# Lecture 07: Attention and Intention

## Part 03

# Auditory Attention

# Relevance

Chen, Y., Nguyen, T.V., Kankanhalli, M., Yuan, J., Yan, S. and Wang, M., 2014. Audio matters in visual attention. IEEE Transactions on Circuits and Systems for Video Technology, 24(11), pp.1992-2003.

Oldoni, D., De Coensel, B., Boes, M., Rademaker, M., De Baets, B., Van Renterghem, T. and Botteldooren, D., 2013. A computational model of auditory attention for use in soundscape research. The Journal of the Acoustical Society of America, 134(1), pp.852-861.

Poguntke, M. and Ellis, K., 2008, May. Auditory attention control for human-computer interaction. In 2008 Conference on Human System Interactions (pp. 231-236). IEEE.

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.

Haghighi, M., Moghadamfalahi, M., Akcakaya, M., Shinn-Cunningham, B.G. and Erdogmus, D., 2017. A graphical model for online auditory scene modulation using EEG evidence for attention. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *25*(11), pp.1970-1977.

Kim, D.W., Cho, J.H., Hwang, H.J., Lim, J.H. and Im, C.H., 2011, August. A vision-free brain-computer interface (BCI) paradigm based on auditory selective attention. In 2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society (pp. 3684-3687). IEEE.

# Learning Objectives

To provide a description of early studies of auditory selective attention-speech shadowing.

To provide a description of studies of auditory selective attention-non-speech tasks.

To provide a description of a typical task used to study auditory change deafness.

To provide an example of a task used to study auditory spatial attention.

# Learning Outcomes

To be able to provide a description of some of the early speech shadowing tasks used to probe auditory selective attention.

To be able to provide a description of some of the early non-speech tasks used to probe auditory selective attention.

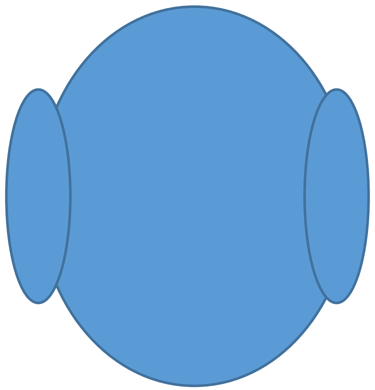
To be able to provide a description of a typical task used to study auditory change deafness.

To be able to provide a description of a typical task used to study auditory spatial attention.

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

# Studying Selective Attention- Speech Shadowing Task

Pay attention to message in this ear



Ignore message in this ear

Repeat aloud auditory message presented to 1 ear over headphones

Cherry (1950s) The participants ‘shadow’, the auditory message presented to one ear over headphones, while ignoring distractor message presented simultaneously to their other ear.

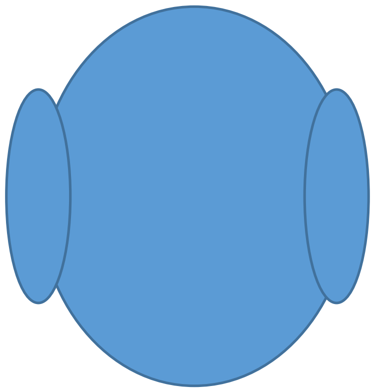
Result: Participants remembered little of the content of the ignored message

- - > Supported early selection model of attention (Broadbent)

- Auditory selective attention based solely on physical features of the auditory stimulus.

# Studying Selective Attention- Speech Shadowing Task

Pay attention to message in this ear



Add name

Ignore message in this ear

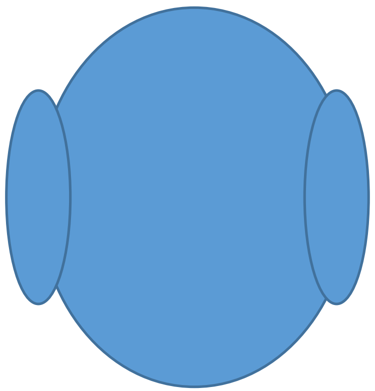
Repeat aloud auditory message presented to 1 ear over headphones

However, later studies showed that some higher level processing of the ignored message can occur.

Moray (1959): 1/3 participants noticed when their name was inserted  … but why only a 1/3? . . .

