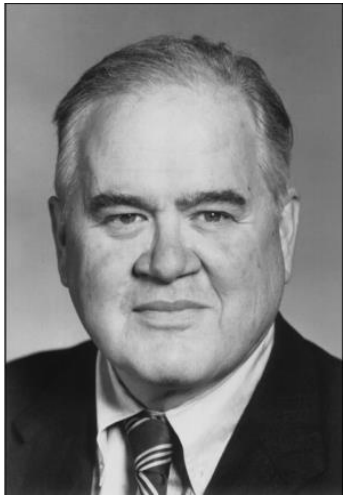
"People Are Different"

David. R. Brillinger, Berkeley

1935 t-shirt



1. Toronto, Canada

July 1, 2016

DAMON WINTER/THE NEW YORK TIMES

Mouhamad and Wissam Ahmed with their newborn daughter, Julia, and Liz Stark, one of the family's sponsors in Canada.

Refugees Hear a Foreign Word: Welcome

How Canadians Adopt Syrian Families With Nowhere Else to Go

Fugitive High Park Zoo capybaras duo elude search party after morning escape

June 9 “Bonnie and Clyde” escape

June 12 “One of two fugitive capybaras captured”

Juen 14 ``Part of Bonnie and Clyde capybara team is still on the run after 3 weeks after escaping Toronto zoo.”

2. **Personal glimpses of JWT**.

John Tukey, the Tuke, JWT, Mr. Tukey, JW Cutey, Professor Tukey, Dr. Tukey

Doctoral supervisor 1959-1961

Lorie and I met in Princeton and lived there several years

From the beginning we had a warm relationship with Elizabeth and John

3. JWT

Child prodigy, home-educated

BSc, MSc in Chemistry, Brown 1936, 1937
MA, Ph.D in Mathematics Princeton 1938

“There is this very bright graduate student, and the remarkable thing is that he does it all on milk.” **John von Neumann**

“We have watched at least four Presidents of the United States listen to him and heed his counsel.” **W. O. Baker, Bell Labs President**

“a bouncy beefy extrovert” **John Wheeler**

LSE 61-62

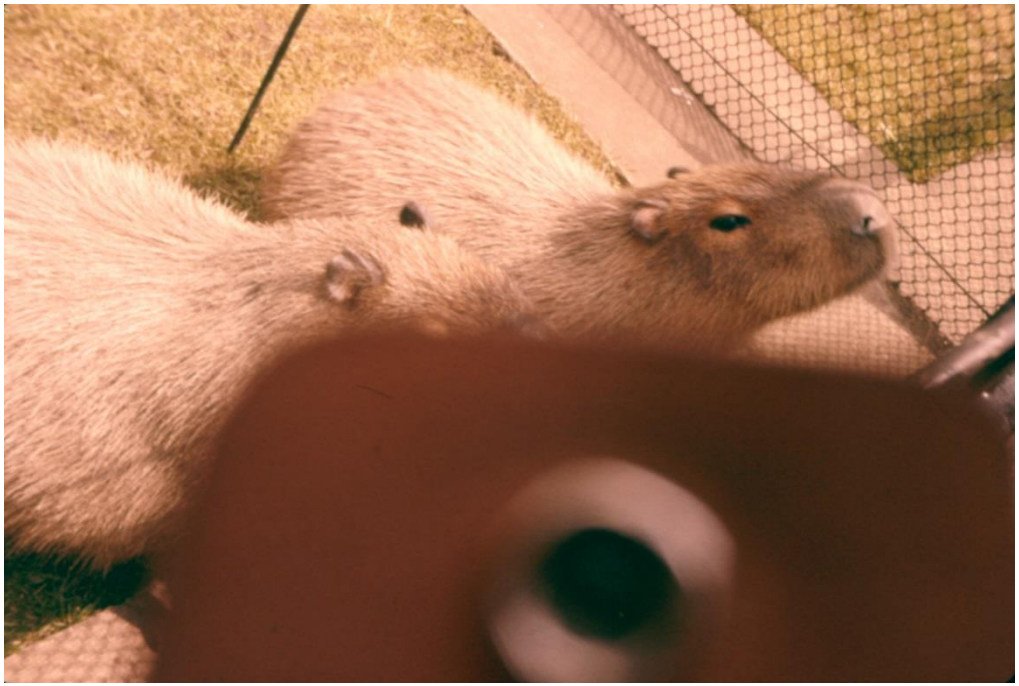


Photo of “furry guys” at Regents Park Zoo

David: “I forget their name”

John: “Capybaras”, then his remarks stopped for 15 minutes.

Elizabeth: “Now John Tukey, don’t you pretend that you haven’t been asleep.”

Pause. John: “Well if Lorie hadn’t made me such a good dinner, I wouldn’t have been.”

“Preliminary highest honors and a distinctive honorary scholarship went to John Tukey of New Bedford, Mass., a sophomore at Brown University. Tutored himself with the aid of his parents” 1935

Husband, uncle, scholar, chemist, mathematician, data scientist, birder, sailor, scientific advisor, committee chair and member, gardener, psephologist

Westport Point house

bridge

Some honours

Samuel S. Wilks Award 1965
National Medal of Science 1973
Shewhart Medal 1976
IEEE Medal of Honor 1982
Deming Medal 1982
James Madison Medal 1984
Foreign Member of Royal Society 1991

"How many honourary degrees do you have?
I think about five" Census testimony

Showed that exploratory data analysis was actively incisive rather than passively descriptive

Put empirical spectrum analysis on firm footing

4. Bell Labs and Princeton.

AT&T Bell Laboratories, Murray Hill

Premier industrial research laboratory until divestiture in 1984

JWT Positions at Labs

Member of Technical Staff (MTS) 1945
Assistant Director of Research, Communications Principles 1958
Associate Executive Director-Research Information Sciences 1961

He could direct, review and absorb research there

Lunches, memoranda, seminars, open doors, sharing, smart people, golf course, data analysis, …

R. Gnanadesikan: “At one party that summer or fall at David’s house, John Tukey, Martin Wilk and I were there together. We were wondering how to bring back the original focus of people like Fisher, Pearson and others into statistics in terms of *data*.

And I remember very well that John Tukey, in his usual fashion, sat silent for a while and then snapped his head up and said `I think what we are talking about is *data analysis*.”

Labs data analysis “team”: Gnanadesikan, Mallows, Pinkham, Wilk, Williams, with JWT hovering

PP and QQ plots, gamma multivariate prob plot (Wilk and Gnanadesikan), “Cp” (Mallows), …

“The hallmark of good science is that it uses models and ‘theory’ but never believes them.”

