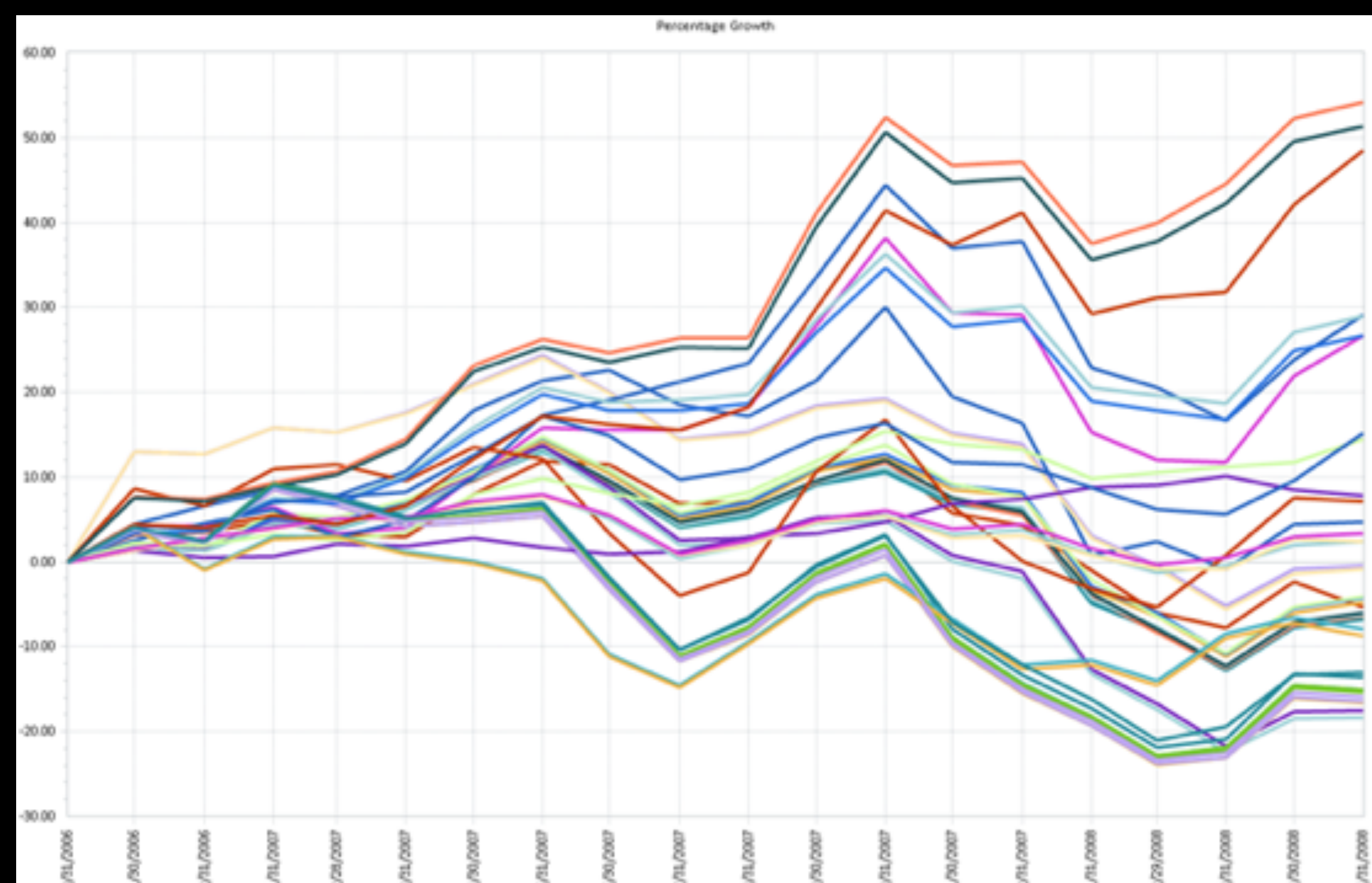
Problems with cognitive load

- **short-term memory** = working memory
- **memory span** is limited : [Miller 1956]
  7 ± 2 *independent* memorable items
- Critical for visualization of large datasets



Implications for Infovis

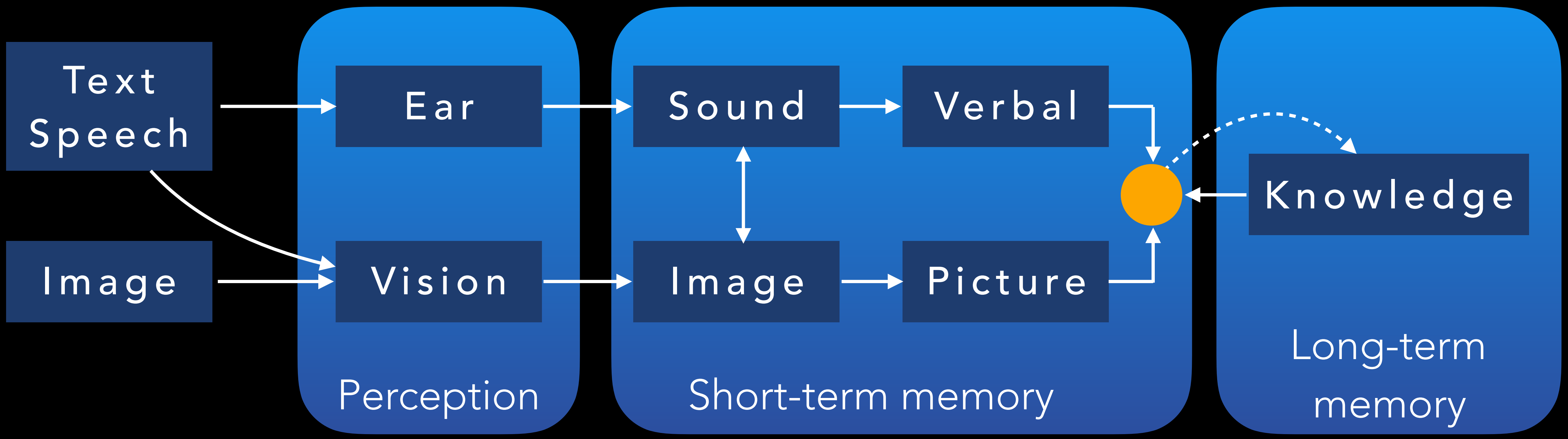
- Group, aggregate in ***chunks*** (analogy: phone numbers)
- Never require to compare more than 3 independent elements at a time



COGNITION & VISION: COGNITIVE LOAD

Cognitive load : workarounds

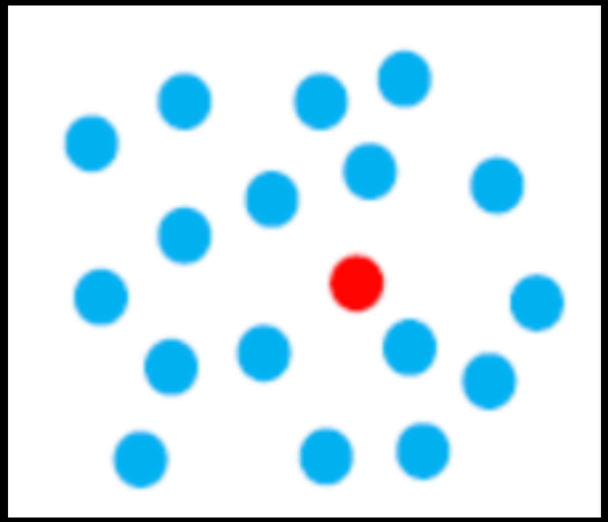
- **Multimodality** to limit cognitive overload
- Multimodality —> different cognitive pathways (i.e. visuospatial sketch pad, phonological loop, episodic buffer) [Baddeley A., Wilson B.A., 2002]

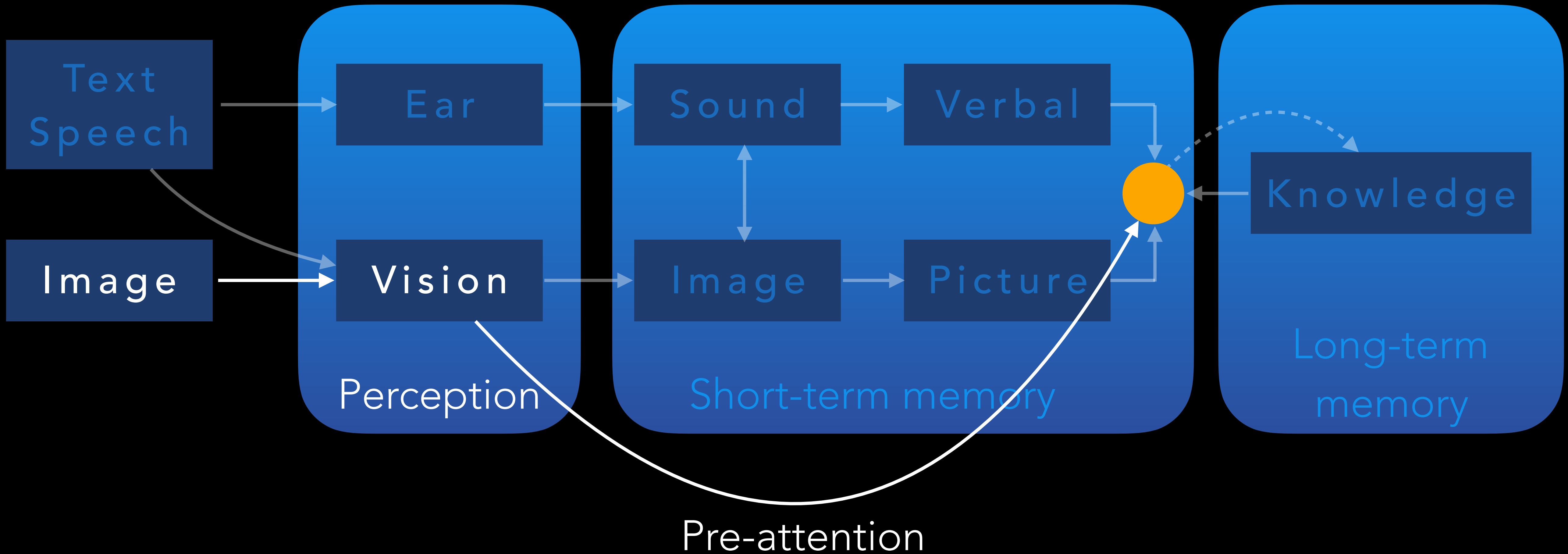


- **Pre-attentive perception**

PRE-ATTENTIVE PERCEPTION [Treisman & Gormican, 1988]

- Some visual features are processed pre-attentively, e.g. without focusing attention
- Low-level (unconscious) cognitive processes
- Reduced reaction time: <200ms (eyes movement > 200ms)
- Witness of our evolutionary story





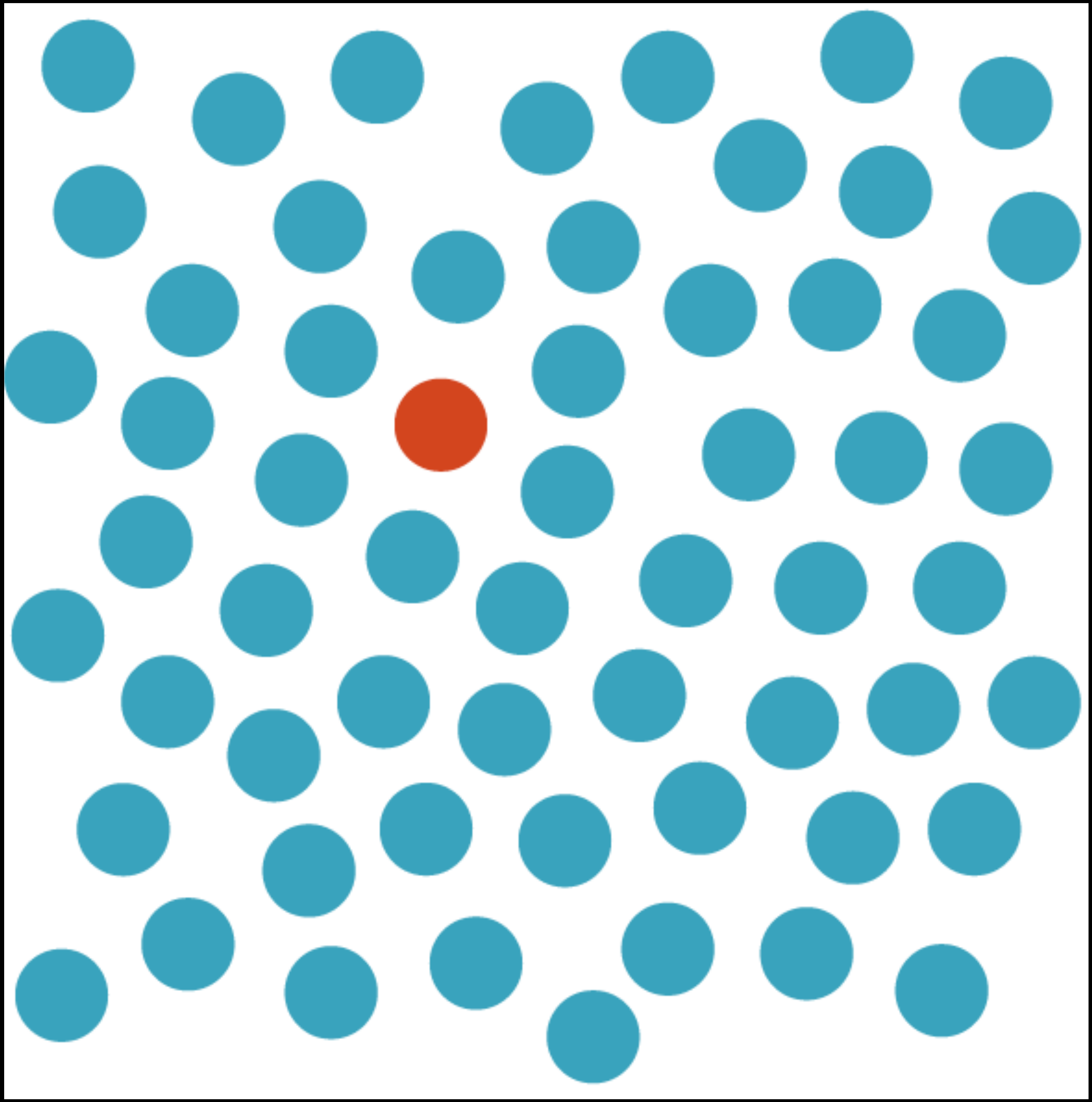
PRE-ATTENTIVE PERCEPTION [Treisman & Gormican, 1988]

- Some visual features are processed pre-attentively,
  e.g. without focusing attention

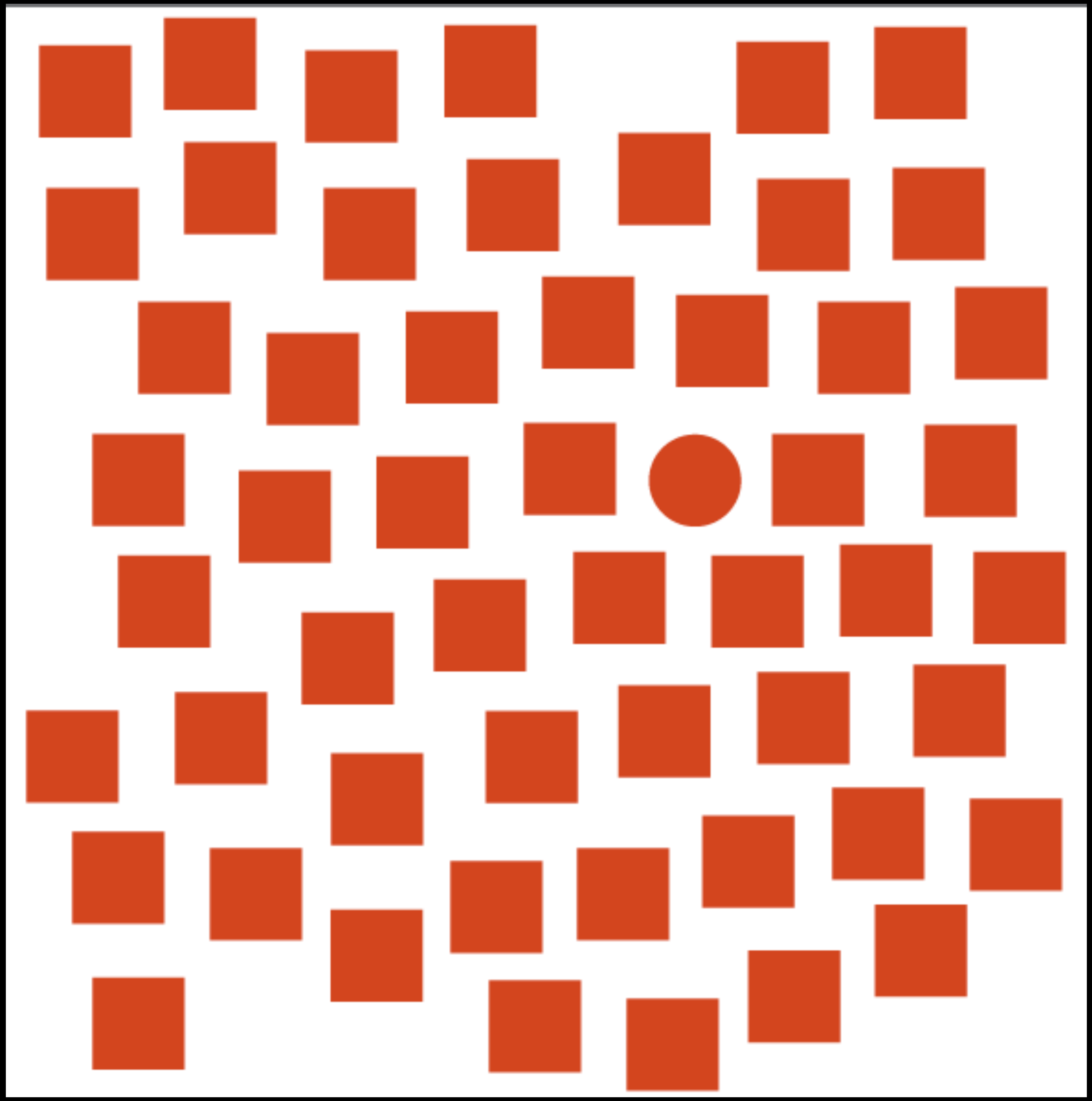
Implications for Information Visualisation

- No cognitive load
- Direct processing : what must be perceived immediately

Is there a red circle?

