

Sound Source Perception: The Importance of Attention and Memory?

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Themes I hoped to learn about and did

- 1) The future of the interaction among modeling, physiology, and perception/psychoacoustics.
- 2) The possible auditory function of various central pathways.
- 3) Don't we want to find out more about how neural units respond when animals actually respond to sounds?
- 4) Does a prior information play a role in hearing, especially in source segregation? And if so, what is this a priori information?
- 5) How will neural imaging (of all sorts) help us better understand audition in the future?
- 6) Can we in the auditory community learn from studies/theories in other fields (e.g., vision, engineering, computational science)?

Sound Source Perception: The Importance of Attention and Memory?

A great deal of what I have to say is based on a book that I am editing, *Sound Source Perception*, for the Fay-Popper Springer Handbook of Auditory Research (the SHAR volumes). The chapters are (only lead authors are listed):

Bill Yost an introduction and synopsis.

Robert Lutfi on the properties of resonant (mainly solids) sound sources and their role in perception.

Roy Patterson on the properties of resonant (mainly tubes and tracts) sound sources and the relationships to size and pitch.

Laurent Demany on auditory memory.

Erv Hafter on auditory attention.

Gerald Kidd on informational masking.

Bob Carlyon on the role of harmonicity and regularity.

Stan Sheft on the role of temporal modulation.

Chris Darwin on the role of spatial separation.

Andy Lotto on speech perception viewed from the perspective of sound source perception.

Dick Fay on sound source perception in non-human animals.

Sound Source Perception: The Importance of Attention and Memory?

While auditory attention and memory have clearly been topics of research for decades they have not been areas of intense study, especially in terms of models and neural mechanisms.

However, reference to auditory attention and memory occur frequently in the literature but often without any citation to a literature or reference to a model.

Sound Source Perception: The Importance of Attention and Memory?

If understanding sound source perception is a major goal, my premise is that this goal will not be achieved until we understand a great deal more about auditory attention and memory. Thus, I predict that these will be topics of renewed and increasing interest in the coming years.

Sound Source Perception: The Importance of Attention and Memory?

Stan Sheft in his chapter in the to be published book makes a useful distinction:

He argues that there are two general and related stages to sound source perception:

Stage 1) Sound source determination, the perceptual organization of a complex sound field into neural subsets that relate to the original sound sources.

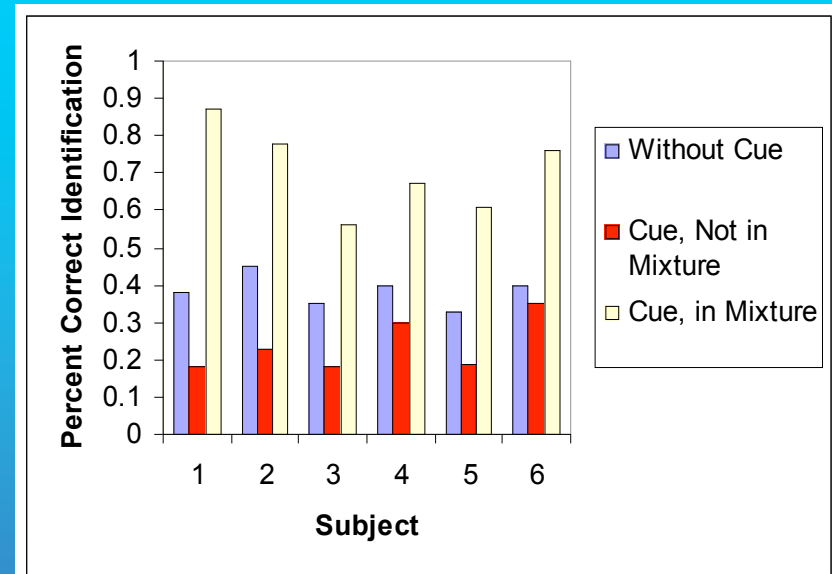
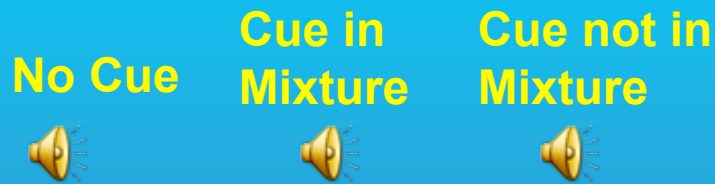
Stage 2) The extraction of information from the received signal (e.g., the neural subsets) especially as that information relates to the individual sound sources.