J. W. Tukey and M. B. Wilk. *Data analysis and statistics: Techniques and approaches*. 1965

“The purpose of computing (EDA) is insight not numbers.” Hamming

C. L. Mallows and J. W. Tukey. *An overview of techniques of data analysis, emphasizing its exploratory aspects*. 1982

Some Labs books

Measurement of Power Spectra R.B.Blackman and J.W. Tukey 1959

Exploratory Data Analysis Limited Preliminary Edition J. W. Tukey 70

Methods for Statistical Data Analysis of Multivariate Observations R. Gnanadesikan 1977

Performance Indices for Multivariate Ice Hockey Statistics W. H. Williams, CUNY Hunter College D. A. Williams, St Louis Blues 1998

Experimental Design, Data, and Analysis C. Daniels, C.M. Mallows 1987

On the Distribution of First Significant Digits R. Pinkham

Time Series: Data Analysis and Theory, D. R. Brillinger 1966

5. JWT service

Education, government, industrial, public

World War II, Fire Control Research Office Princeton Branch, Frankfort Arsenal Fire Control Design Division

Military systems analysis, Princeton's James Forrestal Campus

US Delegation, Conference on Discontinuance of Nuclear Weapons Tests, Geneva 1959 Elizabeth "John had pulled some rabbit out of the hat that made it clear that nuclear underground testing could take place and not be noticeable up on the surface. "

Member US Delegation, UN Conference on the *Human Environment*, Stockholm 1972

Craftsmanship, Comfort, and Elegance: The Architecture of Rolf W. Bauhan, 1920-1966 Historical Society of Princeton

Some reports PSAC panel *Restoring the Quality of Our Environment*

President's Air Quality Board, report *Cleaner Air for the Nation*

Member U.S. Delegation to the *U.N. Conference on the Human Environme*nt, Stockholm 1972 Chair PSAC's Panel on *Chemicals and Health*. Report. 2,5,4-T

NAS, *Halocarbons*: *Environmental Effects of Fluoromethane*

Chair *Review of the results of attempts at weather modification*

Chair NRC/NAS Committee on *The Impacts of Stratospheric Change*

Oversight Review Board, *National Acid Precipitation Assessment*

Advisor Health Effects Institute *effects of auto air pollution*

Chair PSACommittee's *Environmental Pollution Panel* 1964-65

*Chemicals and Health Pane*l 1971-73

Member *President's Air Quality Advisory Board*

President Johnson's *Task Force on Environmental Pollution*

President Nixon's *Task Force on Air Pollution*

National Advisory *Committee on Oceans and Atmosphere*

Halocarbons: Environmental Effect of Chlorofluoromethane Release

Protection Against Depletion of Stratospheric Ozone by Chlorofluoromethane Carbons

Stratospheric Ozone Depletion by Halocarbons: Chemistry and Transport

Chair, Technical Advisory Committee, National Assessment of Educational Progress, Education Commission of the States

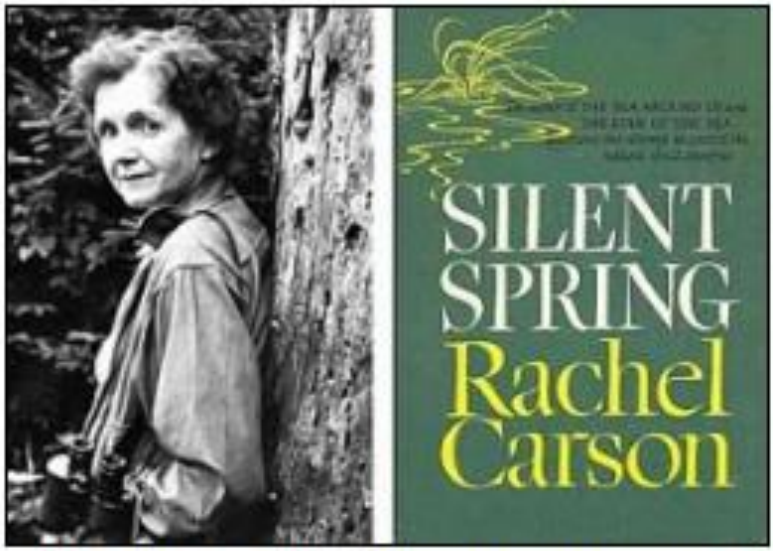
Member, Design and Analysis Committee, Educational Testing Service

Member, Board of Fellows Brown University 1974-1988
Chair, Corporation's Coommittee on Computers in Education.

“It is my guess that statisticians Frederick Mosteller (Harvard) and John Tukey (Princeton) have served on or assisted more technical committees than anyone else alive.” W. W. Lowrance

Health and the environment

JWT: “The PSAC report mention of the Carson book had the entrenched interests `weeping’ in their beer”



Rachel Carson shown here in a 1950s photograph alongside the cover of her landmark 1962 book, “Silent Spring.”

Radical proposals:

Polluters required to pay proportional to damage inflicted e.g. VW

No one has a right to pollute

Some reports

RESTORING THE QUALITY
OF
OUR ENVIRONMENT

Report of The
Environmental Pollution Panel
President's Science Advisory Committee

