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.

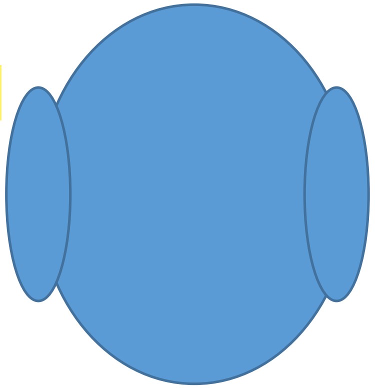
To be able to provide a description of some of the early non-speech tasks used to probe auditory selective attention.

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



Repeat aloud auditory message presented to 1 ear over headphones

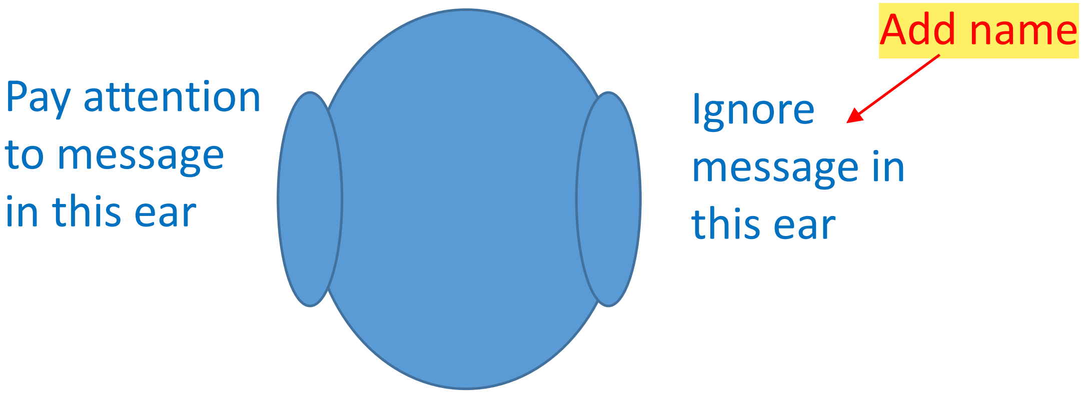
Cherry (1950s) The participants ‘shadow’, the auditory message presented to one ear over headphones, while ignoring distractor message presented simultaneously to their other ear.

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



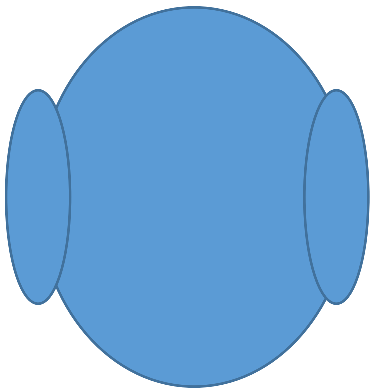
Repeat aloud auditory message presented to 1 ear over headphones

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

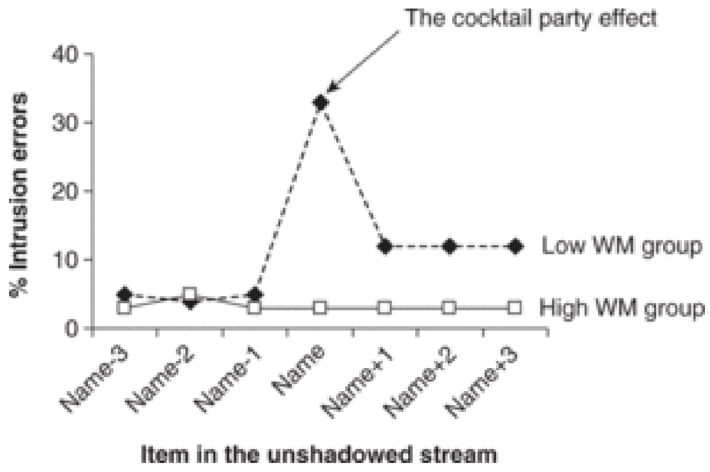
Pay attention to message in this ear



Ignore message in this ear

Add name

Repeat aloud auditory message presented to 1 ear over headphones



Conway et al., 2001.

