Lecture 07: Attention and Intention

Part 01

An Introduction to Attention

Relevance

Vortmann, L.M., 2019, October. Attention-driven interaction systems for augmented reality. In 2019 International Conference on Multimodal Interaction (pp. 482-486).

Ortiz, M., Ferrero, L., Iáñez, E., Azorín, J.M. and Contreras-Vidal, J.L., 2020. Sensory integration in human movement: A new brain-machine interface based on gamma band and attention level for controlling a lower-limb exoskeleton. Frontiers in Bioengineering and Biotechnology, 8, p.735.

Bahramisharif, A., Van Gerven, M., Heskes, T. and Jensen, O., 2010. Covert attention allows for continuous control of brain–computer interfaces. European Journal of Neuroscience, 31(8), pp.1501-1508.

Vertegaal, R., Shell, J.S., Chen, D. and Mamuji, A., 2006. Designing for augmented attention: Towards a framework for attentive user interfaces. Computers in Human Behavior, 22(4), pp.771-789.

Wang, K., Zhang, B. and Cho, Y., 2020, April. Using Mobile Augmented Reality to Improve Attention in Adults with Autism Spectrum Disorder. In Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1-9).

Voinescu, A., Fodor, L.A., Fraser, D.S. and David, D., 2020, July. Exploring attention in VR: effects of visual and auditory modalities. In International Conference on Applied Human Factors and Ergonomics (pp. 677-683). Springer, Cham.

Tan, C., Sun, F., Kong, T., Fang, B. and Zhang, W., 2019, May. Attention-based transfer learning for brain-computer interface. In ICASSP 2019-2019 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 1154-1158). IEEE.

Learning Objectives

To provide an introduction to the topic of attention.

To provide an overview of some of the key concepts and developments within the field of attentional research.

To provide an explanation of the different descriptors associated with attentional research.

To provide an overview of the key concepts used in the study of attention.

Learning Outcomes

To be able to describe some of the key concepts associated with attentional research.

To be able to describe some of the early theories of attention

To be able to provide a description of the main types of attention

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

Attention !

Attention is crucial to our interaction with our environment.

Sometimes attending is easy and at other times it is difficult.

So,

1. What is attention?
2. How do we pay attention?
3. Why do we pay attention?
4. Why is it important for interface design?

Attention !

1. **What is attention?**

Part 01 will provide an overview of attention and introduce some early models of attention.

2. How do we pay attention?
3. Why do we pay attention?

Part 02 and part 03 will cover aspects of both auditory and visual attention to show how and why attention is important in order for us to effectively process the sensory-rich environment around us.

4. Why is it important for interface design?

Part 01 to part 04 will include key research articles and descriptions of how attentional research has been applied to interface design and evaluation.

How is Attention Measured?

Psychological/ Psychophysical	Distinct attentional systems & initial models
Neurophysiology (single-unit neural recordings)	Attentional modulation of neural responses
Electroencephalography (EEG) Positron Emission Tomography (PET) Magnetoencephalography (MEG) Functional Magnetic Resonance Imaging (fMRI)	Studying the brain whilst engaged in attentional tasks
Eye-Tracking	high-resolution imaging of eye movements during tasks involving perception and attention

Computational Modelling of brain mechanisms and architectures underlying attentional effects on perception