THE WHITE HOUSE
NOVEMBER 1965

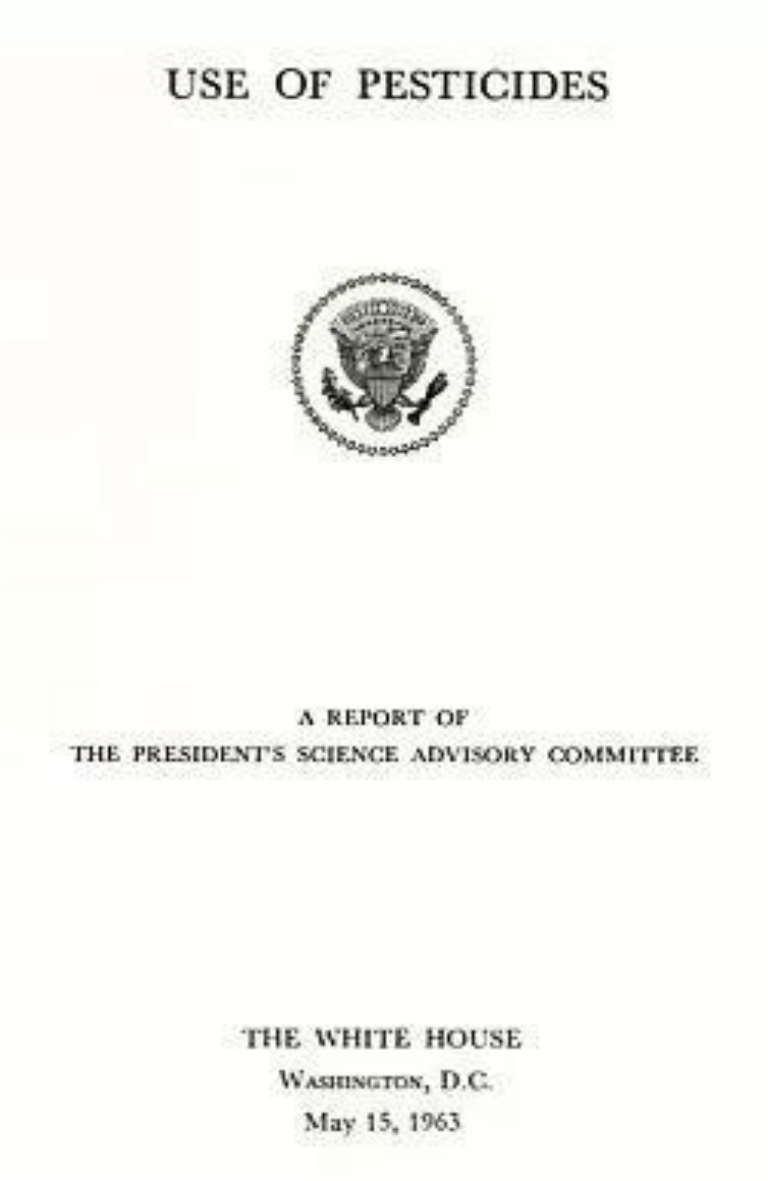
ENVIRONMENTAL POLLUTION PANEL

JOHN W. TUKEY, *Chairman*, Professor of Mathematics, Princeton University, and Associate Executive Director, Research—Communications Sciences Division, Bell Telephone Laboratories

"Through his worldwide industrial civilization , Man is unwittingly conducting a vasr geophysical experiment … The climatic changes that may be increased by the CO-2 content could be deleterious from the point of view of human beings."

Could be "marked changes in climate, not controllable through local or even national efforts."

Gave greater attention to other pollution problems judged to have greater urgency



Use of Pesticides Report on the herbicide

policy judgments about a pesticidal

agencies charged with responsibilities for regulating pesticides and for overseeing integrity of public's health

regulatory action in 1969 restricted some uses of 2,4, 5-T.

recommendation for legislative mechanism to restrict temporarily use of a pesticide on occasion of an unexpected research finding implicating it as health hazard

Chair *Cleaner Air For the Nation* Presidents Task Force on Air Polution, 1970

United States Clean Air Act of 1970 raised unprecidented implementation challenges for governments and affected industries.

EPA extablished health-related quality standards and directed states to implement control panels subject to federal certification.

Chaired Chemicals and Health: Report of PSAC 1973

Studied effects of fluorocarbons on stratosphere, increasing ultraviolet radiation on the earth and consequenteffects on life

More and better information is needed to help man cope with the growing number of chemicals introduced into his environment.

Improved regulatory procedures and greater public understanding and support were required to deal with problems of chemicals and public health.

The biggest chemical threats to health were those an individual brings on himself, such as cigarette smoking and alcohol abuse

****

Oversight Review Board of the National Acid Precipitation Assessment Program (M. Russell, K. Arrow, J. Bailar, J. Gordon, G. Hilst, **S. Levin**, T. Malone, W. Nierenberg, C. Starr, and J. Tukey). 1991. The Experience and Legacy of NAPAP. Report to the Joint Chairs Council of the Interagency Task Force on Acidic Deposition. NAPAP, Washington, DC.

(with others). The experience and legacy of NAPAP (Report of the Oversight Review Board of the National Acid Precipitation Assessment Program), U.S. Government Printing Office, Washington, D.C., 40 pages.

A. Sivak and J. W. Tukey. Comments on predicting EPA's forthcoming CO standards in light of new clinical evidence, *Risk Analysis* **11**, 575-576.

Many papers quote the Mosteller andTukey and Mosteller and Hoaglin, Mosteller and Tukey books

J.W. Tukey, chairman, Response to Ozone Protection, Sections of the Clean Air Amendment 1977: An Interim Report, 1–61, Committee on Impacts of Stratospheric Change, National Academy of Science, Washington, DC, 1977.

1977e (with others). *Response to Ozone Protection, Sections of the Clean Air Amendments 1977. An Interim Report*. 1-61. Committee on Impacts of Stratospheric Change, National Academy of Sciences, Washington, DC.

1977f Statistical considerations important in analyzing measured changes in water-wall tube thickness. *Proceedings of the Second Stationary Source Combustion Symposium* V, Addendum. 79-92. U.S. Environmental Protection Agency, National Technical Information Service, Springfield, VA.

[9]A useful study of ozone politics is by Sharon Roan, *Ozone Crisis* (New York: John Wiley & Sons, nc., 1989). National Research Council, *Response to Ozone Protection*.

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J.W. Tukey, chairman, Halocarbons: Environmental Effects of Fluoromethane Release, Committee on Impacts of Stratospheric Change, National Academy of Science, Washington, DC, 1976.

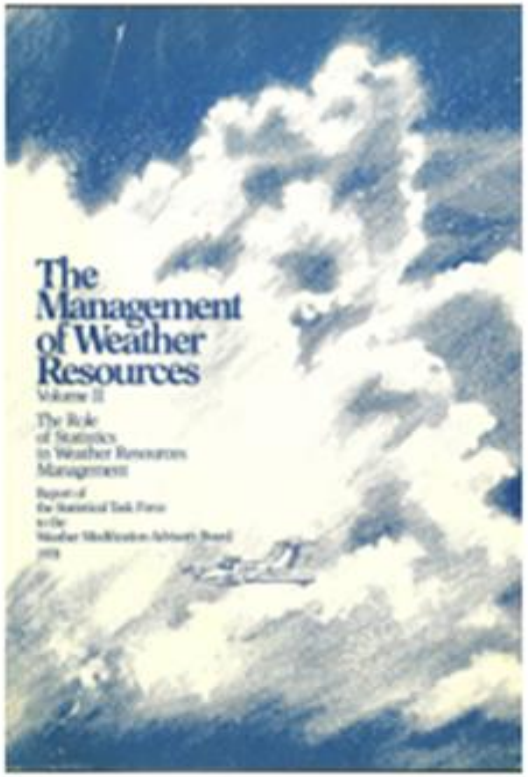
Halocarbons: Environmental Effects of Fluoromethane Release

These very strong greenhouse gases have ability to destroy stratospheric ozone

Sources include refrigerants and propellants.

CFC-12 almost stopped, but long lived gas and responsible for some global warming and ozone hole.

