An analysis of Seashore's musical performance measurements

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Introduction

Why study musical performance?

- **Performances convey musicians' interpretations**
- **Performances are what listeners actually hear**
- **Studying performance can help us gain insight into**
  - how an individual's performance practice evolves as they gain more experience
  - how performance practices evolve over time
- **Observing how performance practices relate to musical materials can help us develop models of "expressive" performance**

A Brief History

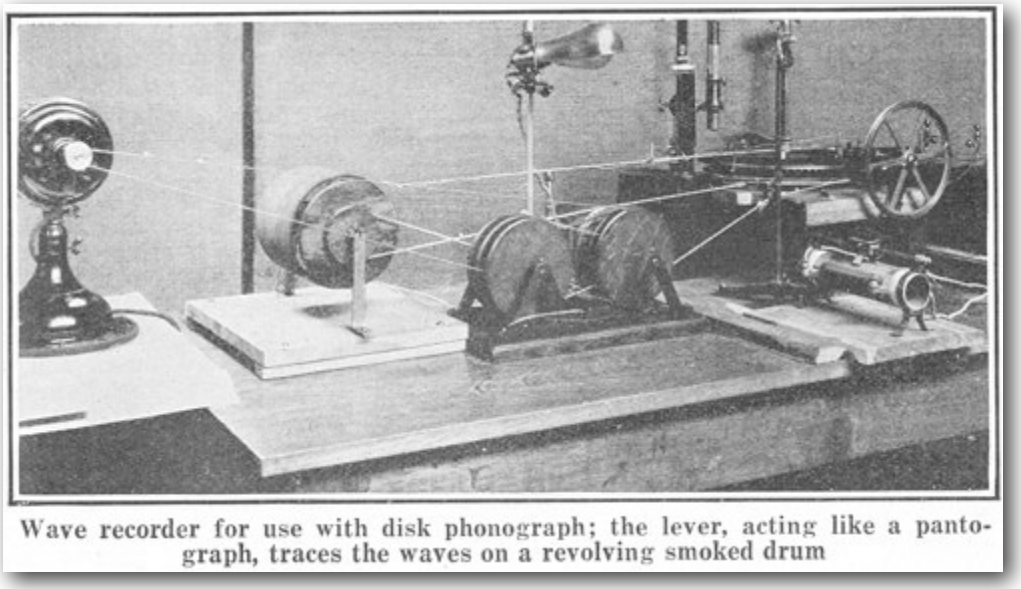
Performance Studies at the University of Iowa

- **Carl Seashore began by studying musical talent (1919)**
- **In the 1920s, Seashore's lab began quantitative research into music performance, e.g., Schoen's work on vocal intonation and vibrato (1922)**
- **By the 1930s, Seashore's lab had a large number of researchers working on music performance, including: Metfessel, H. Seashore, Small, Tiffin, Vernon, and Williams (Seashore 1938)**

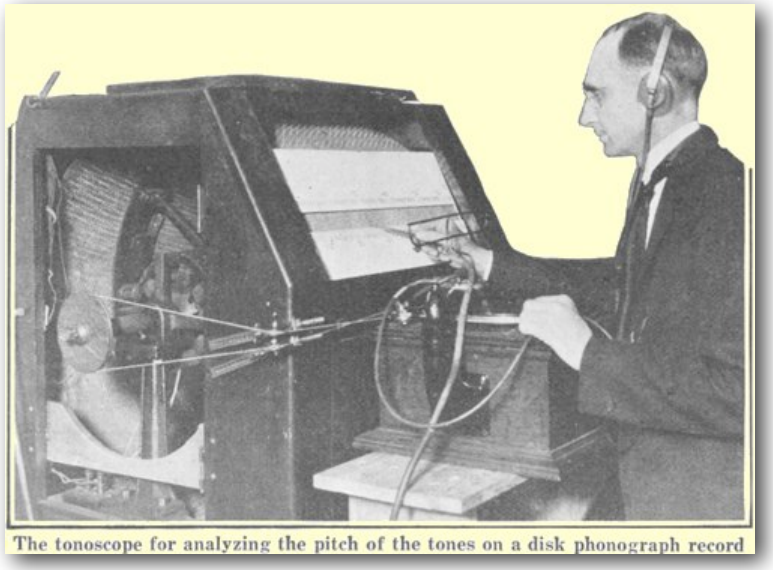
A Brief History

Performance Studies at the University of Iowa

- **Seashore's lab studied timing, dynamics, intonation, and vibrato in pianists, violinists, and singers**
  - Equipment: piano rolls, films of the movement of piano hammers during performance, and phono-photographic apparati