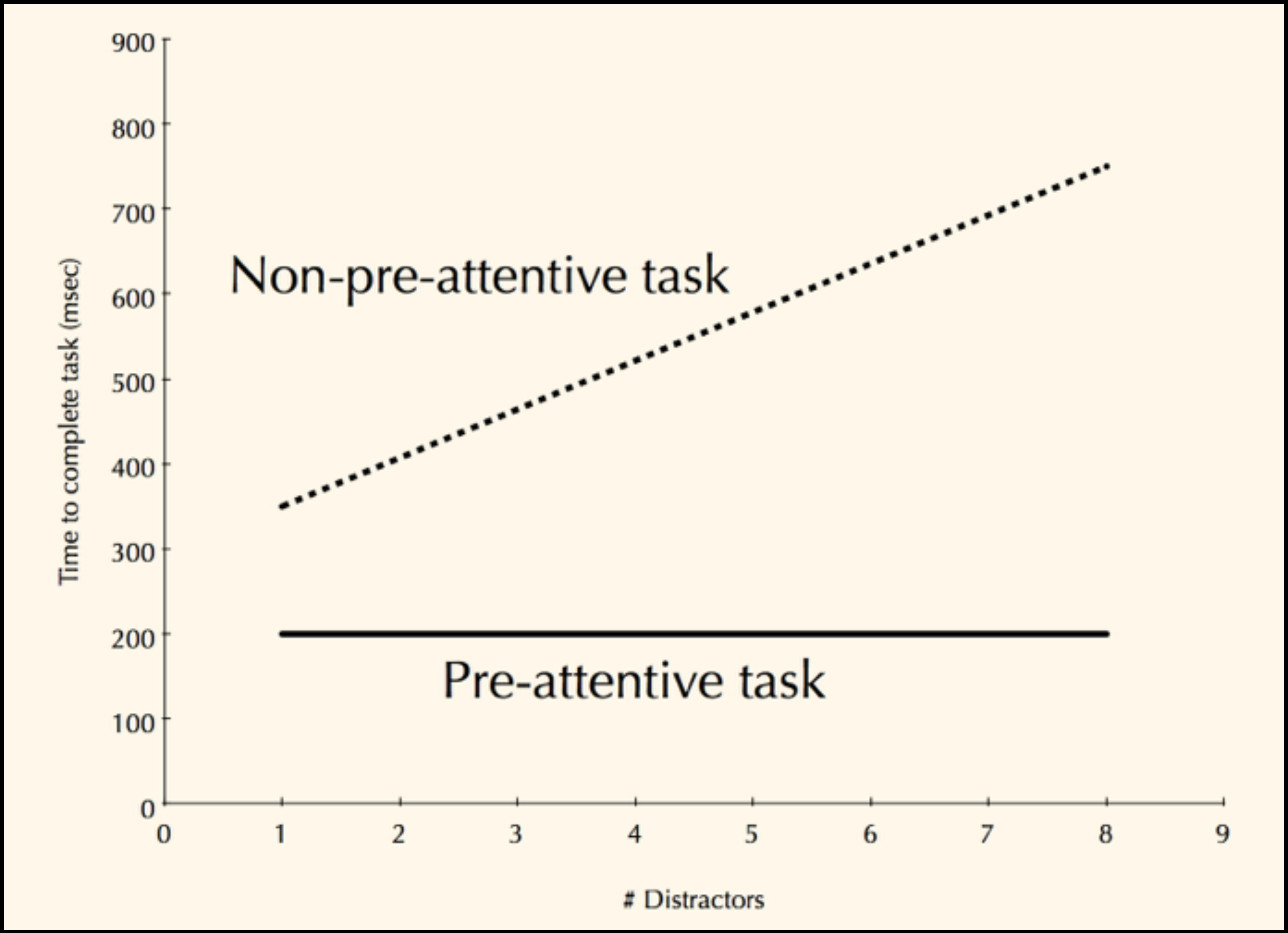


Is there a red circle?



PRE-ATTENTIVE PERCEPTION

Takes the same amount of time, regardless of the number of distractors



[Slide inspired by J. Wirz & S. Bedrid course material]

Find the 3's

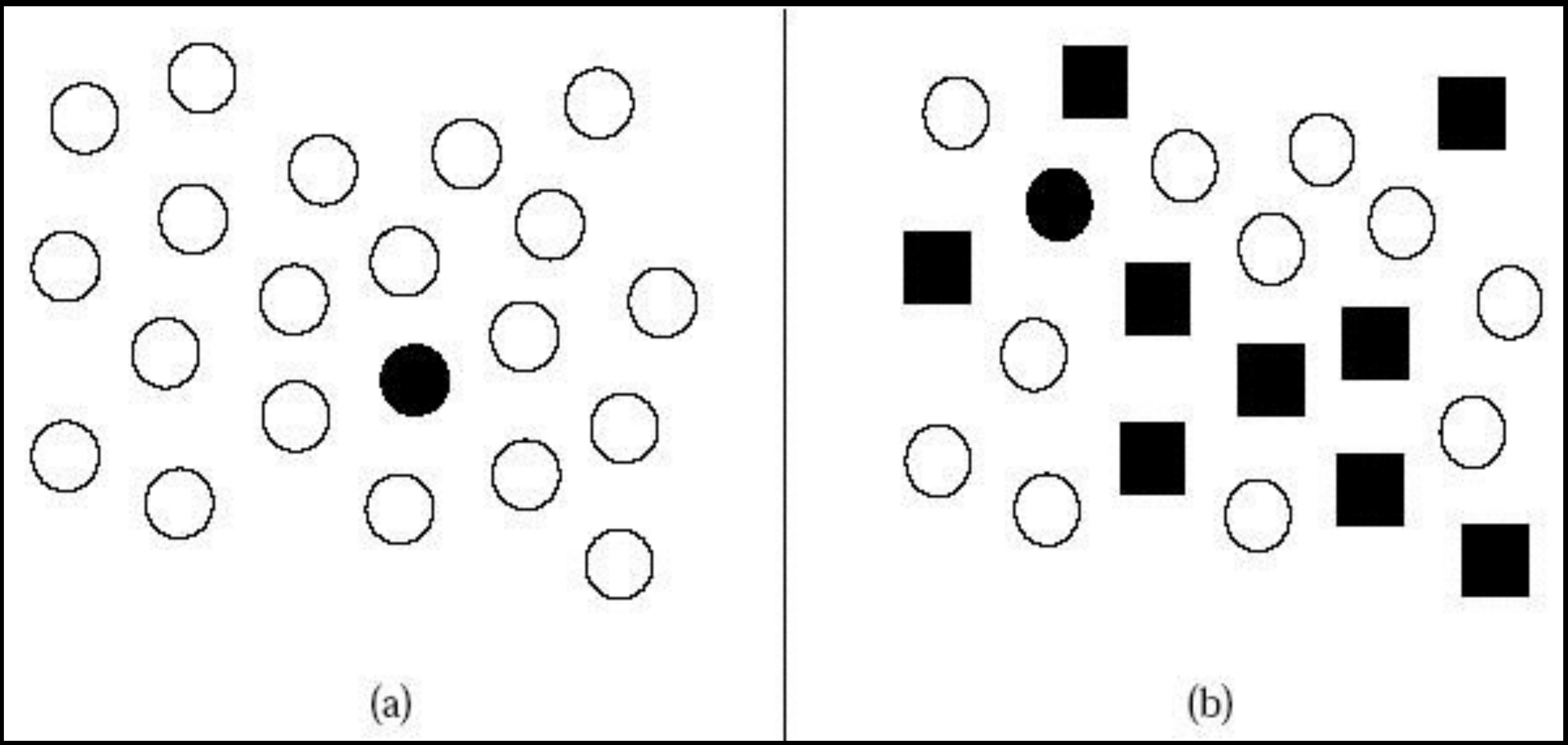
142416496357598475921765968474891728482
285958819829450968504850695847612124044
074674898985171495969124567659608020860
608365416496457590643980479248576960781
285960799918712845268101495969124567781
874241649645757659608149596912456701285
960799164964575127879918712845298496912
223591649645759588198250963576596080596

Find the 3's

142416496357598475921765968474891728482
285958819829450968504850695847612124044
074674898985171495969124567659608020860
608365416496457590643980479248576960781
285960799918712845268101495969124567781
874241649645757659608149596912456701285
960799164964575127879918712845298496912
223591649645759588198250963576596080596

PRE-ATTENTIVE PERCEPTION

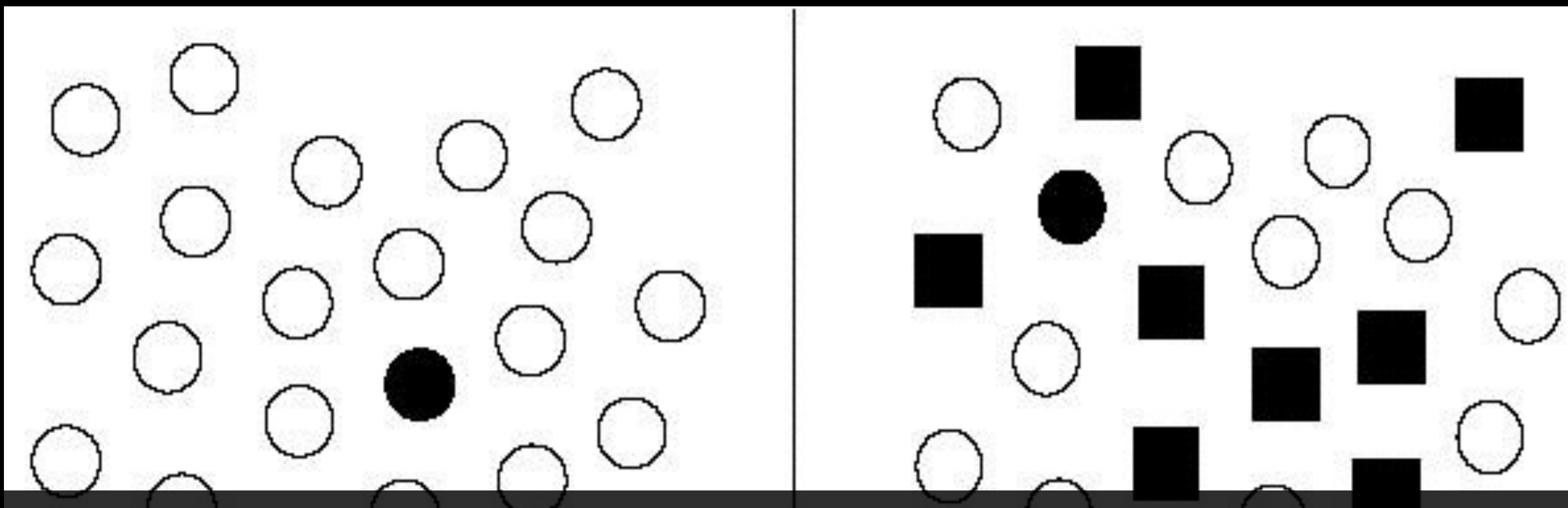
Only works when the distractors differ from one feature:



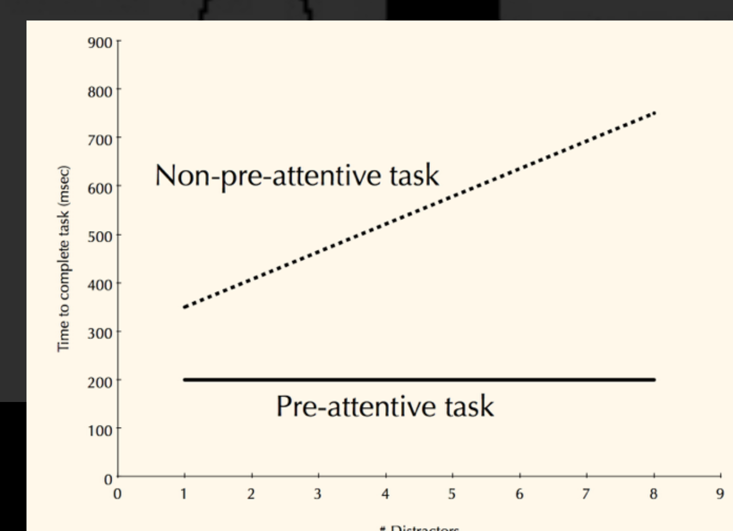
[Healey et al., 1996]

PRE-ATTENTIVE PERCEPTION

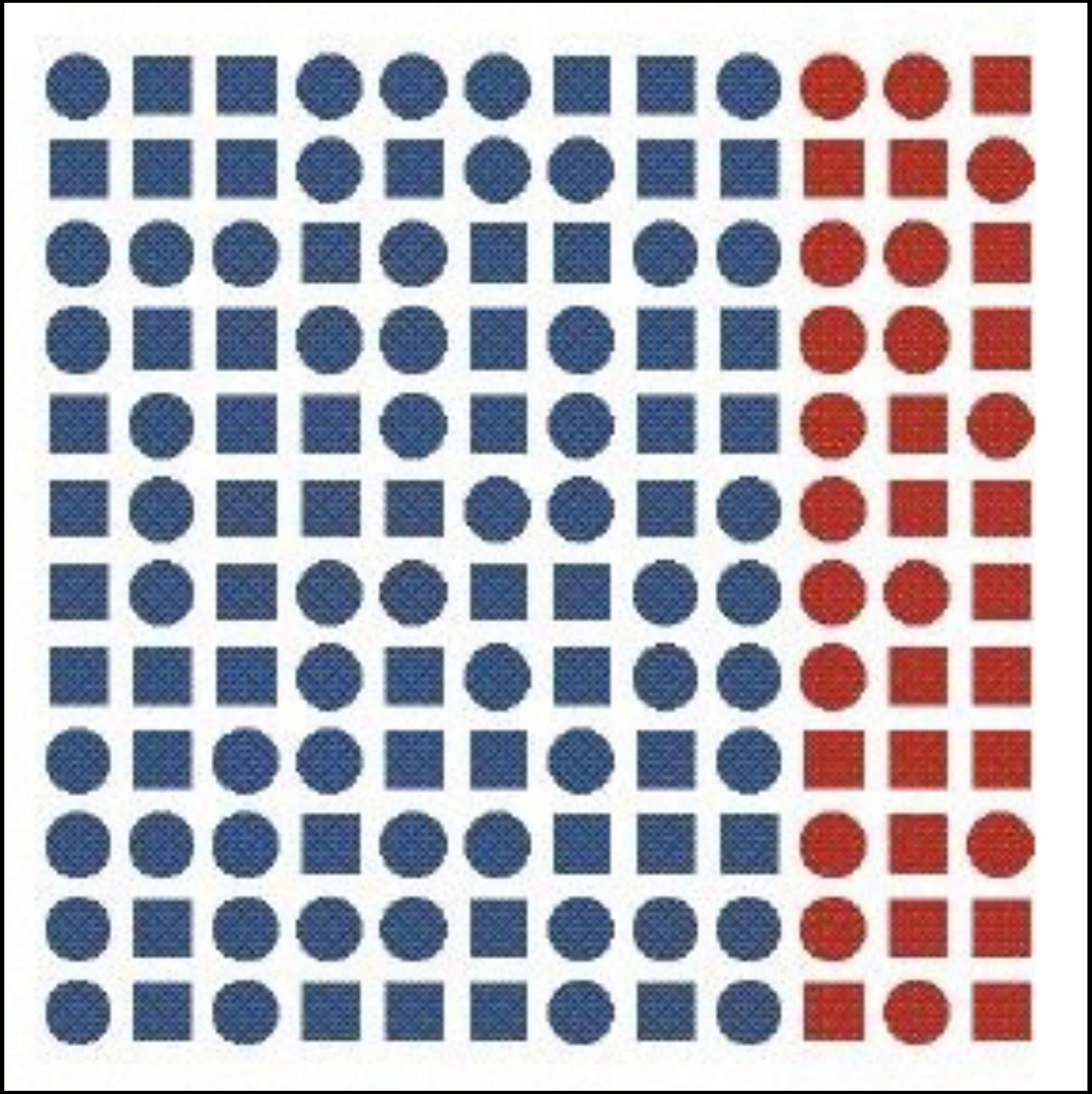
Only works when the distractors differ from one feature:



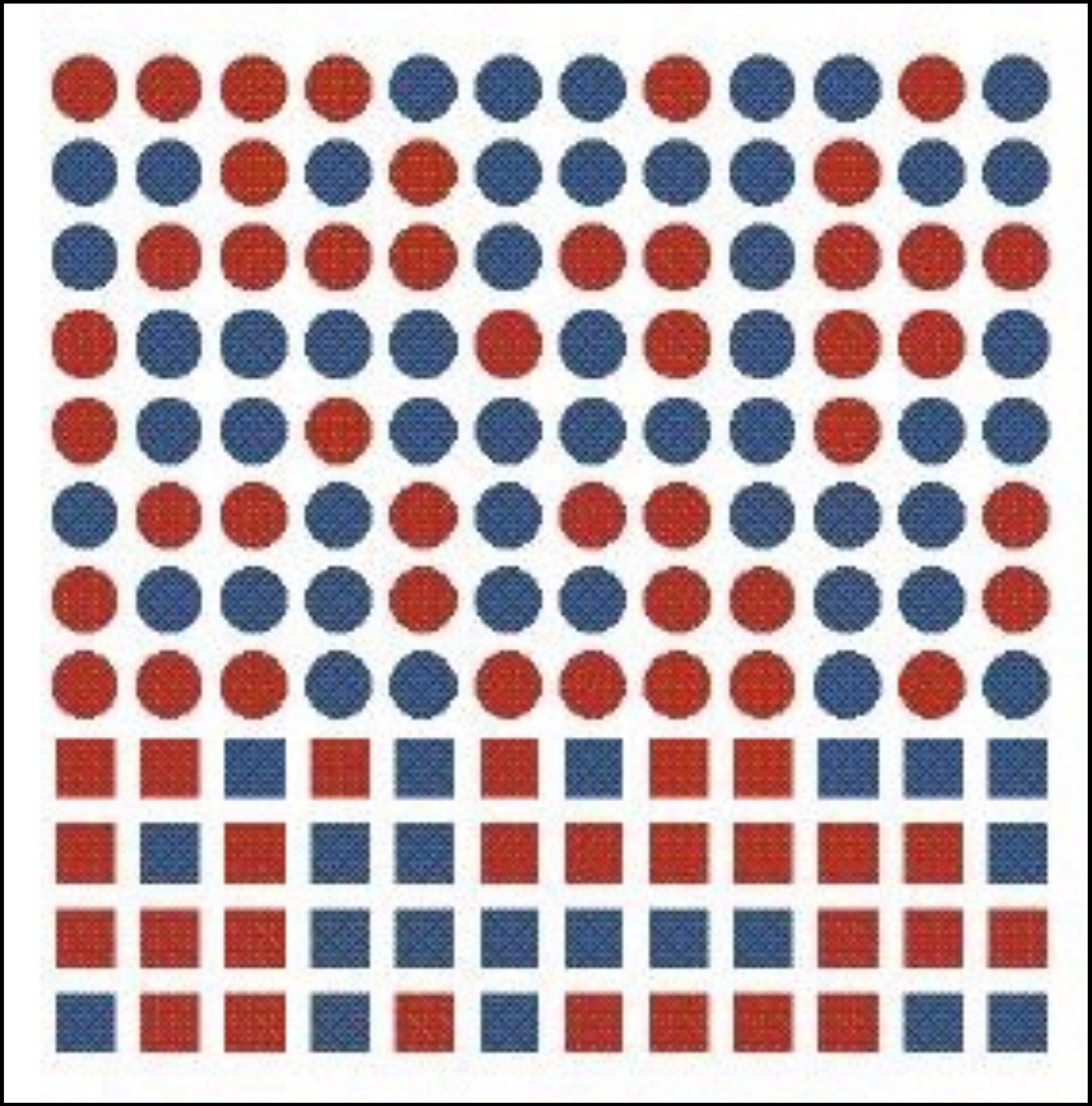
We must fall back on linear scanning when there is a conjunction of features.



