BSc Audiology & MSc Audiological Science
AUDL 4007: Auditory Perception

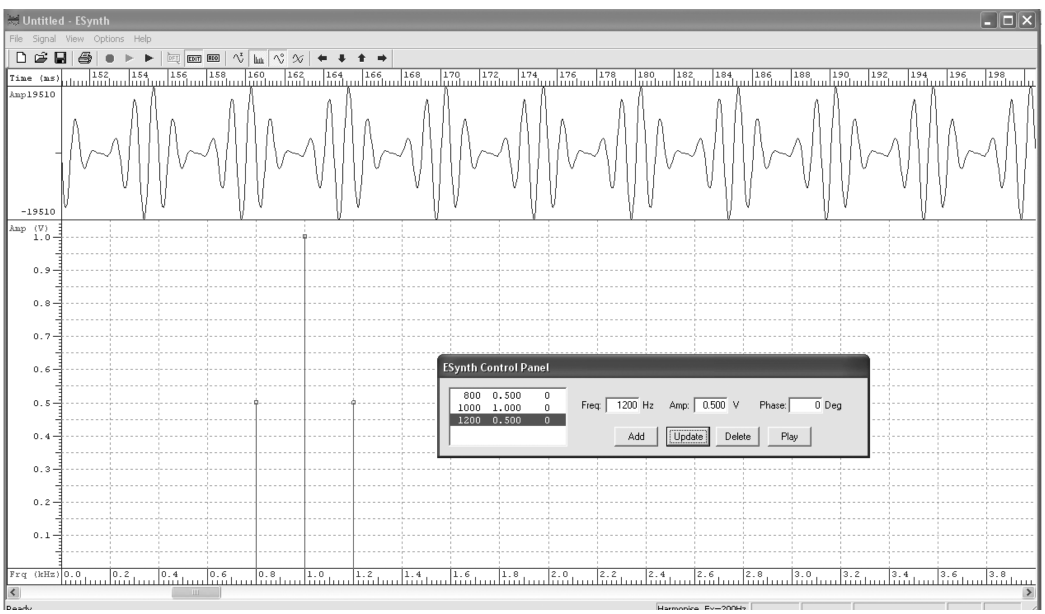
Laboratory session on pitch

Effects of relative phase on pitch of complex tones.

Pitch cues can be conveyed both by resolved harmonics and by the temporal details of the neural firing in response to the basilar membrane vibration due to several unresolved harmonics. This demonstration reflects the limits to the resolution of harmonics as made evident in effects of relative phase. You will use the program ***Esynth*** in the LAB programs folder to generate and listen to complex tones containing 3 adjacent harmonics.

Before you do anything else with Esynth check that “harmonise” is ticked on the options menu. And then select the button labelled EDIT (two to the right of the blue play button). This opens a control panel where you can specify the frequency, amplitude and phase of each harmonic. Note that specifying 0º phase in this program results in a sinusoid that starts at 0 and then goes up (normally known as *sine phase*), so that 90º phase results in a wave that starts at 1 and then goes down (normally known as *cosine phase*).

Start with the 4th, 5th and 6th harmonics of 200 Hz. Give them all a phase angle of 0º and make the middle harmonic have twice the amplitude of the outer two. Select and zoom in to about 50 ms duration of the waveform. Your screen should look like this.



Listen to the tone a few times (use the double blue arrow button to play the whole sound and not just the zoomed selection) Then change the phase of the middle (1000 Hz) harmonic to 90º (select the harmonic to the left of the control panel, type 90 in the Phase box then click update)

Listen again. Do you hear any difference?

Compare and comment on the temporal details of the waveform between the 0º and 90º phases of the middle harmonic. In particular, take note of the time intervals between major peaks in the waveforms.

Now try with higher harmonics of 200 Hz: 2000, 2200 and 2400 Hz. You should be able to hear a change in the quality of the sound when you change the phase of the middle harmonic. When all harmonics have a phase of 0º, the pitch should sound stronger and less ambiguous. Summarise the difference you hear:

How can you explain that the relative phase of the harmonics makes a difference to how we hear a combination of 2000, 2200 and 2400 Hz, but not for the combination of 800, 1000 and 1200 Hz?

