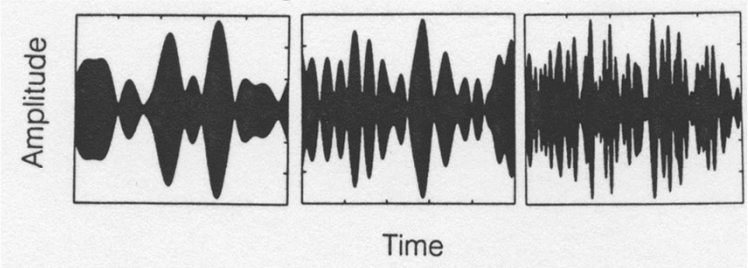
Temporal resolution

The ability to follow rapid changes in a sound over time

Slides courtesy of Lynne Werner, U of Washington, Seattle

Temporal resolution: How good is a listener at following rapid changes in a sound?

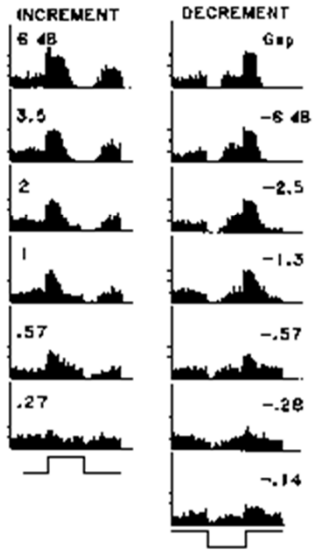


- Auditory nerve fibers do not fire at the instant at which sounds begin or end.
- Auditory nerve fibers do not fire on every cycle of sound.
- Adaptation occurs to longer duration sounds.
- Spontaneous activity occurs when no sound is present

Several characteristics of the auditory nerve response will limit the fidelity with which fluctuations in a sound can be represented.

Following rapid changes in sound

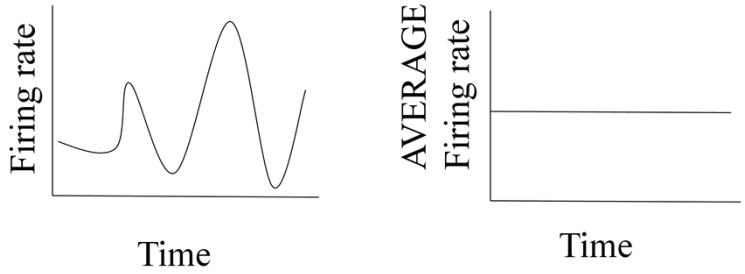
The auditory nerve response is highly accurate in time but does not follow changes with perfect precision … and this must be a limiting factor in performance