Weather



A. Selected issues
B. Evaluations of recent projects
C. The "State of the science"
D. The future
E. Issues of design
F. Fundamentals of confirmation
G. Issues of analysis
H. Support for the evalutaions of sections 11 and 28
I. Appended material

"We admit there are occasions when randomization is not feasible, but we assert confidently (a) that this happens here less frequently than is generally believed and (b) that such exceptions do not arise in experimental weather modification." (1978)

"a properly sceptical audience"

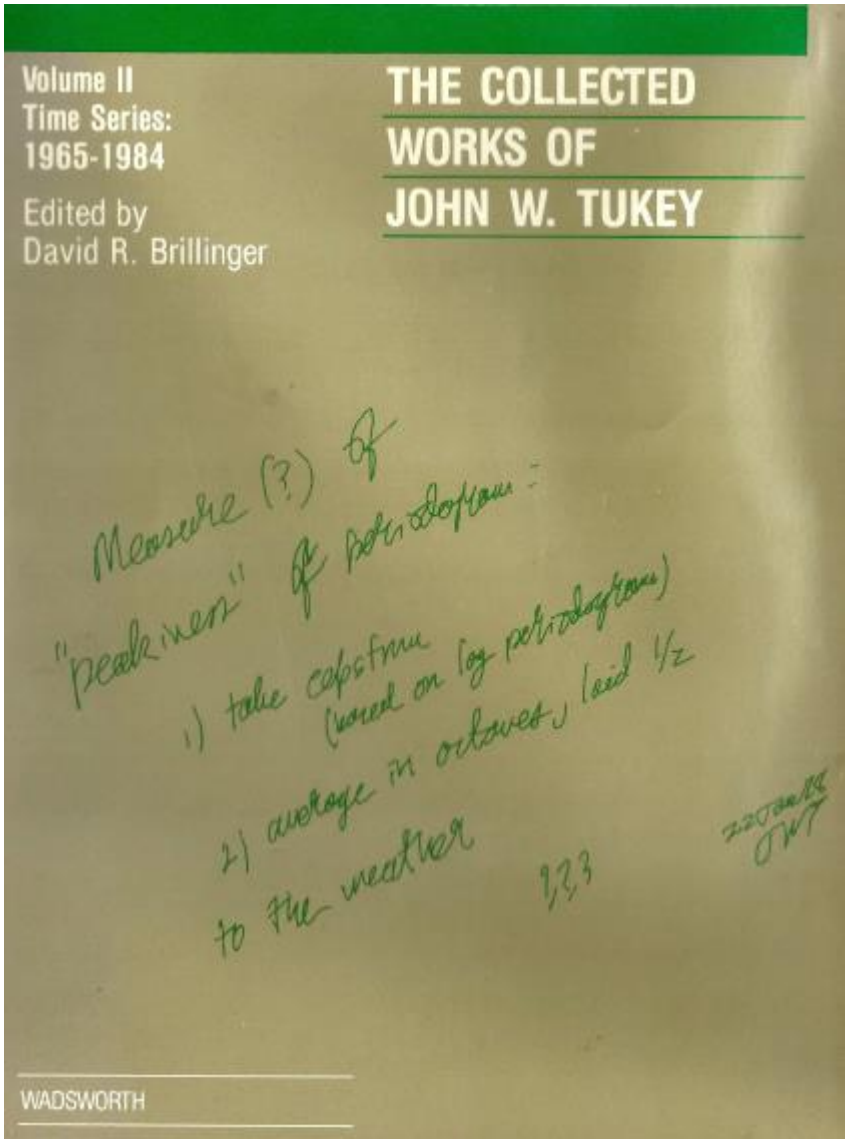
Brillinger, Jones, Tukey (1978)

"I believe that the whole country (USA) – scientificlly, industrially, financially – is better off because of him and bears evidence of his influence"

John Wheeler

[Whole world?]

6. **A JWT question**



"Measure (?) of 'peakiness of periodogram:
1) take cepstrum (based on log periodogram)
2) average in octaves, laid ½ to the weather
22 June 78 JWT"

Periodogram

$|\mathcal{F}[\mathbf{x}]|^2$ **x** a segment of a process

Cepstrum

$\mathcal{F}^{-1}[\log |\mathcal{F}[\mathbf{x}]|]$

$\mathcal{F}^{-1}[\log |\mathcal{F}[a*x]|]$
$= \mathcal{F}^{-1}[\log |A|] + \mathcal{F}^{-1}[\log |X|]$

Cepstrum: “from now on you will be known as J. W. Cutie”
R. Hamming

Where was JWT going? Vocoder? Pitch detection? Automatic speech recognition? Measure?

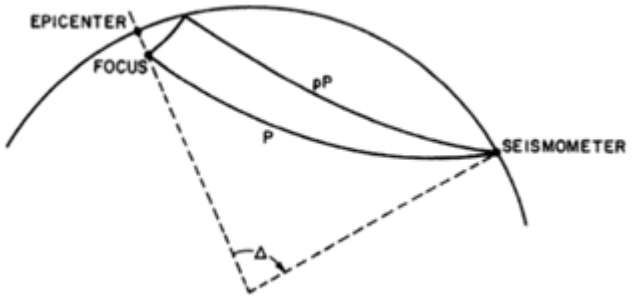
Clue from M. Vallentin (EECS): Speech researchers define *formants* as “spectral peaks of speech sound spectrum”

formants ~ peaks

Cepstrum proposed to distinguish underground nuclear explosions from earthquakes

A signal arrives followed by delayed variant, perhaps different path,

$$z(t) = y(t) + \alpha\, y(t-\tau)$$



Cepstrum, “saphe cracking” also useful for extracting the fundamental speech frequency, *pitch*

Separates long time intervals between puffs, of vocal cords, from short-delay and resonance effects

7. Speech science.

Massive industral enterprise, basic to contemporary life

"The speech analytics market size is estimated to grow from *USD 589.1 Million in 2015 to USD 1.60 Billion by 2020*, at an estimated Compound Annual Growth Rate of 22.0% from 2015 to 2020."

marketsandmarkets.com

Speaker recognition components:

- identification
- verification
- classification
- discrimination
- synthesis
- enhancement

Statistical contributions to speech science

Statistical Techniques for Talker Identification P. D. Bricker, R. Gnanadesikan, M. V. Mathews, S. Pruzansky, P. A. Tukey, K. W. Wachter, J. L. Warner. *Bell System Technical Journal* 1971

Problem of identifying persons acoustical utterances.

"Emphasis on statistical facets of talker identification rather than acoustic significance."

Measure of peakiness, x here cepstrum[log periodogram]

corpus/dictionary C = {y}
"talker" identified as y in C closest to x

Cepstral distances: Euclidean $\|y-x\|$, $\|y-x\|_W$, $\|y-x\|_{I/w}$

“Gratifying identification successes with … unsophisticated representations of data ,*spectrograms*.

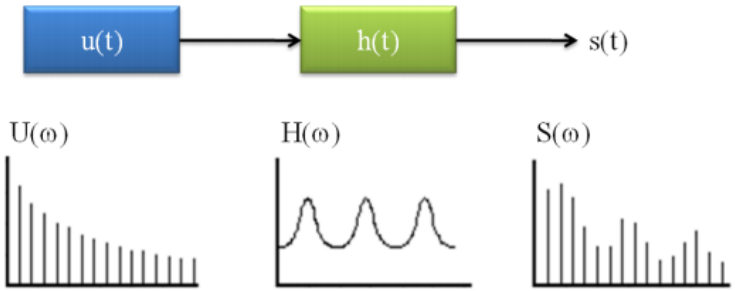
“Investigation … empirical and focused on statistical techniques and strategies … two sizeable bodies of data.”

