Lecture 07: Attention and Intention

Part 02

Visual Attention

Relevance

Le Callet, P. and Niebur, E., 2013. Visual attention and applications in multimedia technologies. Proceedings of the IEEE, 101(9), pp.2058-2067.

Frintrop, S., Rome, E. and Christensen, H.I., 2010. Computational visual attention systems and their cognitive foundations: A survey. ACM Transactions on Applied Perception (TAP), 7(1), pp.1-39.

Vinnikov, M., Allison, R.S. and Fernandes, S., 2017. Gaze-contingent auditory displays for improved spatial attention in virtual reality. ACM Transactions on Computer-Human Interaction (TOCHI), 24(3), pp.1-38.

Astrand, E., Wardak, C. and Ben Hamed, S., 2014. Selective visual attention to drive cognitive brain–machine interfaces: from concepts to neurofeedback and rehabilitation applications. Frontiers in systems neuroscience, 8, p.144.

Biocca, F., Tang, A., Owen, C. and Xiao, F., 2006, April. Attention funnel: omnidirectional 3D cursor for mobile augmented reality platforms. In Proceedings of the SIGCHI conference on Human Factors in computing systems (pp. 1115-1122)

Kishishita, N., Kiyokawa, K., Orlosky, J., Mashita, T., Takemura, H. and Kruijff, E., 2014, September. Analysing the effects of a wide field of view augmented reality display on search performance in divided attention tasks. In 2014 IEEE International Symposium on Mixed and Augmented Reality (ISMAR) (pp. 177-186). IEEE.

Renner, P. and Pfeiffer, T., 2017, March. Attention guiding techniques using peripheral vision and eye tracking for feedback in augmented-reality-based assistance systems. In 2017 IEEE symposium on 3D user interfaces (3DUI) (pp. 186-194). IEEE.

Vortmann, L.M. and Putze, F., 2021. Exploration of Person-Independent BCIs for Internal and External Attention-Detection in Augmented Reality. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 5(2), pp.1-27.

Mathôt, S., Melmi, J.B., Van der Linden, L. and Van der Stigchel, S., 2015. The mind-writing pupil: Near-perfect decoding of visual attention with pupillometry. Journal of Vision, 15(12), pp.176-176.

Learning Objectives

To provide a description of different types of visual attention allocation.

To provide examples of key techniques used to study visual attentional allocation.

To provide an explanation of feature-based attention- theory and studies

To provide an explanation and example of visual intentional blindness and change blindness

To provide examples of studies investigating how attention may enhance perception

To provide examples of how visual attentional research can impact interface design and development

Learning Outcomes

To be able to provide a description of the key types of visual attention allocation.

To be able to provide an example of the type of studies used to investigate visual attentional allocation.

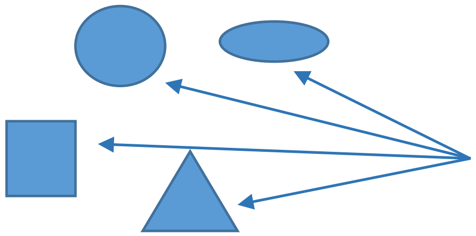
To be able to provide an example of the type of studies used to study feature-based attention and the key elements of a feature-based attentional model.

To be able to compare and contrast visual intentional blindness and change blindness.

To be able to provide an example of studies designed to investigate how attention may enhance perception.

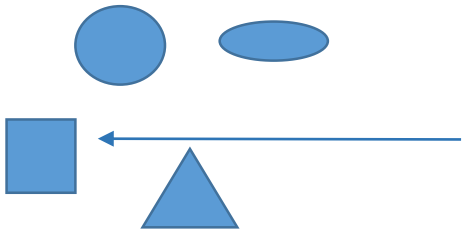
To develop an appreciation of the different ways in which visual attentional research can impact interface design and development.

How is Attention Allocated?

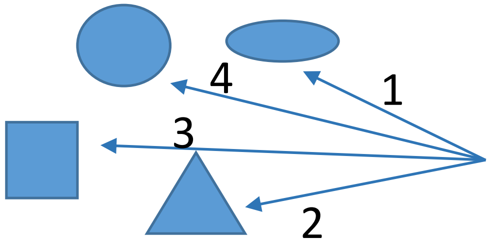


Divided attention: mental focus is directed towards multiple ideas, or tasks, at once - - > multitasking (simultaneously attending to a number of items).

Focused attention: The ability to respond discretely to specific sensory stimuli.

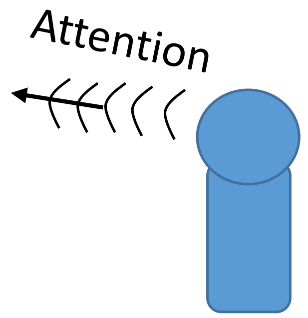


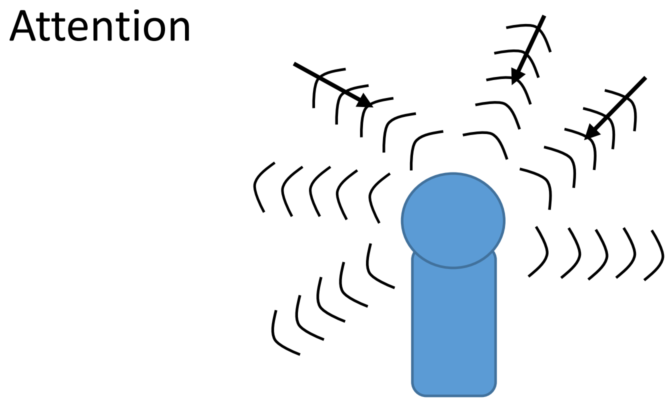
Selective Attention: The ability to attend to a specific stimulus or activity in the presence of other distracting stimuli.



Alternating Attention: The ability to change focus attention between two or more stimuli.

Recap: Endogenous and Exogenous Attention





Attention can alter perception, but this depends on how we orient attention.

Orienting attention can be controlled through external (exogenous) or internal (endogenous) processes.