# Studying Selective Attention- Speech Shadowing Task

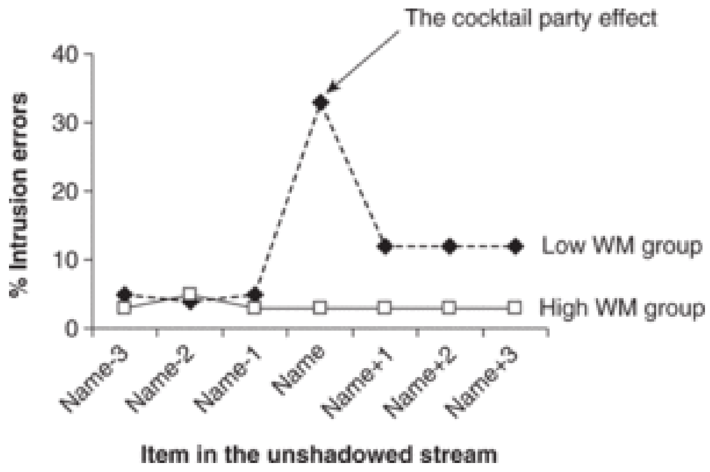
Pay attention to message in this ear



Add name

Ignore message in this ear

Repeat aloud auditory message presented to 1 ear over headphones



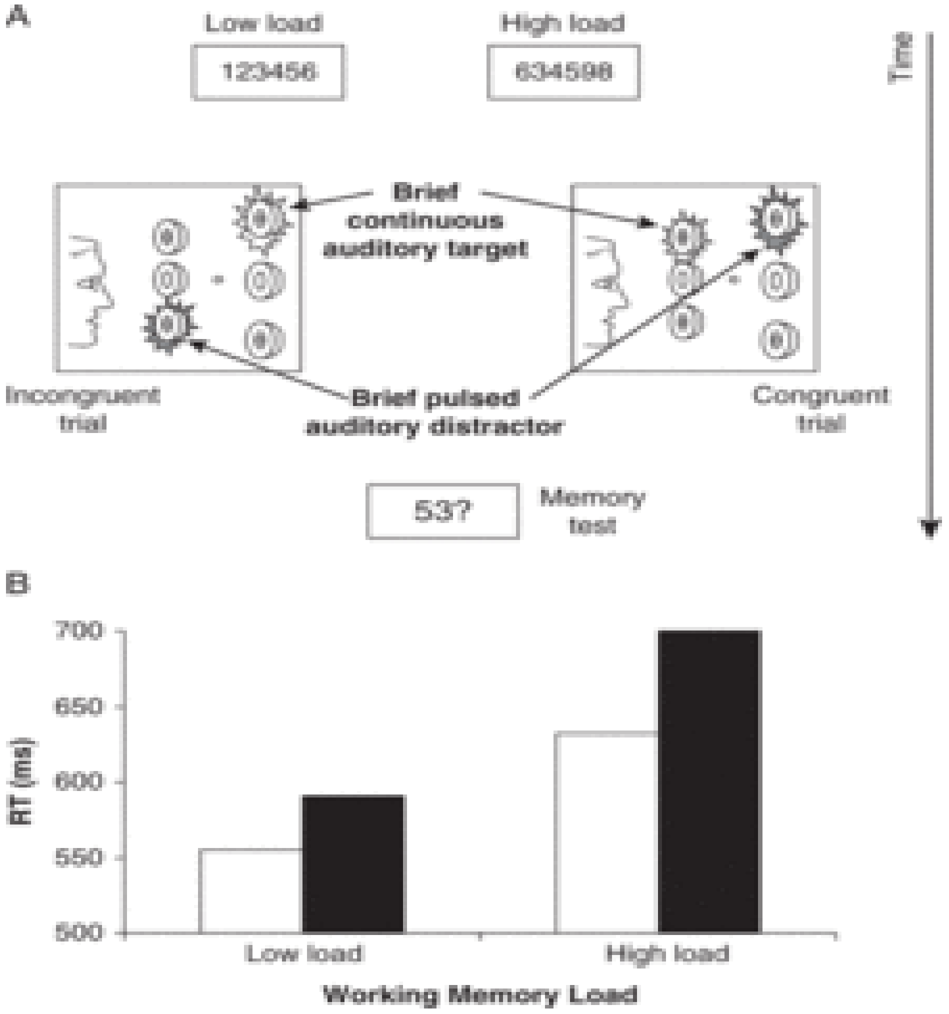

Conway et al., 2001.