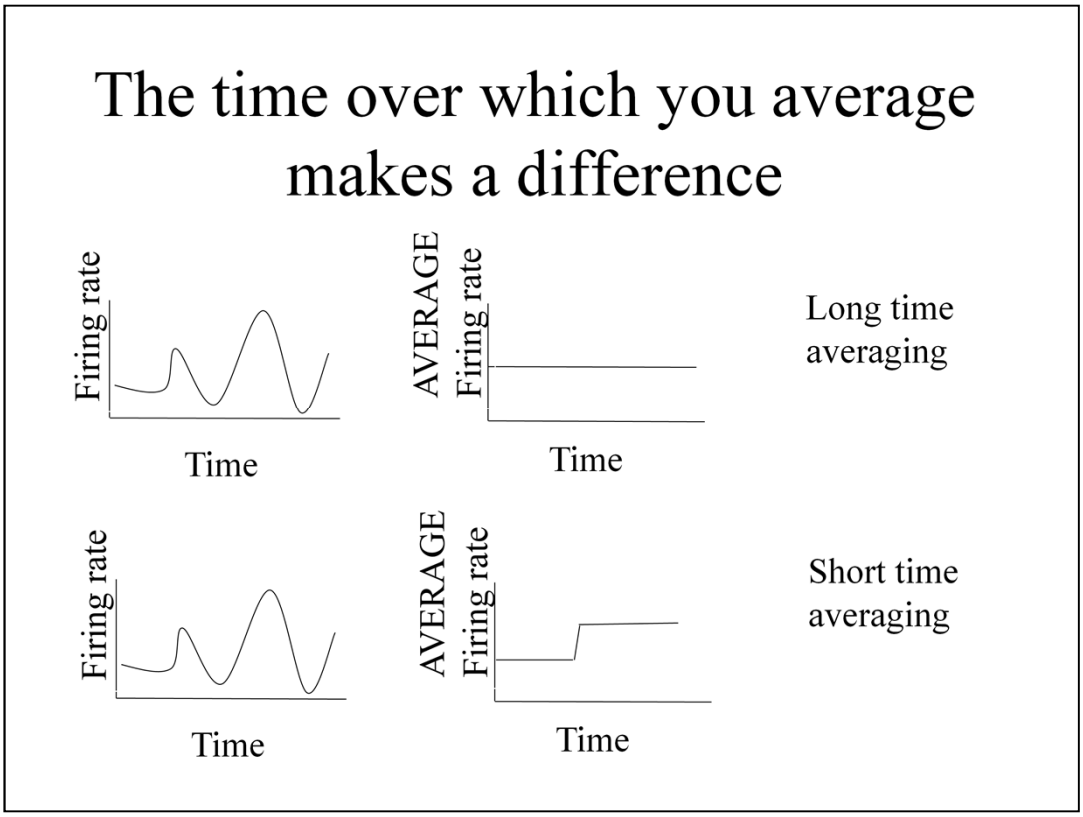


In the PST histograms on the right, the auditory nerve response does not exactly follow the clean increment or decrement in sound that is shown at the bottom of the panel.

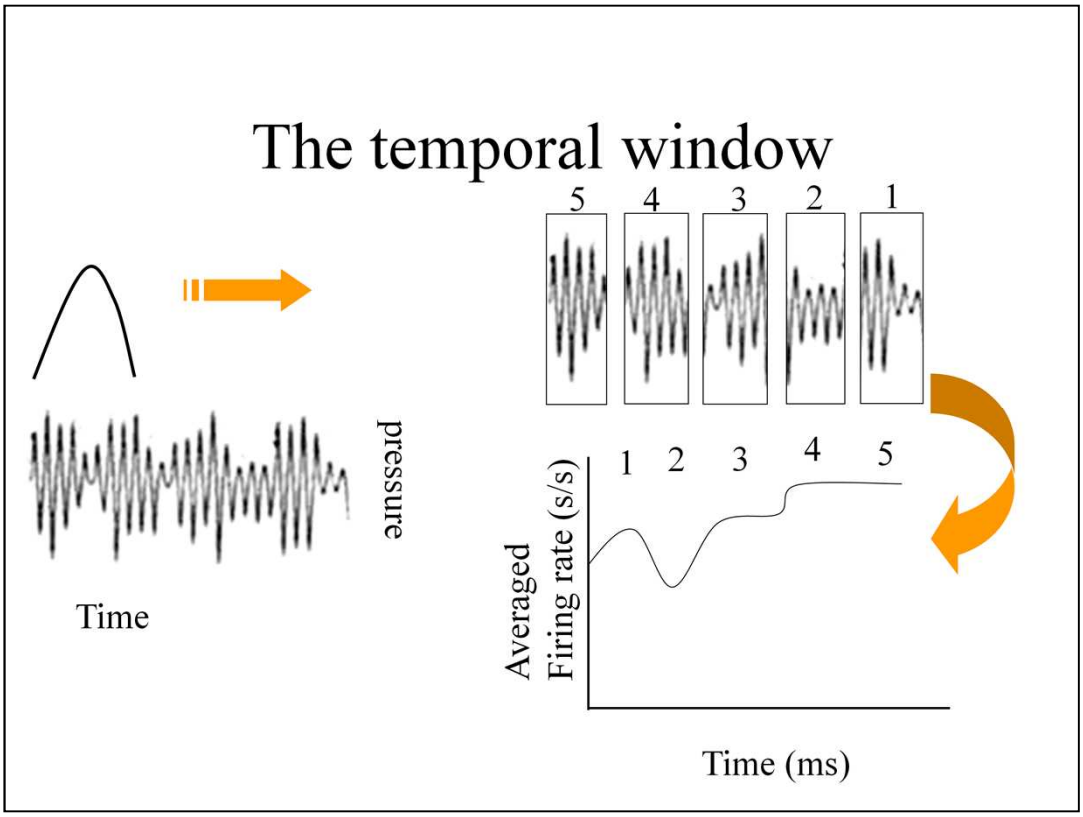
The auditory system can't really respond fast enough to capture little fluctuations, and even if it could, a lot of those little fluctuations in the auditory nerve response would be misleading.