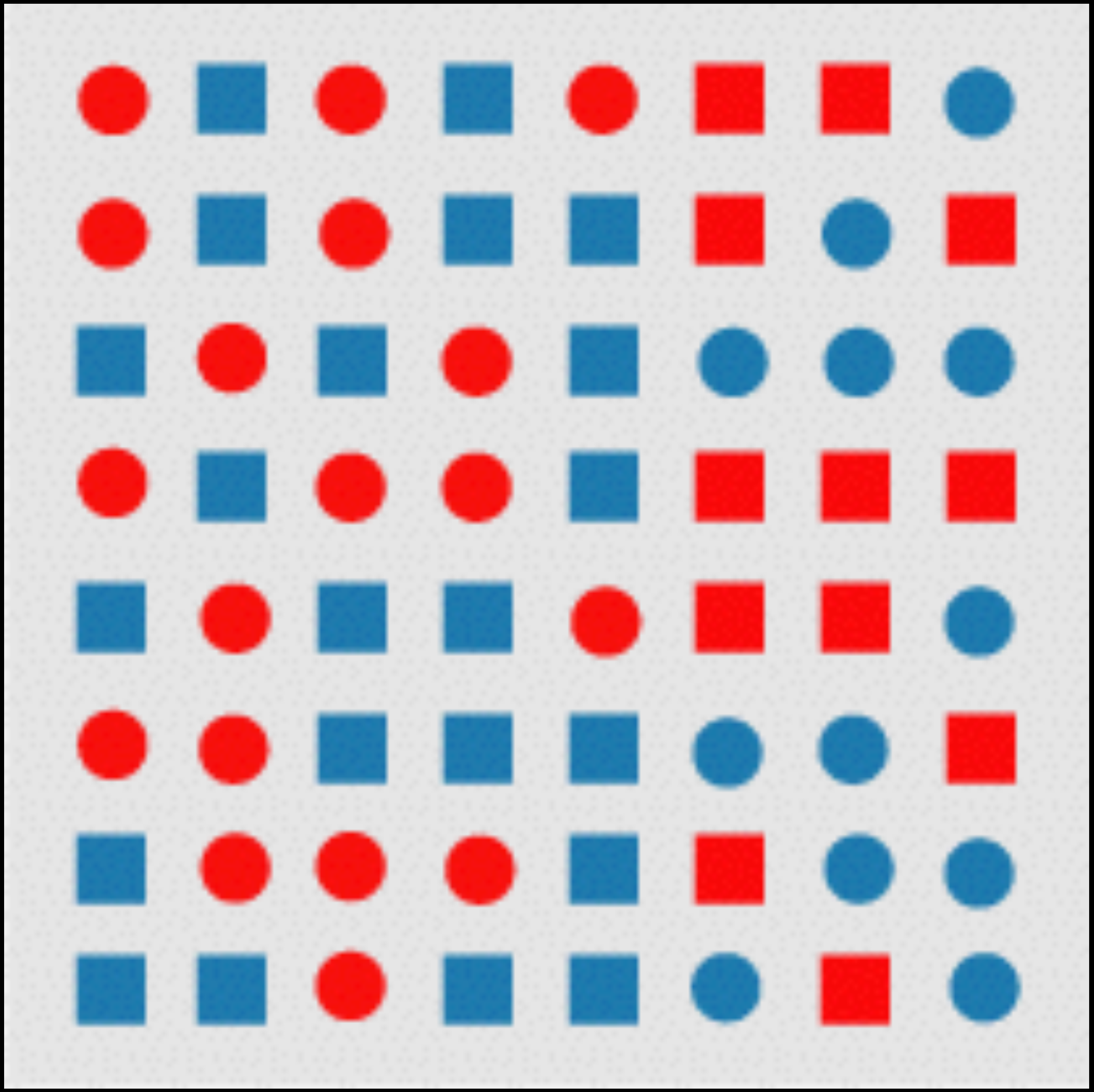
Is there a boundary?



Is there a boundary?

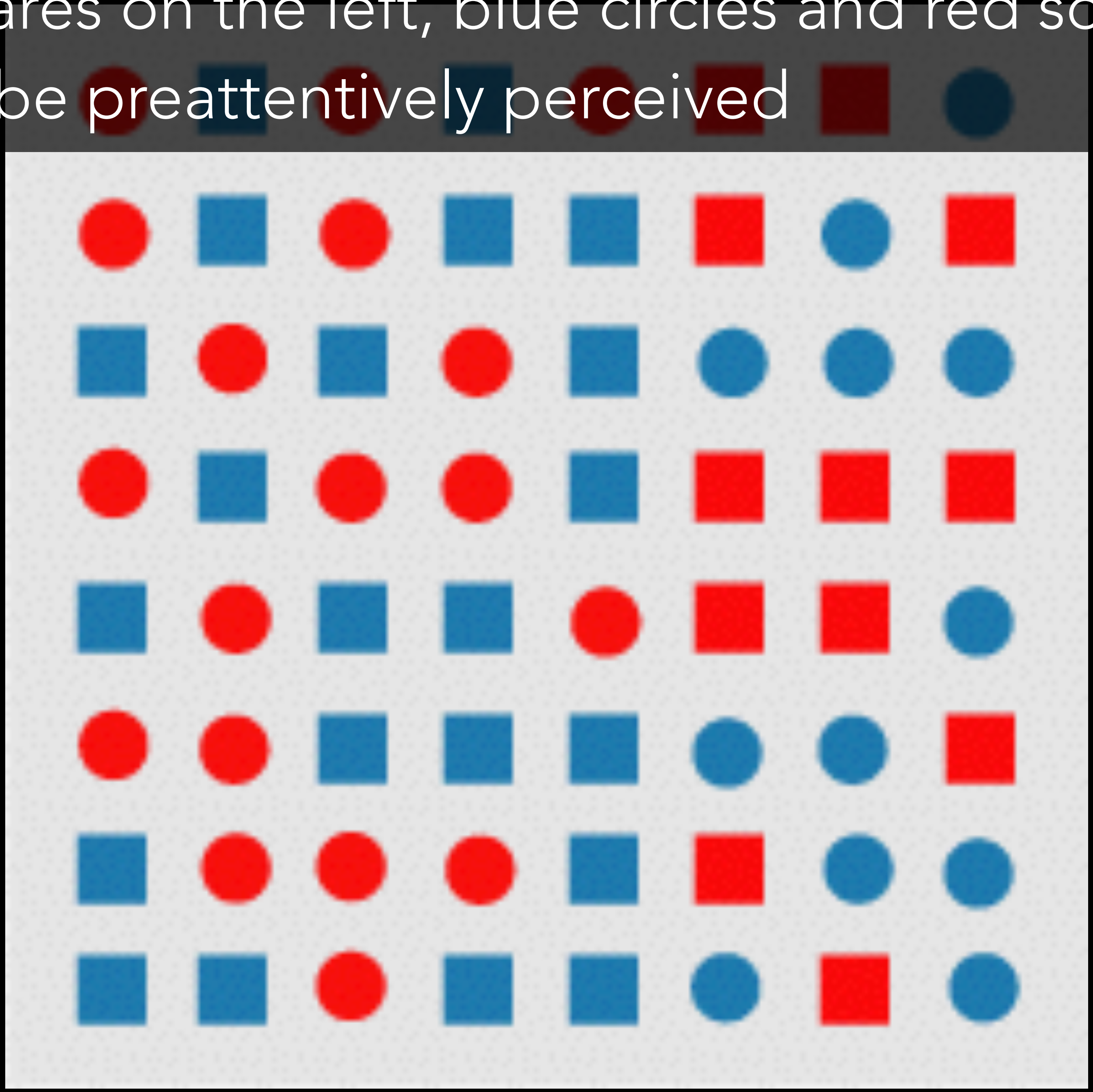


Is there a boundary? (hint: YES!)



Taken from https://www.csc.ncsu.edu/faculty/healey/PP/index.html

a boundary defined by a conjunction of features (here red circles and blue squares on the left, blue circles and red squares on the right) cannot be preattentively perceived

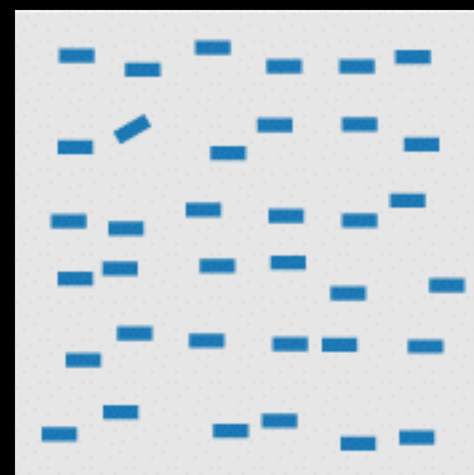


Taken from https://www.csc.ncsu.edu/faculty/healey/PP/index.html

(SOME) PRE-ATTENTIVE VISUAL FEATURES

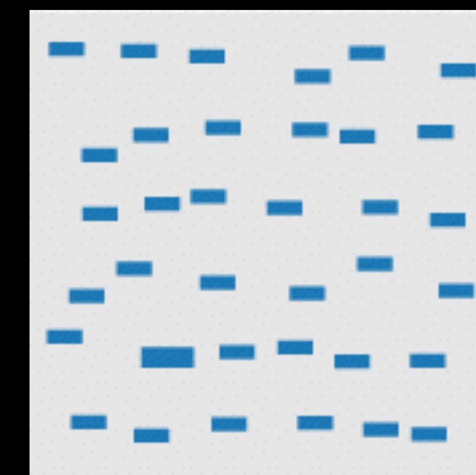
orientation

[Julész & Bergen 83]
[Sagi & Julész 85]
[Wolfe et al. 92]
[Weigle et al. 2000]



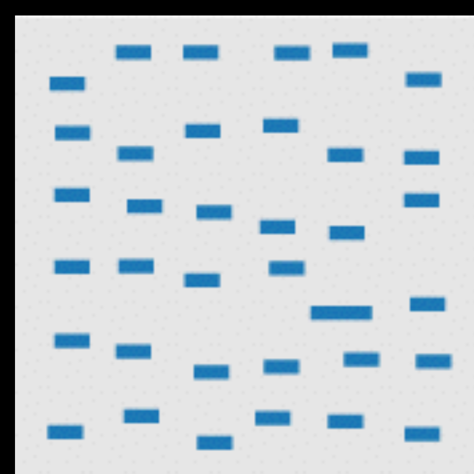
size

[Treisman & Gelade 80]
[Healey & Enns 98]
[Healey & Enns 99]



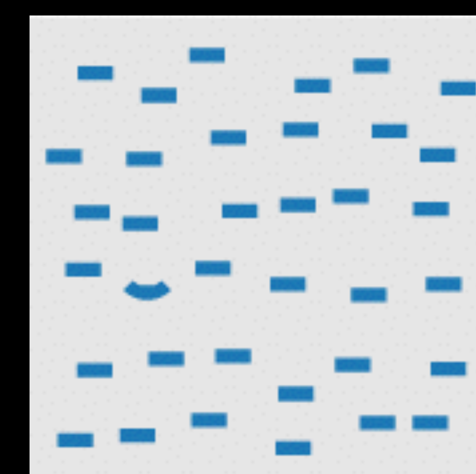
length, width

[Sagi & Julész 85]
[Treisman & Gormican 88]



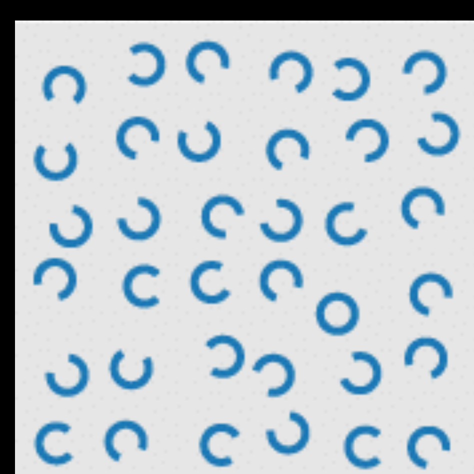
curvature

[Treisman & Gormican 88]



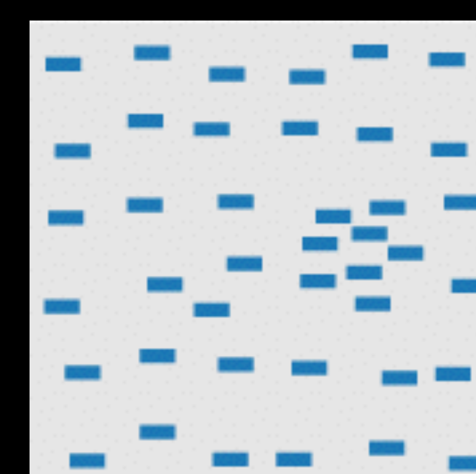
closure

[Julész & Bergen 83]



density, contrast

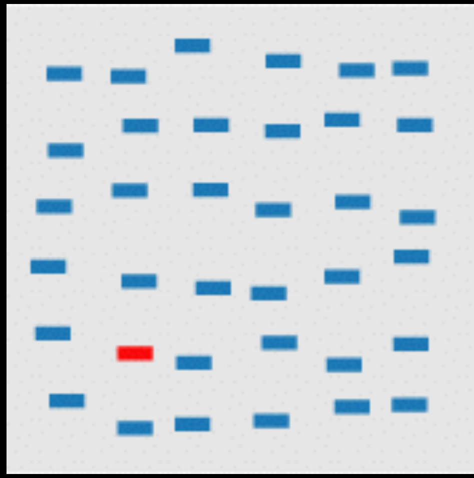
[Healey & Enns 98]
[Healey & Enns 99]



(SOME) PRE-ATTENTIVE VISUAL FEATURES

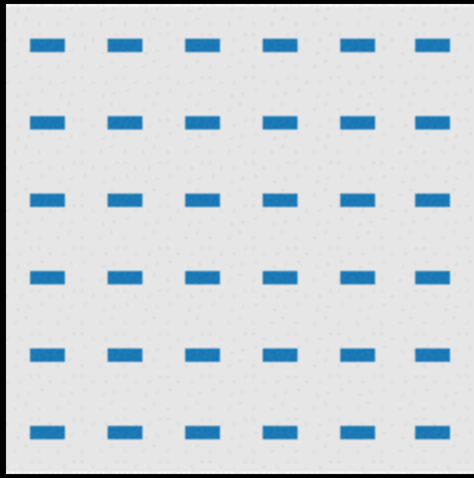
color, hue

Nagy & Sanchez 90; Nagy et al. 90; D'Zmura 91; Kawai et al. 95; Bauer et al. 96; Healey 96; Bauer et al. 98; Healey & Enns 99



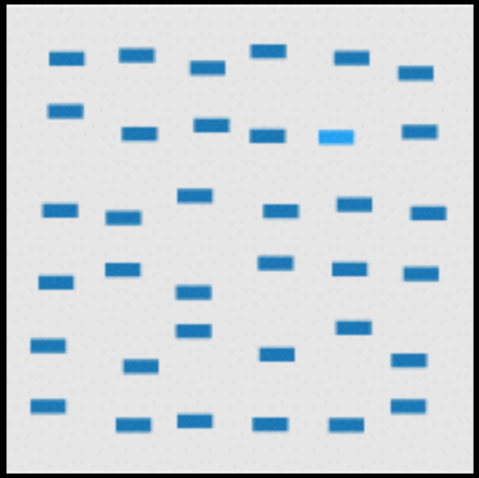
flicker

[Gebb et a. 55; Mowbray & Gebhard 55; Brown 65; [Julész 71] [Huber & Healey 2005]



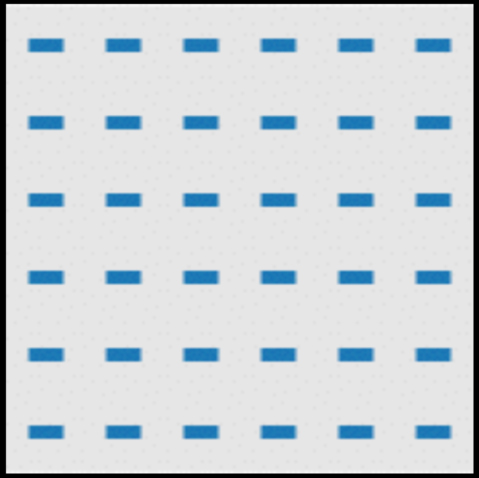
intensity

[Beck et al. 83] [Treisman & Gormican 88] [Wolfe & Franzel 88]



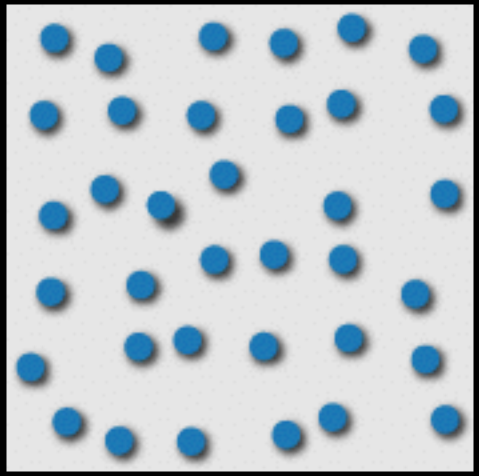
direction of motion

[Nakayama & Silverman 86; Driver & McLeod 92; Huber & Healey 2005]



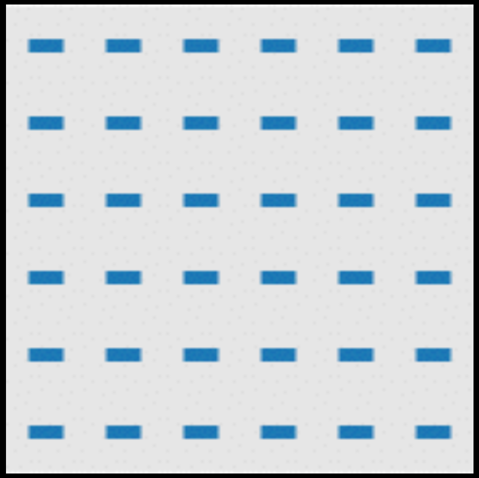
3D depth cues

[Enns 90b; Nakayama & Silverman 86]

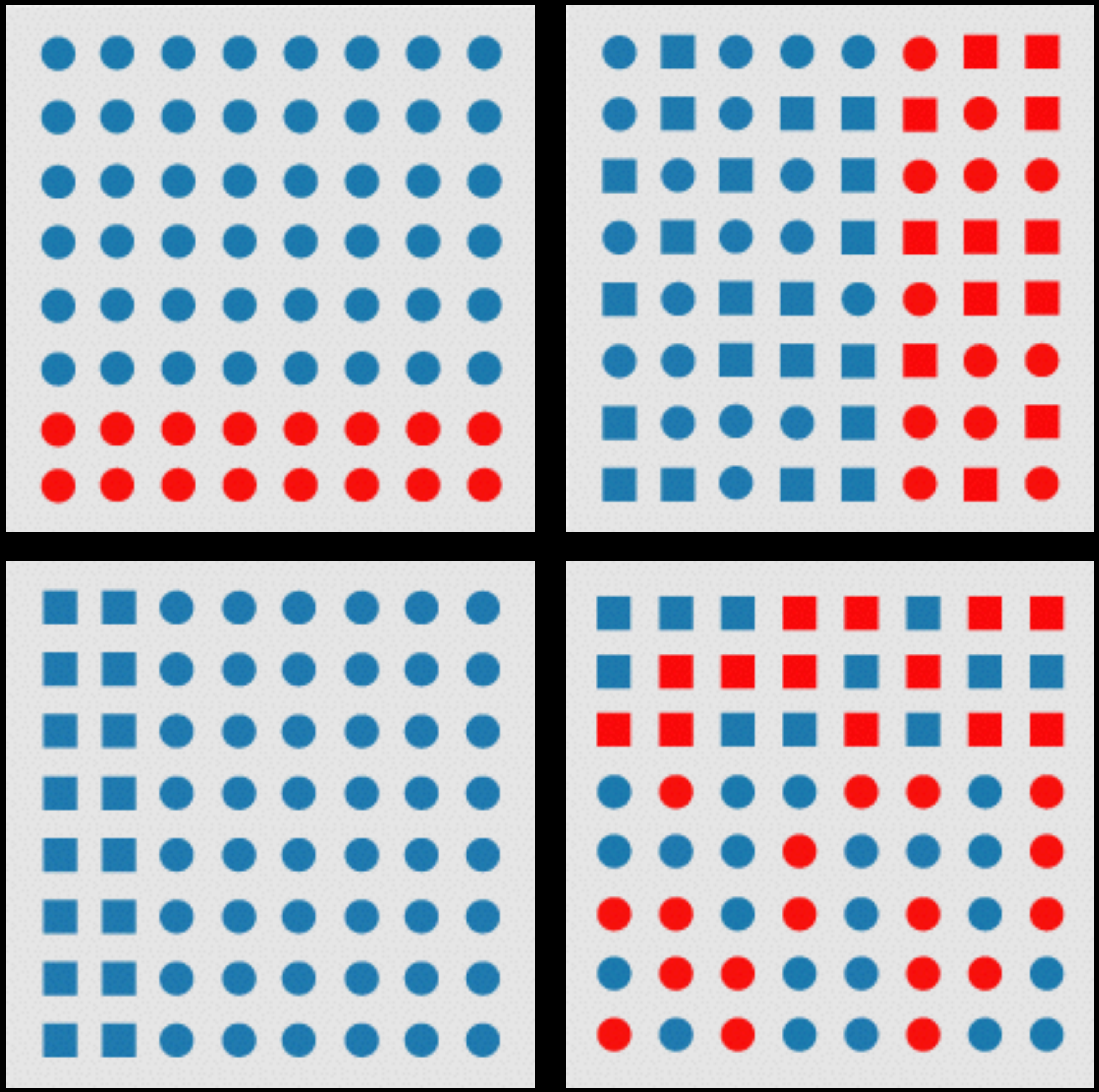


velocity of motion

[Tynan & Sekuler 82; Nakayama & Silverman 86; Driver & McLeod 92; Hohnsbein & Mateeff 98; Huber & Healey 2005]



Note that these various features are not created equal!