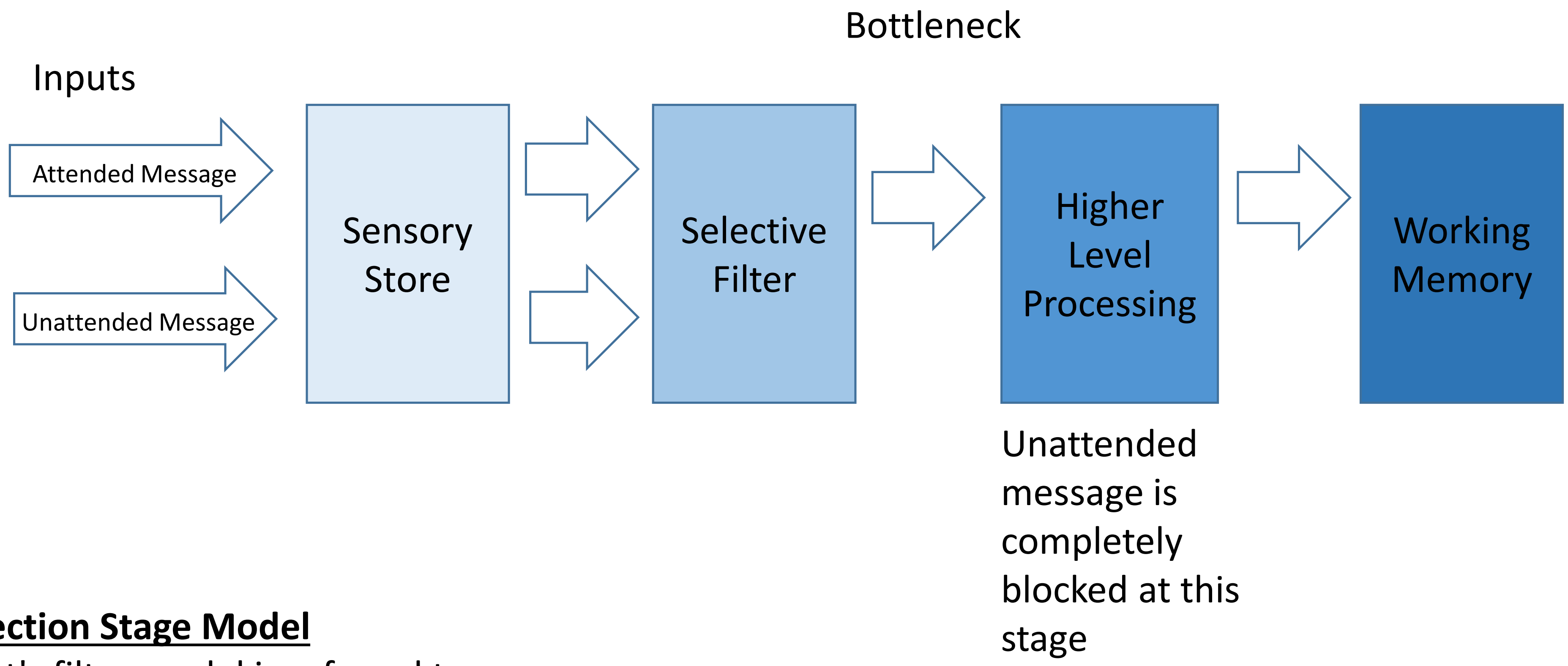
Is Attention a Spotlight or a Zoom lens?

Early studies of visual attention

Spotlight model:
Attention has a focus, a margin, and a fringe.

Zoom-lens model:
Also has a focus, margin, and fringe plus added property of changing in size.

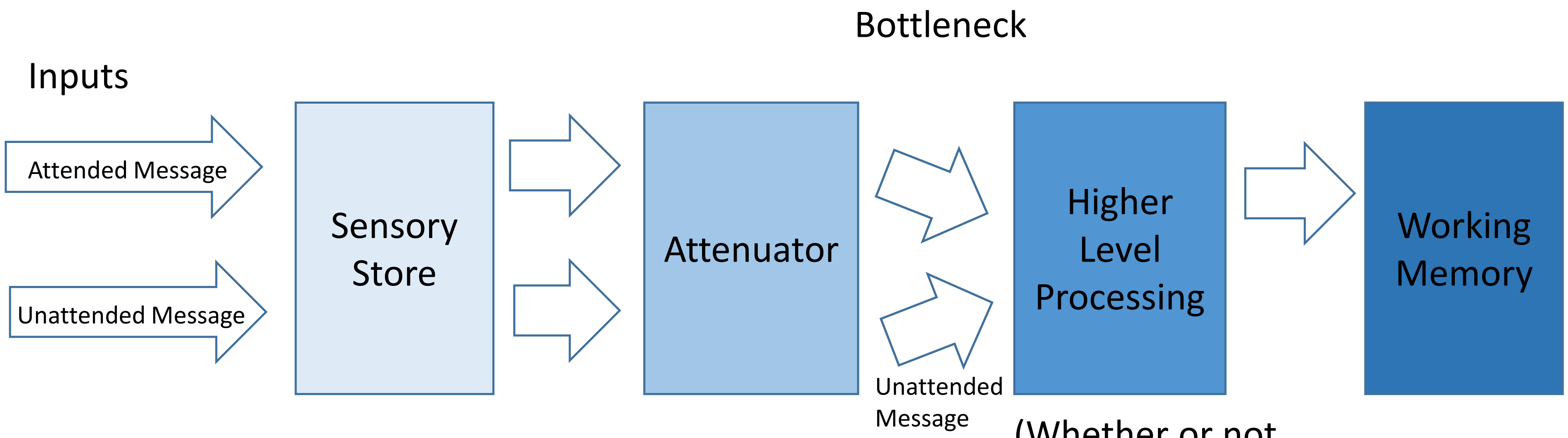
Filter Model of Attention (Broadbent)