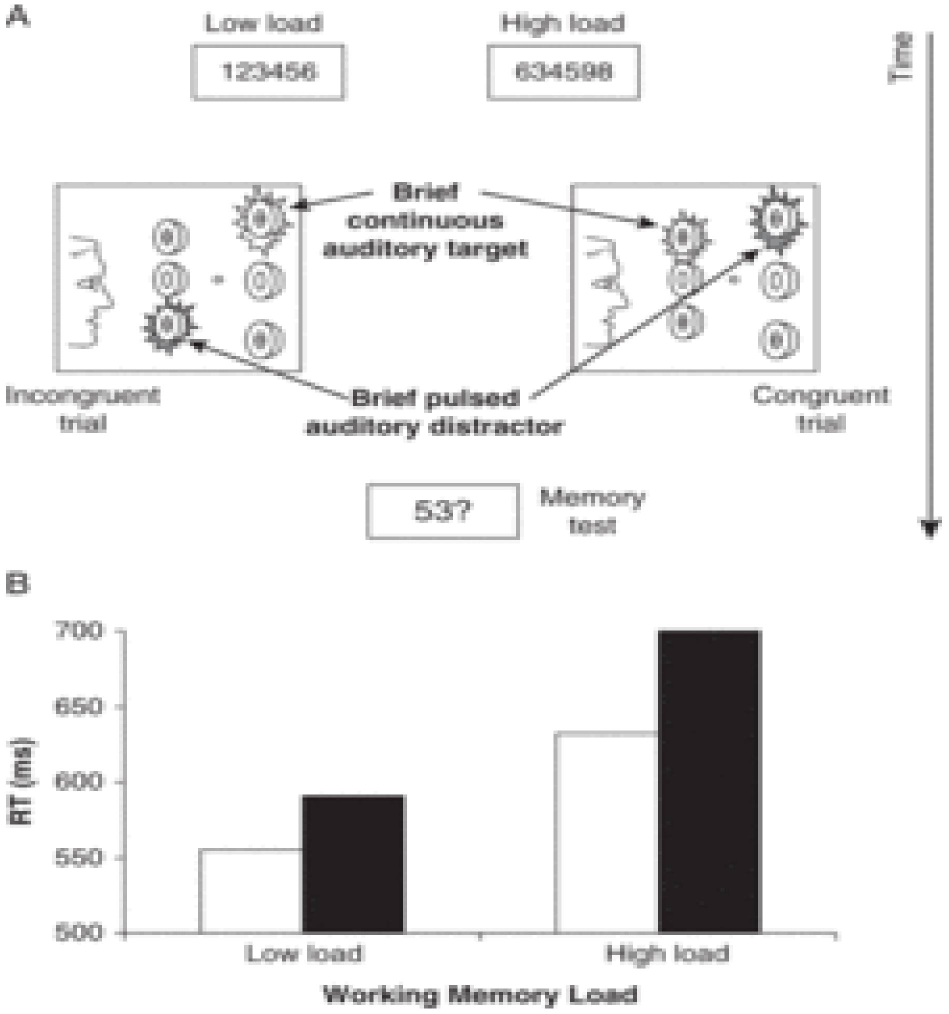
Measured participants’ working memory.

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).