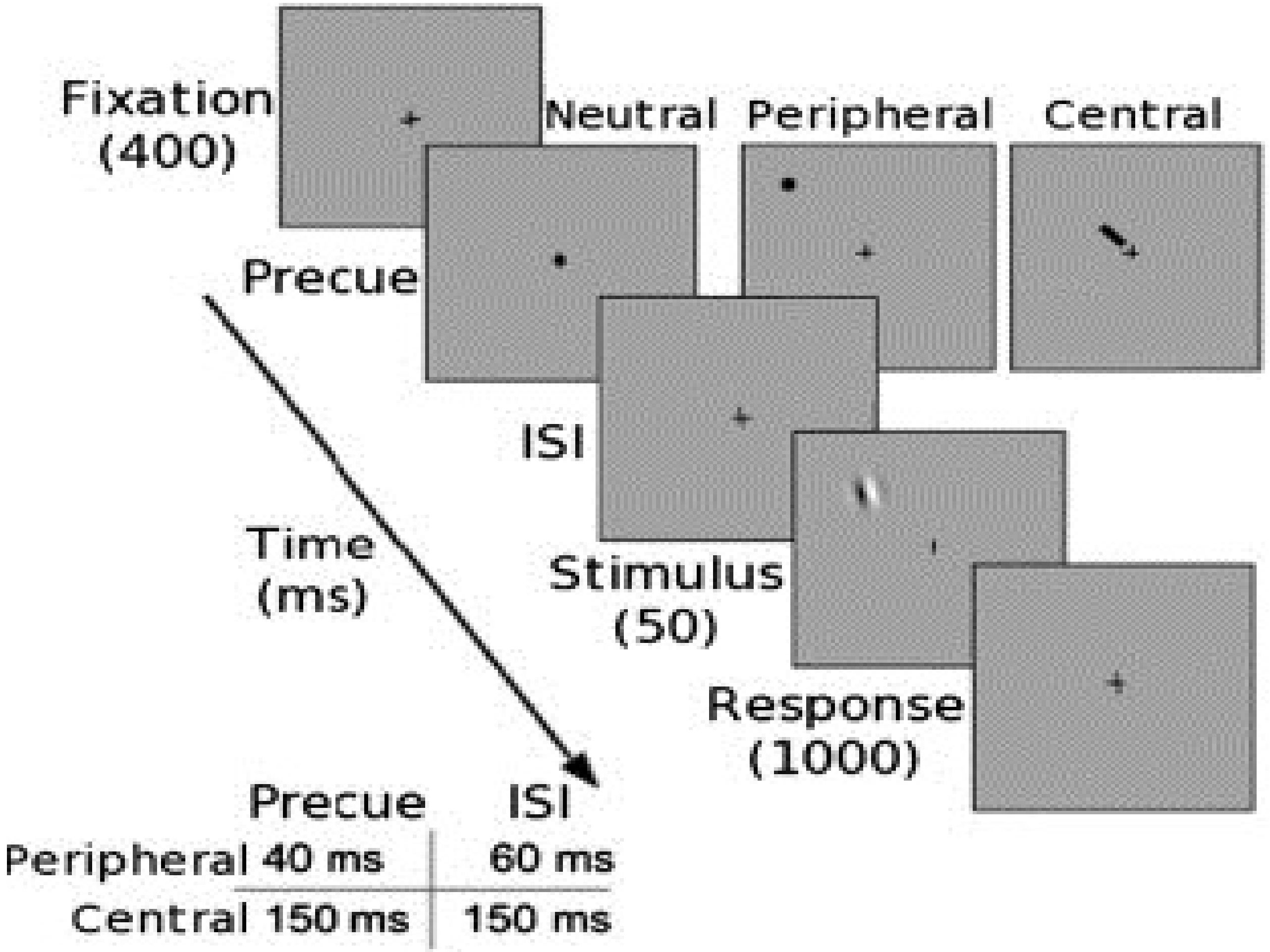
Endogenous (or sustained)

Voluntary. *Paid* to external cue. Goal-directed e.g., concentration, motivation (revision).

Exogenous <u>(or transient)</u>

Involuntary. *Captured* by external cue. Stimulus driven e.g., Caused by a sudden change in the environment. Reaction, pop-up ad.

Assessing Exogenous and Endogenous Attention



Posner Cueing Paradigm

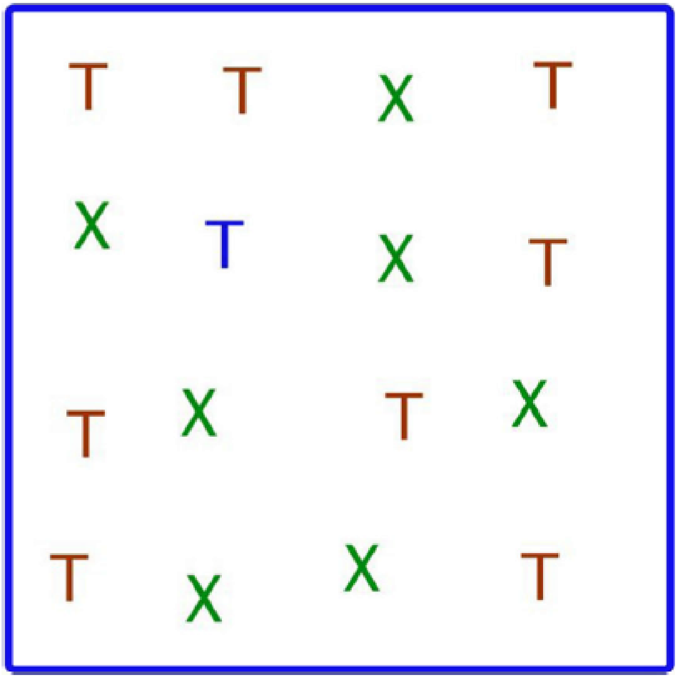
Compare performance when:

- Attention is directed to target location (attended condition),
- Attention is directed away from target location (unattended condition)
- Attention is distributed across the display (neutral or control condition).

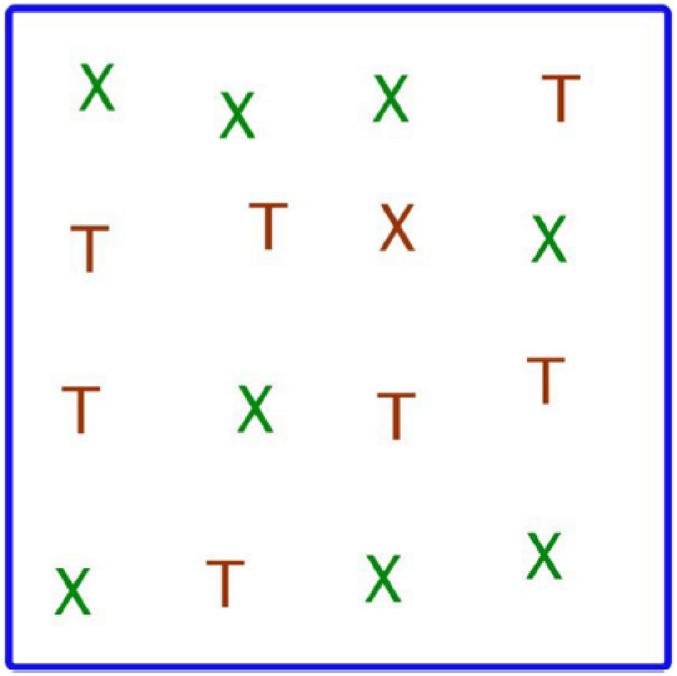
Endogenous attention- central cue indicates most likely location of subsequent target. Exogenous attention- Brief peripheral cue is presented adjacent to one of the target locations.

Feature-Based Attention - The Feature Search

Search 1: Colour Singleton



Search 2: Conjunction Task



Similar task to one used by Treisman.

Search 1: Target blue T is a colour singleton easily spotted amongst other items (brown and green distractors). Detecting the target requires just preattentive processing.

