Perception:
how low can you go?

Meeting
Nov 29th 2022

This short talk

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Unscientific ramblings about how activity can change auditory perception

and by how much?
and how far could it go?
and how far should it go?

What I've found over the years

"Things that I believed not meaningful can sometimes be heard"

Examples:

- **double-precision** Over a full plugin.
  Obviously in IIR delays, but also in FFT, reverbs, sidechain signal…
  though 32-bit float can often sound better because noise

- **sidechain things**
  Because the sidechain is multiplied by input, it matters as much!

- The particular **expf(x)** approximation can have an effect on sound…
  not because it's imprecise, but because x varies

AirWindows experiments

The same song in 32-bit float, 64-bit double, and 80-bit long double

https://soundcloud.com/airwindows/float

rather obvious

https://soundcloud.com/airwindows/double

https://soundcloud.com/airwindows/long-double

Reservations: in long double I fear the differences might be dominated by transcendental approximations

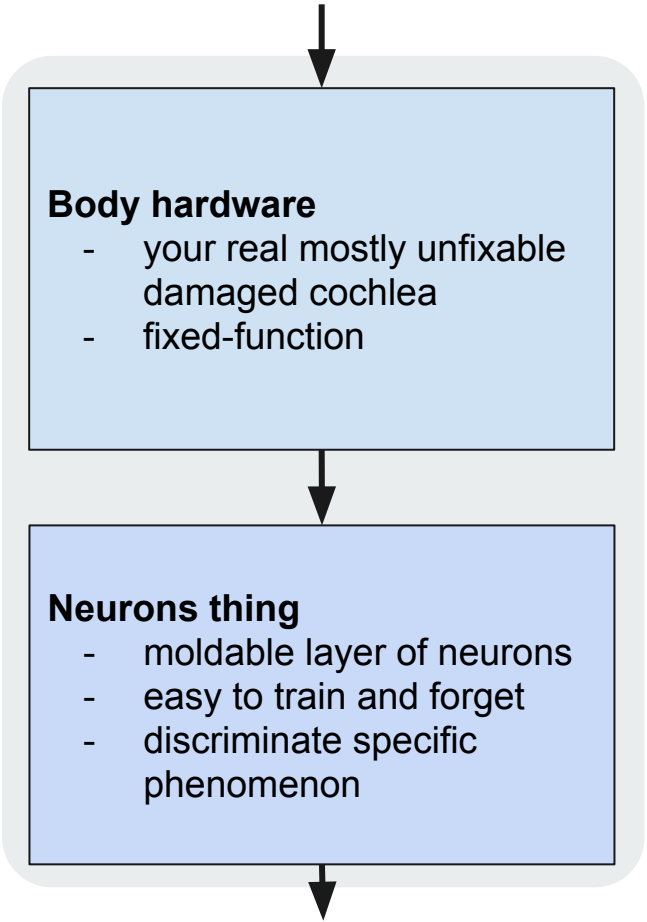
What I've found over the years

"Making a plug-in changes your hearing for a while"
(like: up to a few weeks after doing most critical listening work)

- **Reverb.** *You will notice early reflections.*
- **Distortion.** *You will hear more distortion in things.*
- **Aliasing.** *You might hear exaggerated aliasing, if you can hear it at all.*
- **Dynamics.** *You will notice more the dynamic envelope of sounds.*
  etc…

  It makes sense!