In my interpretation stage 2 involves attention and memory, and stage 2 may help inform the processing required for stage 1.

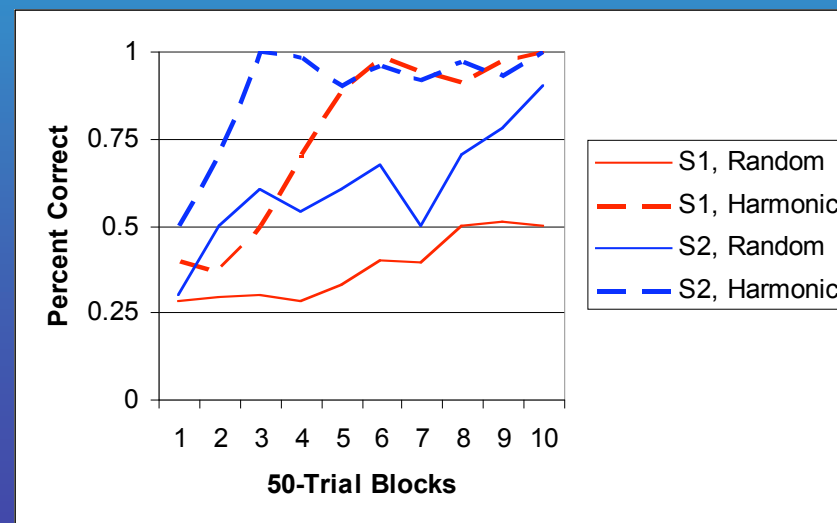
Sound Source Perception: The Importance of Attention and Memory?

Two trivial examples of where I believe attention and memory come into play:

1) Identifying three simultaneously presented spondees with and without a cue.



2) Identifying a sound pattern as a function of “practice” and type of pattern.



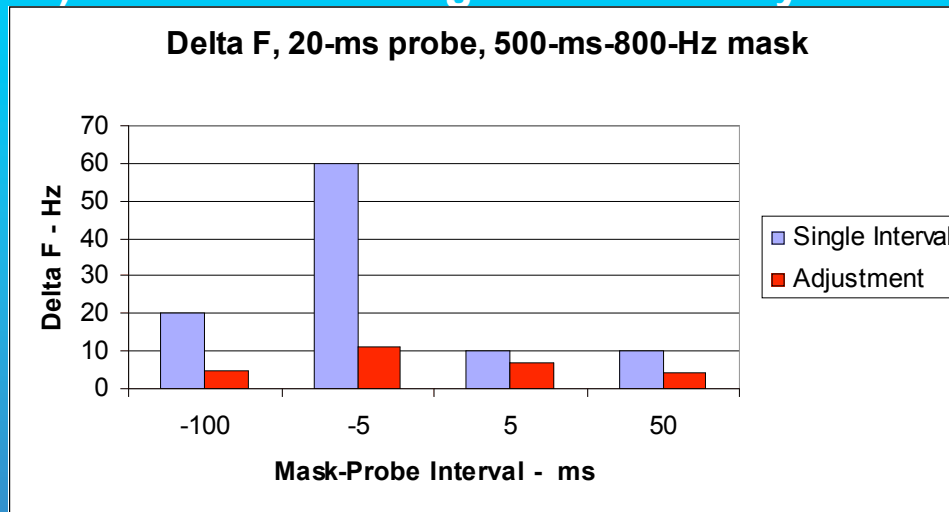
Some of What I Know About the Literature on Auditory Memory Based on Largely on Laurent Demany's Review