“With no general theory … available … in designing a process for talker identification work relied heavily on the analysis of data … to generate ideas and techniques … but also to assess … performance ….”

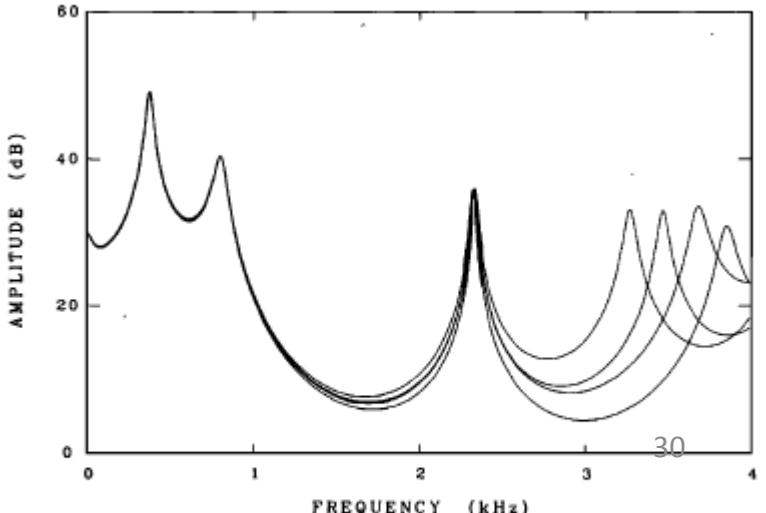
"*Inversion of articulatory-to-acoustic transformation in the vocal tract by a computer-sorting technique*". BS Atal, JJ Chang, MV Mathews, JW Tukey *Bell System Technical Journal* (1978)

Studys relationship between shape of vocal tract and acoustic signal

Speech sounds result from acoustic excitation of the human vocal tract.



Estimated vocal tract output spectra
Peaks identify *formants* and *vice versa*



6. JWT puzzle

"Measure (?) of 'peakiness of periodogram:
1) take cepstrum (based on log periodogram)
2) average in octaves, laid ½ to the weather

22 June 78 JWT

Periodogram is

$|FT[x]|^2$ mean removed, tapered

Averaging in "octaves laid ½ to the weather"