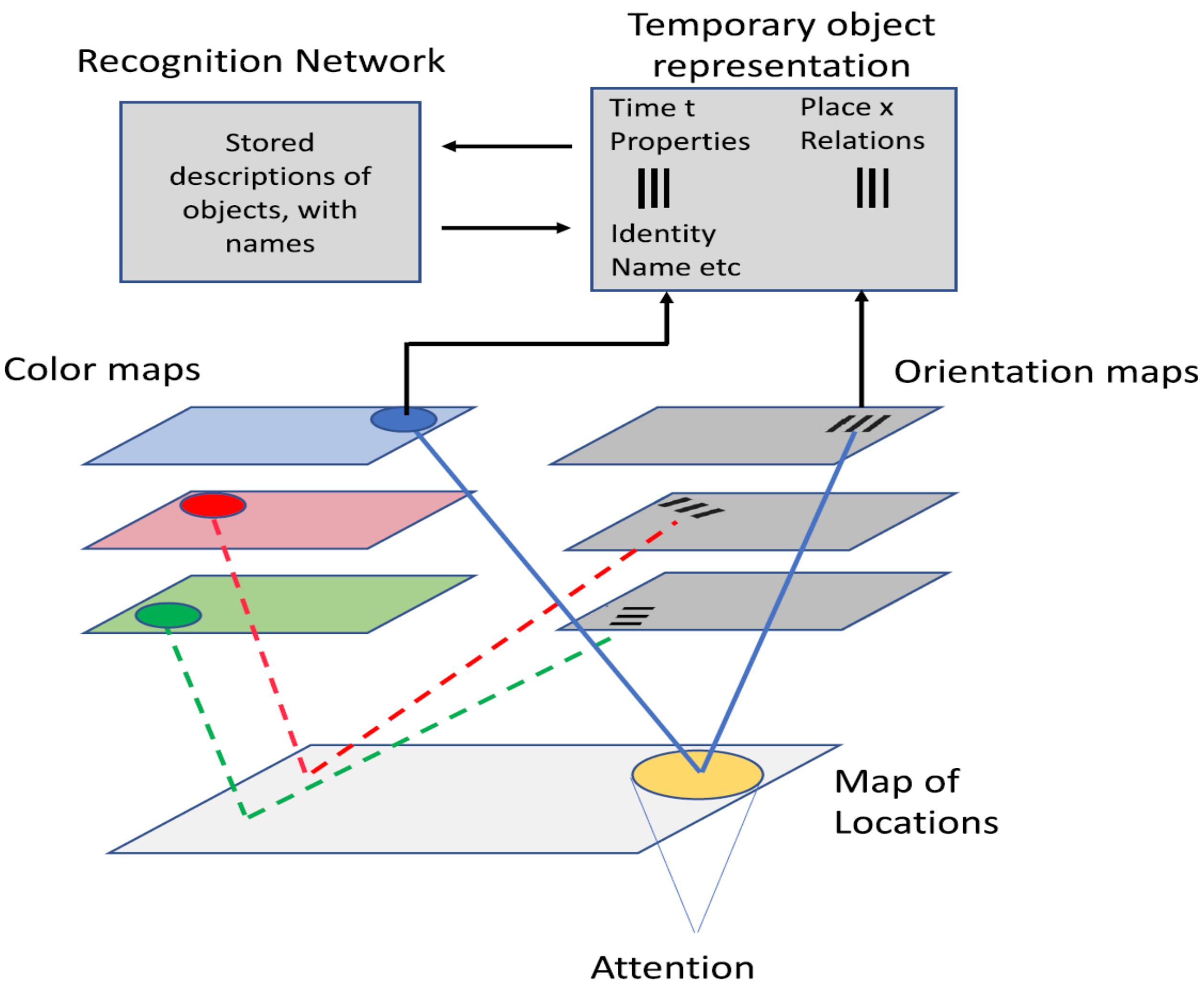
Search 2: Target brown X differs from distractors by its **conjuction** of letter identity and colour. Detecting the target requires attention to integrate its colour and form, which results in an **item-by-item search**.

Feature-Based Attention – Feature Integration Theory

Feature search study results - - > Feature integration theory.

"*objects are retrieved from scenes by means of selective spatial attention that picks out objects' features, forms feature maps, and integrates those features that are found at the same location into forming objects*."

Feature-Based Attention – Feature Integration Theory



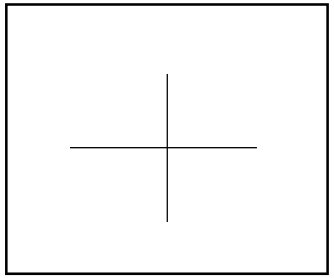
From: Kristjansson, A., and Egeth, H. (2020). Attention, Perception, and Psychophysics, 82, 7-23.

- Preattentive Stage: Unconscious detection and separation of features of an item (color, shape, size).
- Focused Attention Stage: Combining of all feature identifiers to perceive all parts as one whole. This is possible through prior knowledge and cognitive mapping.

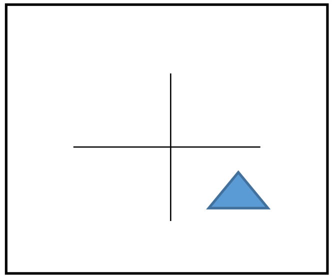
A particular stimulus creates activations in feature maps (e.g., for colour and orientation). Attention then binds features together in the master map of locations, but can only do so for a limited amount of information in the display (other features are "free-floating"). The temporary object representation is then compared against stored object descriptions.

Inattentional Blindness

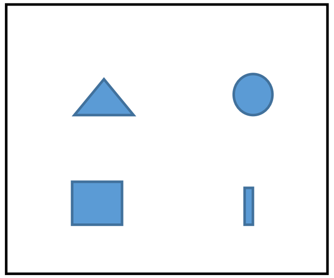
Participant Sees



3-4 more trials



Inattention trial



Recognition test

Participant's Task

Indicate longer arm: Horizontal or vertical?

Which arm is longer?

Which object did you see?