- 1) Despite an often held view to the contrary, there are several auditory examples in which memory affects our sonic perceptions.**
- 2) If one defines memory as processing which occurs after a physical stimulus is turned off, then various forms of neural adaptation may be a form of memory.**
- 3) Backward Recognition Masking may be a form of short-term "iconic" memory.**
- 4) Braida-Durlach's Model of "sensory trace" and "context coding" memories has had success in accounting for several data sets.**
- 5) Short-term memory can and cannot be influenced by attention.**
- 6) Speech and music are "existence proofs" for auditory long-term memory.**
- 7) The role of learning in auditory memory has been studied some, especially by Terhardt and recently by Wright.**
- 8) Neural plasticity and memory are or are not the same thing?
Compelling examples of long term adaptations to changes in spatial cues.**

Some of What I Know About the Literature on Auditory Memory Based on Largely on Laurent Demany's Review

Two examples from the literature on auditory memory:

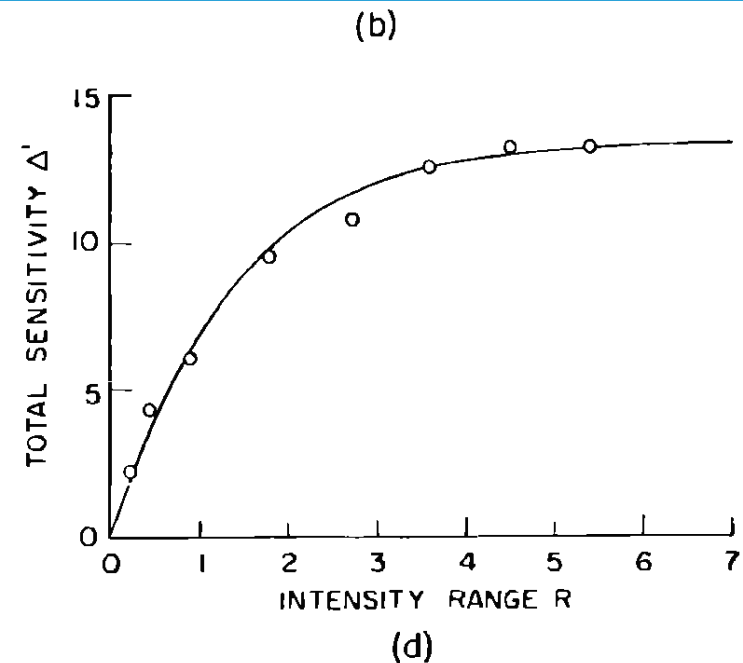
1) Backward Recognition Memory:



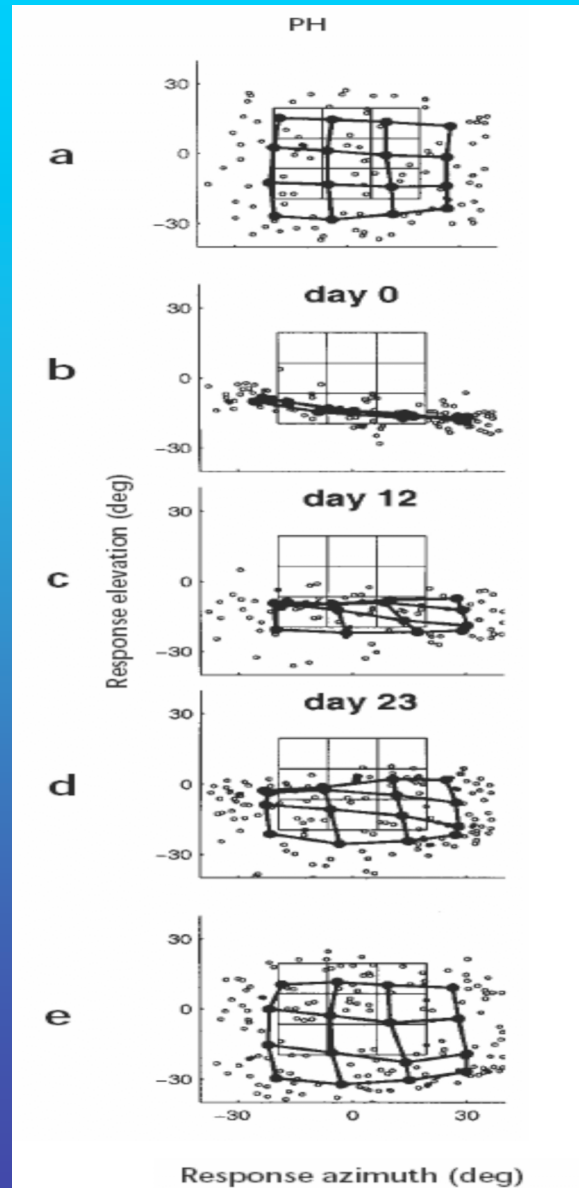
Braida & Durlach, JASA 51, 1972

Yost, Berg & Thomas, P&P 20, 1976

2) Trace - Context Coding



Some of What I Know About the Literature on Auditory Memory Based on Largely on Laurent Demany's Review



Neural Plasticity-Learning-Adaptation in Spatial Hearing:

Hofman, van Riswick, van Opstal, Nat. Neurosci. 1, 1998.

Some of What I Know About the Literature on Auditory Attention Based on Largely on Erv Hafter's Review

Broadbent's filter theory

Two stimuli presented at the same time gain access simultaneously to a buffer. One of the stimuli then passes through a filter—selected by its physical characteristics.

The filter prevents overloading of the mechanism past the filter (STM), which thoroughly processes the input but which only has a limited capacity.

Treisman's attenuation theory

In Treisman's model selection takes place at a later stage than Broadbent proposed. Processing of the unattended message is attenuated or reduced. She proposed that processing takes place in a hierarchical fashion, with processing of physical characteristics early in the hierarchy and semantic processing at a later stage and these stages are differentially affected by attention.

Deutsch and Deutsch's theory

Deutsch and Deutsch argue that selection takes place even later in processing than Treisman proposed. Their theory proposes that all inputs are fully processed—including analysis of meaning—but that the importance and relevance of the input determines the response.

Some of What I Know About the Literature on Auditory Attention Based on Largely on Erv Hafter's Review

Some of the procedures used to study auditory attention:

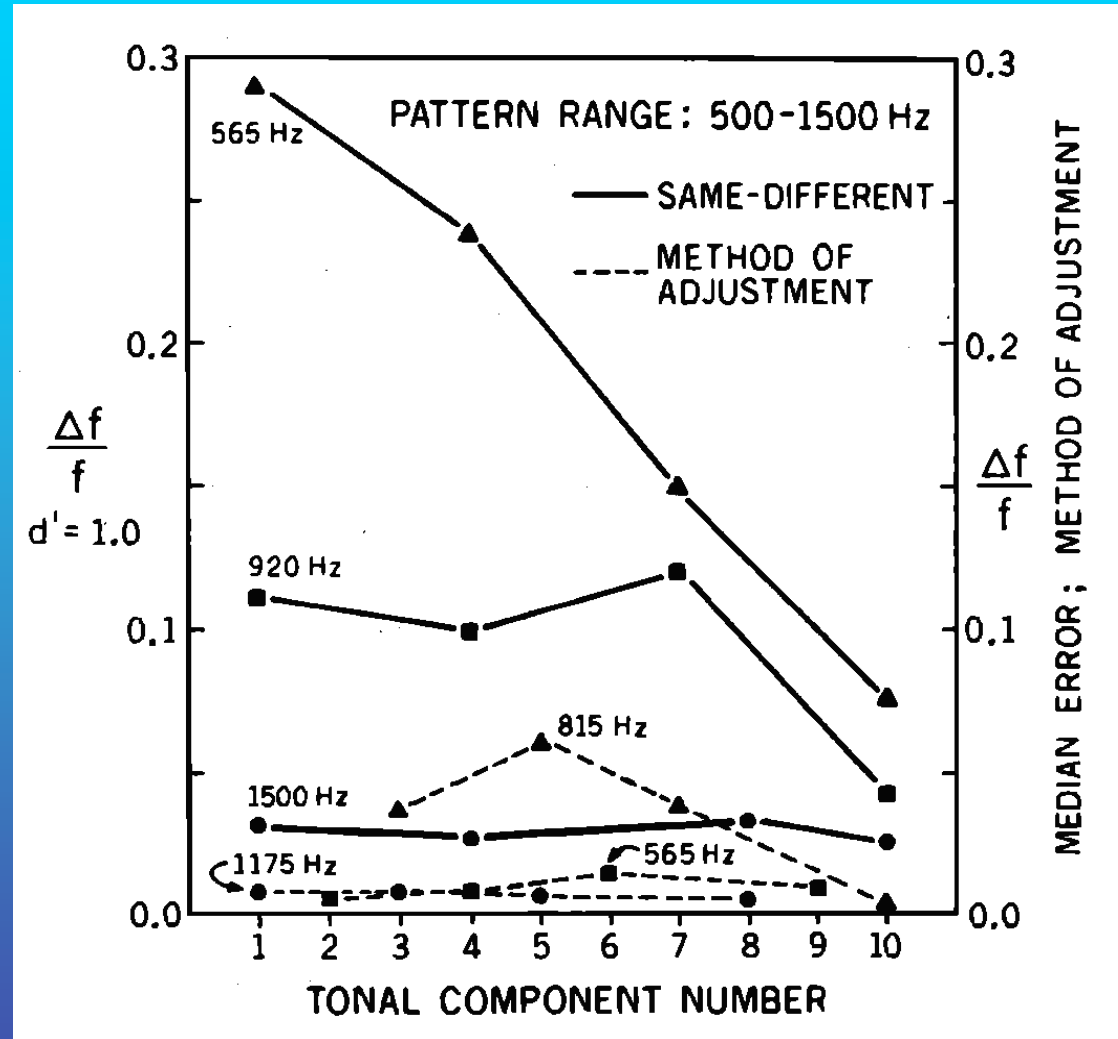
- 1) Dichotic presentations of competing messages, a la Cherry and Broadbent.**
- 2) Detection of Unknown or Uncertain Frequency a la Green.**
- 3) Probe-Tone technique a la Greenberg and Larkin.**
- 4) Streaming a la Bregman; Cusack-Carlyon**
- 5) Cueing procedures a la Posner, including endogenous and exogenous cuing a la Spence and Driver.**
- 6) Entrainment to temporal sequences a la Jones**

Some of What I Know About the Literature on Auditory Attention Based on Largely on Erv Hafter's Review

Some auditory physiology (evoked potentials and imaging) related to attention:

- 1) Greater BOLD-fMRI and PET activity in superior temporal gyrus when listeners attend to a particular sound (e.g., Janata et al, Zatorre, Petkov et al).**
- 2) EEG and MEG results suggest that attention effects the N1 potential arising most likely from primary auditory cortex (e.g., Woldorff and Hillyard, Hillyard et al).**
- 3) Although the MMN was originally thought to be independent of attention (e.g., Naatanen), some work using attended signals in one ear and unattended signal in the other suggest that the MMN response can be influenced by attention (e.g., Woldorff and Hillyard, Sussman, Hackley)**

Informational Masking and Attention



Watson, Kelly, & Worton, JASA 60, 1976

Sound Source Perception: The Importance of Attention and Memory?

Some of the reasons why I believe attention and memory are important:

- 1) Even if an auditory scene might be known to a listener, it is highly likely that at any one moment in time only part of the scene is relevant to the listener.**
- 2) Attentional and memorial processing may be needed to process the auditory scene.**
- 3) I believe that several areas of current interest are mainly studies of attention (e.g., informational masking).**
- 4) The study of sound source perception is often impeded by attention and memory limitations.**
- 5) There are many practical contexts in which attention and memory are required.**