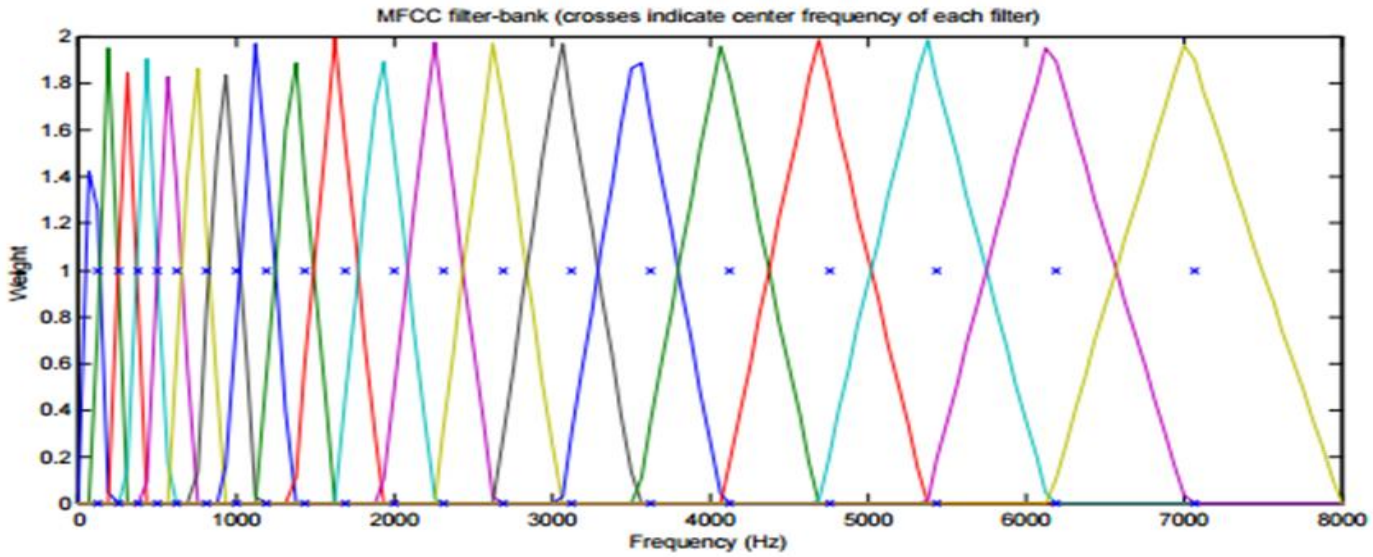
Shingled octave supports

N to N/2, 3N/2 to 3N/4, N/2 to N/4, 3N/4 to N/8, …

Speech researchers developed *mel* filters, centered at

$$\frac{1000 \log (1 + f/1000)}{\log 2}$$

Mel filter bank looks like

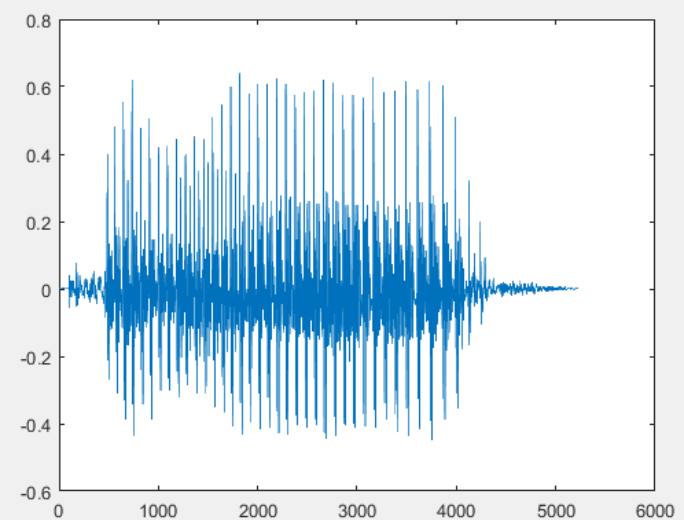


$$m = \frac{1000 \log (1 + f/1000)}{\log 2}$$

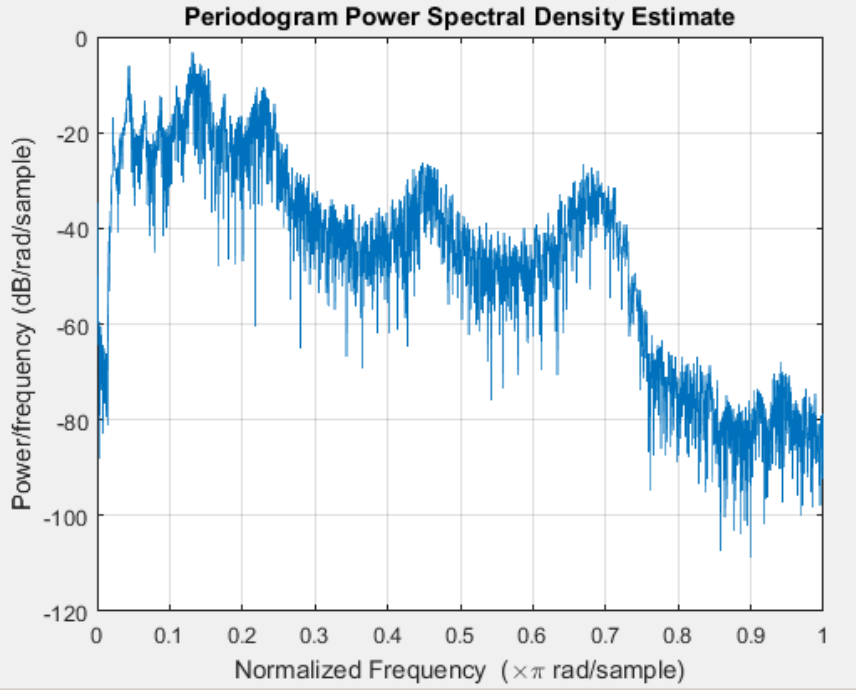
cp. octaves

Weighting based on model of human pitch perception

/ah/

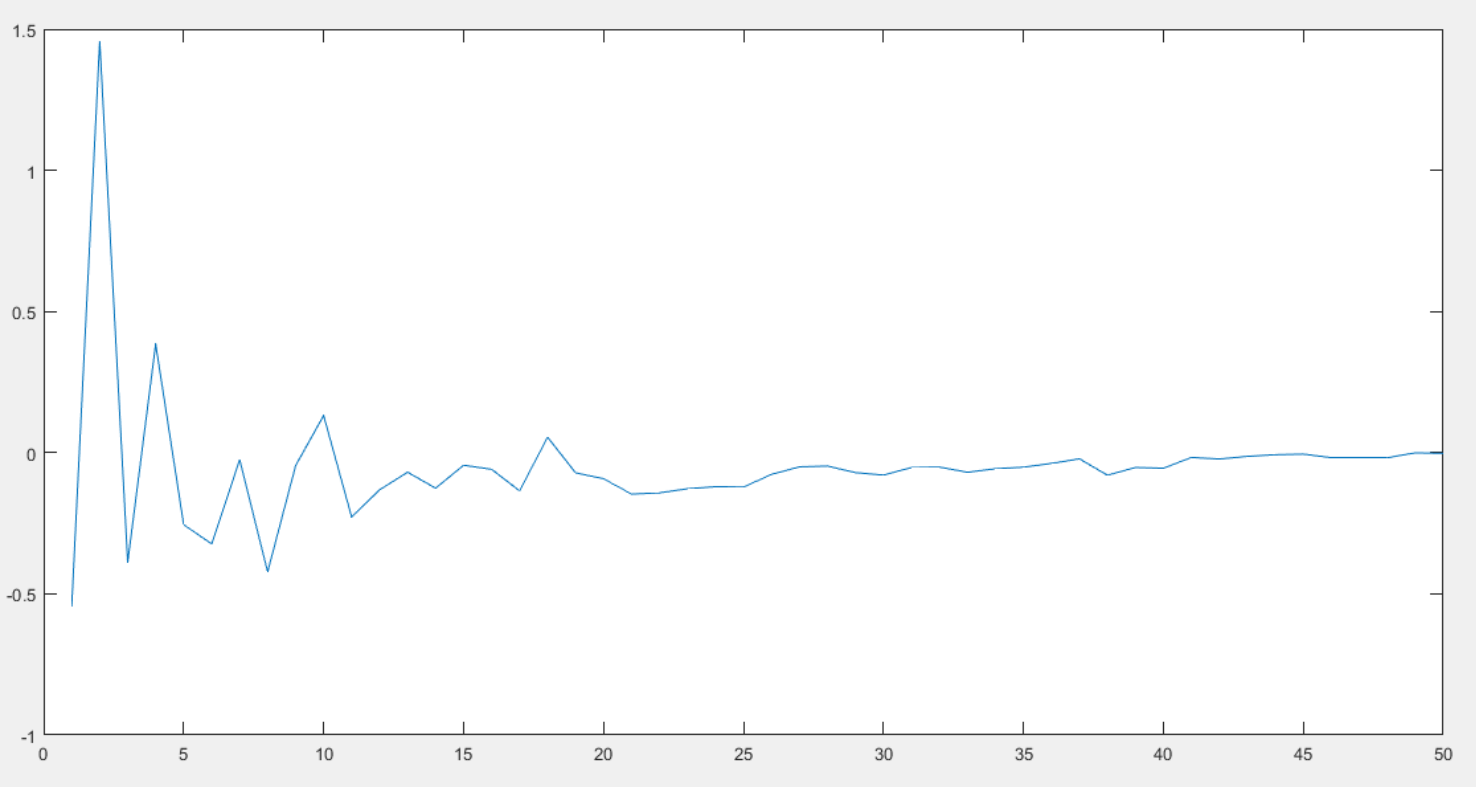


data



periodogram

Cepstrum



Saphe cracking

Personal experiences with JWT

Conversations, thesis guidance, challenges, patent person, collaborating, encouragement, problems, MTS, car rides, prunes

vocoder
pitch detection
cloudseeding
election projection (NBC-RCA)
education assessment (NAEP)
professional time series course (Bloomfield, Cleveland)
reports and papers

Took me along: Union Carbide, NBC, NAEP, cloud seeding, …

Meetings: Atlanta. Berkeley, Boston, Cape Cod, Cherry Hill, Halifax, NCAR, London, Palo Alto, Los Angeles, Madison,

10. "Sunset Salvo" (1985) Labs retirement

"Research can and will go on"

"The data may not contain the answers"

"Move from 'all assumptions are right' to 'all assumptions are wrong' "

"face up to:
1. lack of independence
2. granularity
3. lack of symmetry"

Capybara captured: rodent's brief taste of freedom comes to an end

The capture brought an end to the saga of the missing 'Bonnie and Clyde' capybaras, who bolted after their first day in captivity at a small zoo in Toronto

New Bedford High School Commencement Address – June 16,1974

"New Bedford High was my High School, both personally and through my parents."