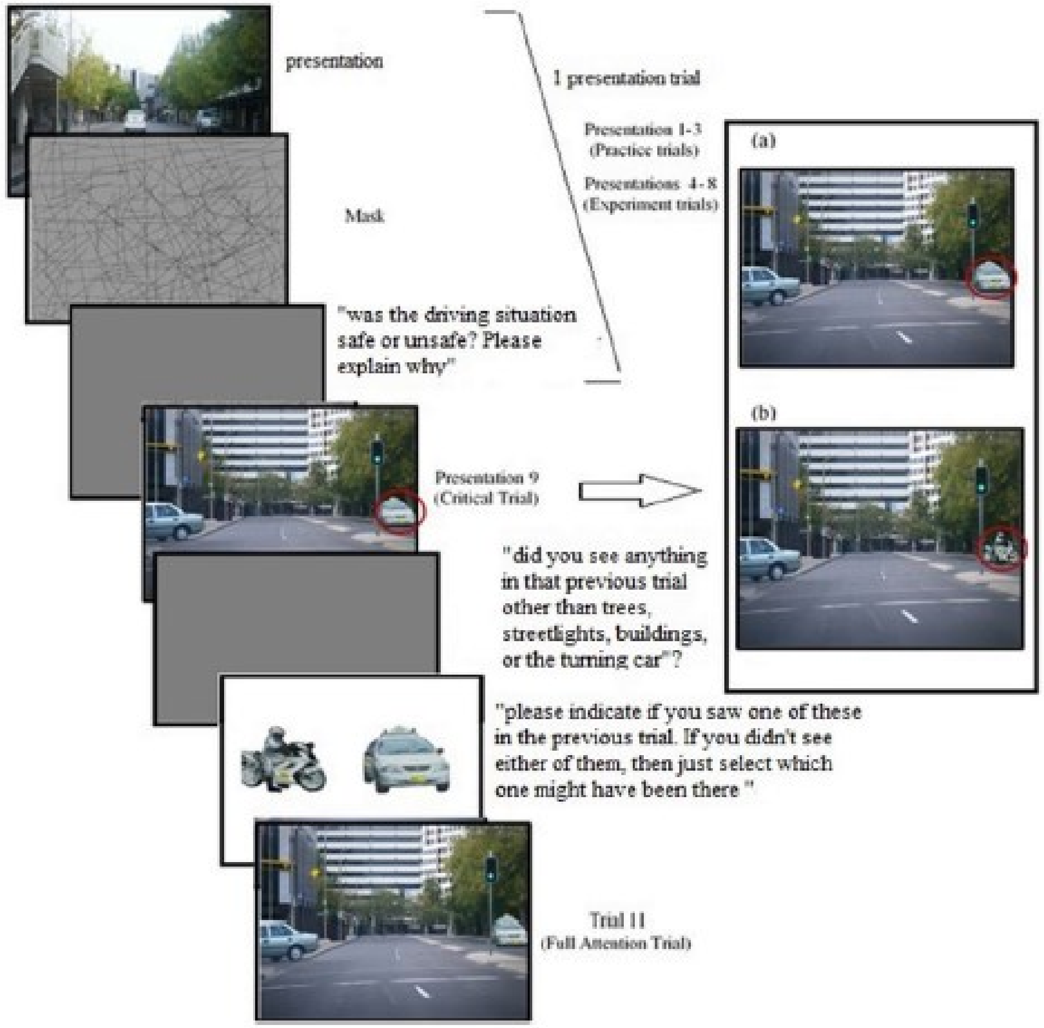
Experiment:

a) Participants judged whether the horizontal or vertical arm is larger on each trial.
b) After a few trials a shape is flashed on screen along with the arms
c) Participant is asked to pick which shape was presented

Result: Participants were often unable to indicate which shape had been presented.

Mack, A., et al. (1998). Inattentional blindness. Cambridge MA:MIT Press.

Inattentional Blindness



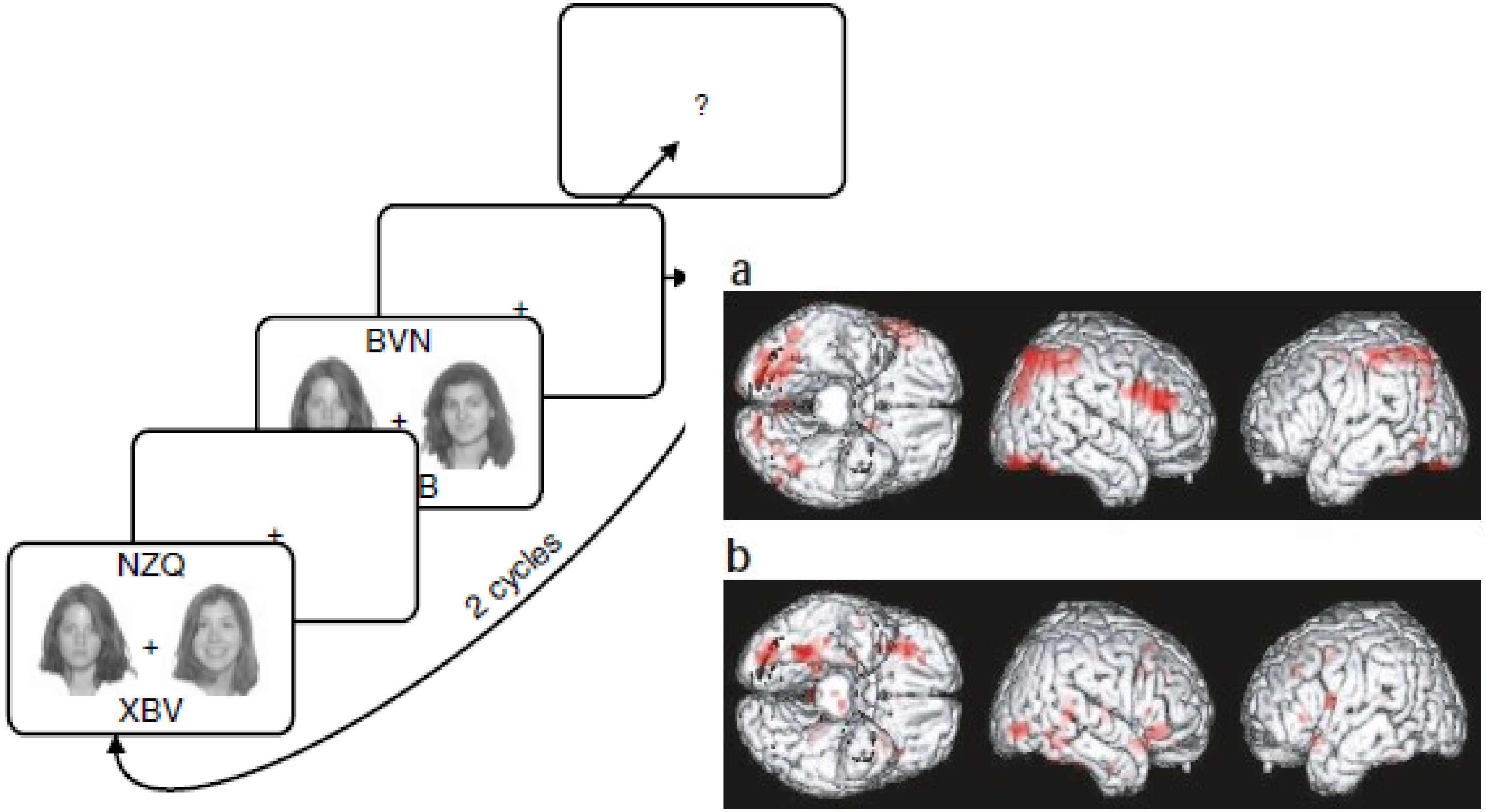
Study: To determine whether inattentional blindness can be used to understand the psychological mechanisms around road incidents involving motorcycles.

Participants: Stimuli presented on a computer screen. Additional item was a taxi/motorcycle.

Result: Participants were twice as likely to miss a motorcycle compared with a taxi.

Pammer, K., Sabadas, S. and Lentern, S., 2018. Allocating attention to detect motorcycles: The role of inattentional blindness. Human factors, 60(1), pp.5-19.