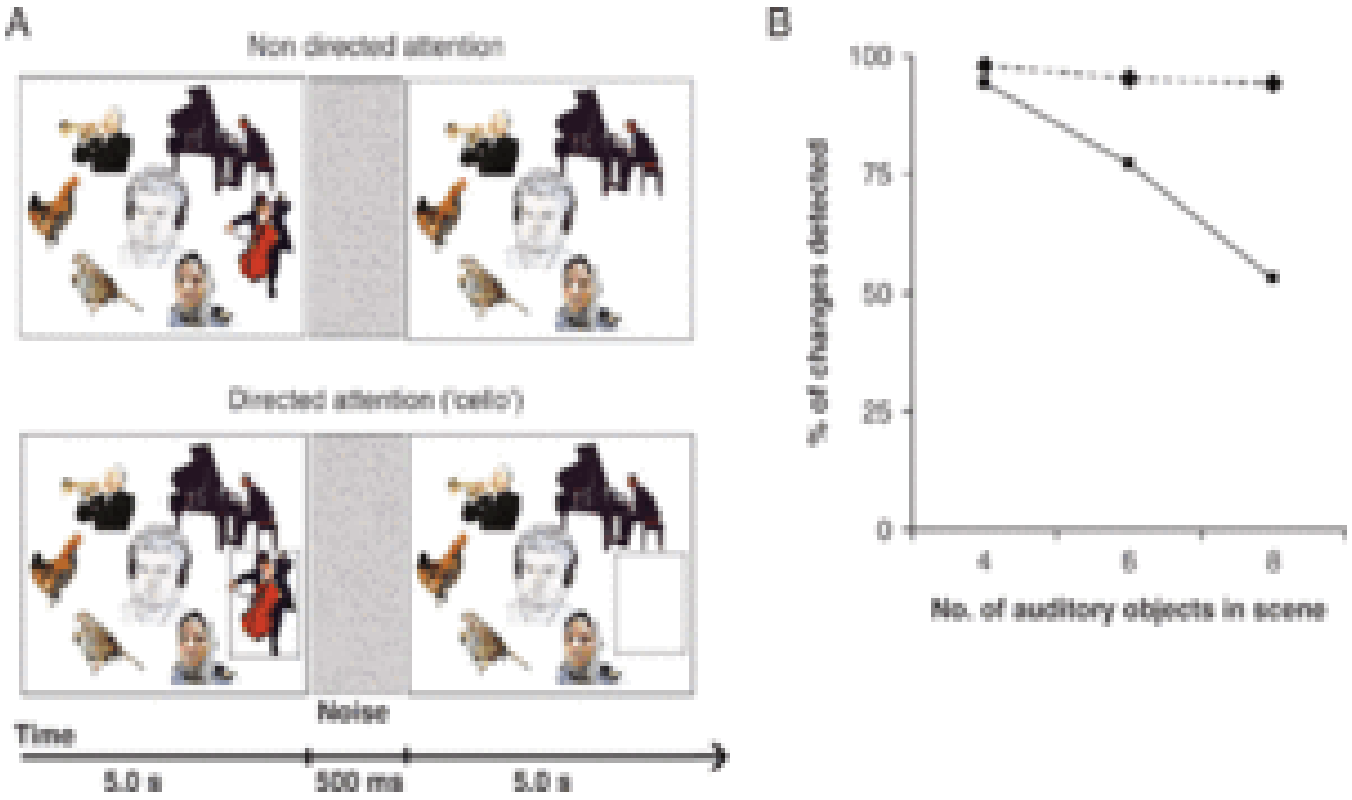
Step 2: Make height judgement for a brief *continuous auditory sound* whilst trying to ignore the height of a *pulsed auditory distracto*r sound presented at the same time.

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 2nd auditory scene of 4, 6, or 8 auditory objects, each presented from a different position for 5 seconds.

