

Physics of Music PHY103 Lab Manual 2011

Lab #10 – Perception of Rhythm and Timing

EQUIPMENT

- This is a multitrack experimental Software lab.
- Headphones
- Headphone splitters.

INTRODUCTION

In the first part of the lab we will experiment with stereo effects by adjusting the pan (volume) between the left and right channels. We will then experiment with introducing a small delay (sub millisecond) in the signal on one channel and not the other. We will also explore the effect of a larger (20-30 msec) delay and different amounts of reverb in one channel compared to the other. These effects mimic differences in sounds detected in one ear and the other and can be used as effects in recording and sound processing. The sound file we are edited has identical channels for right (R) and left (L) channels so stereo variations are particularly noticeable once introduced into it.

Electronically generated rhythms often sound mechanical and lacking in liveliness. Meter is often described in terms of absolute intervals like quarter notes and eighth notes. However musicians often deviate from exact timing sequences. In the second part of the lab we will experiment with our perception of 'microtiming' variations or deviations from exact intervals (of order 20-50 ms) that would be generated electronically or with a metronome.

The duration of short time intervals is conspicuously underestimated if they are preceded by shorter neighboring time intervals. This phenomenon is called 'time shrinking' and is illustrated in the Figure by Petra Wagner and Andreas Windmann on the right. When introducing microtiming variations.

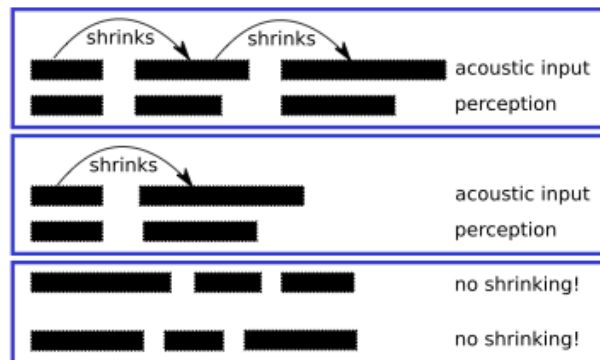


Figure 1: Schematic overview of time shrinking effects. Time shrinking occurs in decelerating sequences and can propagate across several intervals, but is blocked by initial long intervals and in the presence of strict alternation.

In the last part of the lab we will examine the sound file of an auditory illusion to see if we can figure out how it causes the perception of an accelerando.

PROCEDURE

A. Stereo and pan

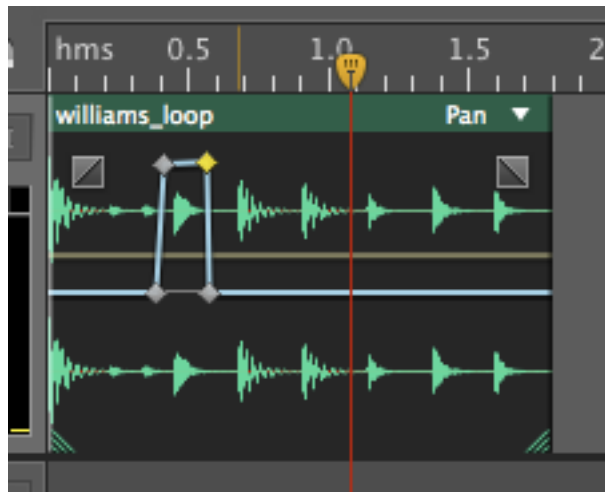
Sounds can be shadowed by our heads or other objects. Hence our ears often do not hear the same volume level. In this part of the lab we will experiment with pan, representing the relative volume between left and right channels of a stereo recording.

1. Download the file `williams_loop.wav` from <http://astro.pas.rochester.edu/~aquillen/phy103/WWW/handouts.html> or from the directory <http://astro.pas.rochester.edu/~aquillen/phy103/Labs/forlab10/>

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Read it in to Audition.

2. On the left top of Audition click on Multi-track and enter multitrack mode.
3. By right clicking on the sound loop you can drag it into one of the tracks.
4. Click on the loop play back button so you can listen to the loop played over and over again.
5. Now click on play to listen to the loop.
6. You should see two horizontal lines on the loop, a yellow one that is for the volume, and a blue one that is for pan.
7. Pan adjusts the right and left speaker balance. You may want to listen to the file with headphones.
8. By clicking on the blue pan line you can change the pan of the whole loop or just parts of it. Try changing the pan of a single drum beat.
9. How much difference between left and right (in %) is needed to make the sound stand out? Try a few different levels. (Right click will let you remove what is called keyframes or the little yellow diamonds)
10. Try varying different beats. Is it easier to hear a difference in pan on the low or high pitched drums? When you adjust the volume between left and right does it sound like the drum beat comes from a different location?
11. Vary the pan from 100% pan on the left at the beginning of the clip to 100% on the right at the end of the clip. See if you can make it sound like the drums are moving across the room.