Change Blindness vs Change detection

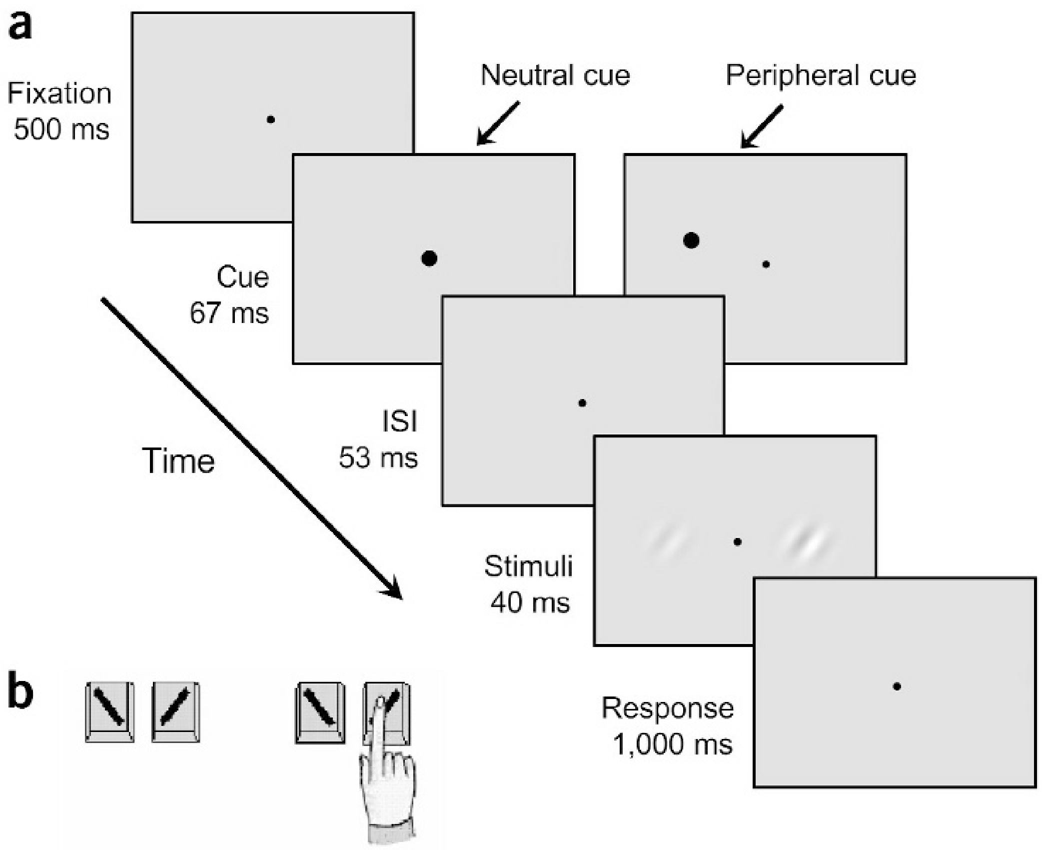


Participants: Face-change trial, have to answer at the end whether a change had taken place or not. Also conducted a place-change trial.

fMRI: Brain areas activated by change detection (a) are different from those activated by change blindness (b)

Beck, D.M., Rees, G., Frith, C.D. and Lavie, N., 2001. Neural correlates of change detection and change blindness. *Nature neuroscience*, *4*(6), pp.645-650.

Does Attention Enhance Perception



Participants: Presented gratings of differing contrast.

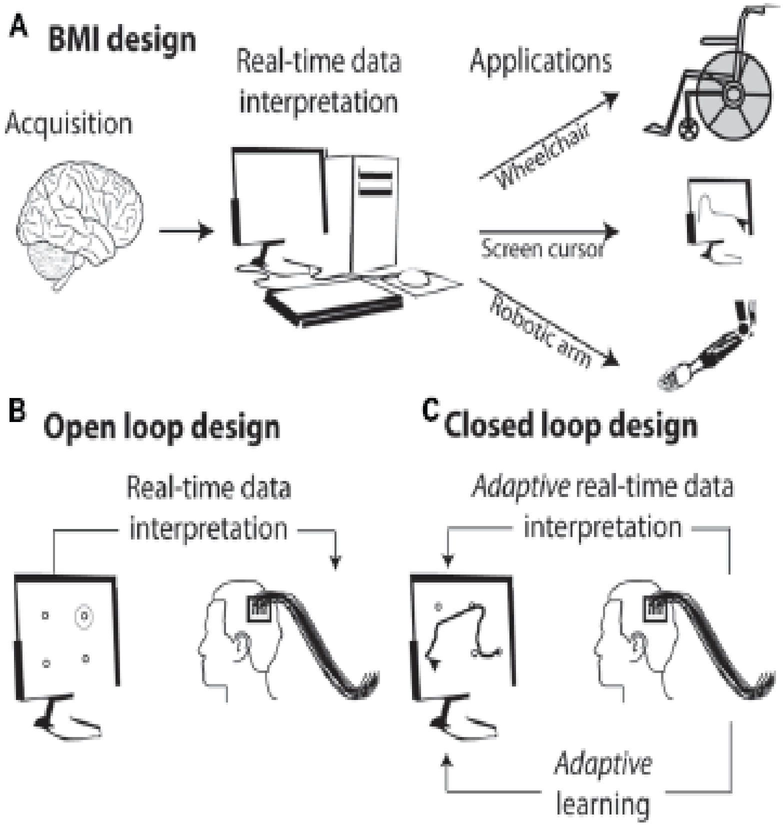
Covert attention directed to a particular cue

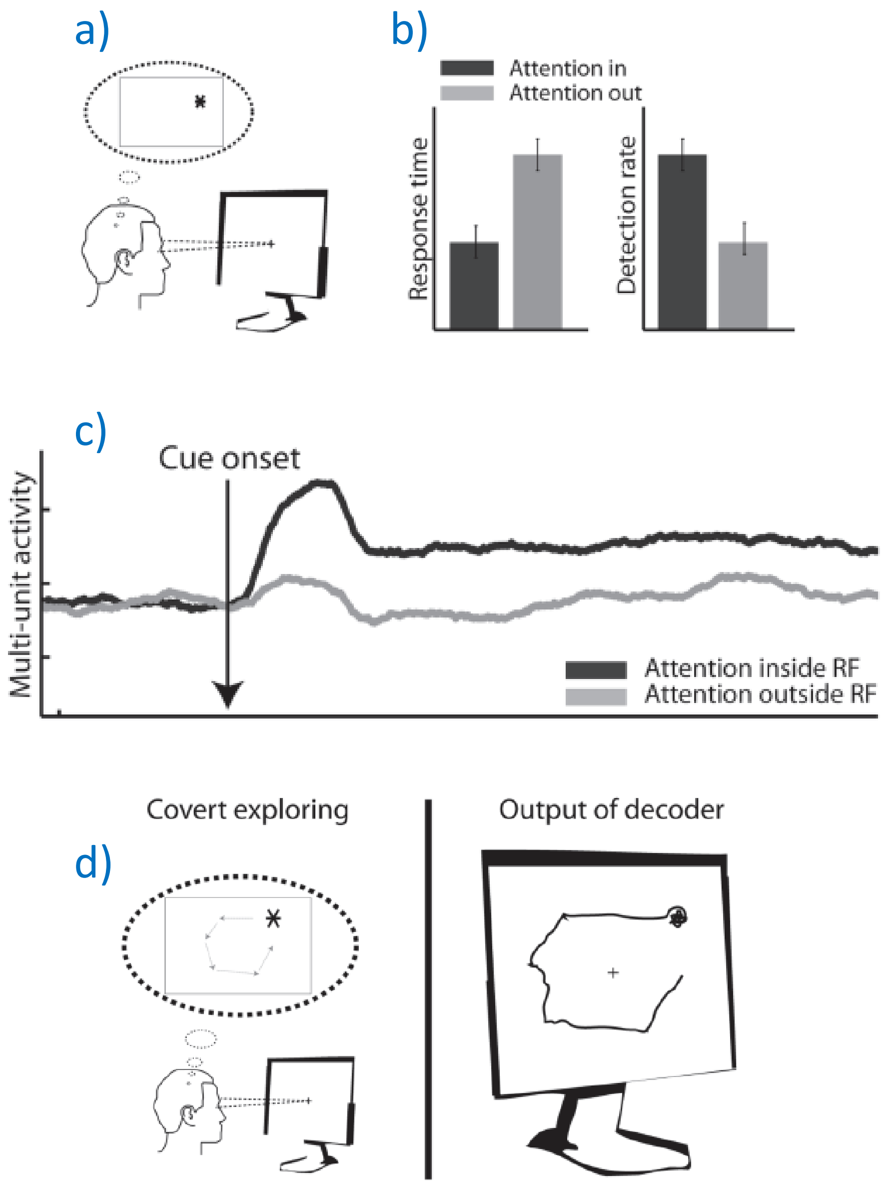
Result: Attention can change the strength of a stimulus by increasing its 'effective contrast' or salience.