<u>Early Selection Stage Model</u>

Broadbent's filter model is referred to as an Early Selection Model because irrelevant messages are filtered out BEFORE the stimulus information is processed for meaning.

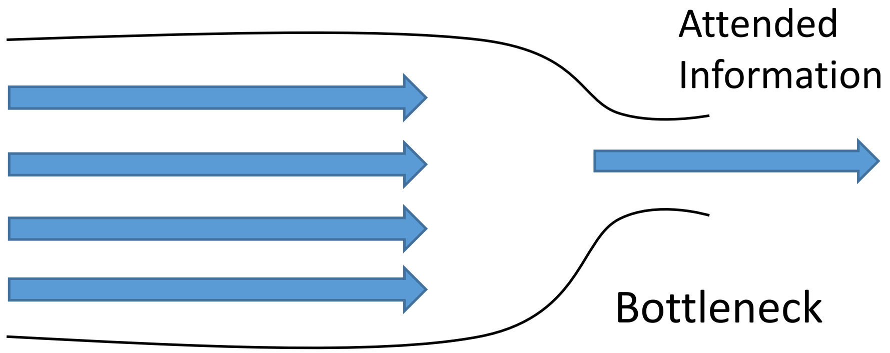
Attenuation Model of Attention (Treisman)



(Whether or not attenuated inputs get processed at this stage, and to what degree is determined by their threshold)

Treisman's attenuation model. Also and Early Selection Model. In this model, both attended and unattended message can be perceived (but the unattended message is perceived to a lesser degree).

How Much Information Can We Take In?



Attentional bottleneck, in term of the amount of data the brain can process.