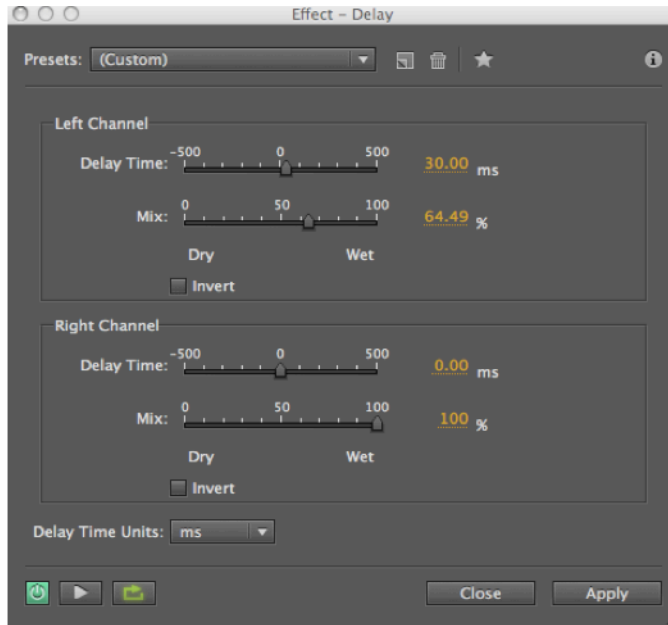


B. Stereo and Delays

The speed of sound is approximately 340m/s. Consider the time it takes a sound wave to travel about 15 cm or the width of a head. $15/(340*100) = 0.00044s = 0.44$ milliseconds. Conceivably one ear could hear a sound that is delayed by about 0.4 milliseconds compared to the sound heard in the other ear. Very small delays introduced between R and L channels do affect the way we perceive the sound. I find that small delays or changes in reverb make the recording sound more alive and as if it were recorded in a live room with live instruments. The sound file we are using has identical channels for R, L so stereo variations are particularly noticeable.

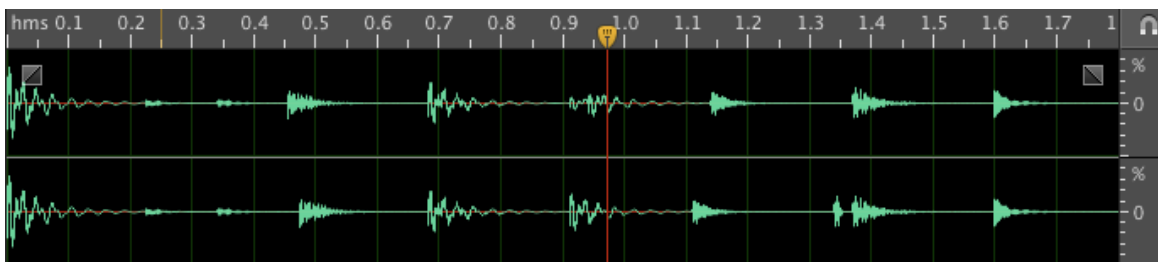
1. Go into waveform view. Select a region around a single drum beat. To introduce a delay into one channel and not the other choose Effects, Delay and Echo, Delay

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On the left is a delay effect box that allows you to set a delay time in right or left channels. If the Mix is 100% wet then the entire signal is delayed. Otherwise a delayed signal is added to the original.

2. Set the mixes to 100% or 'Wet'. This delays the entire signal. Otherwise a delayed signal is added to the original. Delay one channel (left or right) of a single drum beat by 0.5 ms or so. Can you hear a difference at that drum beat compared to the rest when the loop is played repetitively? Does the delay change the perceived location of the sound?
3. Is it easier to hear a delay in the bass drum beats compared to the treble ones? Sound localization may preferentially depend on the low frequencies. Neuron firing rates are observed to depend on phase only at low frequencies.
4. How do larger delays such as 20-30 msec affect the perception of the sounds?
5. Below is an image of the file with various delays introduced, including some drier ones that change the signal shape.