Wave recorder for use with disk phonograph; the lever, acting like a pantograph, traces the waves on a revolving smoked drum

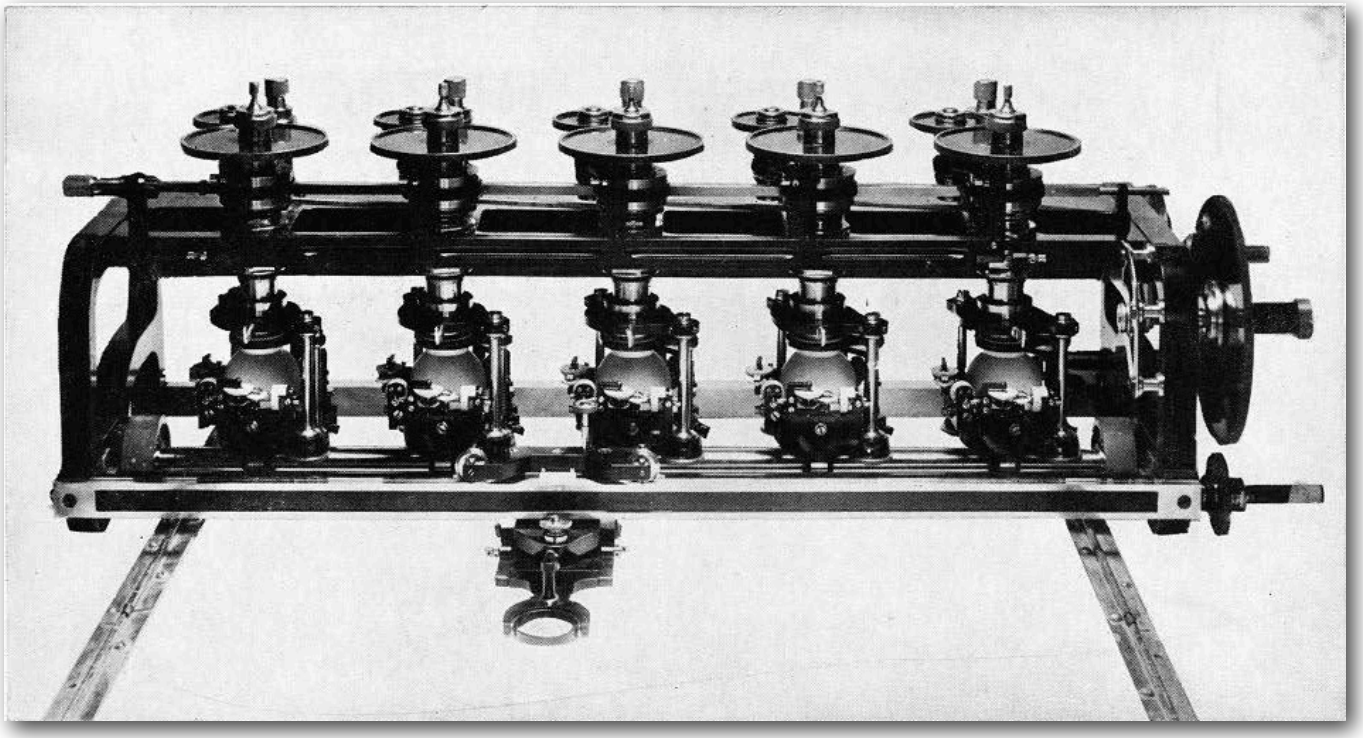


The tonoscope for analyzing the pitch of the tones on a disk phonograph record

Cary (1922)

A Brief History

Phonophotography technique



Henrici Harmonic Analyzer

Seashore (1937)

- **Frequency graphed in 10 cent units**
- **Intensity graphed in decibels**
- **Timing information as a function of linear space**