How might you explain the effect of relative phase for the higher harmonic numbers?

Note: When the three harmonics at 800, 1000 and 1200 Hz have 0º phase and the outer two are half the amplitude of the middle harmonic, the signal is identical to what you would get as a result of applying a 200 Hz sinusoidal amplitude modulation to a 1000 Hz sinewave. However, when the middle harmonic has a 90º start phase, the resulting signal resembles the result of applying a 200 Hz ***frequency modulation*** to a 1000 Hz carrier. In the scientific literature, you will see the effects you explore here referred to as comparisons of SAM (sinusoidally-amplitude-modulated) and QFM (quasi-frequency modulated) tones.

Pitch discrimination with purely temporal cues compared to pitch discrimination for a harmonic complex tone

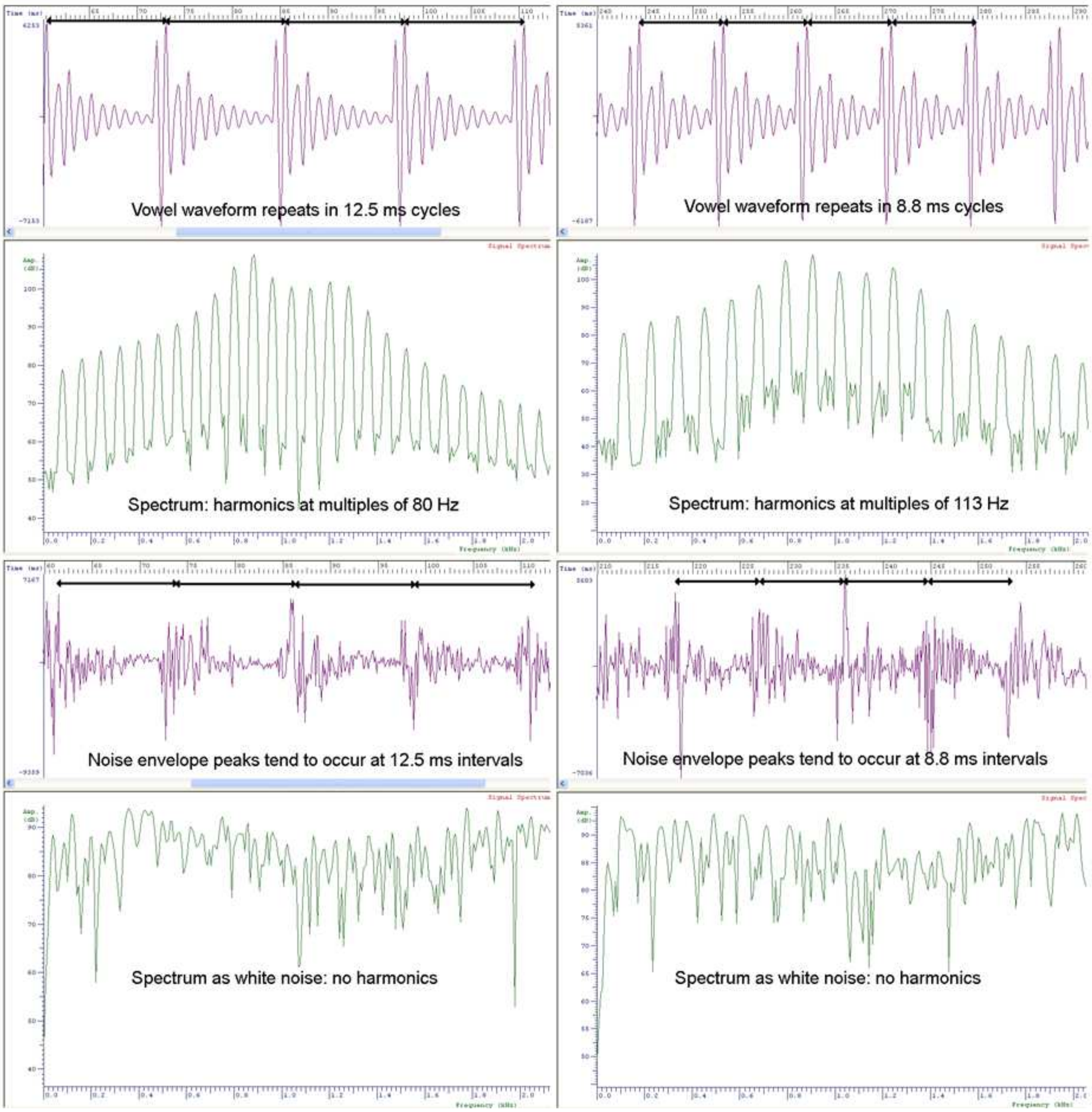
Here you will measure your ability to hear a difference in a purely temporally coded pitch produced by amplitude modulation of noise. You will also measure pitch discrimination for a synthetic vowel sound. The modulated noise you hear in the purely temporal condition is created by modulating a noise by the envelope of the vowel as would happen in the speech processor of a cochlear implant.