Carrasco, Marisa, Sam Ling, and Sarah Read. "Attention alters appearance." Nature neuroscience 7, no. 3 (2004): 308-313.

Astrand, E., Wardak, C. and Ben Hamed, S., 2014. Selective visual attention to drive cognitive brain–machine interfaces: from concepts to neurofeedback and rehabilitation applications. *Frontiers in systems neuroscience*, *8*, p.144.

From brain signals to external devices





a) Covert attention orientation

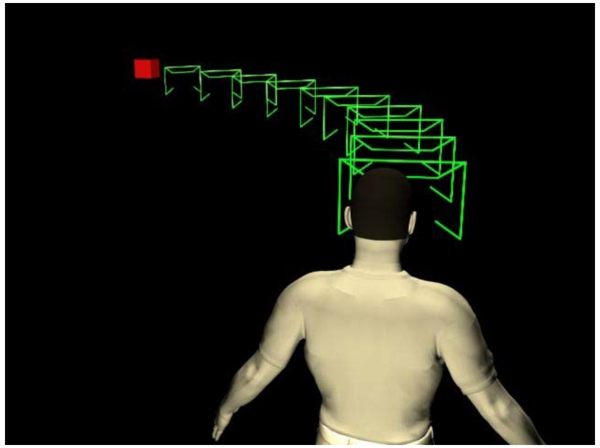
b) Behavioural benefits of attention

c) Neural bases of attention

d) Online monitoring of attentional locus

Biocca, F., Tang, A., Owen, C. and Xiao, F., 2006, April. Attention funnel: omnidirectional 3D cursor for mobile augmented reality platforms. In *Proceedings of the SIGCHI conference on Human Factors in computing systems* (pp. 1115-1122).

a)



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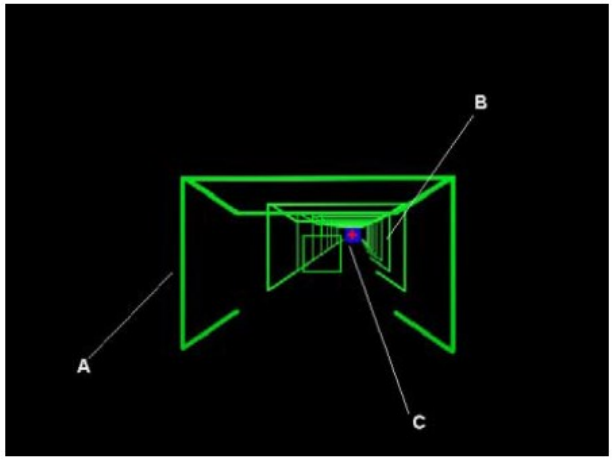
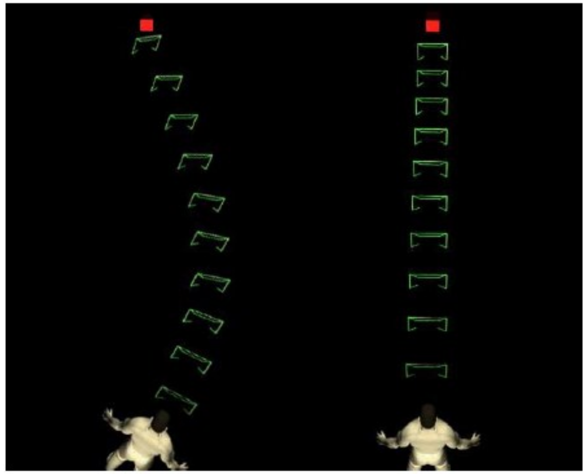
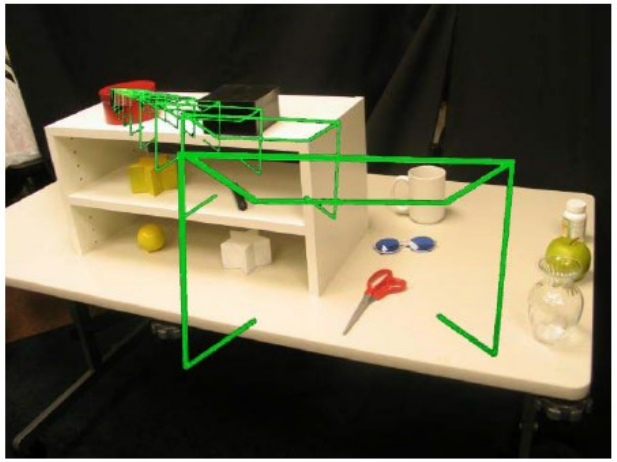


c)



d)



a) Attentional funnel links head of viewer to an object.

b) 3 basic patterns used to construct funnel.

c) As head and body moves, attentional funnel continuously provides feedback.

d) Example of attentional funnel drawing attention of the user to an object.