Averaging over time is one way the auditory system could "smooth out" the bumpy response of auditory nerve fibers



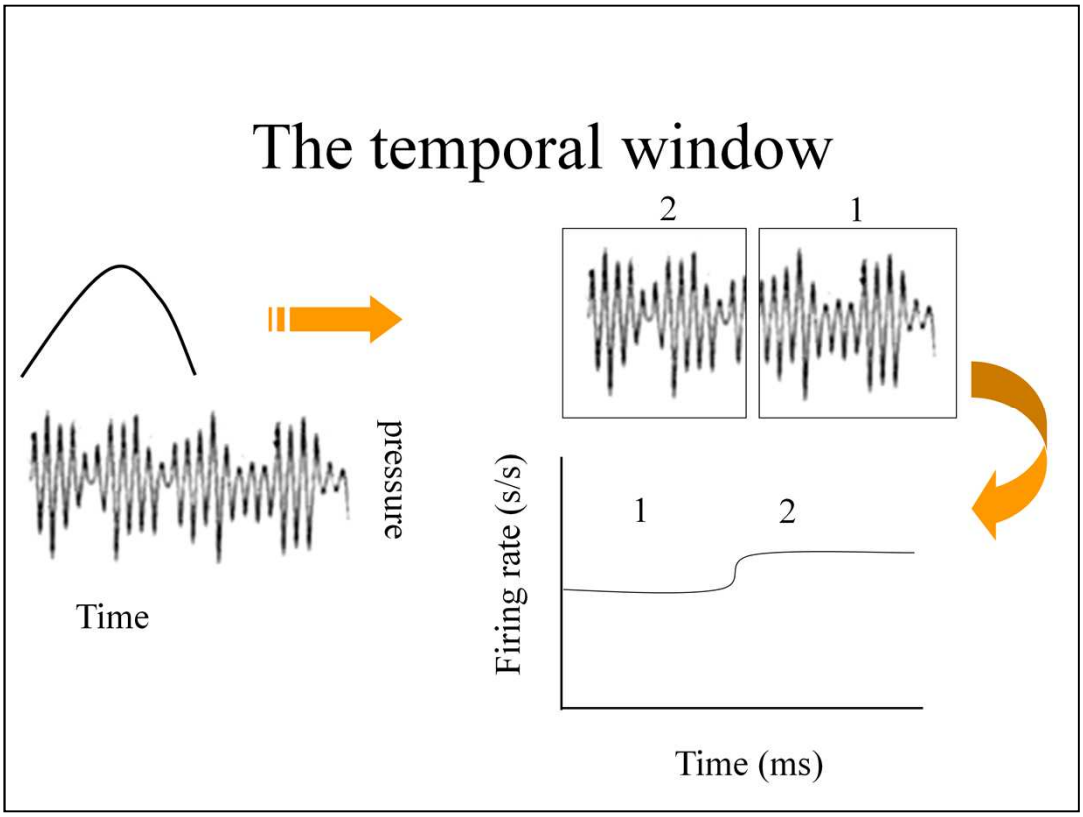


If you average over too long a time, you won't know when the intensity has changed. But if you average over too short a time, you will be fooled into thinking that an onset response or a recovery period represents a change in intensity.



We refer to the time over which the auditory system averages firing rate the “temporal window”. As the sound passes through the temporal window, all of the response that fits into the window at one time gets averaged. I’ve shown this in terms of the time waveform of a sound, but remember it is really the firing rate of auditory nerve fibers that is getting averaged.

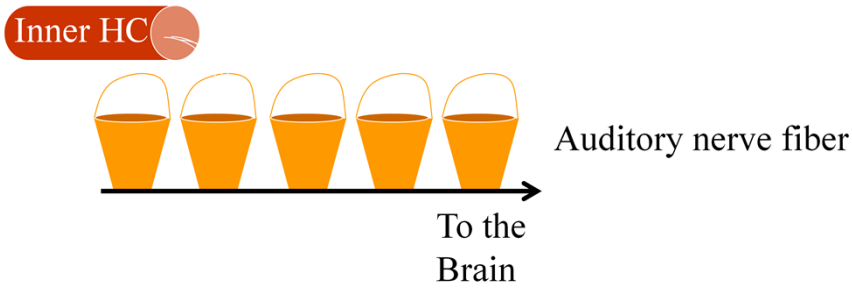
Notice that the average firing rate “captures” the decrease in intensity in the second “window”, but it misses some of the shorter decreases in the intensity that occur in the last 3 windows.



If the temporal window is longer, then we see even less of the details about the changes in the sound over time.

Hydraulic analogy: How long before the next bucket leaves for the brain?

The buckets can slide slowly or quickly.



One way to think of this: The auditory nerve is delivering the message from the cochlea to the brain in “chunks”, like the buckets in a bucket brigade. Each bucket is under the spigot for a certain period of time before it proceeds. Whatever message (“water”) collects in the bucket during that time is what the brain has to tell it what the sound amplitude was during that time period. It could go slow or fast.