My own mental model of hearing



My own mental model of hearing

DSP work period

say, 6 to 8 weeks

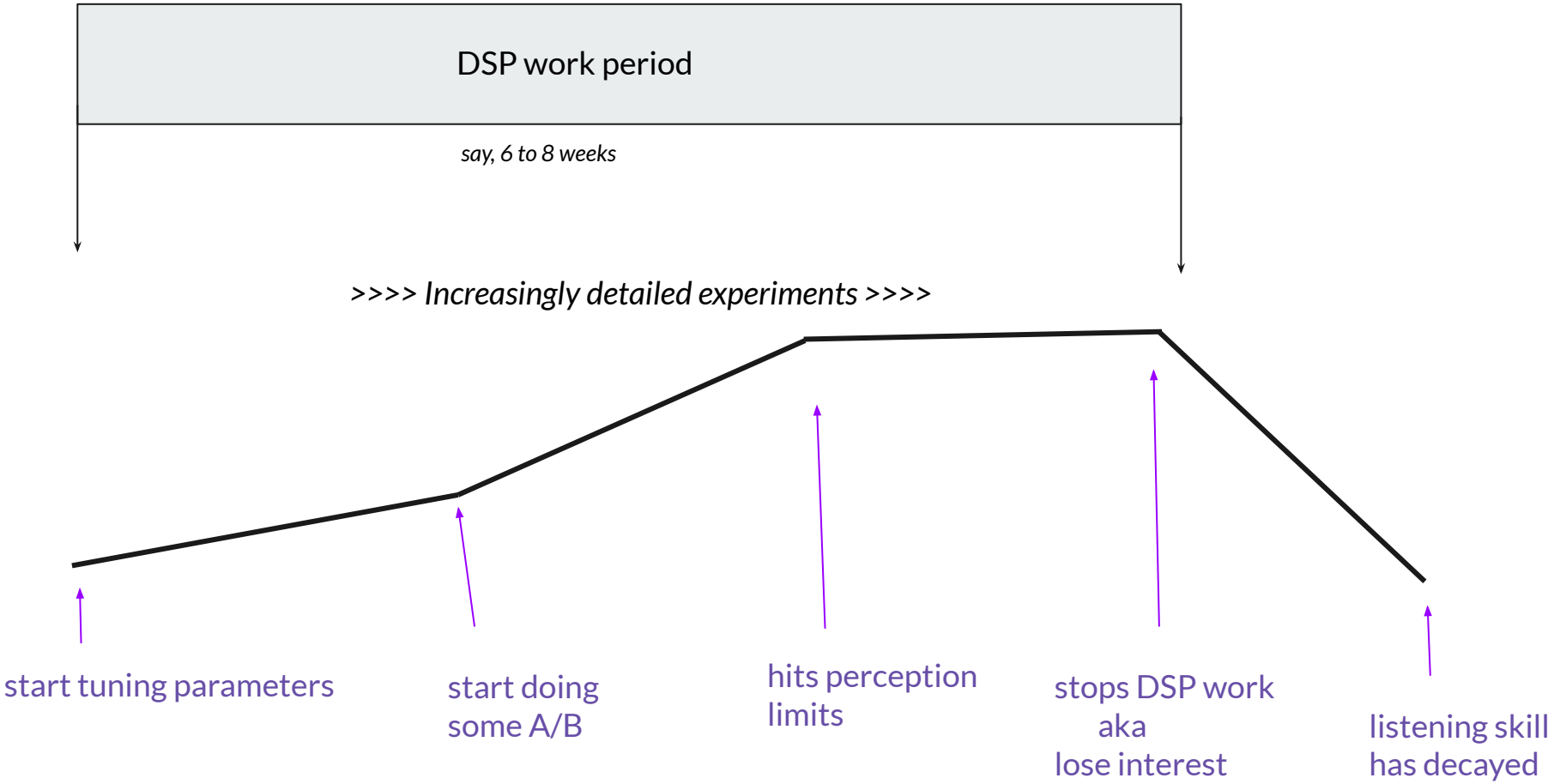
SKILL CURVE

Body hardware
- your real mostly unfixable damaged cochlea
- fixed-function

Can't change this

Neurons things
- moldable layer of neurons
- easy to train and forget
- discriminate specific phenomenon

It changes by itself just by listening with attention


DSP work period
say, 6 to 8 weeks
>>>> Increasingly detailed experiments >>>>
start tuning parameters
start doing some A/B
hits perception limits
stops DSP work aka lose interest
listening skill has decayed

What I've found over the years

"Making a plugin changes your hearing for a while"
(like: up to a few weeks after doing most critical listening work)

- **Reverb.** *You will notice early reflections.*
- **Distortion.** *You will hear more distortion in things.*
- **Aliasing.** *You might hear exaggerated aliasing, if you're young.*
- **Dynamics.** *You will notice more the dynamic envelope of sounds.*

etc…

It makes sense!

A few weeks only?

- That “skill” evaporates once not needed.

  Making **critical listening a relatively bad investment** in specialization.