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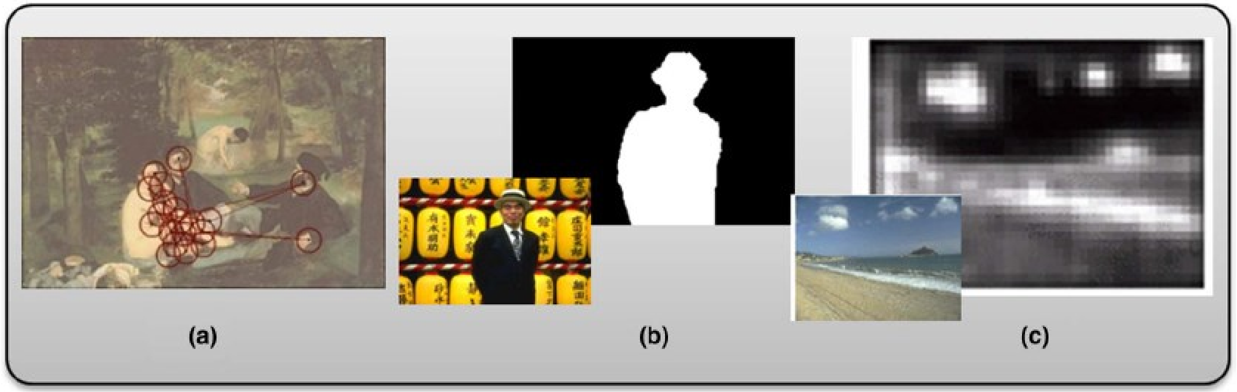

a) Examples of the scanpath
b) Region of interest map and content
c) Fixed density map and content

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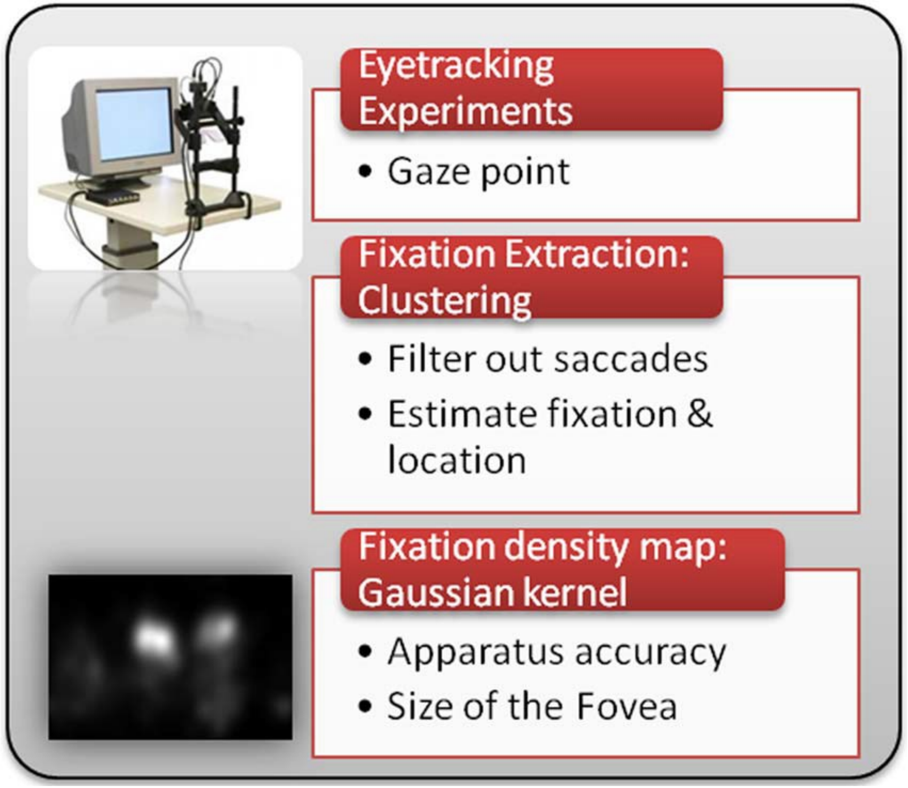
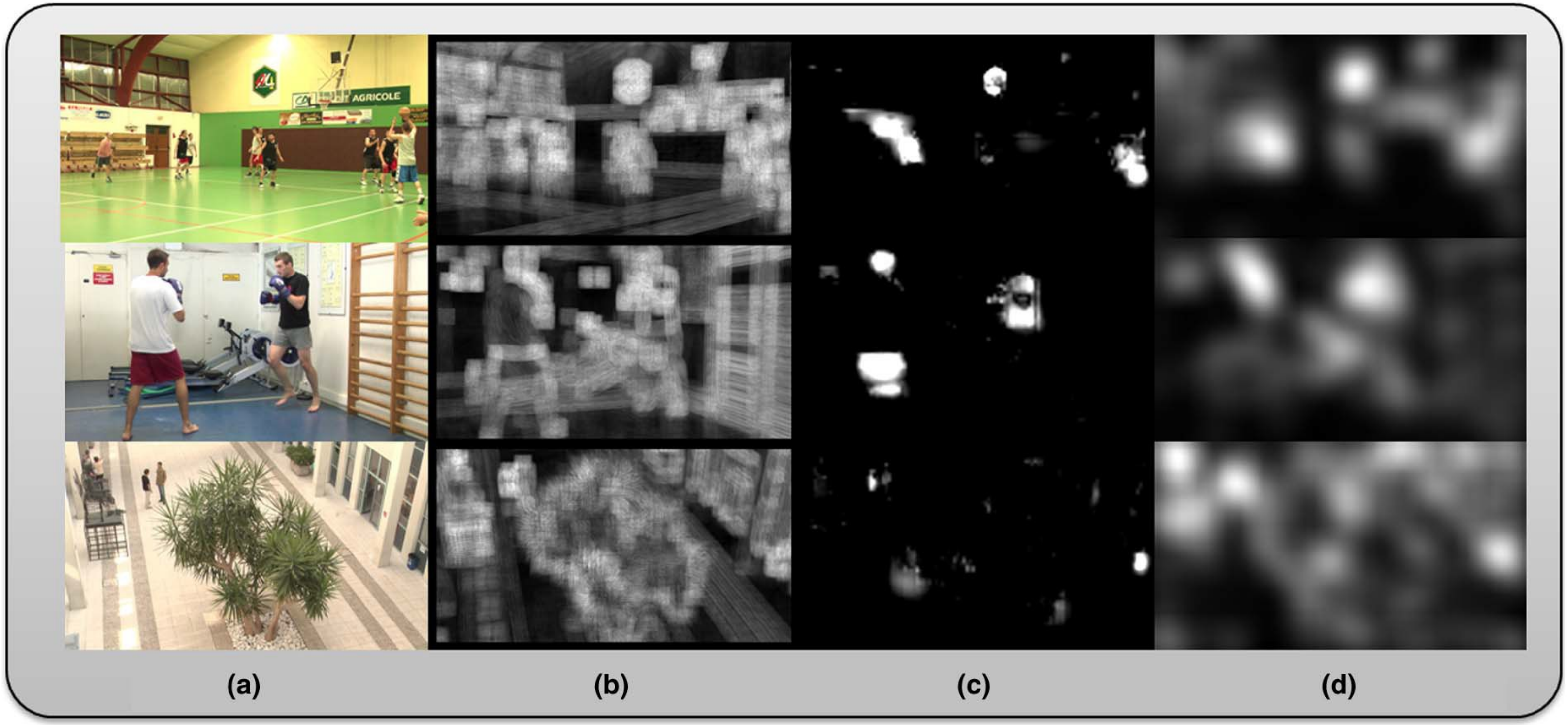


Steps for transforming eye-tracking data into a fixation density map (FDM).

Le Callet, P. and Niebur, E., 2013. Visual attention and applications in multimedia technologies. *Proceedings of the IEEE*, *101*(9), pp.2058-2067.