Measured participants' working memory.

Differences in working memory (WM) capacity correlated with differences in ability to selectively focus attention on a particular auditory message.

20% of high WM participants reported hearing their own name in ignored message
65% of low WM participants reported hearing their own name in ignored message

# Other Selective Attention Tasks




Participants:
Step 1: Presented with 6 digits which are predictable (low memory load) or unpredictable (high memory load).

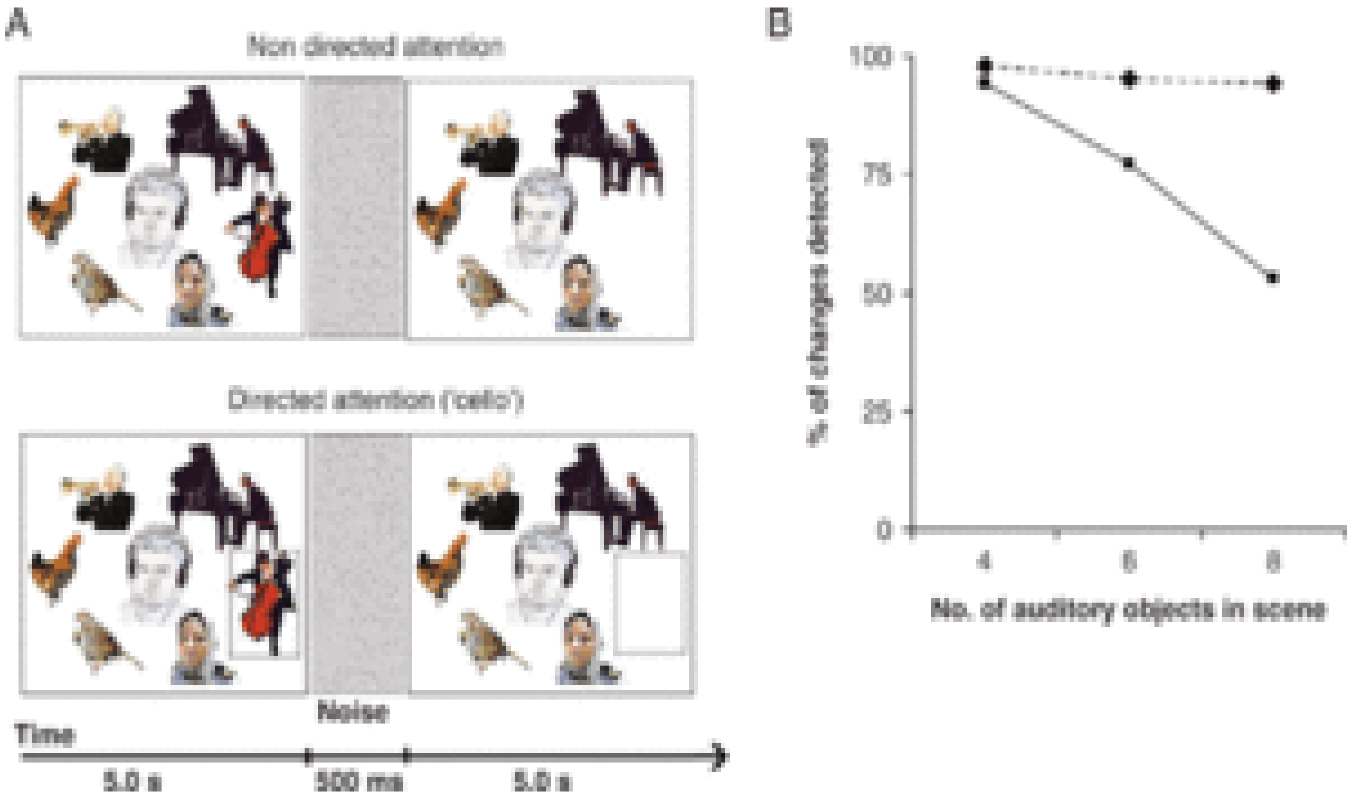
Step 2: Make height judgement for a brief *continuous auditory sound* whilst trying to ignore the height of a *pulsed auditory distracto*r sound presented at the same time.

