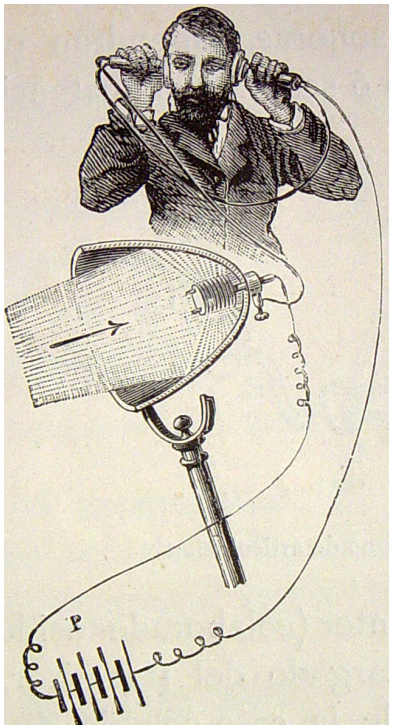
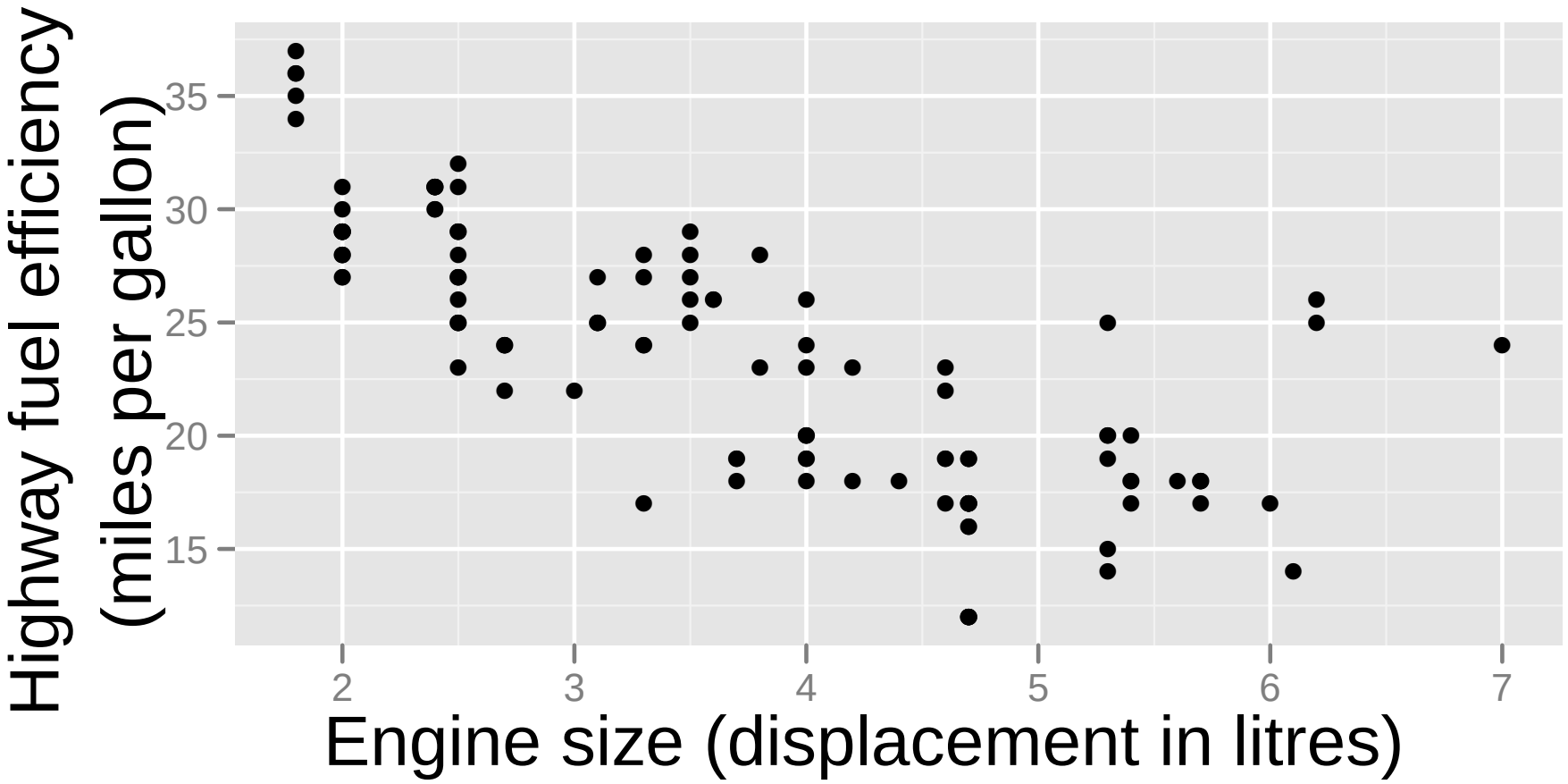
Engaging Auditory Learners with Statistical Sonification

Ethan Brown

ethancbrown@gmail.com
Blog: statisfactions.com
Slides/Media: statisfactions.com/ecots/