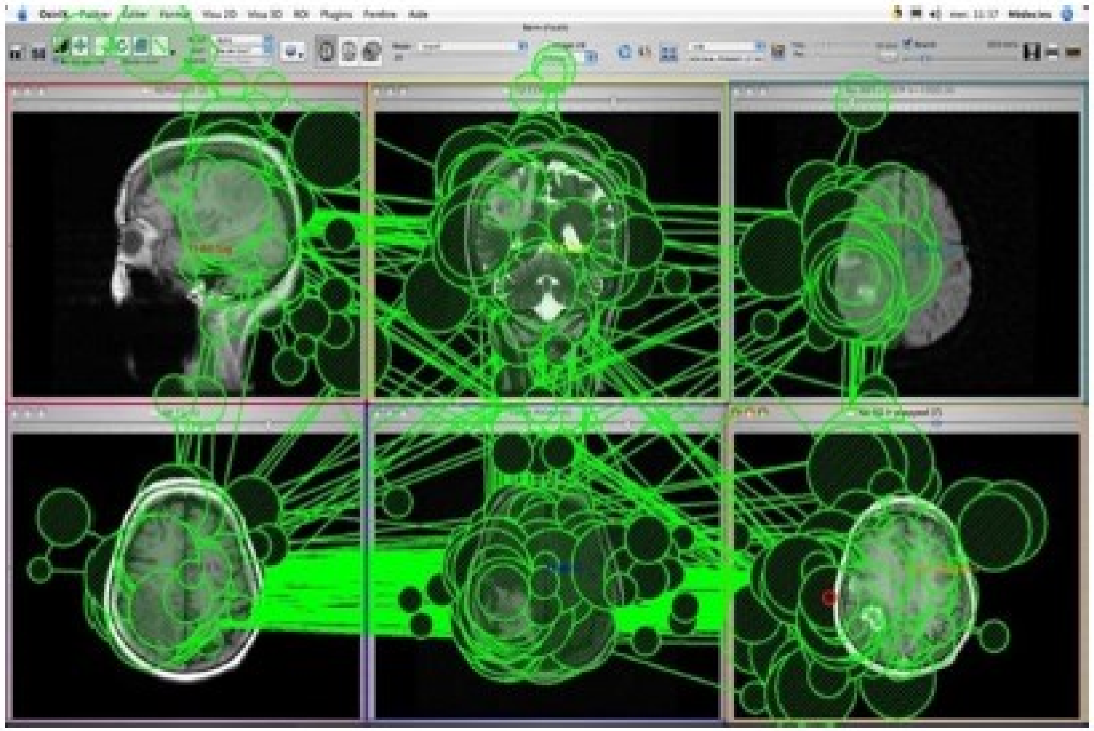


Examples of FDMs generated by visual attention models.

a) Original content
b) AIM model
c) STB model
d) SR model

(model details in the paper)

Le Callet, P. and Niebur, E., 2013. Visual attention and applications in multimedia technologies. *Proceedings of the IEEE*, *101*(9), pp.2058-2067.

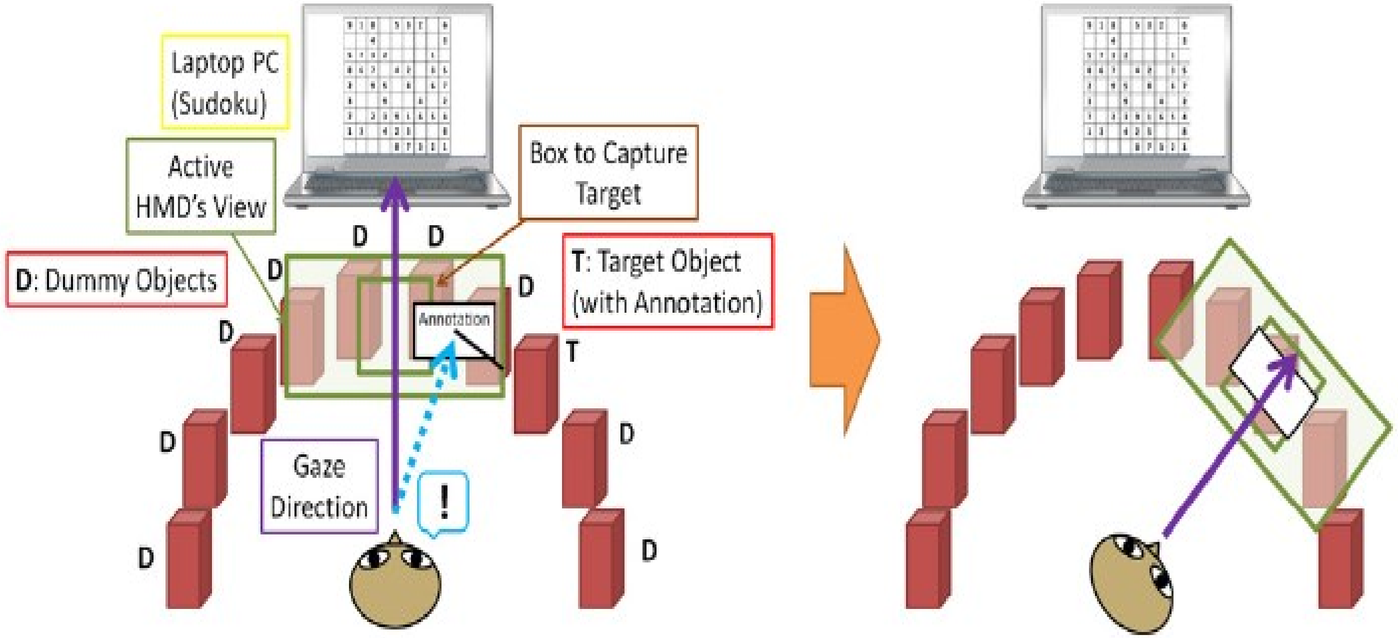


Scanpath and gaze fixations on multiple MRI sequences.

Shown are different MRI sequences from 1 patient's head overlaid with eye movement data of a clinical expert (green)

Lines = saccades
Shaded circles = fixations (diameter proportional to viewing time)

Kishishita, N., Kiyokawa, K., Orlosky, J., Mashita, T., Takemura, H. and Kruijff, E., 2014, September. Analysing the effects of a wide field of view augmented reality display on search performance in divided attention tasks. In *2014 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)* (pp. 177-186). IEEE.



Study: To investigate effect of divided attention when using a wide field of view (FOV) augmented reality display.

Green box- "window on the world" can be a different size (different FOV).

Overall Summary

Description of different types of visual attentional allocation.
Assessments of exogenous and endogenous attention.
Feature-based attentional theory and tasks.
Key experiment to show how attention may enhance visual perception.
Provided examples of studies demonstrating how visual attentional research can impact interface design and development.

Resources

Essential:

Carrasco, M. (2011). Visual attention: The past 25 years. Vision Research, 51, 1484-1525.

Goldstein, E.B. Sensation and Perception, 8th Edition. Chapter 6 Visual attention.

Supplementary:

Pammer, K., Sabadas, S. and Lentern, S., 2018. Allocating attention to detect motorcycles: The role of inattentional blindness. Human factors, 60(1), pp.5-19.

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