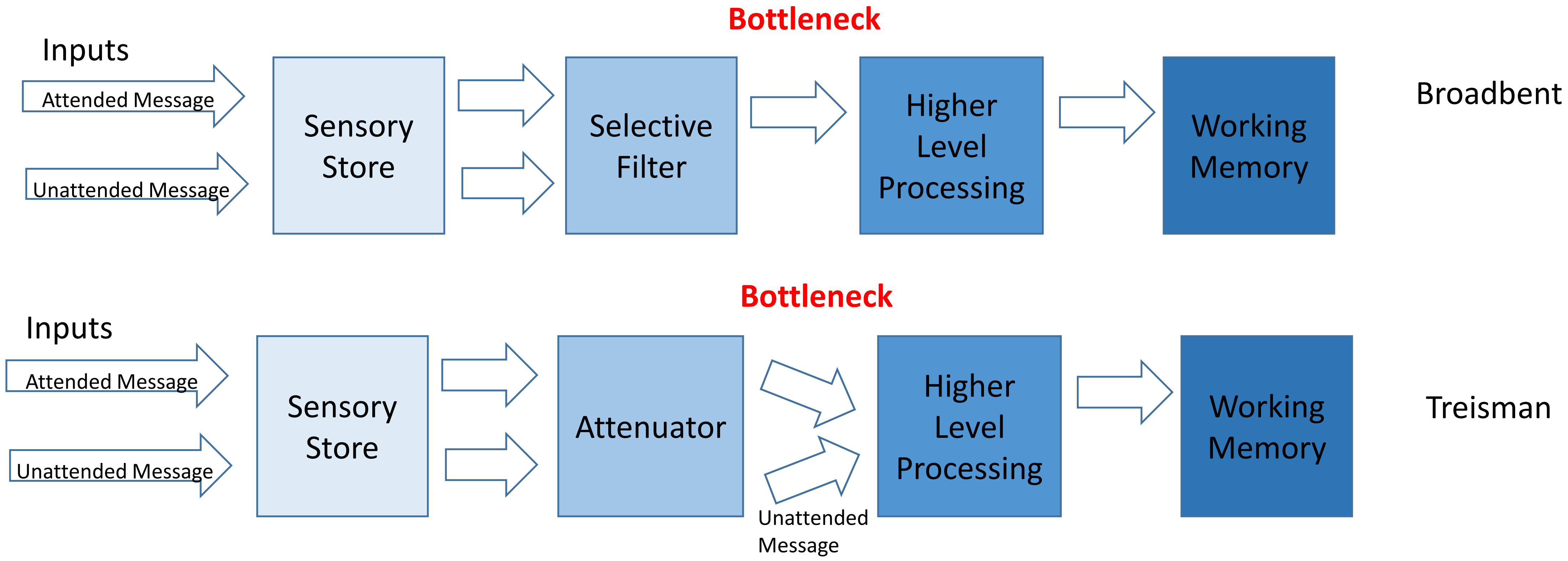
Cost to the brain- high neuronal activity.

- - > Selective attention arises from brain’s limited capacity to process information.

- - > Selective attention results in greater resource allocation to attended location.

Bottleneck in the Models of Attention (Broadbent and Treisman)

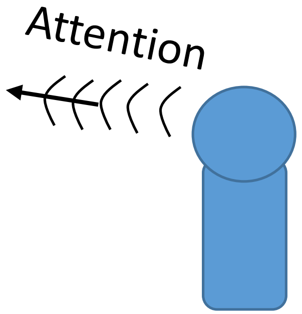
In the filter theories of Broadbent and Treisman, attentional selection occurs before stimulus recognition. Such theories are called *early-selection* theories



Terminology: Endogenous and Exogenous Attention

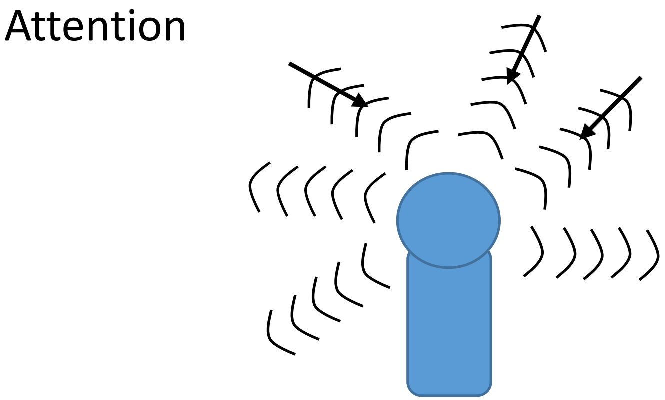
Attention can alter perception, but this depends on how we orient attention.

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



Endogenous (sometimes also called sustained)

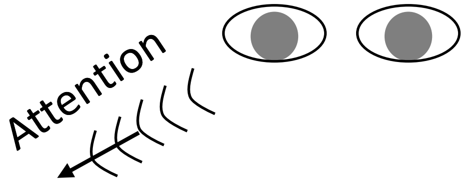
Voluntary. *Paid* to external cue. Goal-directed e.g., concentration, motivation (e.g., revision).

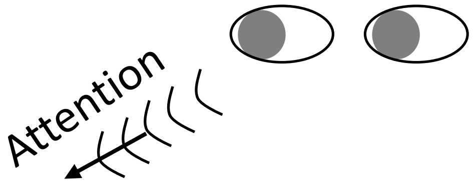


Exogenous (sometimes also called transient)

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

Terminology: Overt and Covert Attention





Attentional orienting can be:

Covert

Shifting focus without moving eyes

Perhaps important for scanning the environment for items/locations of interest.