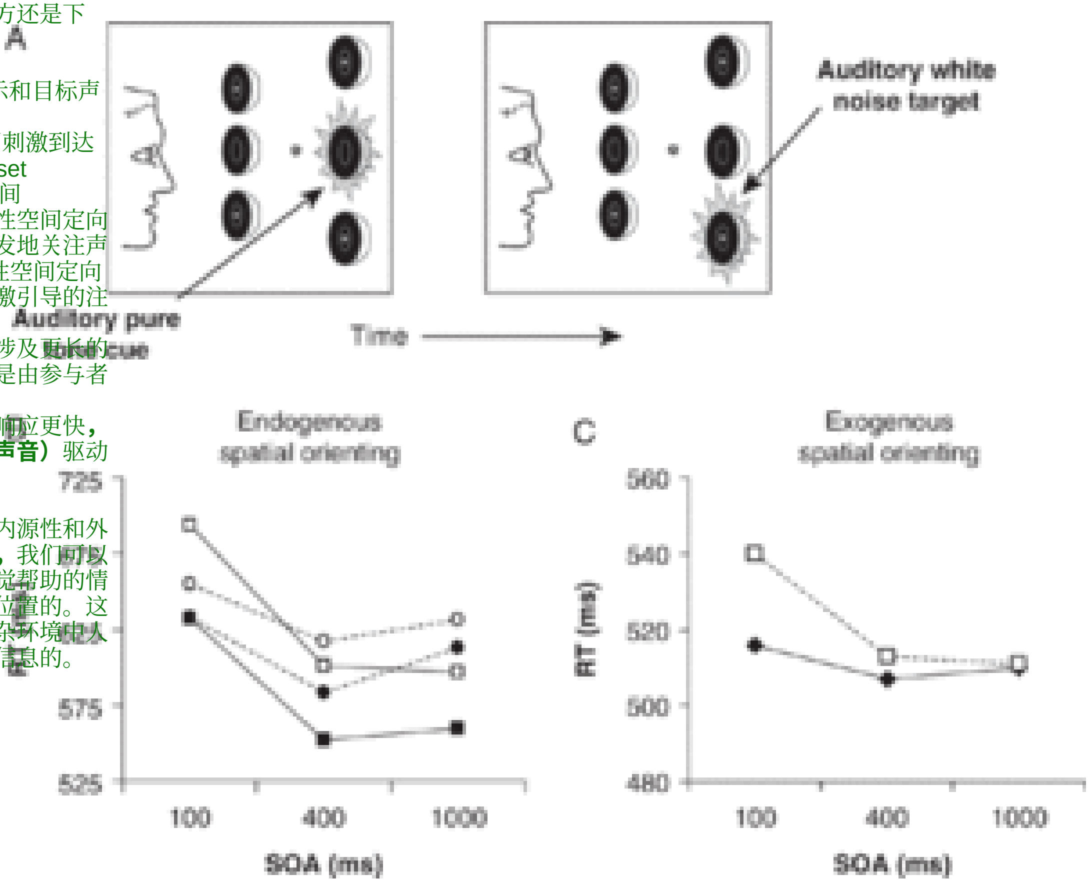
The two scenes were identical except that on half of the trials one of the auditory objects was removed from the 2nd display
Participants had to decide if an auditory object was missing.

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

实验设计
参与者的位置：参与者坐在两列扬声**器前，**每列各有三个扬声器，**分别位**于参与者的左侧和右侧。
实验步骤：
步骤1：从左侧或右侧扬声器列的中间扬声器播放一个纯音调（cue）。【endogenous】
步骤2：从四个角落的扬声器之一播**放一个脉冲声**（target）。**参与者需**要判断这个声音是来自上方还是下**方。**[exdogenous]
实验结果分析
左侧图A：展示了声音提示和目标声音的时间序列。
左侧图B**和**C：显示了不同刺激到达间隔（SOA, Stimulus Onset Asynchrony）下的反应时间（RT）。图B展示了内源性空间定向的反应时间，即参与者自发地关注声**音来源；**图C展示了外源性空间定向的反应时间，即由外部刺激引导的注意力转移。
内源性空间定向：这通常涉及更长的预备时间和思考，因为它是由参与者的意图和期望驱动的。
外源性空间定向：这通常响应更快，因为它是由直接刺激**（如声音）**驱动**的。**
结论
这个实验表明，通过比较内源性和外源性空间定向的反应时间，我们可以区分人们是如何在没有视觉帮助的情**况下，**仅凭声音判断声源位置的。这种方法可以帮助理解在复杂环境中人们是如何处理和反应声音信息的。