"My own experience …. Scientific advisor … committee member and chairman … in the areas of polution and chemicals."

Balanced Judgement, how I see what is ahead

Discussion and summary.

Characteristics of data – short deterministic signals, small sample

What was N Morgan's comment? Best for …

He had an impact, particularly on dealing with environmental problems

His teaching.
Hartigan: "No one ever left class early"

His students had a 5-10 or more years advantage

I was lucky. Bell Labs was the best job I ever had

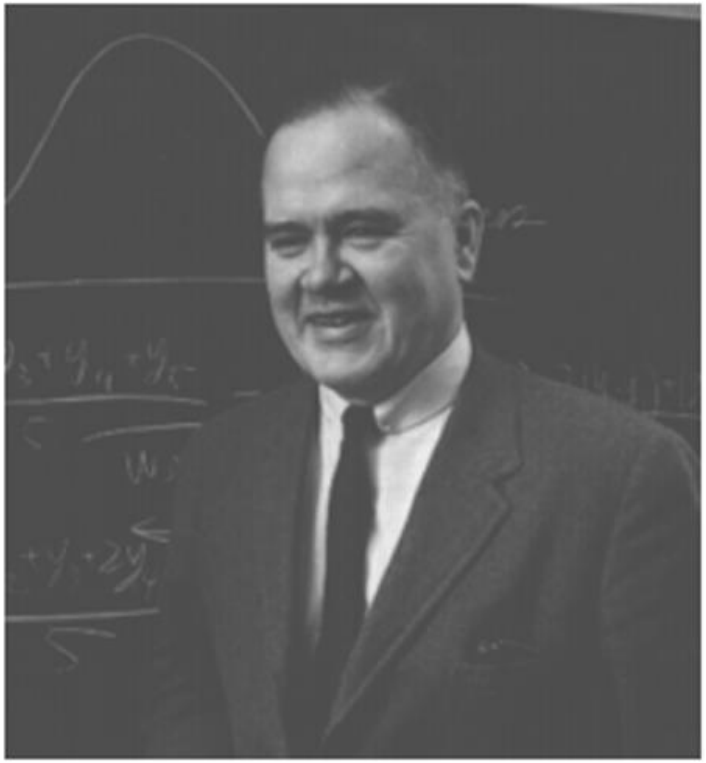
Sections

1. Toronto, Canada
2. Personal glimpses
3. JWT
4. Bell Labs and Princeton
5. JWT's Service
6. A JWT question
7. Speech science
9. Some results
10. Sunset Salvo
11. Discussion and summary
12. Acknowledgements

(8. A spreading fire)

Acknowledgements.

A. G. Adami, F. R. Anscombe, D. Hoaglin, K. Kafadar, M. Valenntin? , N. Morgan, undo command, R. Romero



“The stronger the qualitative understanding the data analyst can get of the subject-matter field from which his data comes, the better – just so long as he does not take it too seriously” Mallows and Tukey (1982)

8. A spreading fire.

"EDA of heat spread in a fuel bed"

Questions

Pulsing?

Turbulent? Buoyancy?

Turbulence in speech .

Occurs in rapid air flow at a constriction

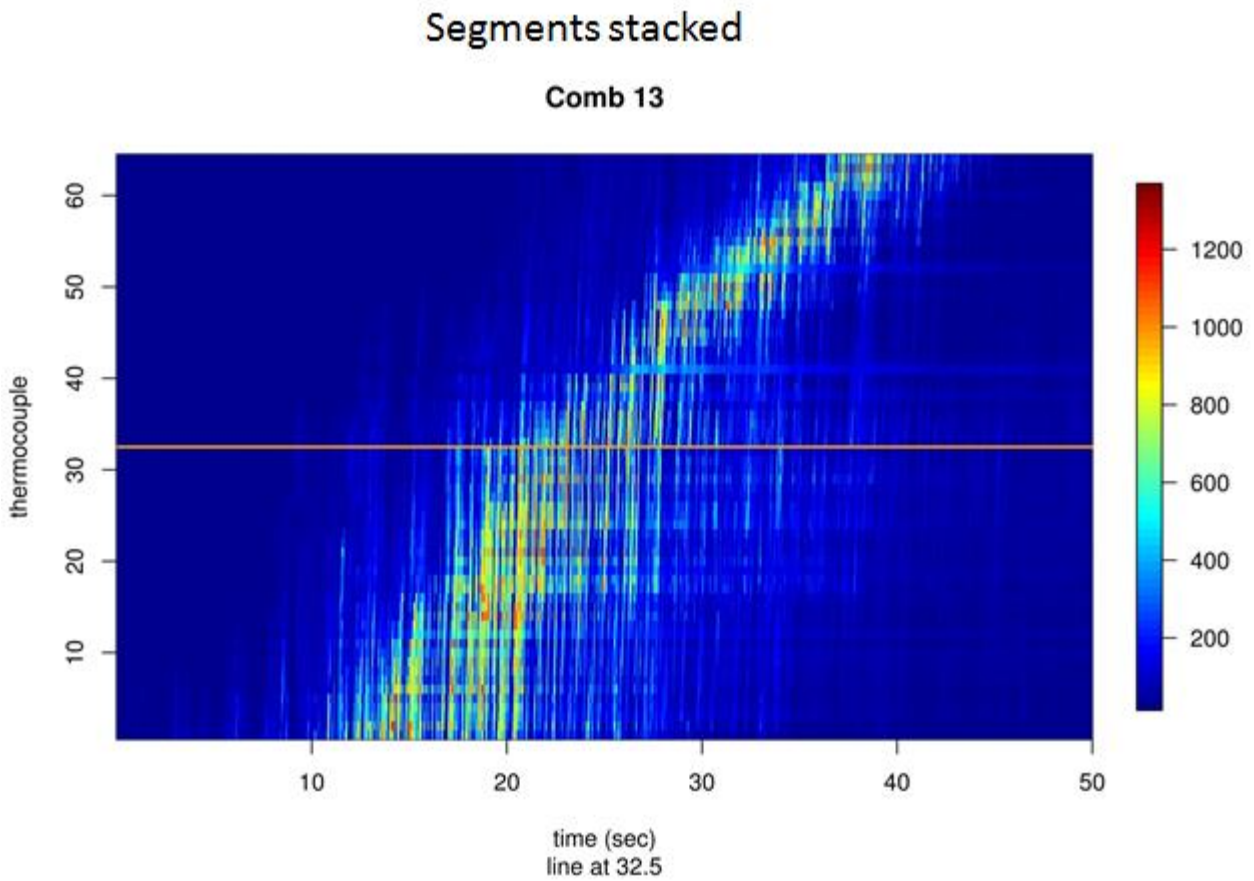
Consists of fluctuations in the velocity of the air flow.