Or

Overt

Shifting focus with moving eyes

Selectively attending to an item/location

Can be measured by observing eye movements

Three Main Types of Attention

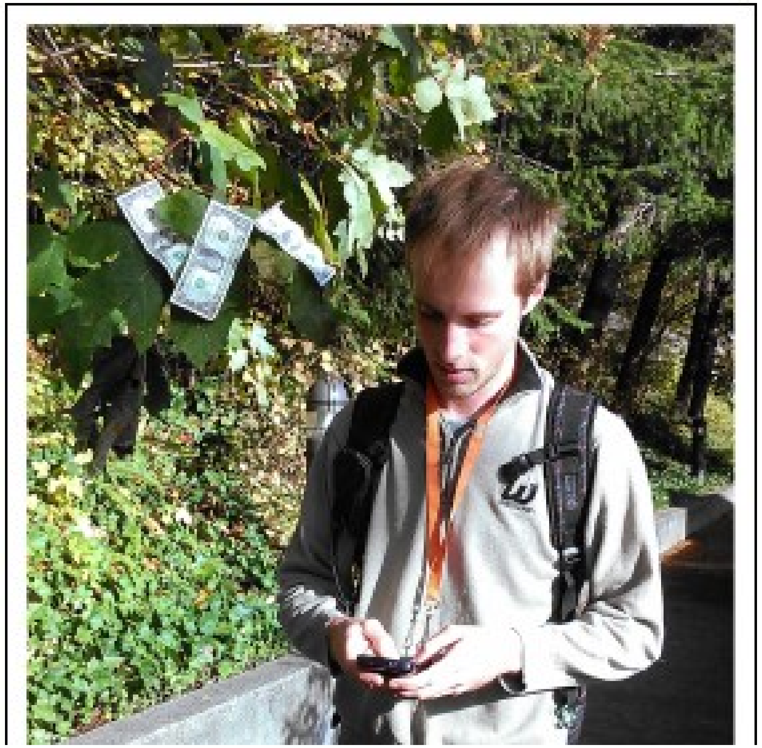
A: Spatial Attention: Which can be overt (move eyes to a relevant location and focus of attention coincides with movement of the eyes) or covert (attention is deployed to relevant locations without accompanying eye movements).

B: Feature-based Attention (FBA): Which can be deployed covertly to specific aspects (e.g., colour, orientation or motion direction) of objects in the environment, regardless of their location.

C: Object-based attention: In which attention is influenced or guided by object structure.

Inattentional Blindness

Failure to see money on a tree…



Hyman Jr, I.E., Sarb, B.A. and Wise-Swanson, B.M., 2014. Failure to see money on a tree: inattentional blindness for objects that guided behavior. Frontiers in psychology, 5, p.356.

Inattentional blindness - Failure to perceive an unexpected stimulus in plain sight, purely as a result of a lack of attention rather than any sensory defects/deficits.

Following criteria required to classify an event as an inattentional blindness episode:

1) Observer must fail to notice a visual/auditory object or event,
2) Object/event must be fully visible/audible,
3) Observers must be able to readily identify the object if they are consciously perceiving it
4) Event must be unexpected and the failure to see the object or event must be due to the engagement of attention on other aspects of the visual scene and not due to aspects of the stimulus itself.

Change Blindness

Change blindness - failure to detect when a change is made to a visual stimulus.

Josephs, E., Drew, T. and Wolfe, J., 2016. Shuffling your way out of change blindness. Psychonomic bulletin & review, 23(1), pp.193-200.

Stroop Task

Time how long it takes to read each word list:

RED	BLUE
GREEN	GREEN
YELLOW	RED
RED	BLUE
BLUE	YELLOW
GREEN	BLUE
BLUE	GREEN
RED	RED
YELLOW	YELLOW

This list takes longer than the other

Task is more difficult when the printed word is different than the font colour (mismatch).

Requested to pay attention to reading the word while ignoring the font colour.