Introduction 1
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Performance scores 2
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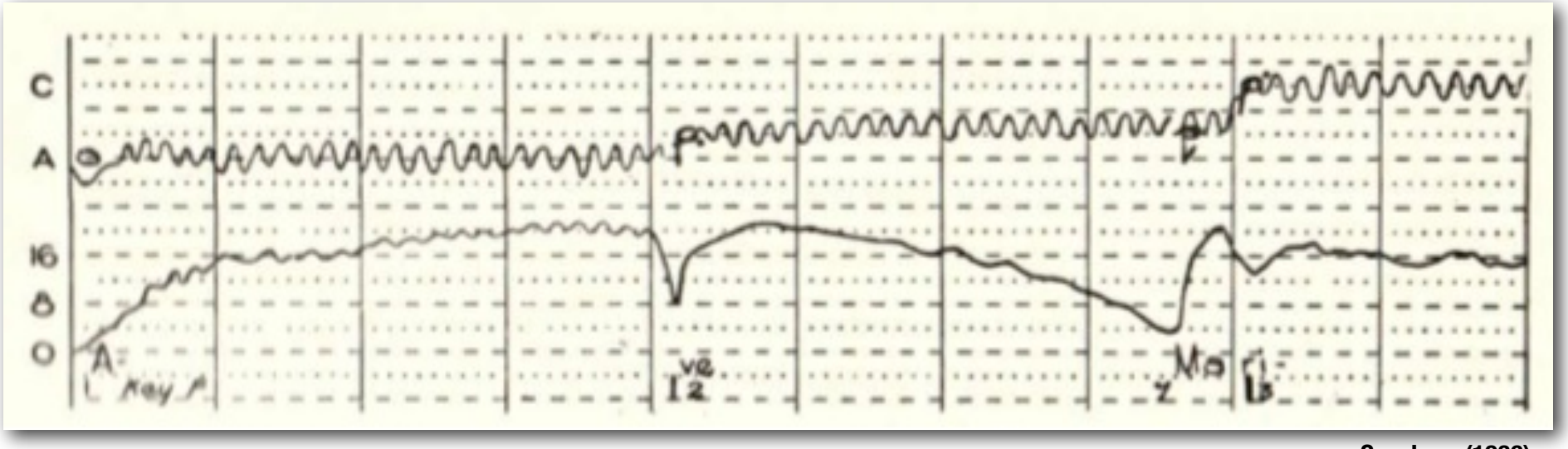
Performance Scores

University of Iowa



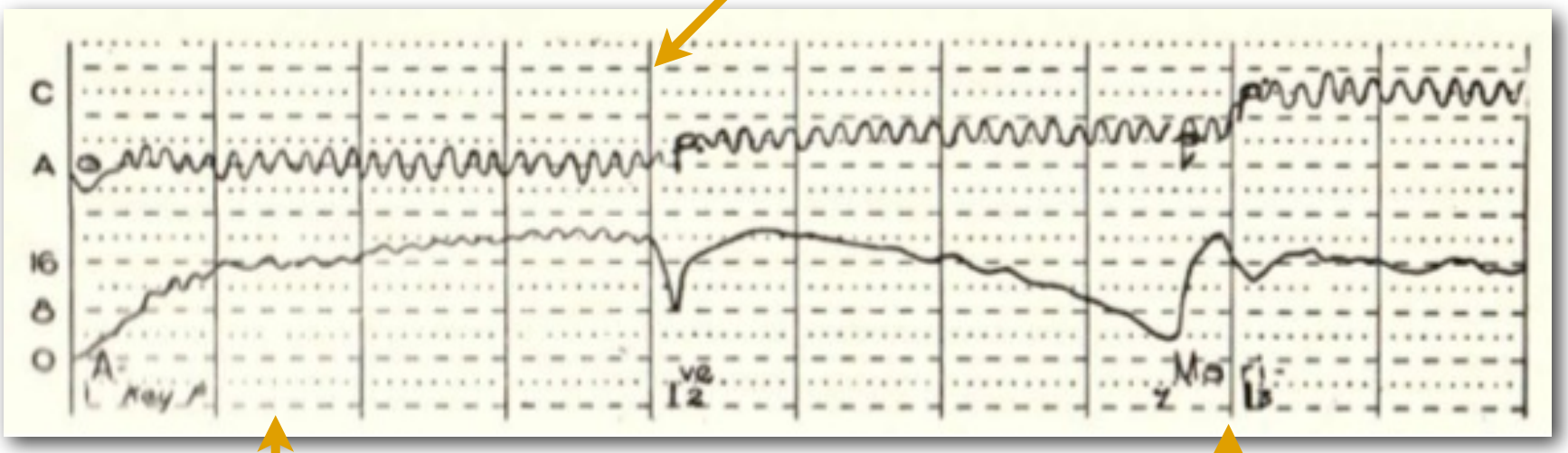
Seashore (1936)

“there is rich raw material to work upon in the performance scores”
Seashore (1938, 129)

Performance Scores

University of Iowa

Each vertical space represents one semitone and a specified number of db



Seashore (1936)