For this, use the GLIMPSE program. Select Tasks → Triples →Triples2AFC
and enter your initials. Then load the file Triples\Triples_VSP.txt for the synthetic vowel or Triples\Triples_V1.txt for the AM noise.

When you run the task each trial has 3 sounds. The ‘different’ sound will be either the 2nd or 3rd, never the 1st, and will always be ***higher*** in pitch than the other two – although sometimes the difference will be too small for you to detect.

The fixed standard sound has a fundamental frequency (F0) of 80 Hz. Use the table overleaf to interpret the threshold value from Glimpse as a frequency difference in Hz (DLF) and a relative frequency difference limen (DLF/F).

Compare the threshold values that you get with the vowel and the AM noise and compare your results to the class as a whole. How might you explain the difference between the two conditions?



The figure shows waveforms and spectra for vowel (upper) and AM noise signals (lower) at the 80 Hz standard F0 (left) and at 113 Hz (right panels)

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Glimpse level	Semitones re 80 Hz	Comparison F0 (Hz)	DLF (Hz)	DLF/F %
47	12.00	160.00	80.00	100.00%
46	10.09	143.29	63.29	79.12%
45	8.49	130.60	50.60	63.25%
44	7.14	120.80	40.80	51.01%
43	6.00	113.14	33.14	41.42%
42	5.05	107.07	27.07	33.83%
41	4.24	102.22	22.22	27.77%
40	3.57	98.31	18.31	22.88%
39	3.00	95.14	15.14	18.92%
38	2.52	92.55	12.55	15.69%
37	2.12	90.43	10.43	13.04%
36	1.78	88.68	8.68	10.85%
35	1.50	87.24	7.24	9.05%
34	1.26	86.05	6.05	7.56%
33	1.06	85.05	5.05	6.32%
32	0.89	84.23	4.23	5.29%
31	0.75	83.54	3.54	4.43%
30	0.63	82.97	2.97	3.71%
29	0.53	82.49	2.49	3.11%
28	0.45	82.09	2.09	2.61%
27	0.38	81.75	1.75	2.19%
26	0.32	81.47	1.47	1.84%
25	0.27	81.23	1.23	1.54%
24	0.22	81.04	1.04	1.30%
23	0.19	80.87	0.87	1.09%
22	0.16	80.73	0.73	0.91%
21	0.13	80.62	0.61	0.77%
20	0.11	80.52	0.52	0.65%
19	0.09	80.43	0.43	0.54%
18	0.08	80.37	0.37	0.46%
17	0.07	80.31	0.31	0.38%
16	0.06	80.26	0.26	0.32%
15	0.05	80.22	0.22	0.27%
14	0.04	80.18	0.18	0.23%
13	0.03	80.15	0.15	0.19%
12	0.03	80.13	0.13	0.16%
11	0.02	80.11	0.11	0.14%
10	0.02	80.09	0.09	0.11%
9	0.02	80.08	0.08	0.10%
8	0.01	80.06	0.06	0.08%
7	0.01	80.05	0.05	0.07%
6	0.01	80.05	0.05	0.06%
5	0.01	80.04	0.04	0.05%
4	0.01	80.03	0.03	0.04%
3	0.01	80.03	0.03	0.03%
2	0.00	80.02	0.02	0.03%
1	0.00	80.01	0.01	0.01%
0	0.00	80.00	0.00	0.00%