Step 3: Presented with 2 digits on screen, participants had to decide whether they appeared in the same order as in earlier digit list.

Results: Auditory distractors interfered much more (i.e. with height judgement of the continuous auditory sound) in the high memory-load condition than in the low-memory load condition.

Dalton, P., et al., 2009. Quarterly Journal of Experimental Psychology, 62, 2126-32.

# Auditory change deafness




Step 1: Participants presented with a 1st auditory scene of 4, 6, or 8 auditory objects, each presented from a different position for 5 seconds.

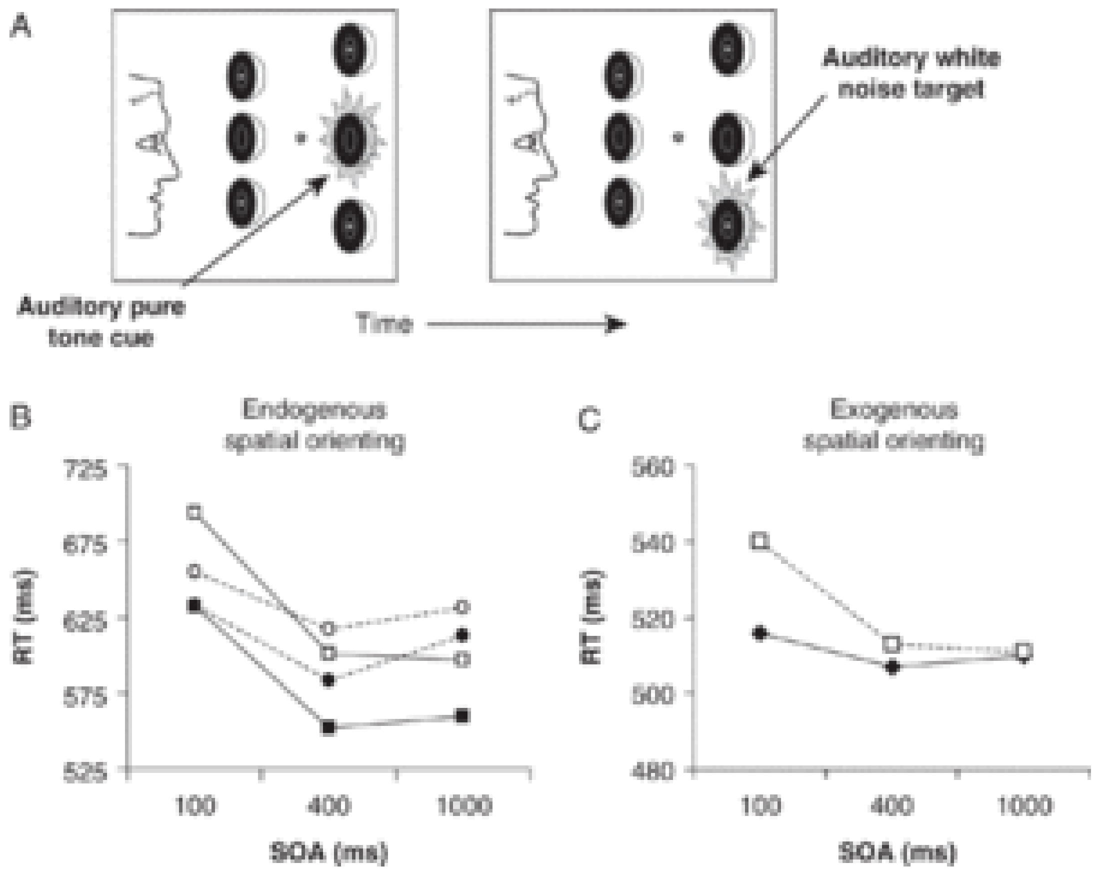
Step 2: Participants presented with a 2$^{nd}$ auditory scene of 4, 6, or 8 auditory objects, each presented from a different position for 5 seconds.