We seem to have a strong bias towards color perception over shape perception, etc…

Taken from https://www.csc.ncsu.edu/faculty/healey/PP/index.html

What does all of this mean?

[Slide inspired by J. Wirz & S. Bedrid course material]

1. Certain tasks that depend on pre-attentive features can sometimes be done "for free" by our brains:

Target detection *Boundary detection*
Region tracking *Counting (estimation)*

2. The more of our story we can tell using pre-attentive features, the faster and better our viewer will "get it".

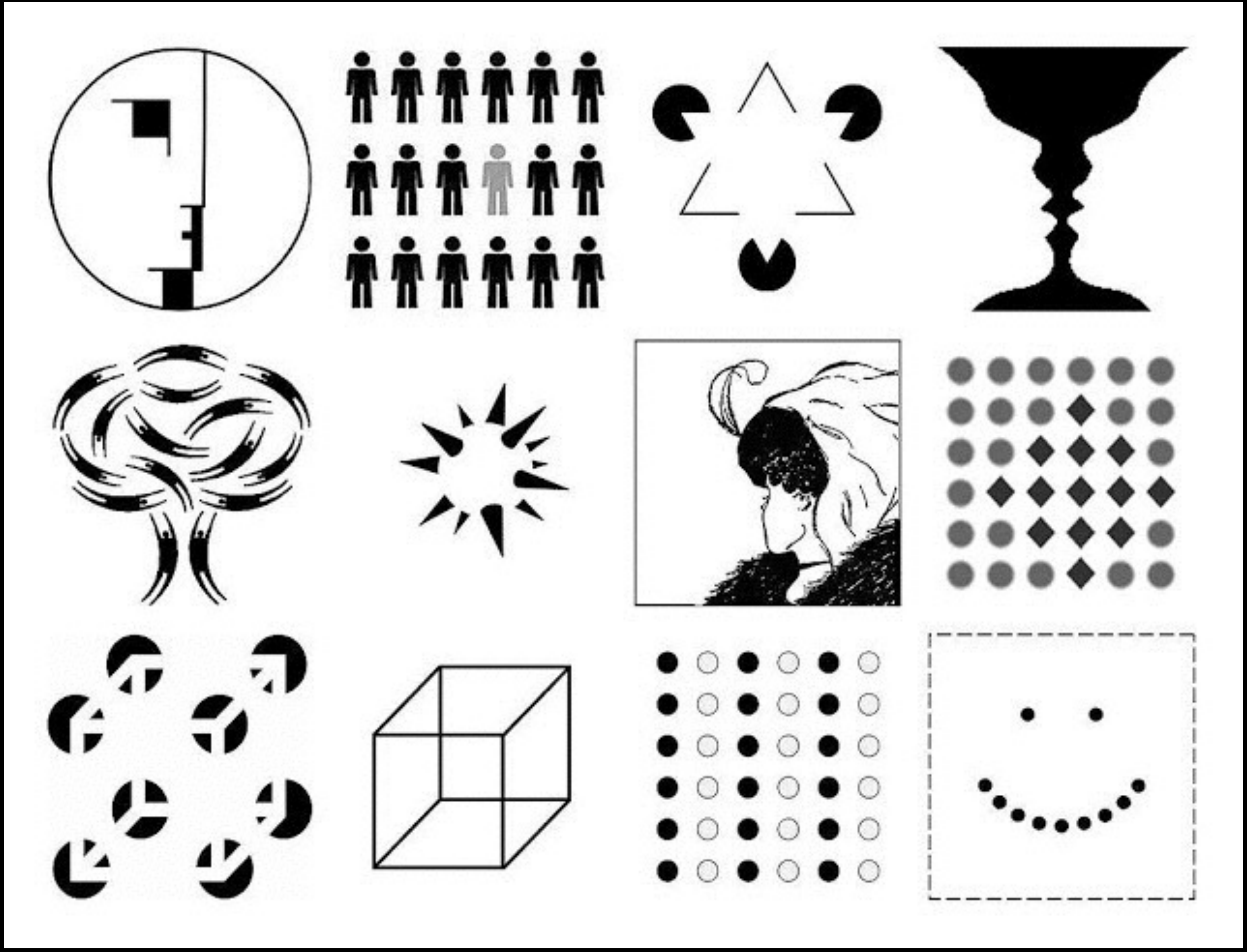
[Slide inspired by J. Wirz & S. Bedrid course material]

3. We can easily mess up our viewer's ability to interpret our visualisation by "triggering" pre-attentive perception inappropriately!

Many of the things that make a bad visualisation "bad" can be traced back to problems relative to pre-attentive processing.

[Slide inspired by J. Wirz & S. Bedrid course material]

ANOTHER PERSPECTIVE:
GESTALT PSYCHOLOGY



DEFINITION

The Gestalt psychology is a **theory of perception** that is often summed up by:

"The whole is other than the sum of the parts"

— Kurt Koffka (1922)

THE BASIC IDEA:

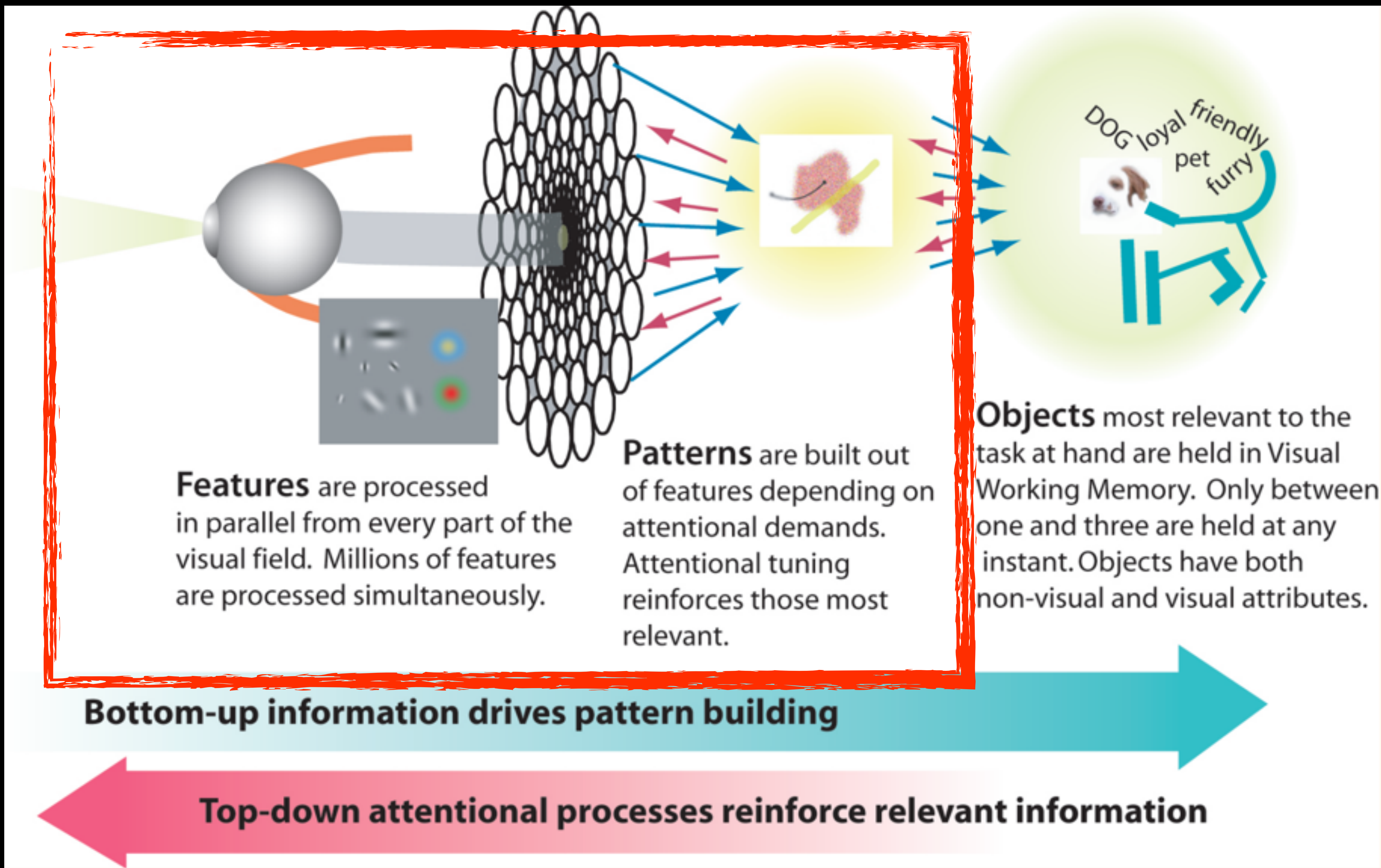
Our brains operate less on individual points, lines, etc…

… but rather on **higher-level constructs** …

… which is what our perceptual systems are **optimised for.**

[Slide inspired by J. Wirz & S. Bedrid course material]

DIFFERENT FROM



[Source: Ware et al.]

The Gestalt psychology notably describes the **perception of forms** by the visual system.

It relies on four **principles**:

- Emergence
- Reification
- Multistability
- Invariance

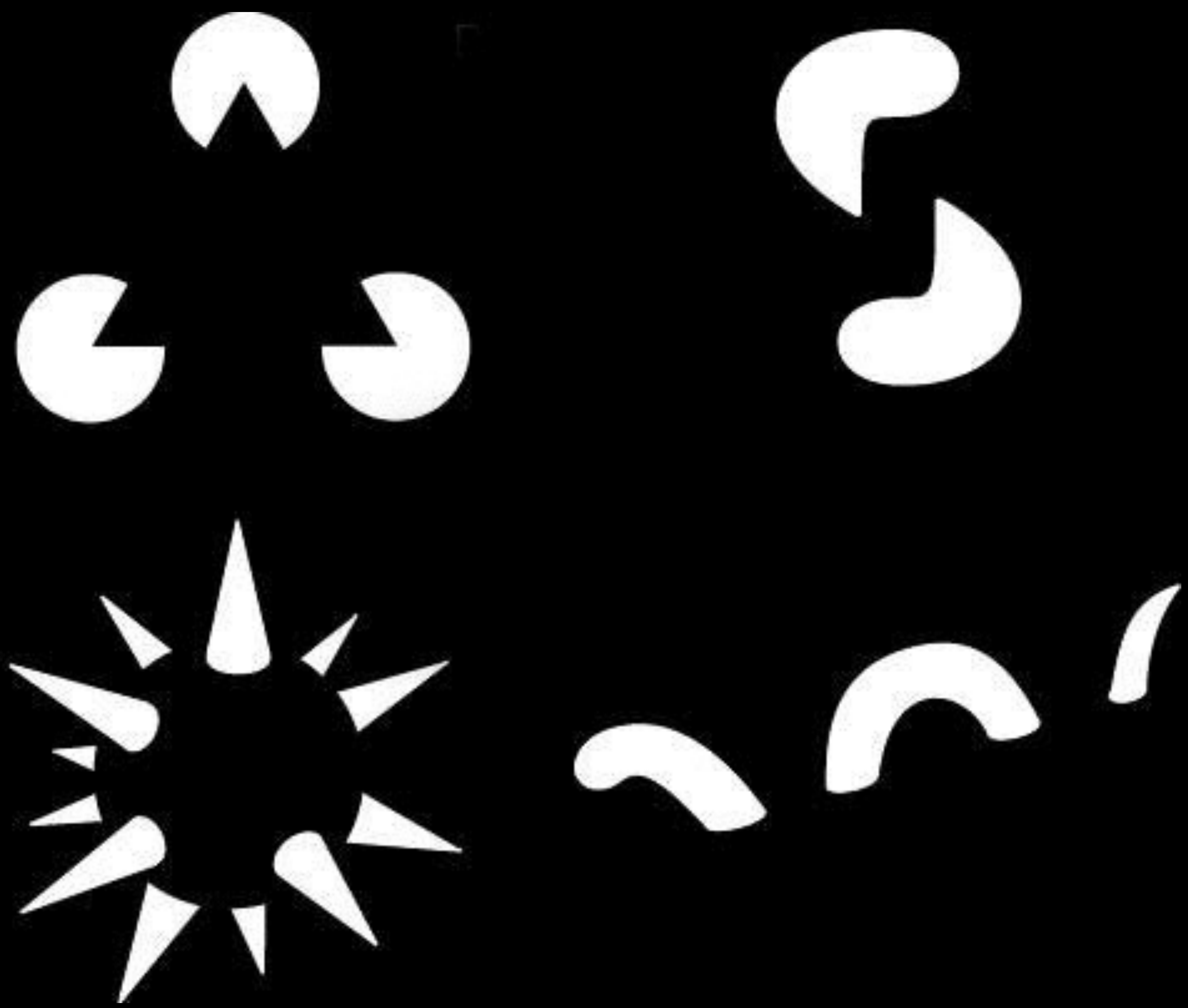
It also describes our visual perceptions by a set of **laws**.

EMERGENCE

The **global perception** can **not** be explained by the **sum of its parts**.

EMERGENCE

REIFICATION



REIFICATION

The **perception** contains **more spatial information than the stimulus** on which it is based: **part of the perception is generated**.

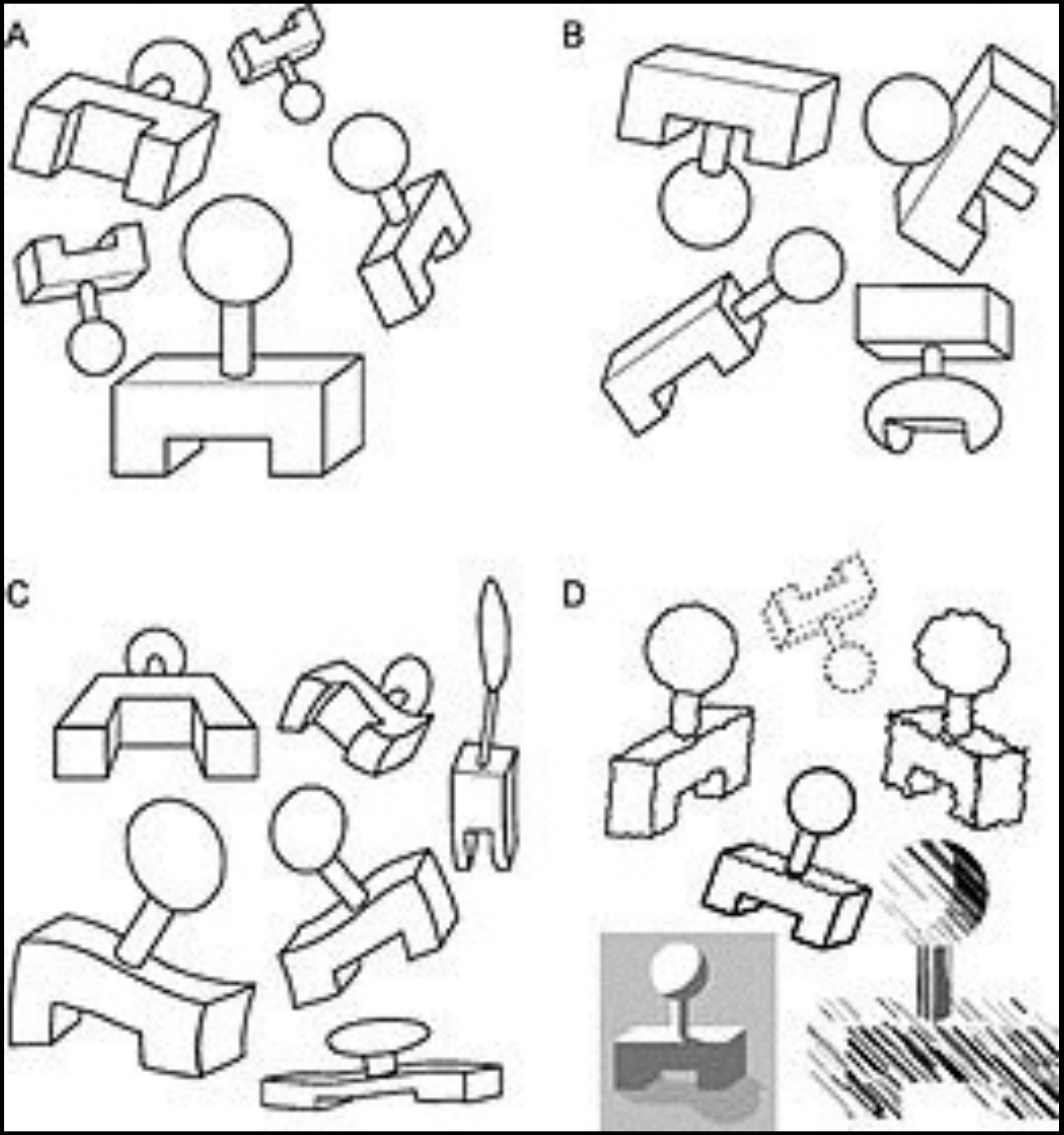
MULTISTABILITY

"My wife and my mother-in-law." (1915)

MULTISTABILITY

Ambiguous stimuli can generate **different perceptions** but they **can not coexist** simultaneously.