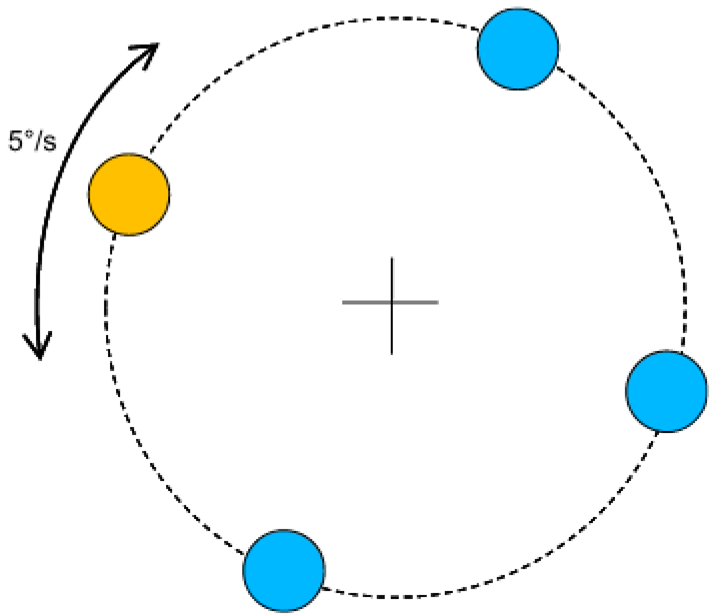
Attention dynamically allocated to the colour word or font colour via some central control
(a late, response-related stage of processing).

Word ≠ font colour - - > control engaged to enhance focus.

Word = font colour - - > control relaxed.

Some examples of how attentional research has been used in interface development and design.

Bahramisharif, A., Van Gerven, M., Heskes, T. and Jensen, O., 2010. Covert attention allows for continuous control of brain–computer interfaces. European Journal of Neuroscience, 31(8), pp.1501-1508.

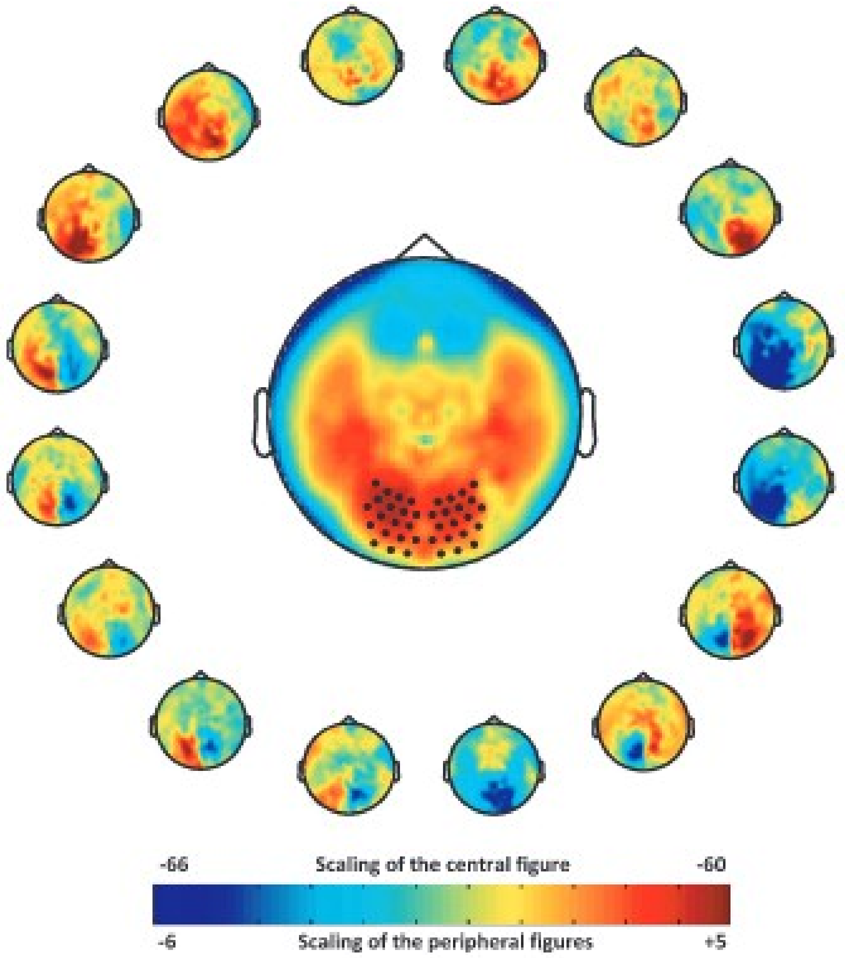


Display used in the task. Participants covertly attended to the target dot whilst fixating at the cross.