Frequency/Loudness

Time

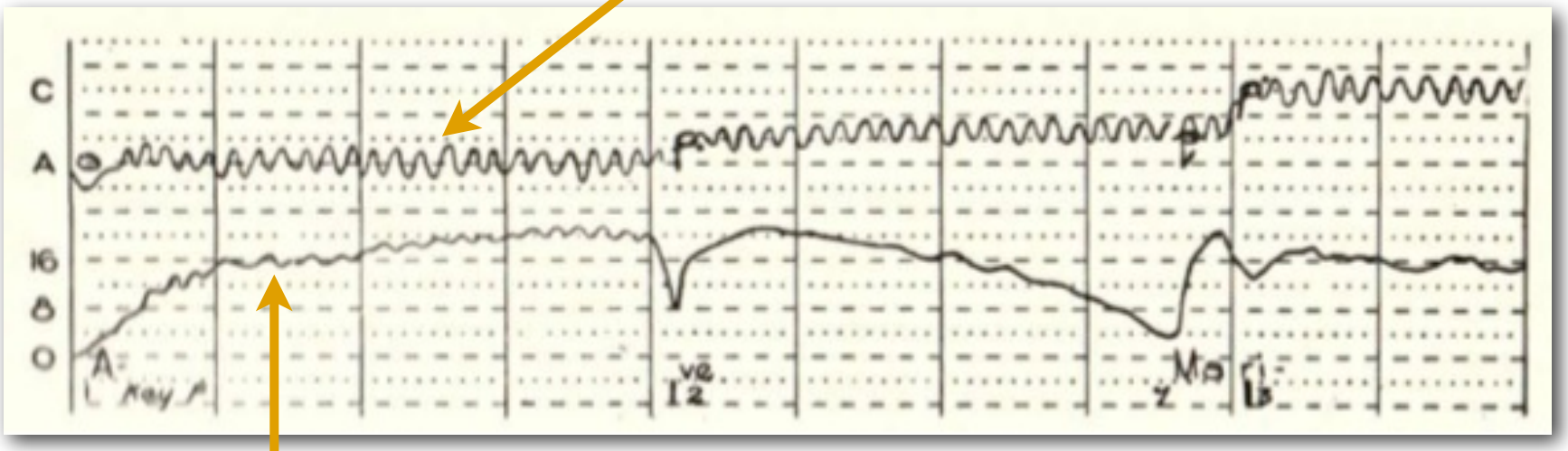
Dots/Dashes represent 0.1 sec

Solid lines represent 1 sec

Performance Scores

University of Iowa

Frequency curve



Seashore (1936)