The two scenes were identical except that on half of the trials one of the auditory objects was removed from the 2$^{nd}$ display
Participants had to decide if an auditory object was missing.

Results: Accuracy of participants' auditory change detection responses dropped as number of auditory objects in the scene increased.
Performance unaffected if spatial attention was directed to location where change may occur.

Eramudugolla et al. (2005). Current Biology, 15, 1108-13..

# Auditory Spatial Attention



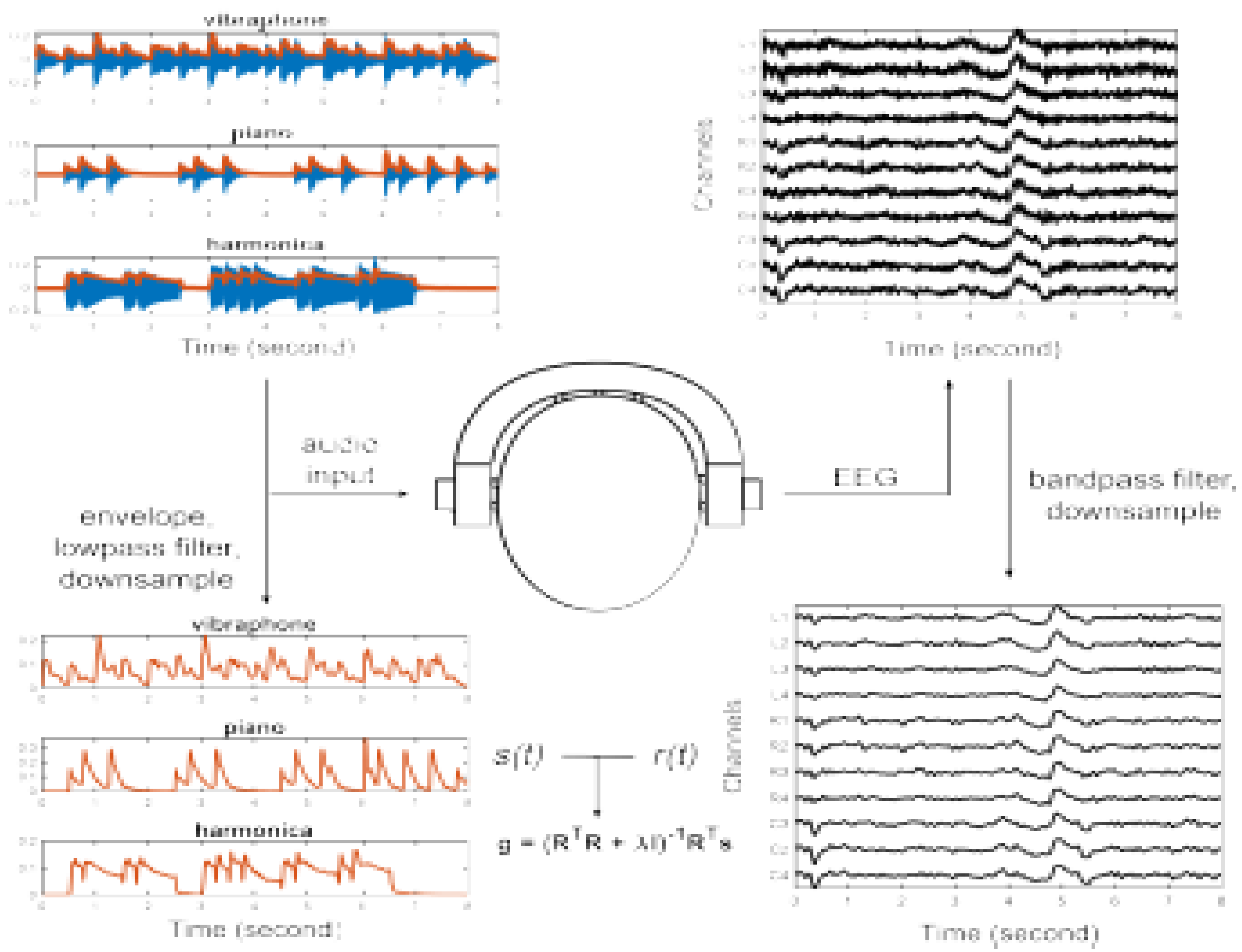

Participants sat in front of a column of 3 speakers on left and a column of 3 speakers on right.