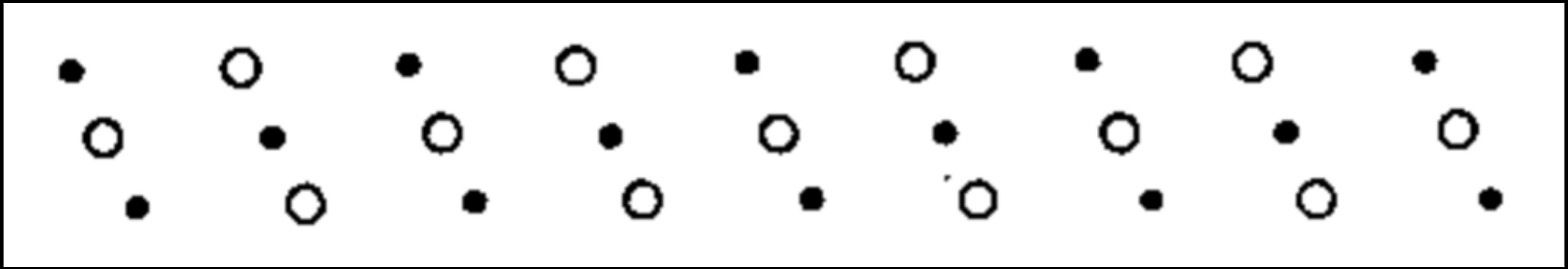
INVARIANCE



INVARIANCE

Objects are **recognized independently of various variations**, such as geometrical transformations, lighting, etc.

GESTALT LAWS OF GROUPING



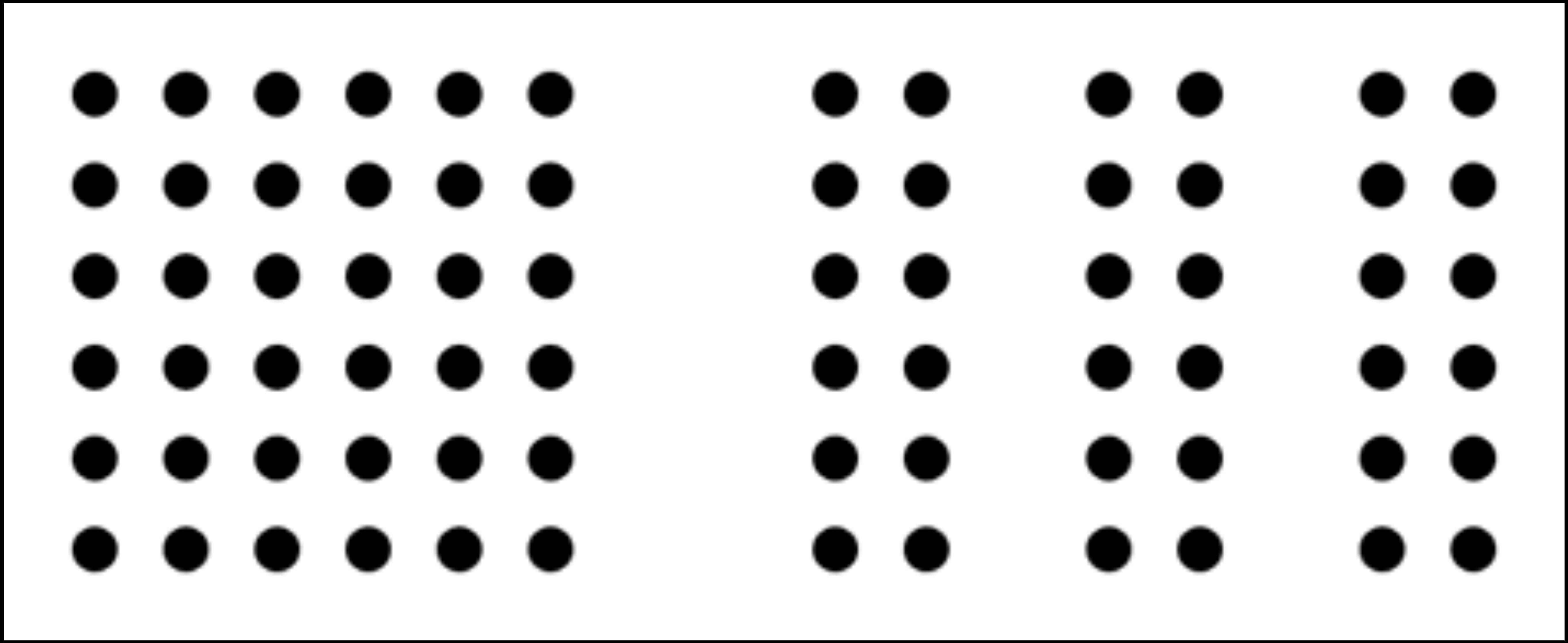
The **laws of grouping** state how **low-level perceptions** are **grouped** into higher-level objects.

Good Gestalt (Prägnanz)

We tend to order our experience in a manner that is regular, orderly, symmetric, and simple.

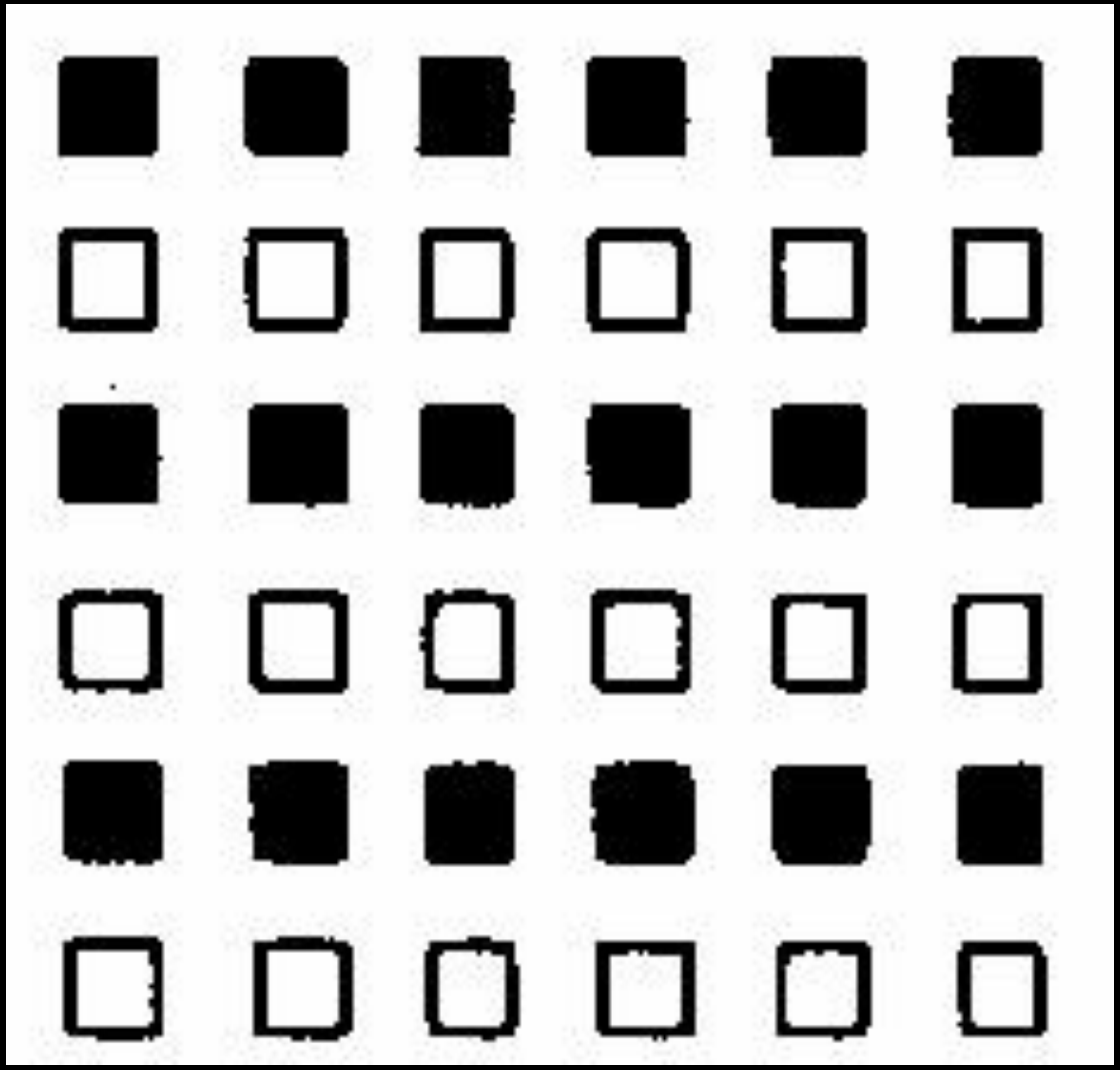
LAW OF PROXIMITY

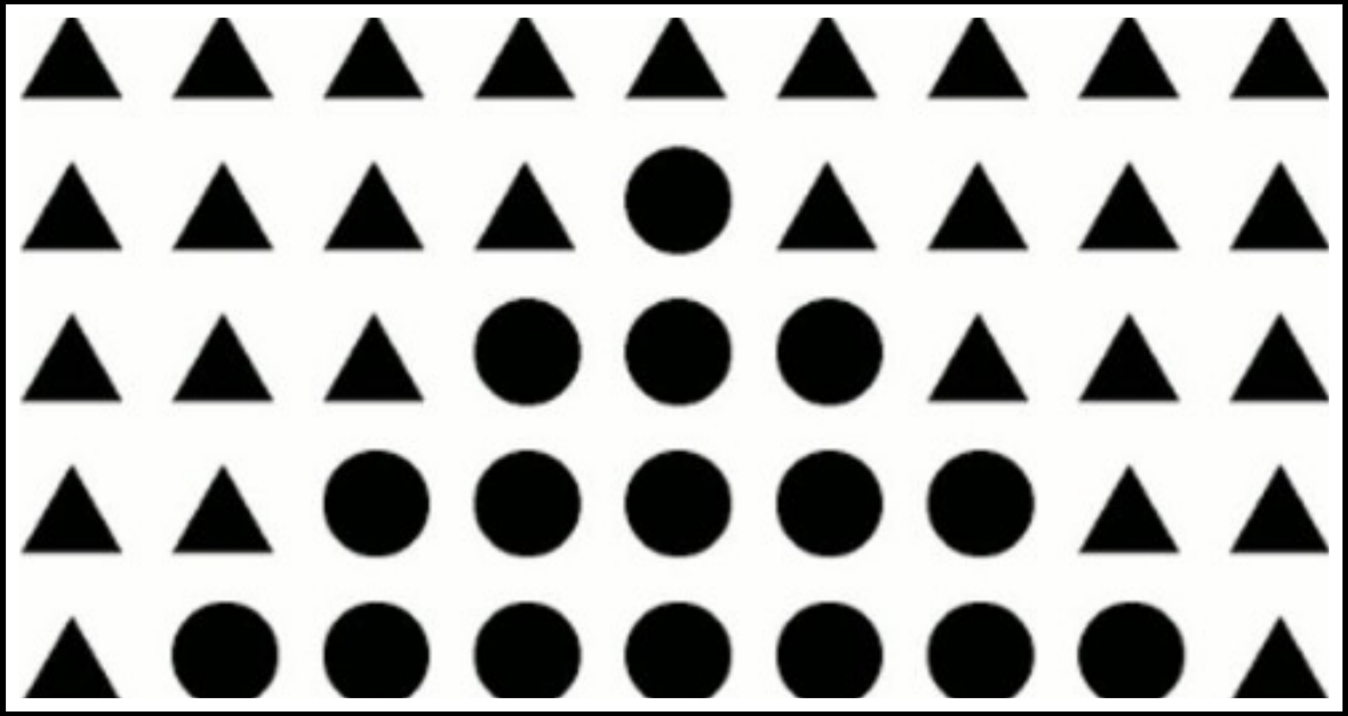
Objects that are close tend to be perceived as a group.



LAW OF SIMILARITY

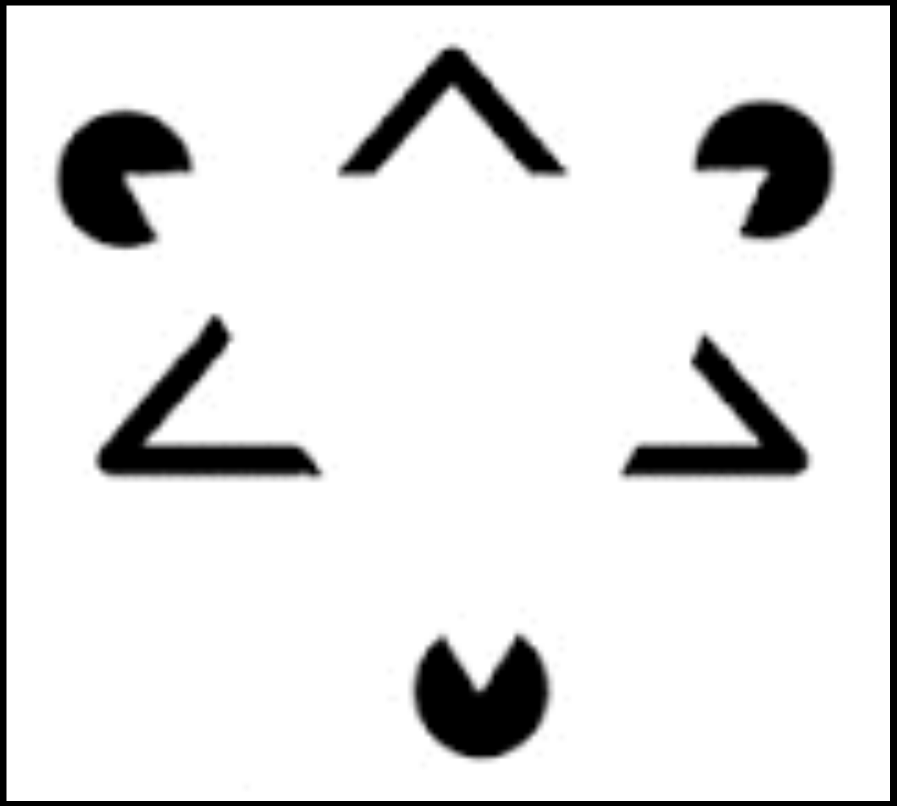
Objects that are similar (in shape, color, shading, etc.) tend to form a group.

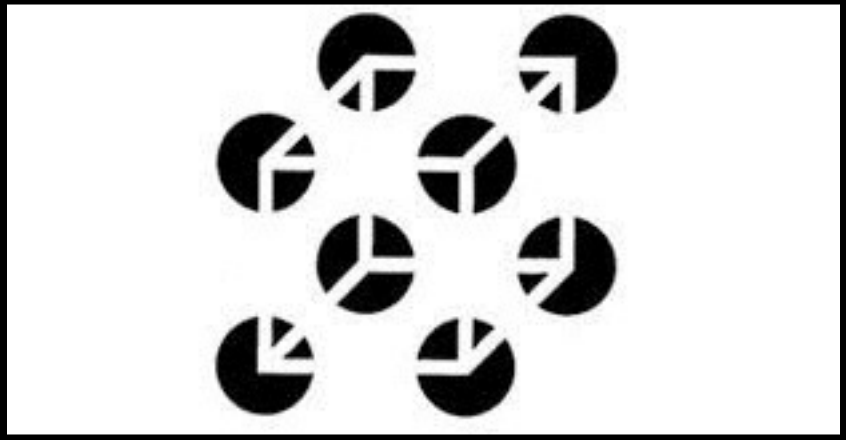


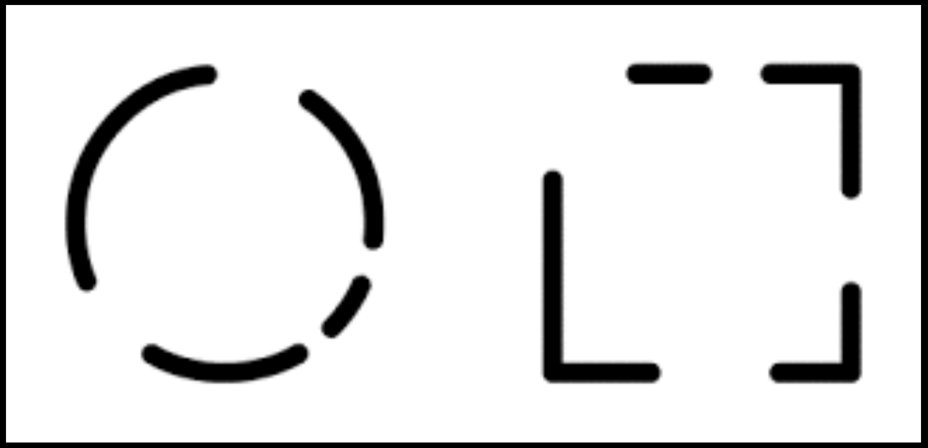


LAW OF CLOSURE

The perception fills gaps in stimuli.







LAW OF SYMMETRY

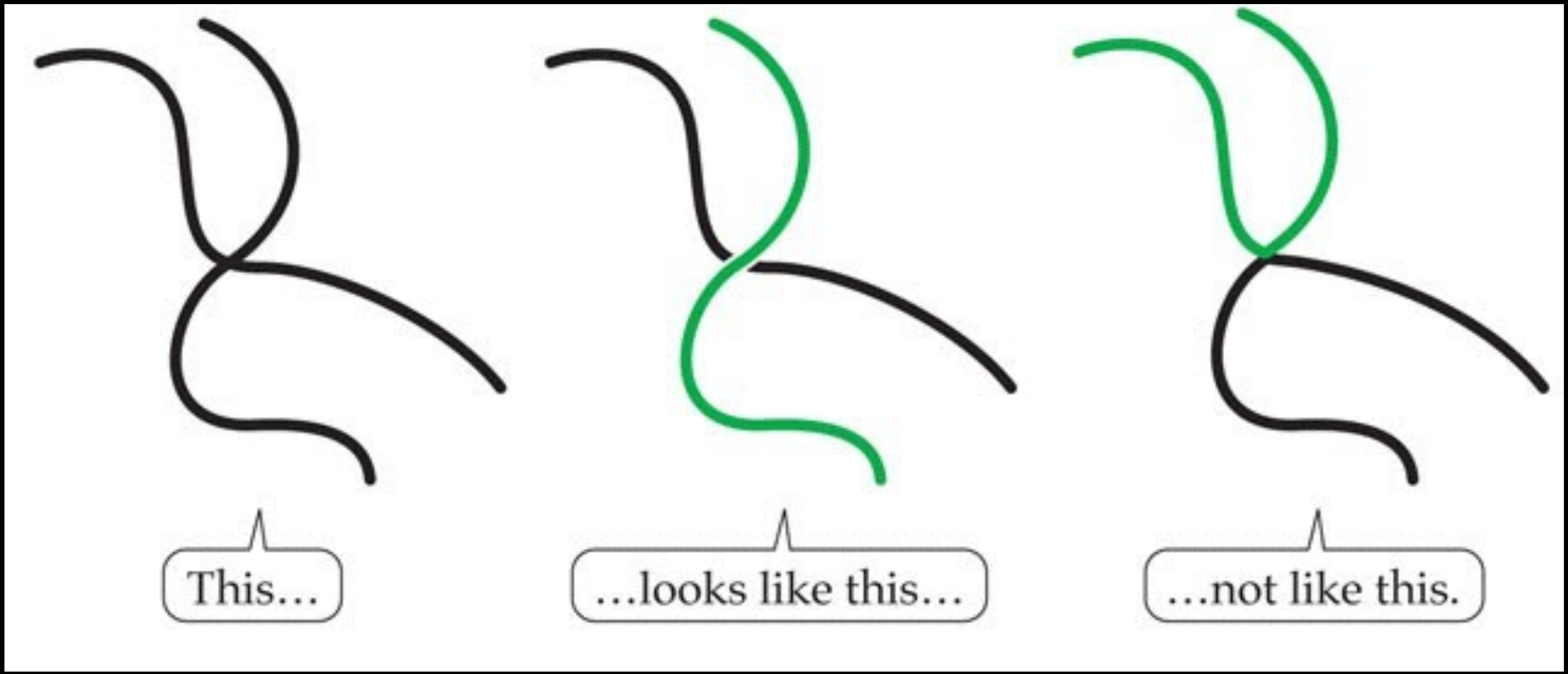
Objects with symmetric disposition tend to be perceived as forming a whole.