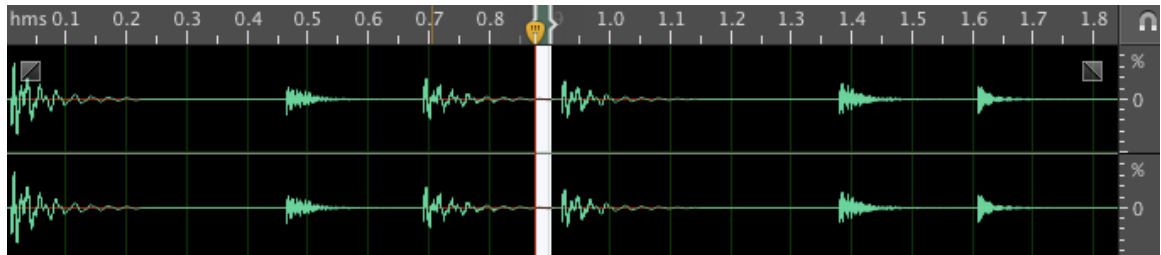
6. Make a sound file like the one above with various delays in it. When you listen to it do you perceive a change in rhythm or beat? I find that quite large variations in each channel can be introduced without changing the perception of a precise beat.
7. Read in the unedited sound file again.
8. By clicking on R or L on the right hand side you can selectively edit only the Right or Left channel. Try introducing reverb into a single channel at a single drum beat. (Click on Effects, Reverb, Reverb..) The key parameter to adjust is the decay time. How does introducing reverb into a single channel affect your perception of the sound in context with the other beats? Is it more noticeable on a low pitched drum beat rather than a high drum beat?

C. Perception of Microtiming Delays and Advances

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The sound file `williams_loop.wav` is fairly electronic. The drum beats have been set to be precise intervals apart. In general musicians tend to play with variations in timing. In this section we will investigate our perception of delays and advances of individual beats.

1. Read into Audition the sound file `'williams_loop_t.wav'` from <http://astro.pas.rochester.edu/~aquillen/phy103/Labs/forlab10/>. A couple of beats have been removed from the file compared to `williams_loop.wav`. This is so we have a file that has different intervals between beats.



The sound file `willams_loop_t.wav` has 6 beats in it.

Advances:

2. Remove 30msecs (in both channels) before beat 2. To do this select a small region by left-clicking and holding. You can adjust the duration length by typing a number in to the duration in the selection/view section. If you don't see this click on "Window" at the top, chose "Selection/View". This window will show you the beginning and end of your selected time. The duration length is usually in seconds. 30 milliseconds would be 0.030 in seconds. After you have selected the time interval you can remove it (cut it) with $\text{⌘}X$. You can put it back (undo cut) with $\text{⌘}Z$. Listen to the loop with 30ms removed just before beat 2. Listen to it as a loop. Does this small advance strongly affect your perception of the rhythm? Does it affect your ability to tap to the beat?
3. Try removing 30ms before beat 3 and listening (then restore it). Then try removing 30ms before beat 4 and listening (and then undo the cut). Repeat for beat 5 and then 6 and then at the end of the file (just before beat 1 when in a loop). In which cases is the removal of 30ms more noticeable? In which cases does it make it harder to tap to the beat? *Does this make sense in context with the time shrinking perception effect discussed in the introduction?*

Delays or Rubato:

4. Just before beat 2 cut 30msecs of time ($\text{⌘}C$) and paste it back in at the same spot ($\text{⌘}Z$). This adds an additional 30msecs before beat 3. How does this change perception of the rhythm? Does this affect how you tap the rhythm?
5. Restore the file to its original form. Try the same experiment by extending the time just before beat 3 then repeat for beat 4, 5 and 6. When is the extension or delay most noticeable?
6. Try advancing one beat but insert the same time later in the file. Is this less or more noticeable than advancing or delaying a beat? Does it make it easier to tap to the rhythm?

D. Interpretation of an Auditory Illusion

1. Read in the sound file `'beat.mp3'` from <http://astro.pas.rochester.edu/~aquillen/phy103/Labs/forlab10/>
2. Play the file and listen to it
3. Examine the file and see if you can figure out how it causes the perception of speeding up the beat.

LAB REPORTS

- Abstract summarizing your findings
- I am not sure what to focus on here. Perhaps you can discuss your perception of the various experiments suggested here. Issues to discuss are perception of environment due to stereo effects.

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Echo suppression and how it might affect our perception of timing variations. What types of timing variations are most noticeable and how musicians exploit them?

- What should we do differently in this lab for next year?

Suggestions for next year: Consider trying two different drum beats (with different timbres) together and exploring what they sound like with different offsets between each other.