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

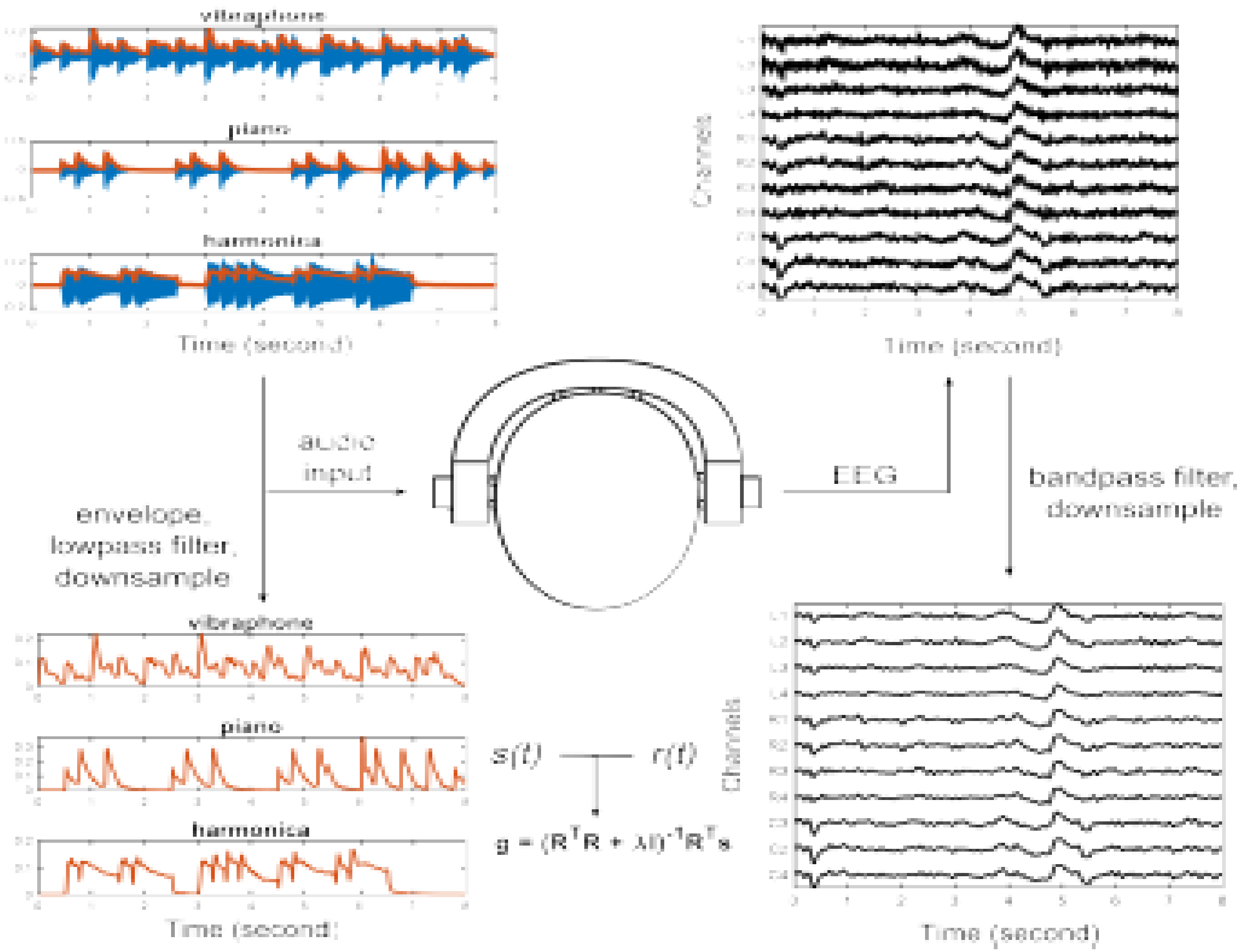
Step 1: A puretone ***cue*** was played from middle speaker in right or left column.
Step 2: A pulsed ***target*** sound played from one of the 4 corner speakers. Participants decided if the sound was from an up/down position.

/ek's^d^^n^s/

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.

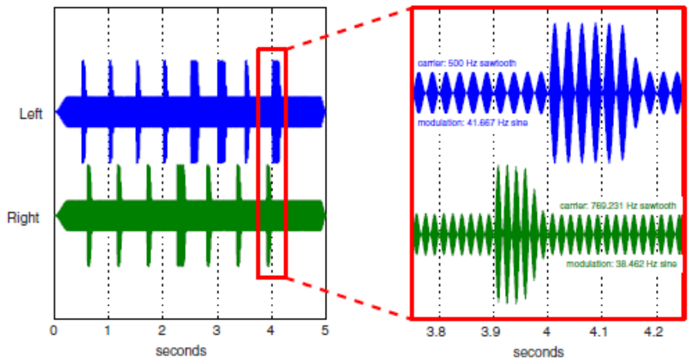


Study: BCI using music stimuli, collecting brain EEG signals.