Step 1: A puretone ***cue*** was played from middle speaker in right or left column.
Step 2: A pulsed ***target*** sound played from one of the 4 corner speakers. Participants decided if the sound was from an up/down position.

Can separate exogenous from endogenous spatial orientating.

Spence, C and Driver, J. (1994). Journal of Experimental; Psychology: Human Perception and Performance, 22, 1005-30.
Spence, C and Driver, J. (1994). Perception and Psychophysics, 59, 1-22.

An, W.W., Shinn-Cunningham, B., Gamper, H., Emmanouilidou, D., Johnston, D., Jalobeanu, M., Cutrell, E., Wilson, A., Chiang, K.J. and Tashev, I., 2021, June. Decoding music attention from “eeg headphones”: A user-friendly auditory brain-computer interface. In ICASSP 2021-2021 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 985-989). IEEE.

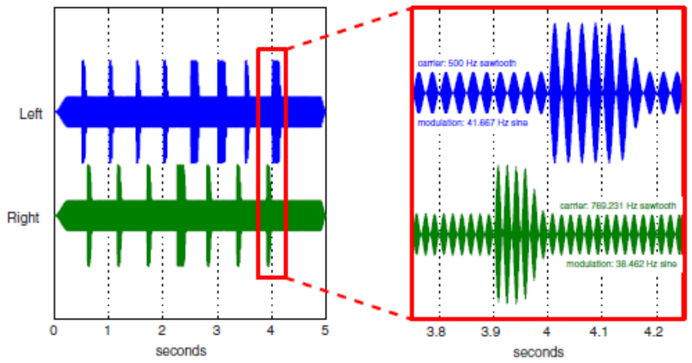



Study: BCI using music stimuli, collecting brain EEG signals.

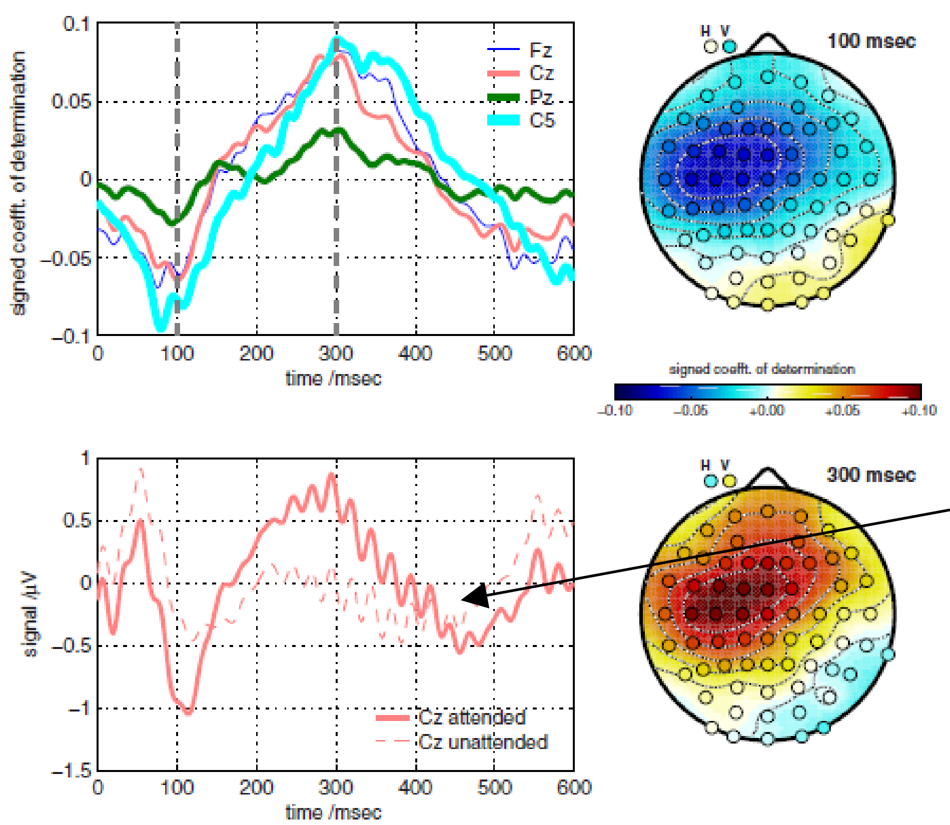
Participants: Paid attention to 1 of 3 musical instruments playing in separate spatial locations.
Used auditory attention decoding AAD.