[ ]{ }[ ]

How many groups of elements are there?

LAW OF CONTINUITY

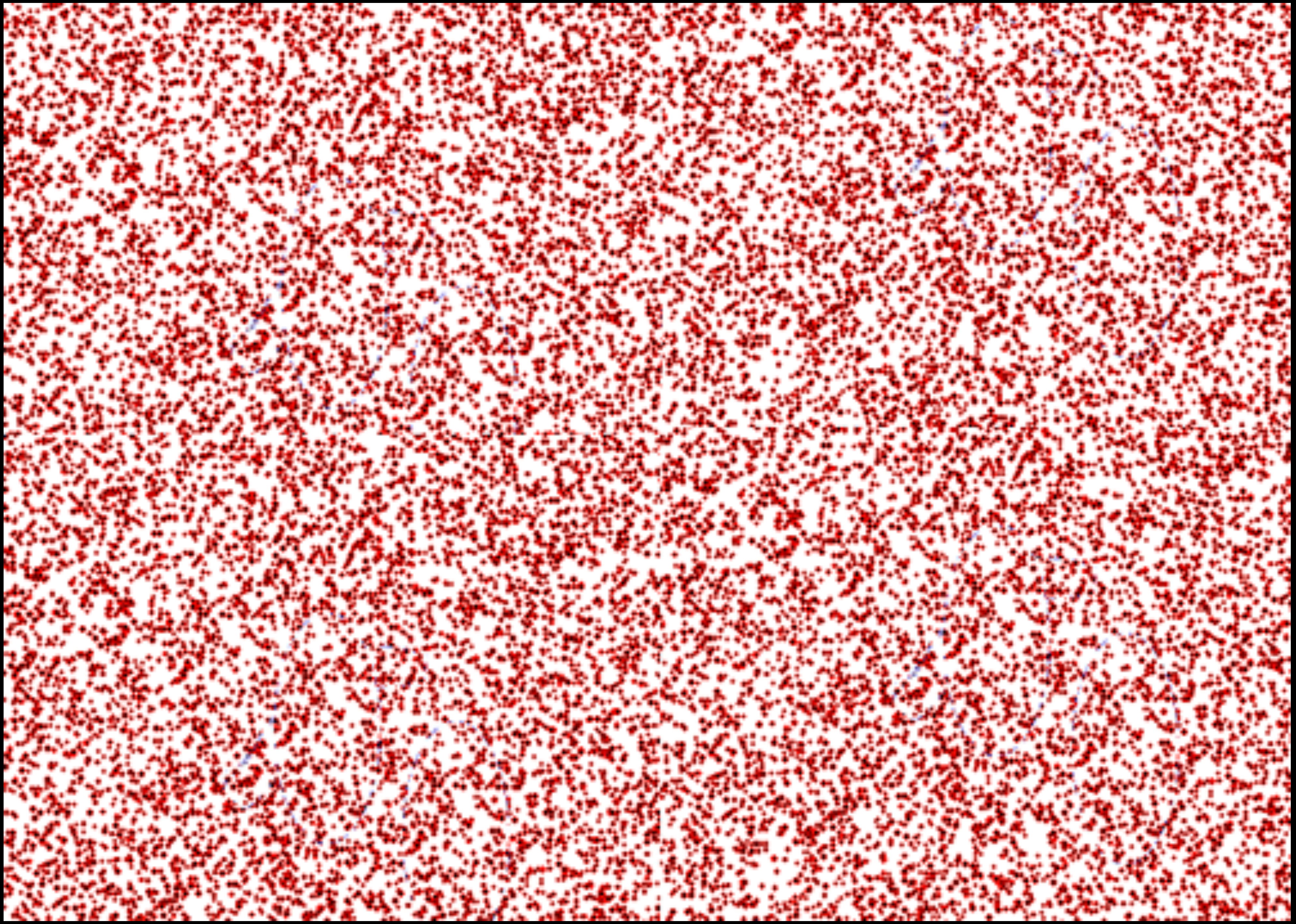
Ambiguous stimuli are perceived preferentially with the interpretation that is the most continuous.



[Source: Goldstein's Sensation and Perception]

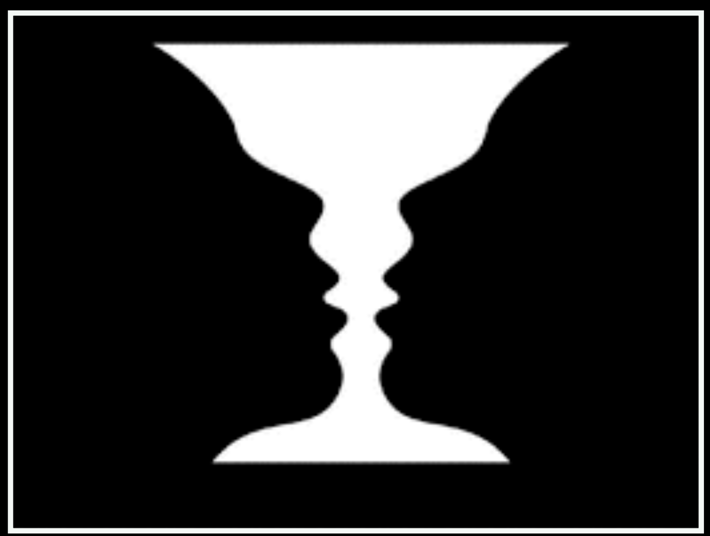
LAW OF COMMON FATE

Objects evolving together are perceived as a group.



LAW OF FIGURE & GROUND

Elements are perceived as either a **figure** (element of focus) or **ground** (background on which the figure sits)





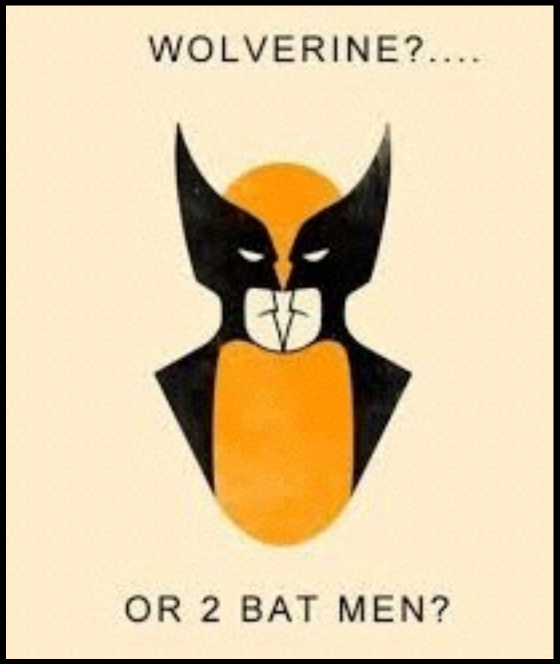
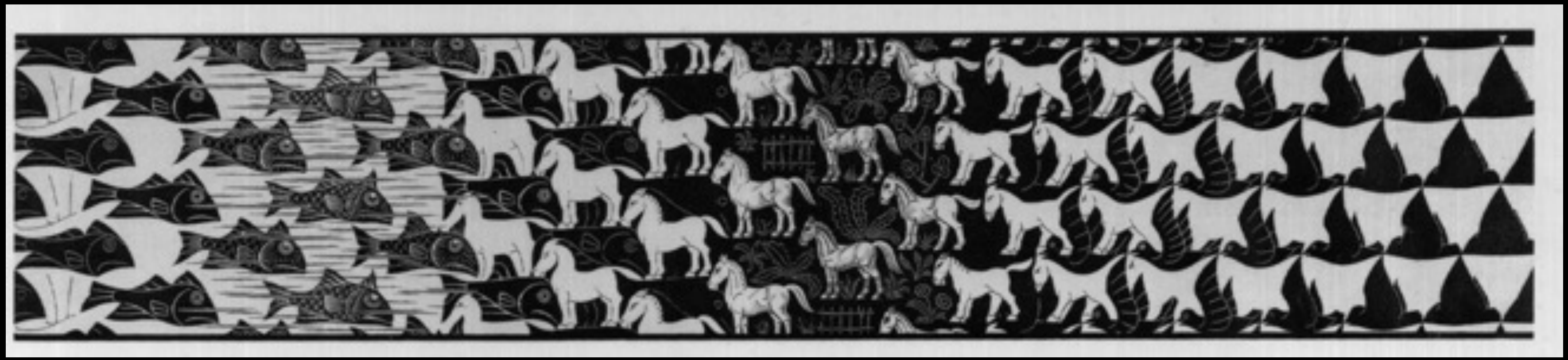



FIGURE & GROUND IN ART

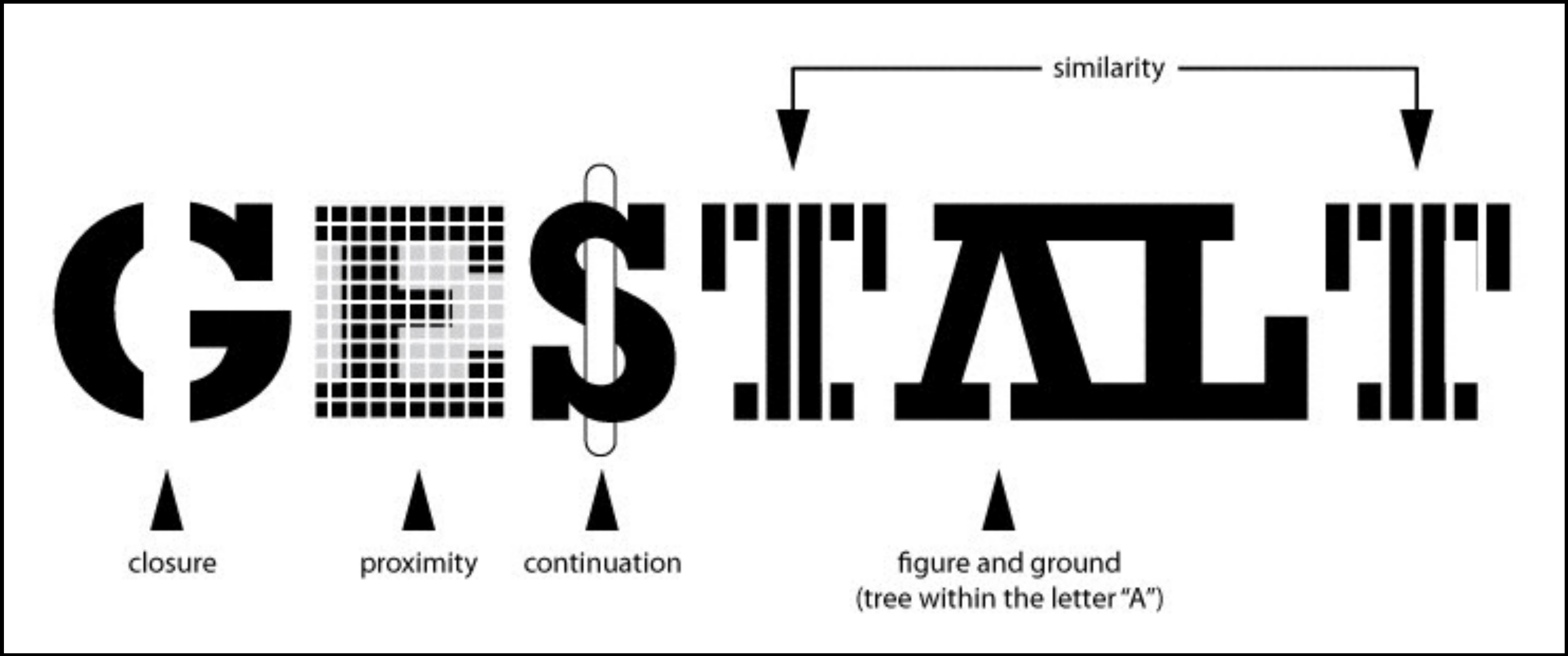
FIGURE & GROUND IN ART

FIGURE & GROUND IN DESIGN

FIGURE & GROUND: BEFORE GESTALT

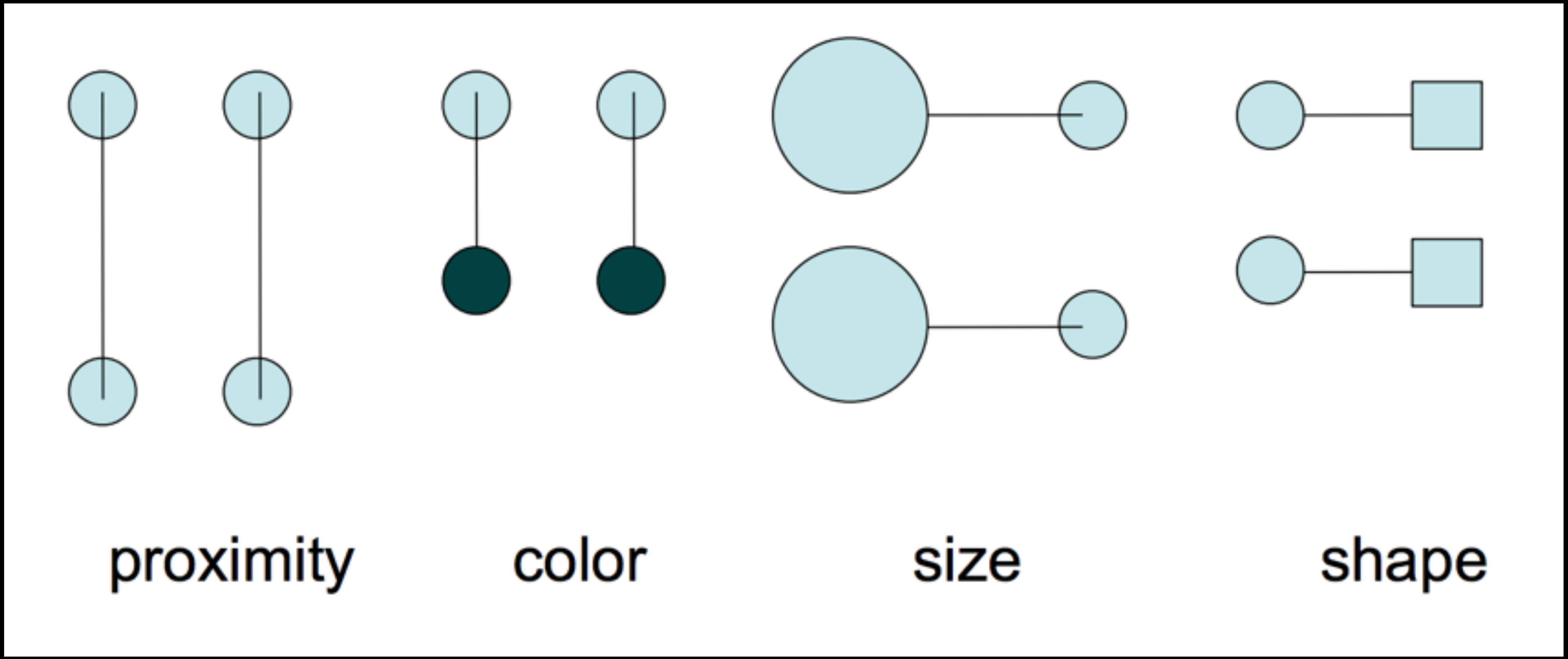


Escher's Metamorphosis


similarity
closure
proximity
continuation
figure and ground
(tree within the letter "A")

MORE LAWS!
LAW OF CONNECTEDNESS

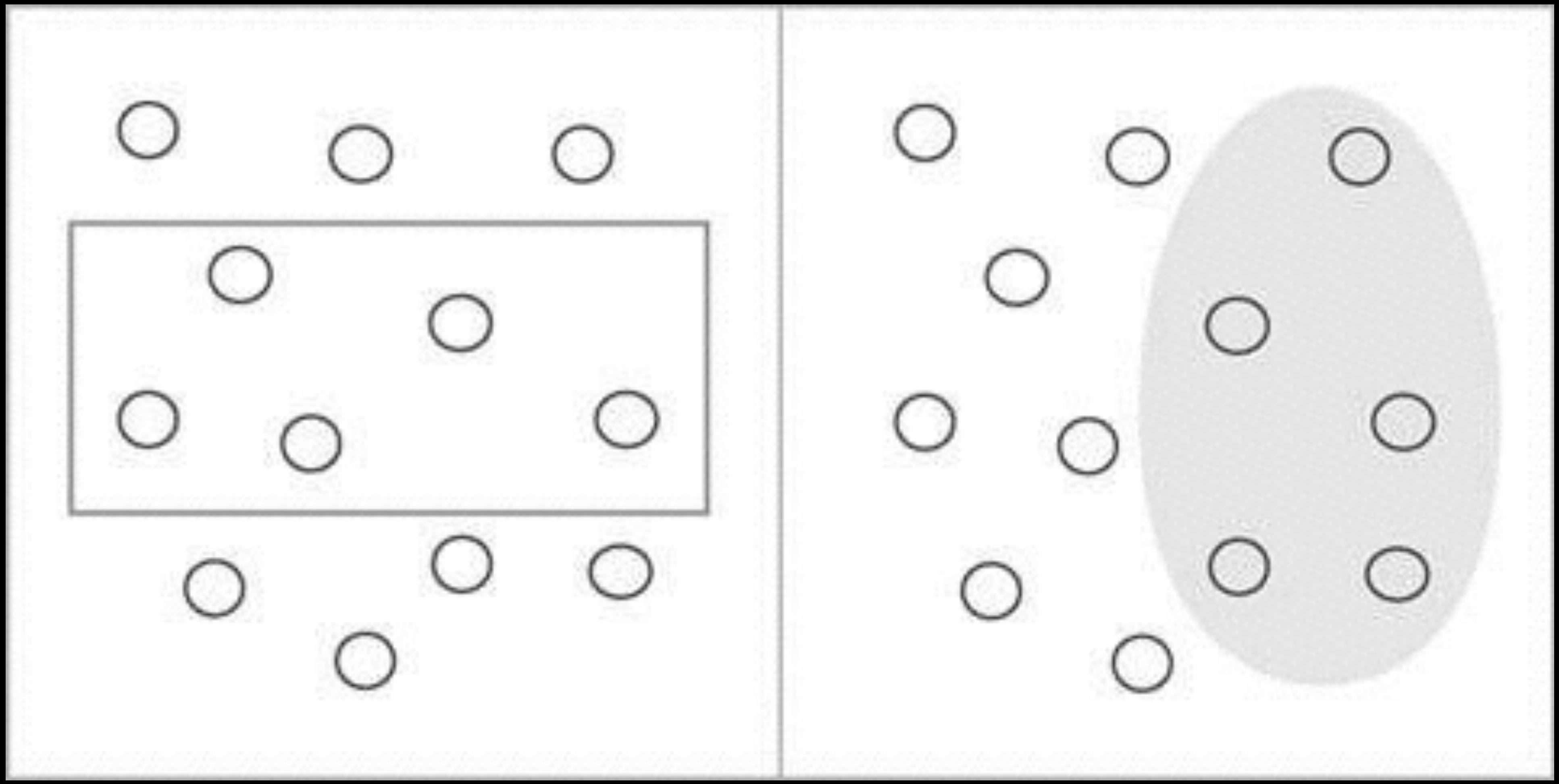
Things that are linked are perceived as belonging to the same group.