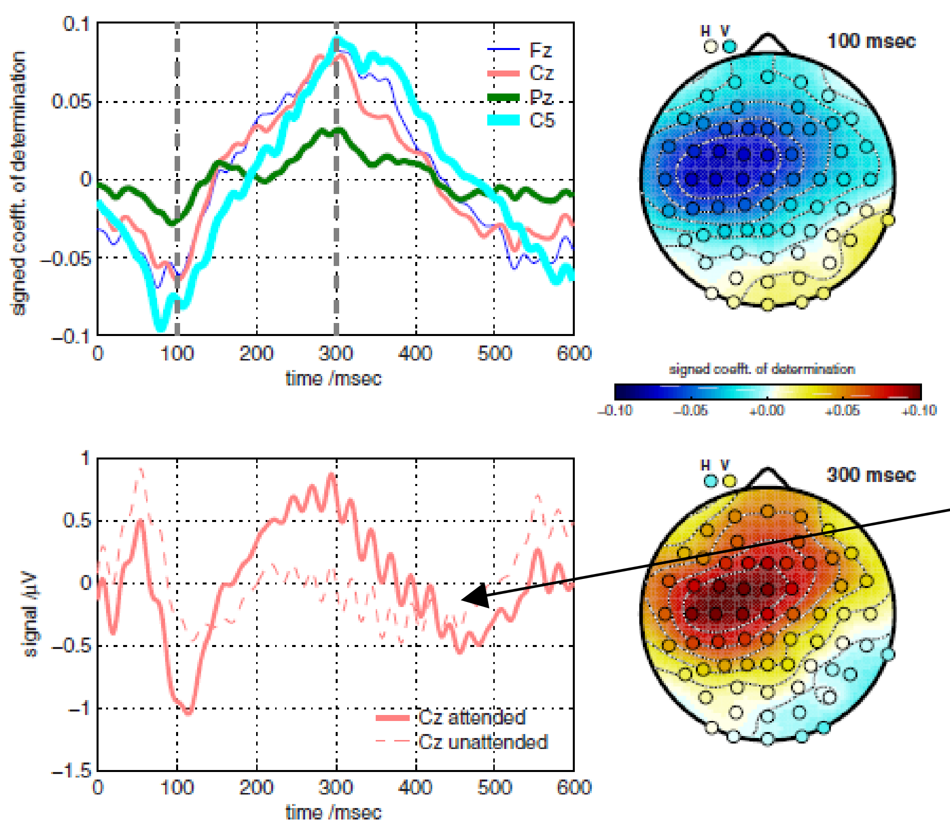
Participants: Paid attention to 1 of 3 musical instruments playing in separate spatial locations.
Used auditory attention decoding AAD.

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



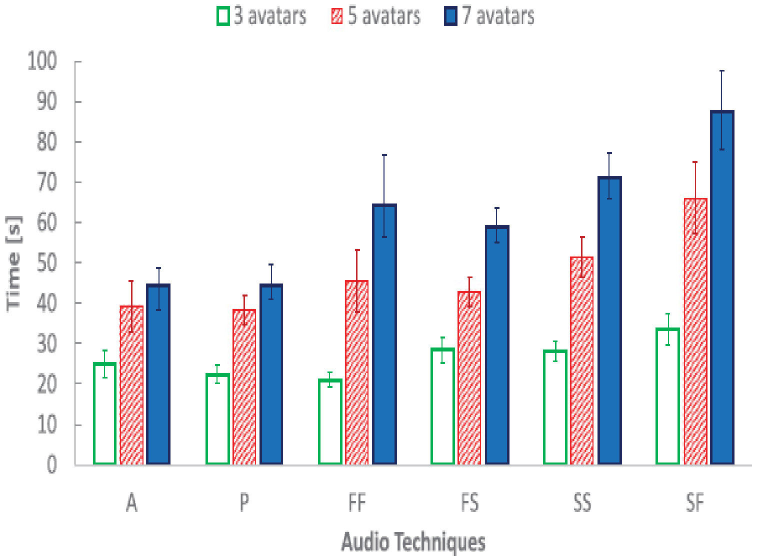
Project: BCI using brain EEG signals, reliant on the information derived from covert shifts of attention to auditory stimuli.

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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