Investigated whether modulation of brain activity by changes in covert attention can be used as a continuous control signal for a BCI.

Participants: Ongoing brain activity recorded using magnetoencephalography (MEG) whilst they covertly attended to a moving cue on screen while maintaining fixation.

Bahramisharif, A., Van Gerven, M., Heskes, T. and Jensen, O., 2010. Covert attention allows for continuous control of brain–computer interfaces. European Journal of Neuroscience, 31(8), pp.1501-1508.



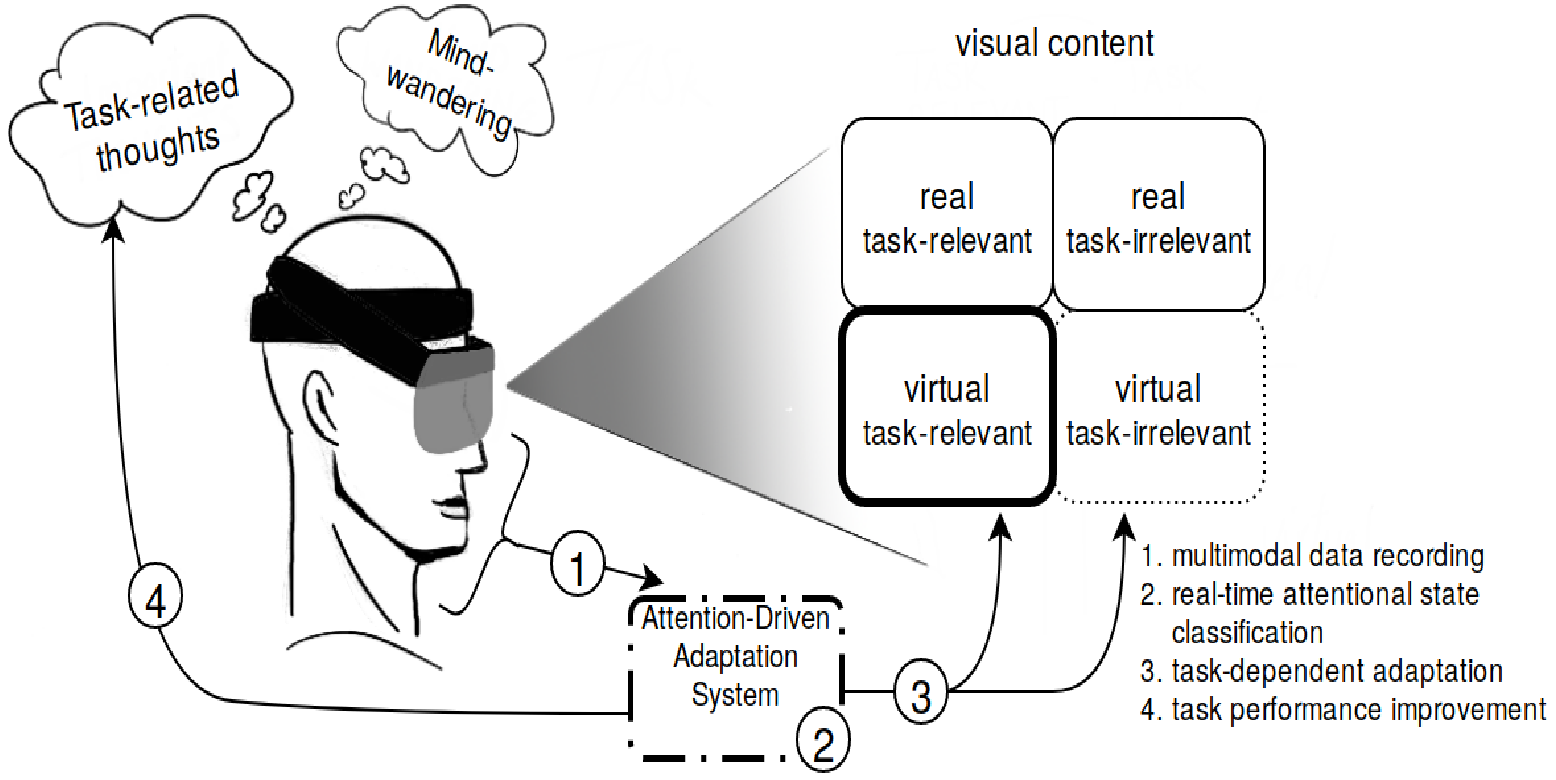
The distribution of alpha power with respect to 16 divisions. The central figure shows the alpha power averaged over all directions and the black dots show the selected sensors.