These give rise to source of sound pressure in vocal tract at point where turbulence occurs..

Turbulence noise can be produced at a constriction at the glottis, or at a constriction made with the tongue or lips above the glotti

Some EDA of temperature fluctuations in a spreading fire

Work with M. Finney



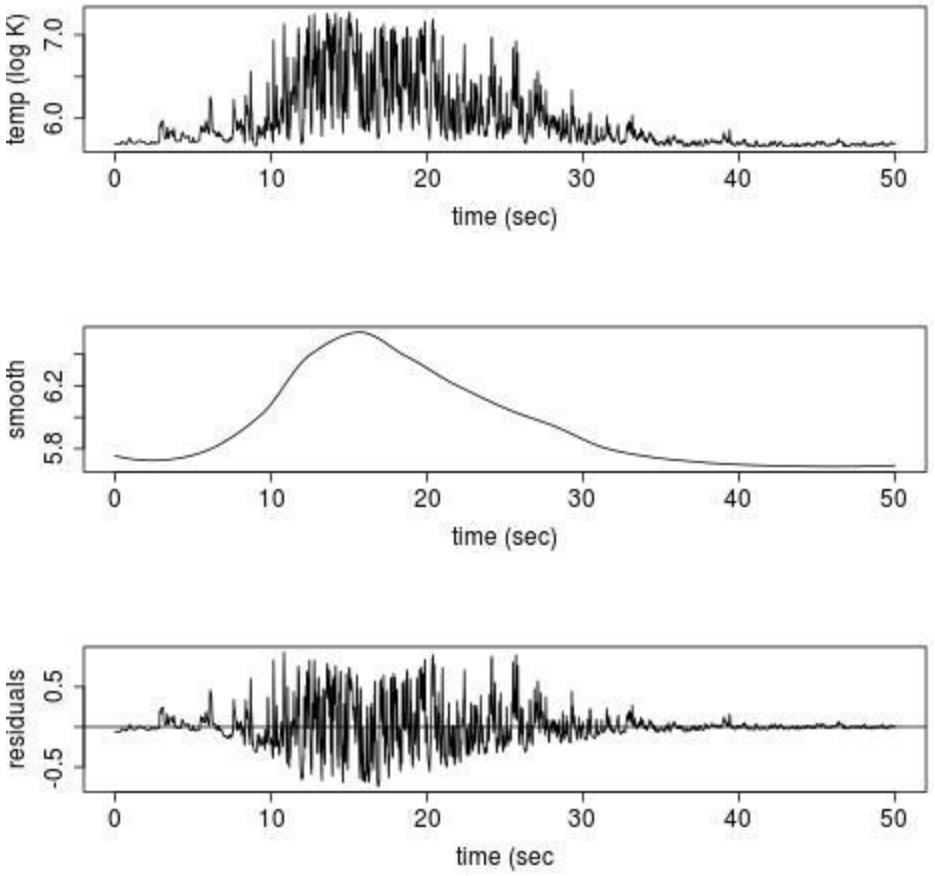
Velocity estomate

The stacked inage suggests change around comb 33
In fact thermocouple spacing doubled there

Estimating velocity

Wave equation, projection pursuit

Can proceed because know locationsof thermocouples

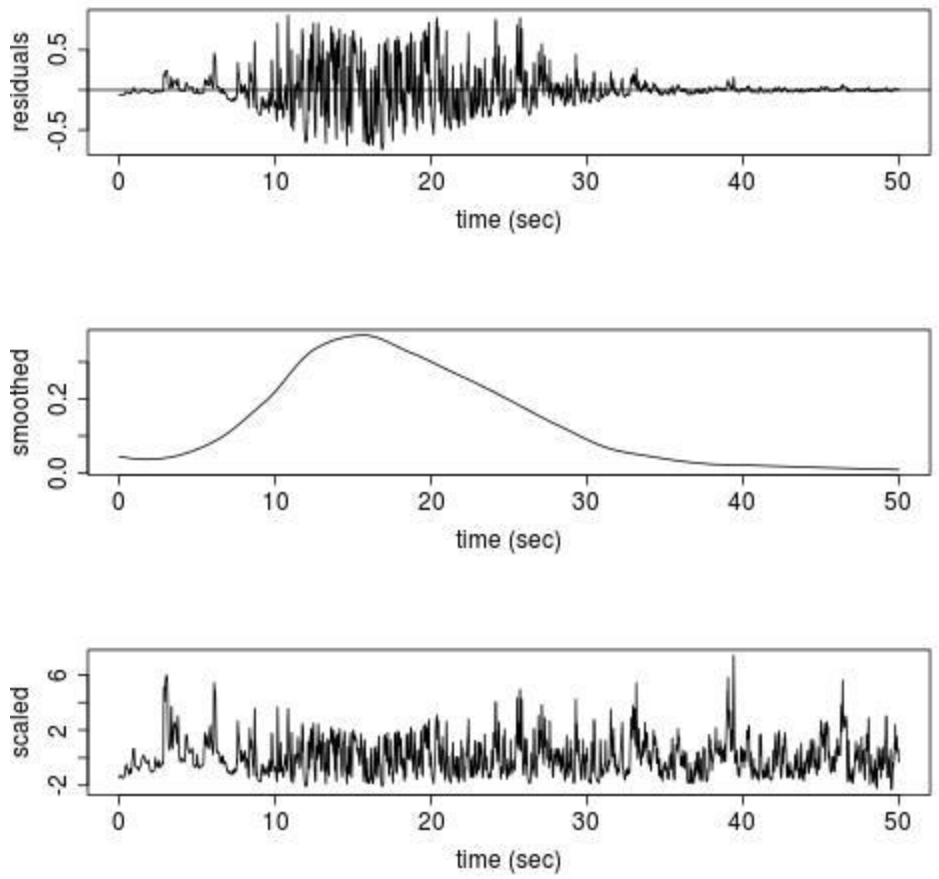


Signal

Smooth

residual

Signal generated noise



Prewhitened]

9. Results

Did not find regular pulsing

“The typical statistician has found from bitter experience that negative results are just as important as positive ones, sometimes more so.” JWT 1967

I asked Vern to nudge Morgan about peakiness, here's what Morgan had to say:

> I would guess that if anyone is working on that, it would be in the speech enhancement field, which I'm not up on. Or possible in speaker recognition, where measures in that category might help to identify a person. Ordinarily variations in peakiness of the spectrum are essentially "noise" to someone who mostly cares about what words were said (speech recognition).
>
> In speech recognition, the current dominant paradigm (which I'm not a fan of) is to use some simple spectral measure (possibly designed to have a little bit of the characteristics of hearing, primarily to have coarser resolution at high frequencies) and then let the deep learning (in deep neural nets) figure out everything else. I like using these nets but I'd prefer to do a bit more processing first, but I'm in the minority.