More powerful than proximity, color, size, shape…

MORE LAWS!
LAW OF ENCLOSURE

Objects that are enclosed are perceived as a group



Again, more powerful than proximity, color, size, shape…

IN SUMMARY

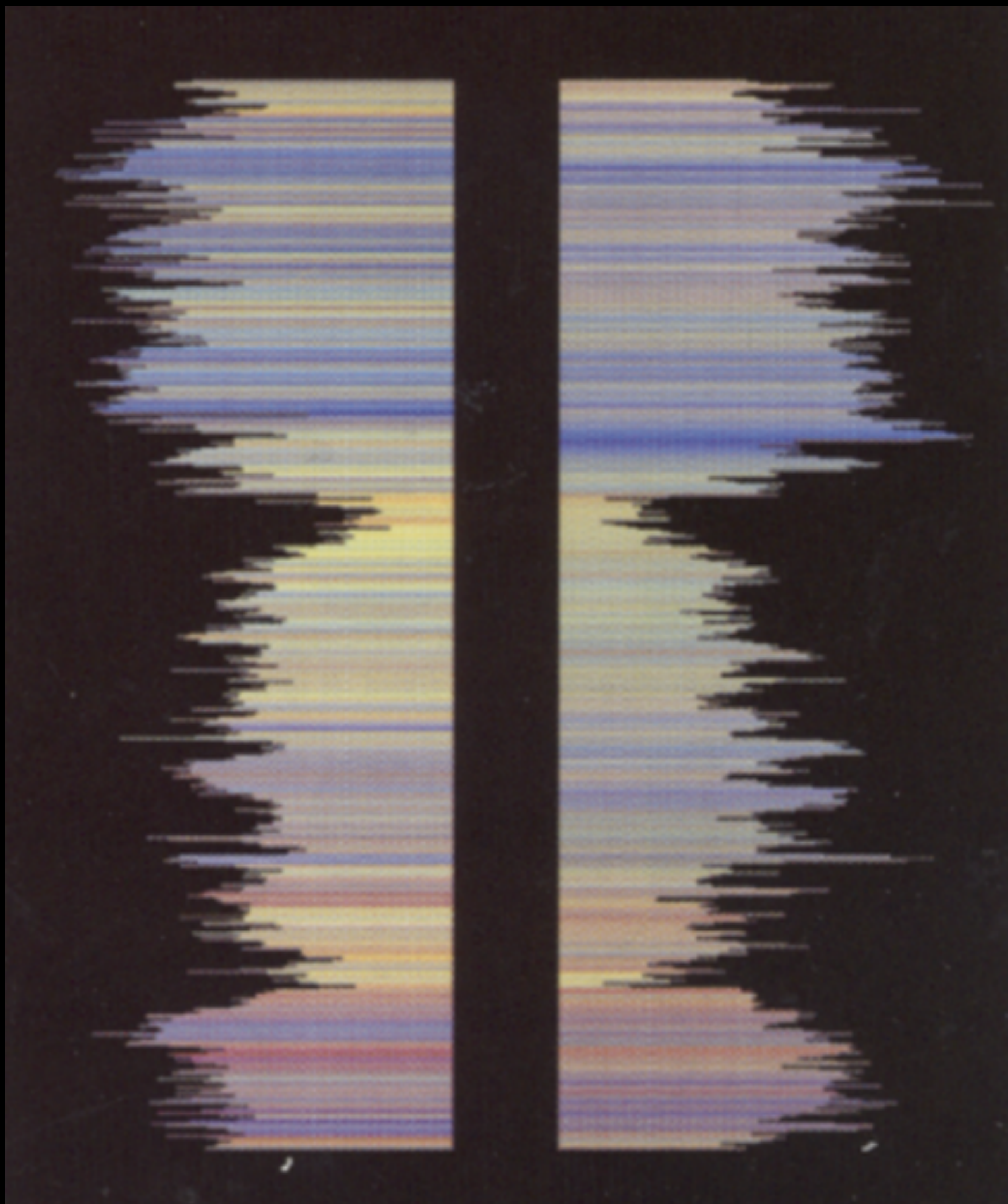
Our brains take lots of perceptual “shortcuts”…

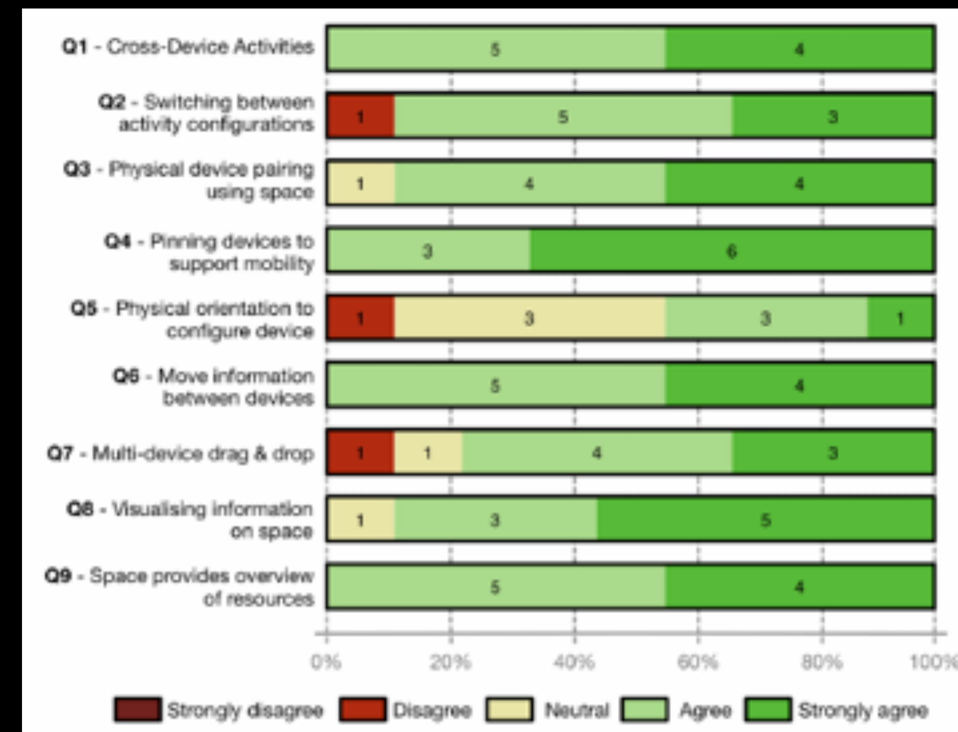
… which can either help or harm our visualizations!

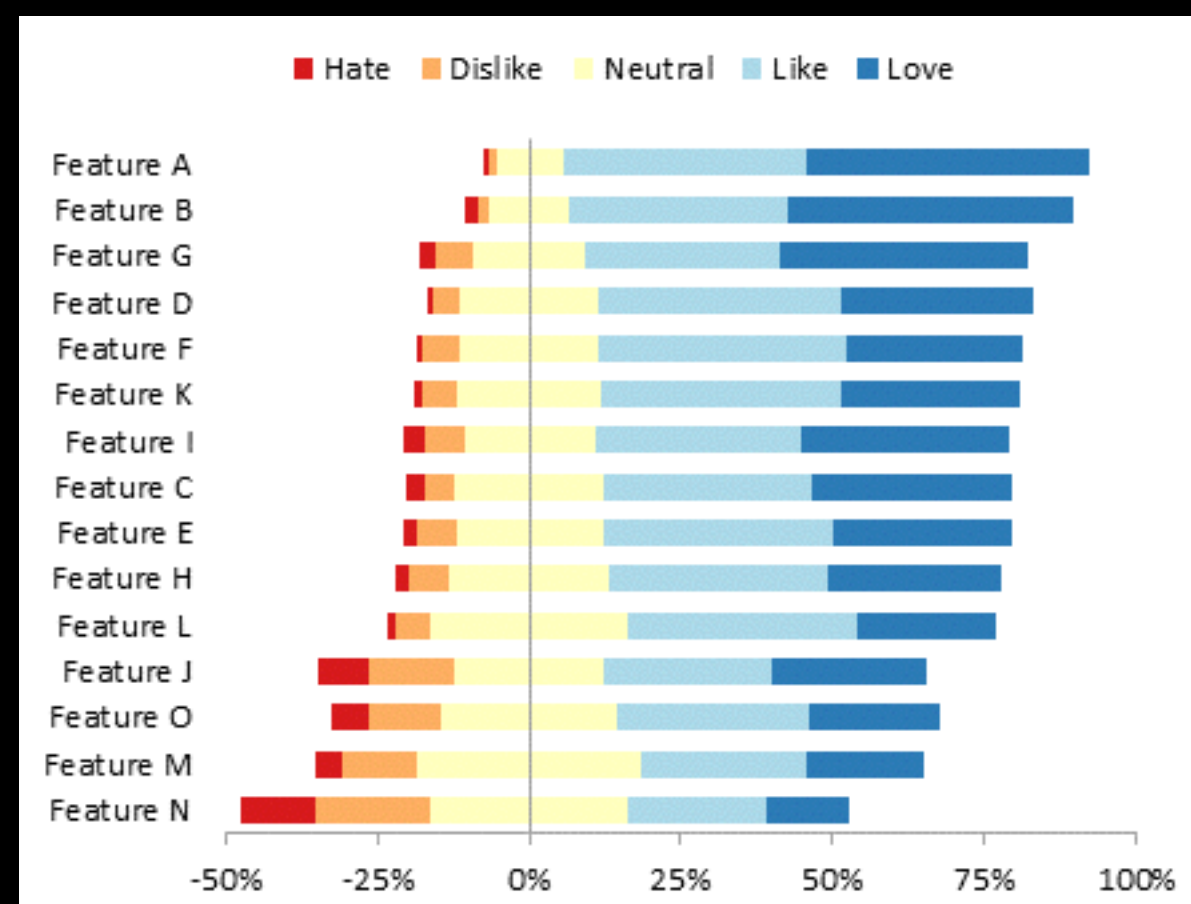
It is not enough to simply show something, we need to pay attention when and how it is shown.

A GOOD UNDERSTANDING OF PERCEPTUAL AND COGNITIVE PROCESSES IS CRITICAL!

IMPLICATIONS FOR INFOVIS







IMPLICATIONS FOR INFOVIS

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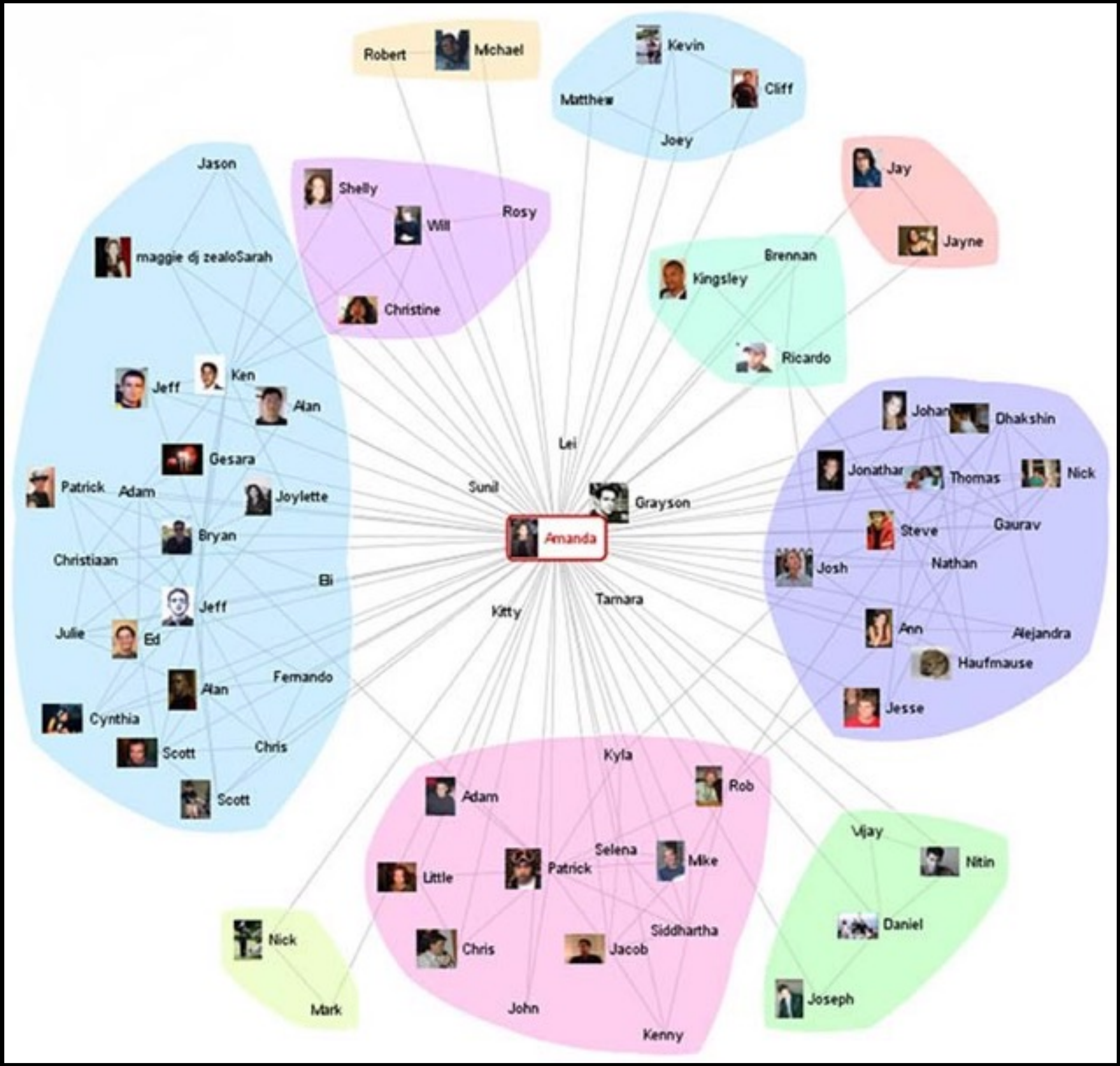
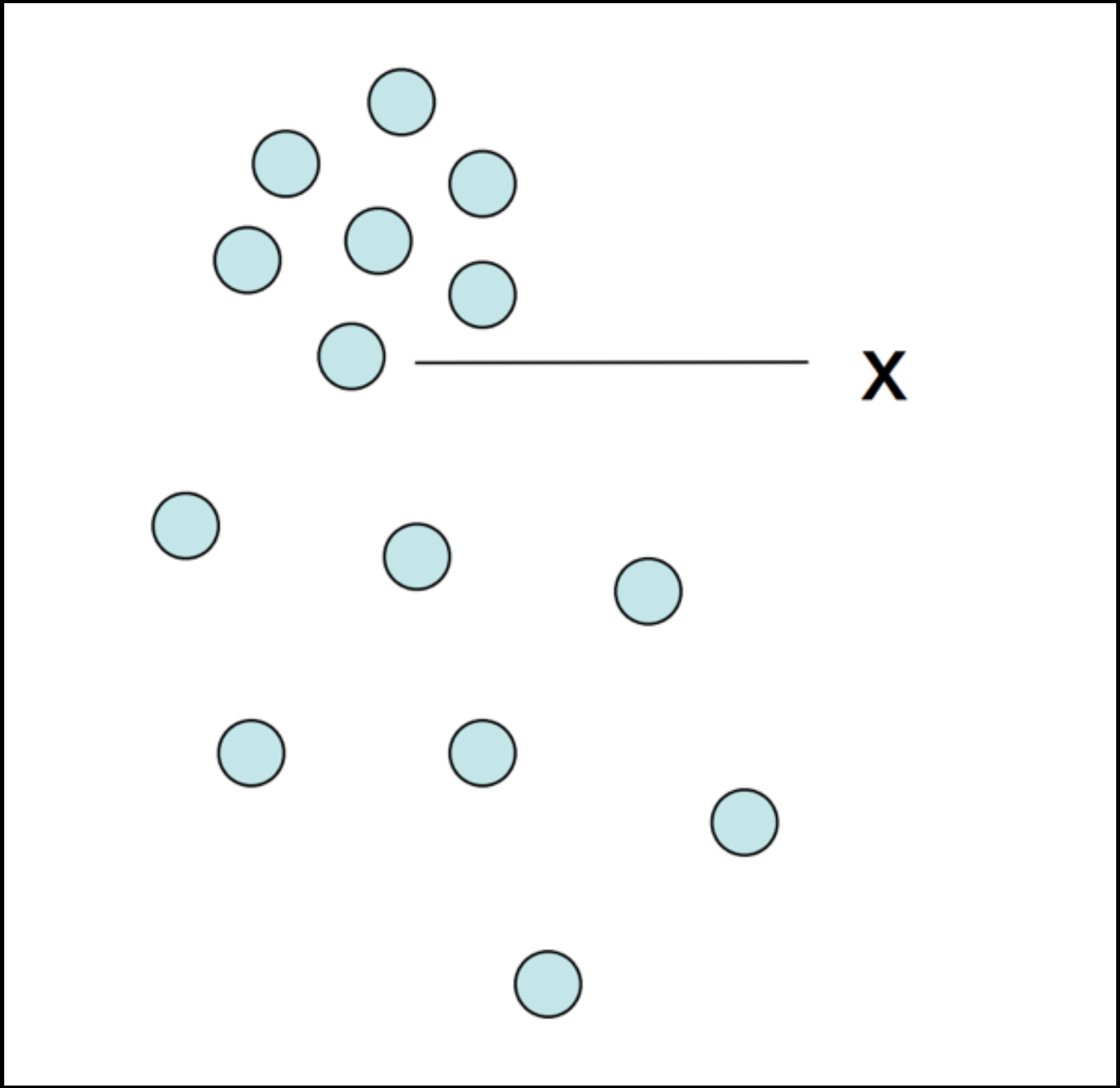


IMPLICATIONS FOR INFOVIS



ASSIGNMENTS

PAPER PRESENTATIONS & PROSPECTIVE PROJECTS

PLANNING

WEEK 1	WELCOME - INTRODUCTION
WEEK 2	VISUAL PERCEPTION, DATA MODELS / PROSPECTIVE PROJECTS
WEEK 3	NETWORKS / MULTIDIMENSIONAL DATA
WEEK 4	INTERACTION / ANIMATION
WEEK 5	~ HOLIDAY ~
WEEK 6	GUEST SPEAKER : CHRIS COLLINS — TEXT VISUALISATION
WEEK 7	MID-TERM REVIEW
WEEK 8	GUEST SPEAKER : RICHARD BRATH — VISUALIZATION IN INDUSTRY
WEEK 9	STUDENTS PAPER PRESENTATION
WEEK 10	GUEST SPEAKER : JUSTIN MATEJKA — VISUALIZATION AESTHETICS
WEEK 11	GUEST SPEAKER : ISABEL MEREILLES — DESIGN
WEEK 12	STUDENTS PAPER PRESENTATION
WEEK 13	FINAL PRESENTATIONS + WRAP UP