Result: Modulations of brain (posterior) alpha-band activity due to the direction of covert attention.

Figure: Distribution of alpha-band power across 16 divisions. Figure arrangement reflects direction of covert attention, which is correlated with spatial arrangement.

Alpha-band modulation could be used as a control signal for use in a BCI.

Vortmann, L.M., 2019, October. Attention-driven interaction systems for augmented reality. In 2019 International Conference on Multimodal Interaction (pp. 482-486).



Investigated user interfaces which can adapt to the cognitive state of the user, e.g., by re-directing user's attention towards missed information.

Participants: User data is captured- Brain activity via EEG, eye tracking, physiological measurements.

Modelling: Data modelled with machine learning techniques.

- - > Develop prototypical user interfaces for AR glasses

Vertegaal, R., Shell, J.S., Chen, D. and Mamuji, A., 2006. Designing for augmented attention: Towards a framework for attentive user interfaces. Computers in Human Behavior, 22(4), pp.771-789

A framework for the design of user interfaces that can support users' attentional capacities.

five key properties of attentive systems:

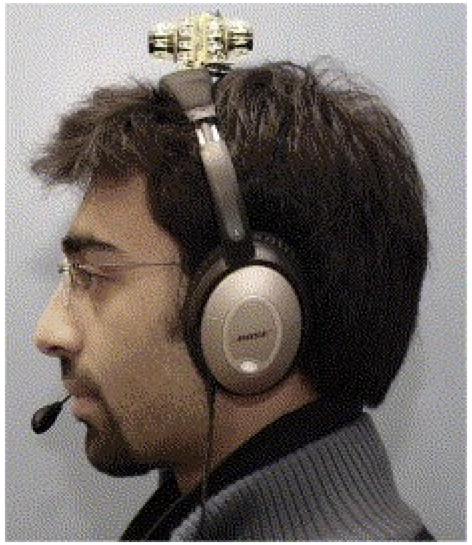
(i) to sense attention
(ii) to reason about attention
(iii) to regulate interactions
(iv) to communicate attention
(v) to augment attention

Vertegaal, R., Shell, J.S., Chen, D. and Mamuji, A., 2006. Designing for augmented attention: Towards a framework for attentive user interfaces. Computers in Human Behavior, 22(4), pp.771-789

Sensing attention: the eye contact sensor (ECS)

eyePLIANCES - smart ubiquitous appliances with embedded attention sensors.

Attentive Headphones- pair of noise cancelling head phones augmented with a microphone and eye contact sensors.



Overall Summary

Description of attention
Early models of attention
Summarised some of the key terminology used in attentional research
Also introduced inattentional blindness and change blindness
Provided examples of studies demonstrating how 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:

MacLeod, C.M. and MacDonald, P.A., 2000. Interdimensional interference in the Stroop effect: Uncovering the cognitive and neural anatomy of attention. *Trends in cognitive sciences*, *4*(10), pp.383-391.

Hyman Jr, I.E., Sarb, B.A. and Wise-Swanson, B.M., 2014. Failure to see money on a tree: inattentional blindness for objects that guided behavior. Frontiers in psychology, 5, p.356.

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