- Also, most useful audio changes are not the smallest

  People will hear your -80dB RMS change better than your -90dB RMS change… because it’s louder.

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NEED TOOLS TO GET BACK CRITICAL LISTENING

wav-compare

It is a sound file comparator tool in Dplug

```
C:\Users\guill\Desktop\ab\haming vs hann window>wav-compare hann.wav hamming.wav

 Comparing hann.wav vs hamming.wav

    ================================
        RMS difference = -0.11 dB
    ================================

 An opinion from the comparison program:
    "This is a big difference, should be something that changes the phase, or something very audible (possibly an error)!"
```

wav-compare

Root Mean Square energy of (a - b)

```
C:\Users\guill\Desktop\ab\haming vs hann window>wav-compare hann.wav hamming.wav

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```

Gives its opinion

RMS over the whole file can be locally misleading

- wav-compare can output spectrograms with **-o**
  wav-compare can skip first seconds with **-s** *(often first seconds of DAW diff have more energy)*

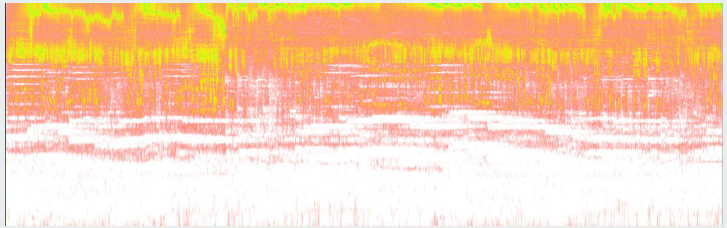
```
Comparing hamming2.wav vs hann2.wav

   ================================
       RMS difference = -26.98 dB
   ================================

An opinion from the comparison program:
   "This might be a hearable difference inside your DAW, but this might also require an A/B test if it's mostly a phase thing."


Create a difference PNG in output.png
* Resize to 2583 x 800...
* Convert to PNG...
```

Result =



Audio diff can be misleading (because phase)

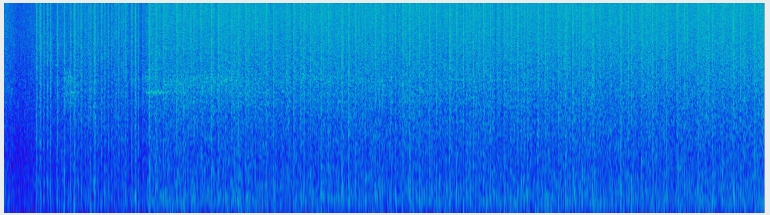
1. *If you add 0.01ms to the release curve of your compressor, it won't meaningfully change its sound.*
   However the measured RMS difference will be massive.

2. *If you set a single sample to zero, the sound will be massively disrupted.*
   But not changing the RMS difference meaningfully over a long period.

3. *Inverting phase yields massive RMS diff.*

Spectrograms say if it's a big or small diff

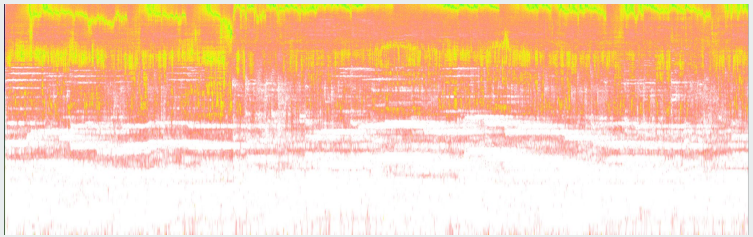
Small diff =



Comparing two different powf
Very very subtle diff.

```
================================
RMS difference = -113.43 dB
================================
```

Big diff =



Probably a bug?
Very audible thing

```
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RMS difference = -26.98 dB
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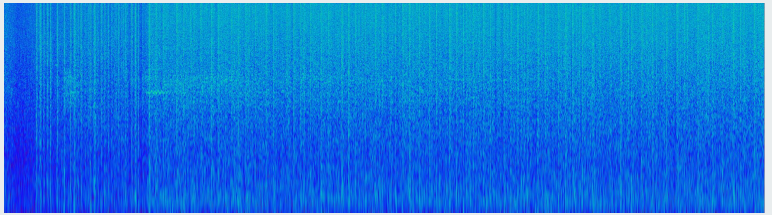
Spectrograms say if it's a big or small diff