PAPERS PRESENTATIONS

Upcoming week (week 3)

Rametin Rassoli

Egocentric Analysis of Dynamic Networks with EgoLines

Laura Chen

Telling Stories about Dynamic Networks with Graph Comics

Sophia Hyunh

Edge compression techniques for visualization of dense directed graphs

PAPERS PRESENTATIONS

12-minute presentation
3-5 minute questions

Should I stick solely to the content of the given paper?
Absolutely not! Context + related research welcome

Shall we all read the papers **before** the presentation?
Not necessarily

Shall we all read the papers **after** the presentation?
Absolutely

PROJECTS

Individual projects, or group of 2 students

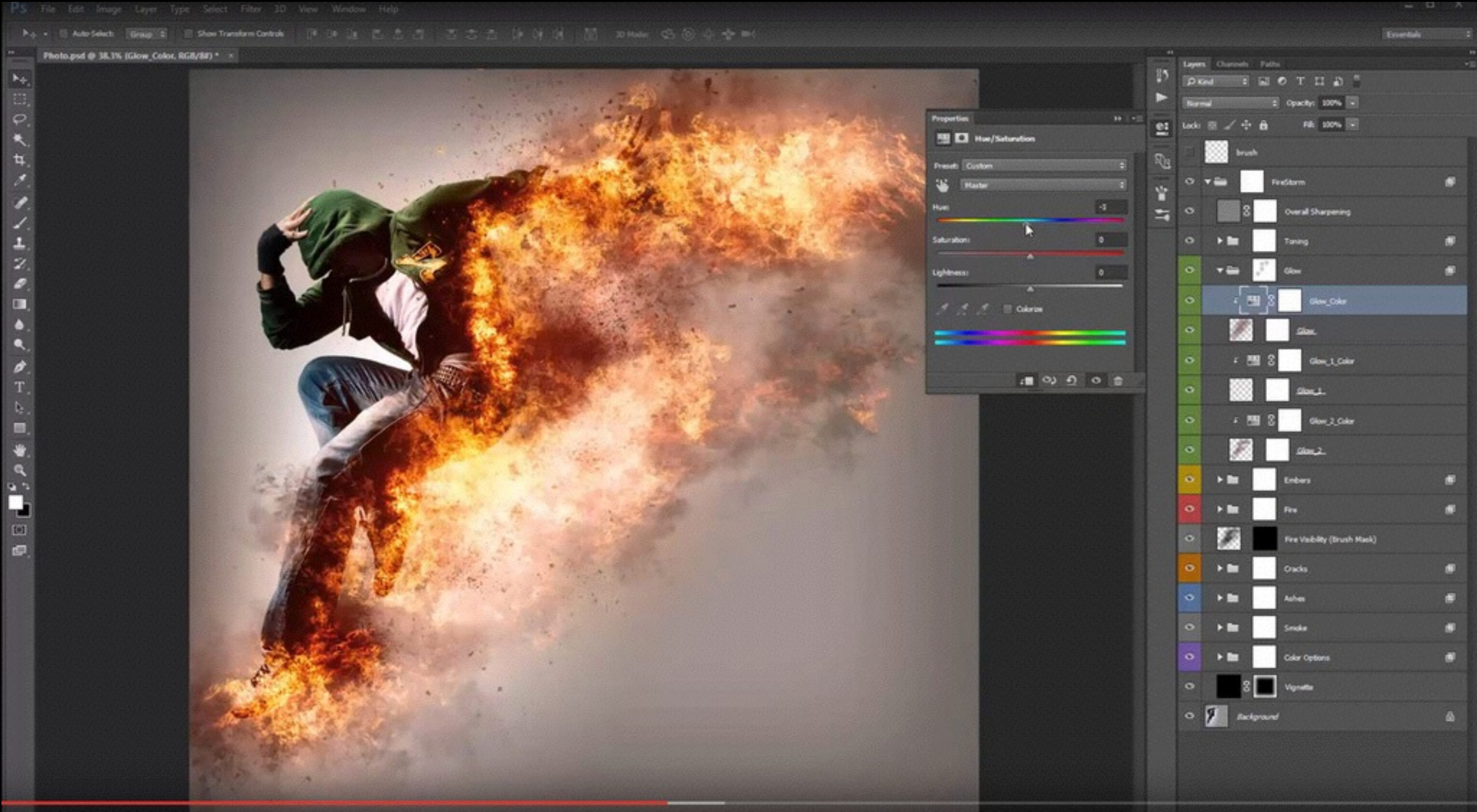
It is expected that you explore and discuss

- Related work
- Analysis of domain, tasks, design goals
- Implementation
- (evaluation)

Deliverable

- mid-term presentation (5-10min presentation of the project)
- Stand-alone demo
- Final presentation (live demos welcome!)
- Paper (4-6 pages)

PROSPECTIVE PROJECT 1
VISUALIZING PIXEL HISTORY / LAYERS



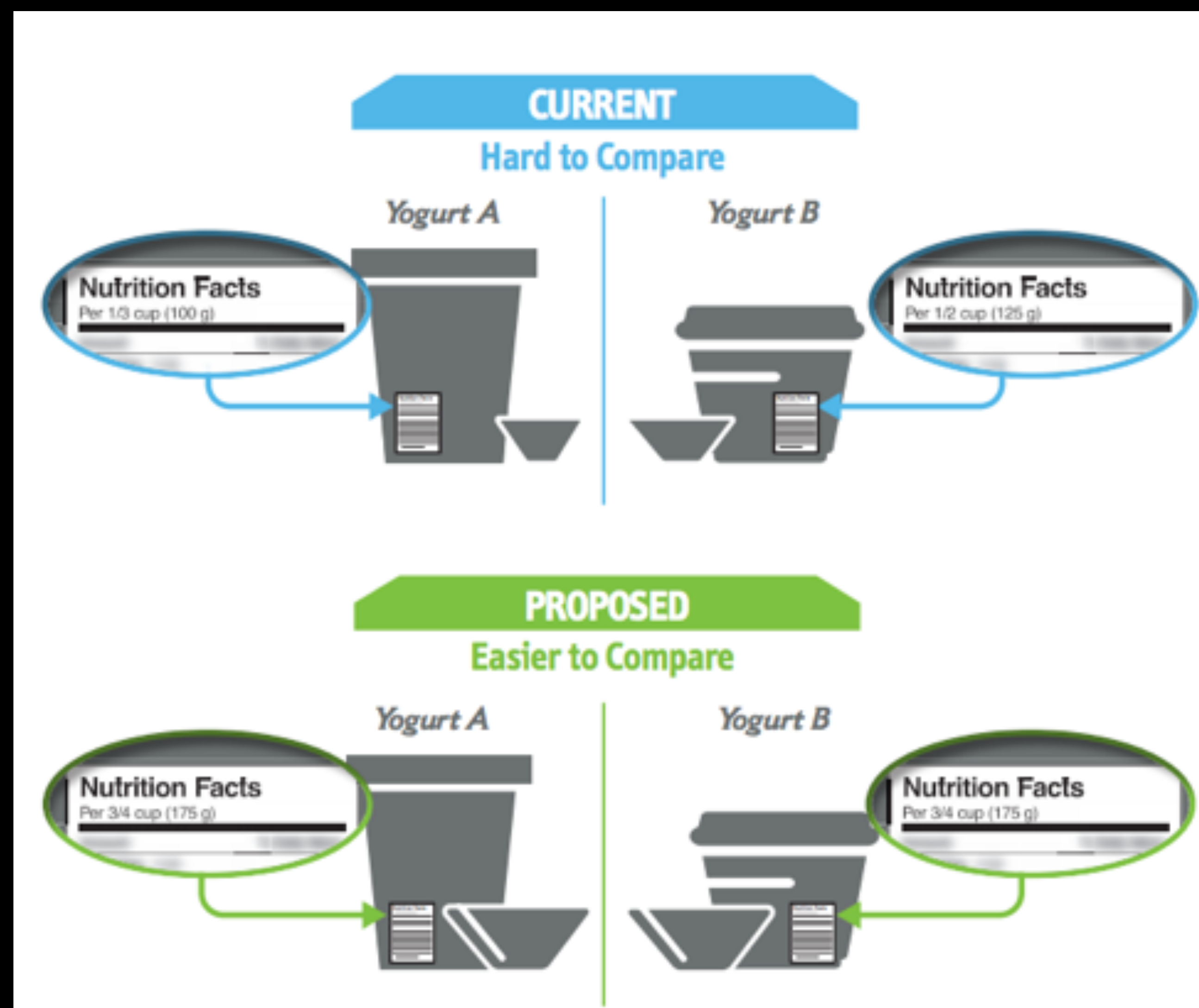
PROSPECTIVE PROJECT 2
VISUALIZATION OF NUTRITIVE PROPERTIES

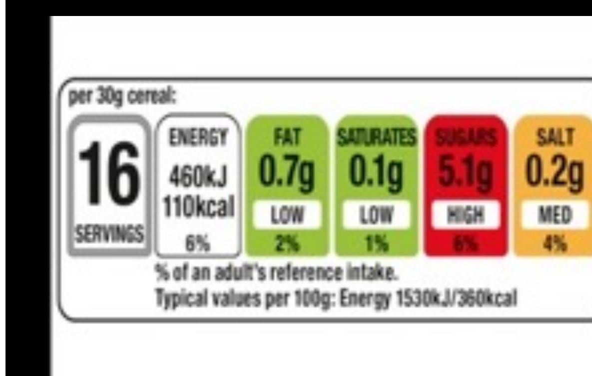
Cracker B

Nutrition Facts
Per 4 crackers (20 g)

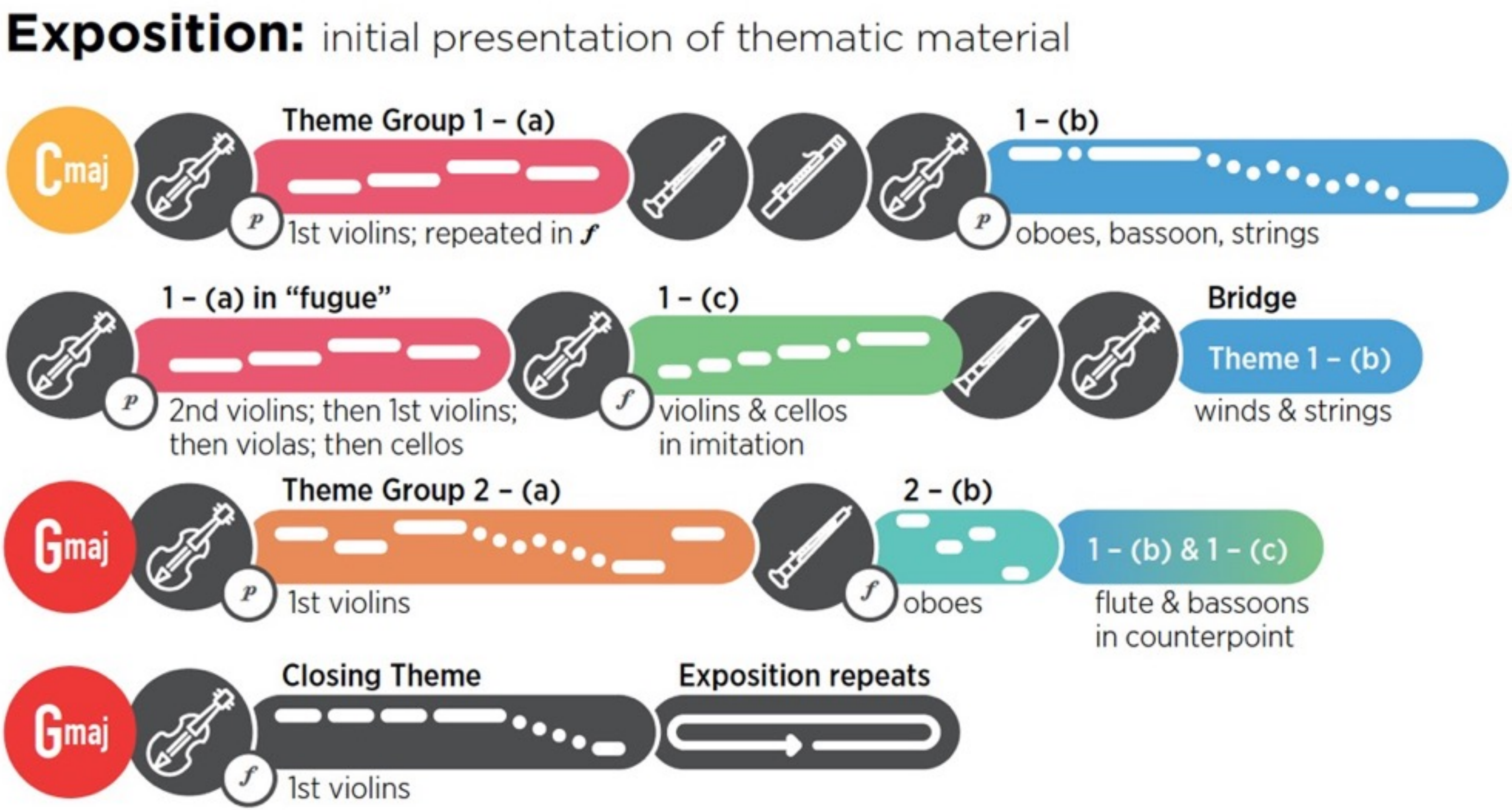
Amount	% Daily Value
Calories 85	
Fat 2 g	3 %
Saturated 0.3 g + Trans 0 g	2 %
Cholesterol 0 mg	
Sodium 90 mg	4 %
Carbohydrate 15 g	5 %
Fibre 3 g	12 %
Sugars 1 g	
Protein 2 g	

Vitamin A	0 %	Vitamin C	0 %
Calcium	2 %	Iron	7 %





PROSPECTIVE PROJECT 3
VISUALIZATION OF MUSIC (ORCHESTRA)



PROSPECTIVE PROJECT 4
ANIMATED TRANSITIONS OF THE INTERNET

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<h2>
<font face="Courier New" color=#FFFFFF> What you glimpse is </font>
</h2>

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<br><br><br><br>
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<font size=4 face="Helvetica" color=99CCFF> <b><i>Pierre Dragicevic</i></b>
</font><br>
<font face="Helvetica" color=6699CC> INRIA </font><br><br>

<font size=4 face="Helvetica" color=99CCFF> <b><i>St&eacute;phane Huot</i></b>
</font><br>
<font face="Helvetica" color=6699CC> LRI - Universit&eacute; Paris-Sud & CNRS, INRIA
</font><br><br>

<font size=4 face="Helvetica" color=99CCFF> <b><i>Fanny Chevalier </i></b>
</font><br>
<font face="Helvetica" color=6699CC> OCAD University </font>

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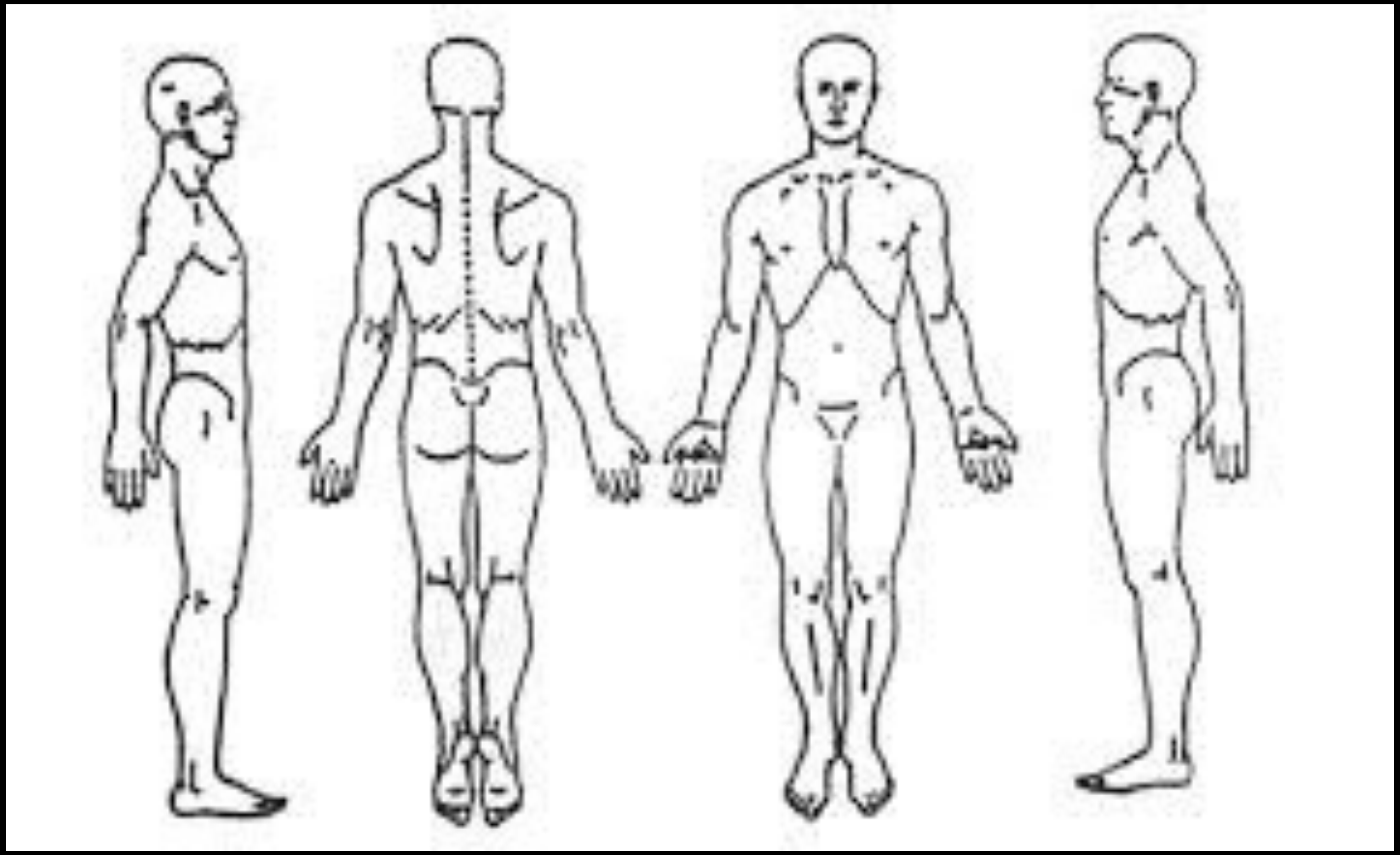
PROSPECTIVE PROJECT 5
(SKETCH-BASED) TOOL FOR AUTHORING ANIMATION

PROSPECTIVE PROJECT 6
EXPRESSING AND VISUALIZING BODY PAIN


(b) Back pain drawn using pen.
(c) Grouped leg pain drawings.
(d) Changing the duration and starting time.



PROSPECTIVE PROJECT 7
VISUALIZATION LITERACY AT SCHOOL

PROSPECTIVE PROJECT X
VAST CHALLENGES