Results: BCI system can decode auditory attention.

Hill, N.J. and Schölkopf, B., 2012. An online brain–computer interface based on shifting attention to concurrent streams of auditory stimuli. Journal of neural engineering, 9(2), p.026011.




The dichotic stimuli used



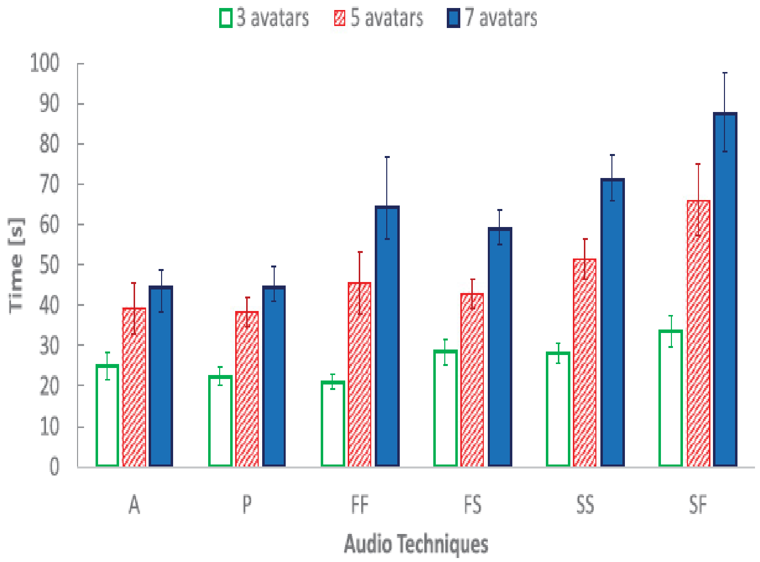

Project: BCI using brain EEG signals, reliant on the information derived from covert shifts of attention to auditory stimuli.

Participants: Used BCI , undertook a dichotic auditory task involving covert attentional shifts.

Attentional modulation of the EEG signals measured and analysed- to obtain the difference between attended and unattended response. Some of the identified markers could have potential to be used as a simple communication device.

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.


User sits in front of a screen whilst eyes are tracked.




Different audio techniques for modifying speaker audio in response to attended/unattended information.

Project: Investigated whether gaze-contingent audio enhancement driven by inferring audio-visual attention in virtual displays could be used to enable effective communication in virtual environments.

Built a gaze-contingent display allowing tracking of users' gaze in real time and modified volume of speakers' voices contingent on current region of overt attention.

Result: Users liked ability to control the sound with their eyes.

# Overall Summary

Key early experiments of auditory selection attention-speech shadowing

Key early experiments of auditory selection attention-non-speech tasks

Studies of auditory change deafness

Studies of auditory spatial attention.

Provided examples of studies demonstrating how auditory attentional research can impact interface design and development.

# Resources

Essential:

The Oxford Handbook of Auditory Science: Hearing. D. R. Moore. 2010. Chapter 11 Auditory attention.

Fritz, J.B., Elhilali, M., David, S.V. and Shamma, S.A., 2007. Auditory attention—focusing the searchlight on sound. Current opinion in neurobiology, 17(4), pp.437-455.

Supplementary:

An, W.W., Shinn-Cunningham, B., Gamper, H., Emmanouilidou, D., Johnston, D., Jalobeanu, M., Cutrell, E., Wilson, A., Chiang, K.J. and Tashev, I., 2021, June. Decoding music attention from “eeg headphones”: A user-friendly auditory brain-computer interface. In ICASSP 2021-2021 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 985-989). IEEE.

Hill, N.J. and Schölkopf, B., 2012. An online brain–computer interface based on shifting attention to concurrent streams  of auditory stimuli. Journal of neural engineering, 9(2), p.026011.

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