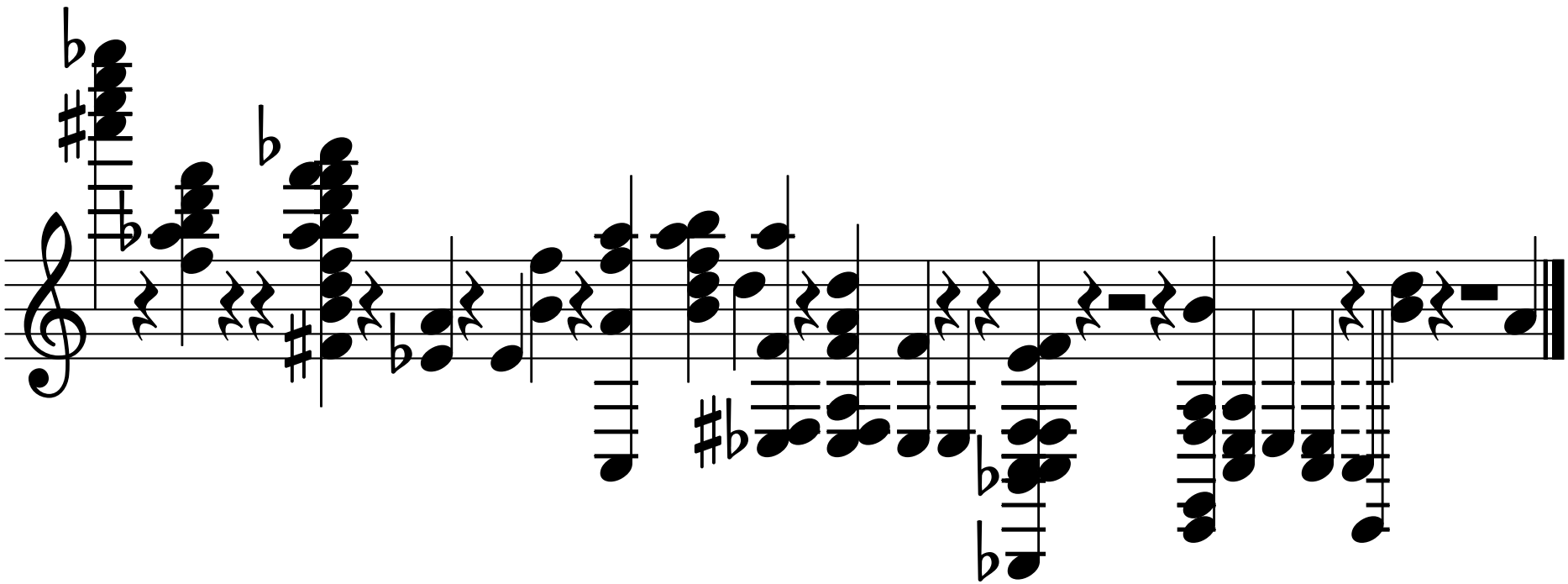


Fuel efficiency scatterplot: visualization



Engine size $\rightarrow x$, *fuel efficiency* $\rightarrow y$

Fuel efficiency scatterplot: sonification



Engine size $\rightarrow$ *time, fuel efficiency* $\rightarrow$ *pitch*

Why sonify?

- Display data for students with vision disabilities and auditory learners
- New, exciting ways to engage with statistical information
- Particularly nice for understanding time series data and theory

Accessible data displays

- Motivation
  - Blind students not well-served by standard, visually-focused stats courses
  - Adding sound to visualizations, animations can help all students who are auditory learners
  - Accessibility issues with statistical software impede independence
- Existing accessible math/statistics education work
  - MathTrax from NASA: sonified graphs and computer-generated text descriptions (middle & high school)
  - Graph and Number line Input and Exploration (GNIE) from Georgia Tech (6th grade Common Core)
  - Museum exhibits: Accessible Aquarium Project, Walk on the Sun
- Next steps?
  - Improve obvious accessibility issues in statistical software
  - Define priorities for statistical concepts in need of accessible display
  - Design and evaluate solutions
  - Create easy-to-use software for sonification that integrates with statistical software

Statistical Sonification Demonstrations

- Time series analysis
- Listening to a Poisson process

Time series analysis

Example autoregression of the second order, widely used in time series analysis:

$$X_t = 0.6165X_{t-1} - 0.995X_{t-2} + \varepsilon_t$$

- Tone: periodic behavior
- Audio is a time series; white noise, filtering, smoothing, can be demonstrated audibly
- Can listen to sound-like datasets such as seismic movements

Exponential Horsing Around

Image ©Thowra_uk,
Flickr user (Creative Commons 3.0 BY)

Horse neigh sample ©3bagbrew,
Freesound user (Creative Commons 3.0 BY)

- Expected waiting time is five seconds
- BUT exponential waiting times are *memoryless*
- You are never "due" for a whinny no matter how long you wait

(Inspired by "Livin' la vida Poisson" on Statistics Blog, `www.statisticsblog.com/2010/11/livin-la-vida-poisson/`)

Data's many soundscapes

Physics CERN's LHCsound, has been exploring high-energy particle collisions from the Large Hadron Collider; NASA has created a tool to sonify the cosmic background radiation in a variety of model universes with different physical constants than ours.

Optimization Germany's Bielefeld University sonifies machine learning algorithms so users can interact with neural network models and optimizations as they progress.

Sport Nina Schaffert, a human movement scientist at the University of Hamburg, leads research on training elite rowers by sonifying their acceleration.

Exhibits University of California at Santa Barbara exhibited "The Allobrain" recently, an interactive and multimedia virtual-reality world created from fMRI data.

Learning more about sonification

Again, this presentation is also available at `statisfactions.com/ecots/`

- *The Sonification Handbook*, a summary by experts in the field, freely available at `sonification.de/handbook`; Chapter 8 is specifically on statistical sonification
- The Georgia Tech Sonification Lab, `sonify.psych.gatech.edu/`, which provides a nice no-cost tool in Java for simple data sonification
- Leading researcher Thomas Hermann's web site: `sonification.de`
- My open-source `R` package for data sonification: `playitbyr.org`

Thanks to Ben Davison and Vincent Martin of the Georgia Tech Sonification Lab for pointing me towards resources for accessible statistics while preparing this presentation.