Small diff =



```
The palette of the spectrogram is as follow:
- white   means    0dB difference
- red     means  -20dB difference
- yellow  means  -40dB difference
- green   means  -60dB difference
- cyan    means  -80dB difference
- blue    means -100dB difference
- magenta means -120dB difference
- black   means -140dB difference or below
```

Comparing two different powf
Very very subtle diff.

```
================================
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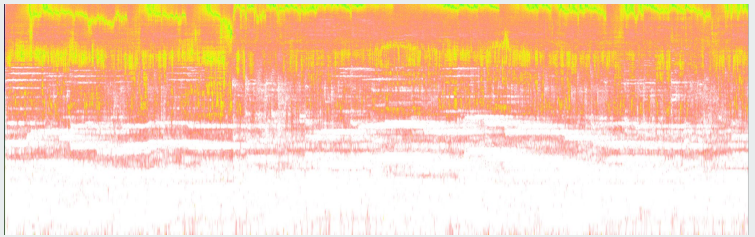
```

Big diff =



Probably a bug?
Very audible thing

```
================================
RMS difference = -26.98 dB
================================
```

Also this spectrogram is full double-precision.

Typical RMS(difference) of small operations

exp vs expf (Digital Mars)
sinus(float) vs sin(double)
cos(float) vs cos(double)
summing 256 tracks (some -60 dB below) with float accumulator
summing 256 tracks (same level) with float accumulator

summing 16 tracks (some -60 dB below) with float accumulator
summing 16 tracks (same level) with float accumulator

Multiplying two signals in float domain = -147 dB
float vs double hypot
Adding two signals of same RMS in float domain

Adding two signals, one 100dB above the other, in float domain
sqrtf vs sqrt (MSVC runtime)
tanh vs tanhf (MSVC runtime)
one single double-to-float conversion = -152.9 dB

Typical RMS(difference) of small operations

but I've just not measured those bigger things yet.

Example:

- smoothing the smoothing coefficients
- table approximations
- all sort of algorithm details

abtest tool

- An A/B comparison tool in Dplug.

  Instant switch from A to B to avoid short iconic memory

- Diffuse and/or concentrated attention questions
  Diffuse attention often better to spot "naturalness"

  Not everything deserves to be A/B. A/B is often with a fixed source, unlike interactive tuning. Questions can be distracting

```
 Which sound is the CLEANEST?
   * Type 'a' to listen to A
   * Type 'b' to listen to B
   * Type ' ' to choose current (B) and move to next question
   * Type '=' to declare a draw and move to next question
   * Type 's' to skip this question

   Choice?

*** TOTAL RESULTS
 => baseline2.wav got 2.5 votes
 => fmath2.wav got 3.5 votes

*** DETAILS
             What would you rather hear in YOUR MUSIC? => fmath2.wav
                        Which sound feels more TRUE? => baseline2.wav
               What would you rather hear in your CAR? => fmath2.wav
                       Which sound has the best LOWS? => draw
                      Which sound has the best HIGHS? => fmath2.wav
                        Which sound is the CLEANEST? => baseline2.wav
```

abtest WARNING

Placebo is absolutely MASSIVE and often LOUDER than your diff

Once you know which is A and B, you ***will*** *have a favourite.*

Where to position audio placebo?

0 dB RMS diff

-20 dB RMS diff

-40 dB RMS diff

-60 dB RMS diff

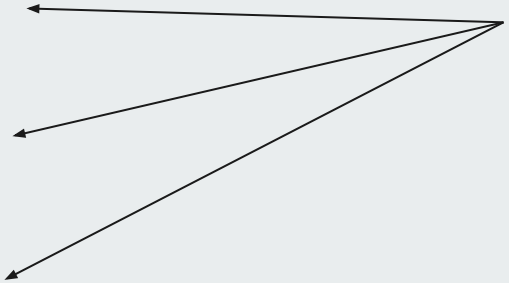
- 80 dB RMS diff

- 100 dB RMS diff

------ Documented limits of hearing ------

- 120 dB RMS diff

- 140 dB RMS diff



Certainly above -110 dB RMS, should probably measure where it is… and for whom

Questions?