Frequency/Loudness

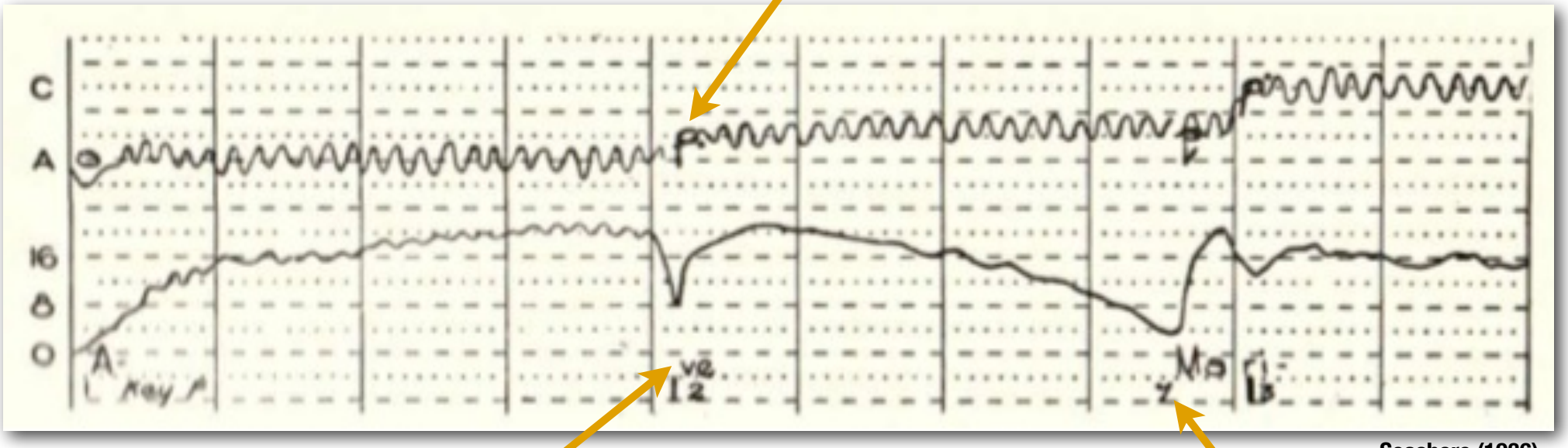
Time

Loudness curve

Performance Scores

University of Iowa

Notes from the musical score are marked roughly at the time where they occur



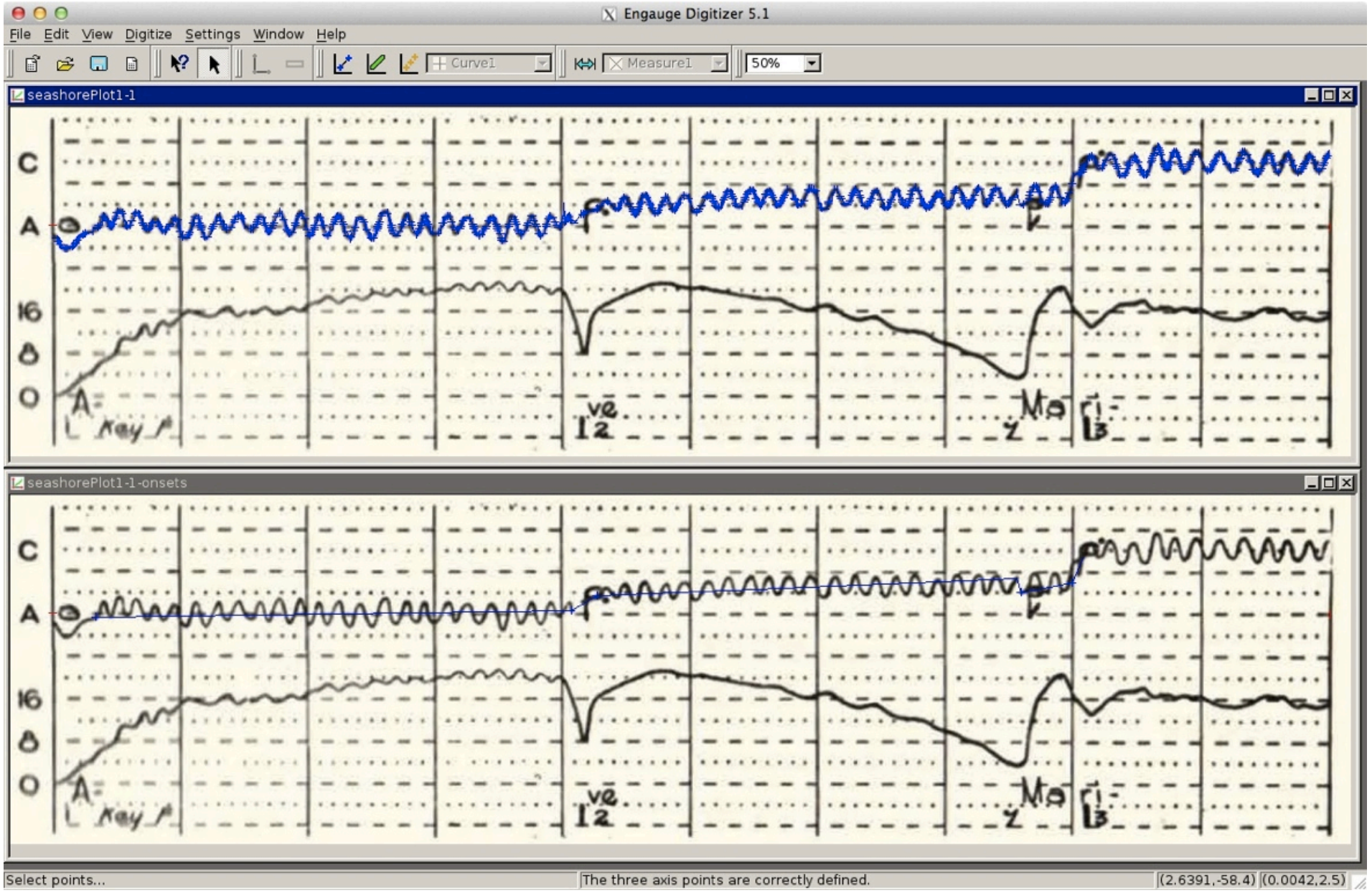
Seashore (1936)

Lyrics are annotated in line with the notes from the score

Rests from the musical score are marked roughly at the time where they occur

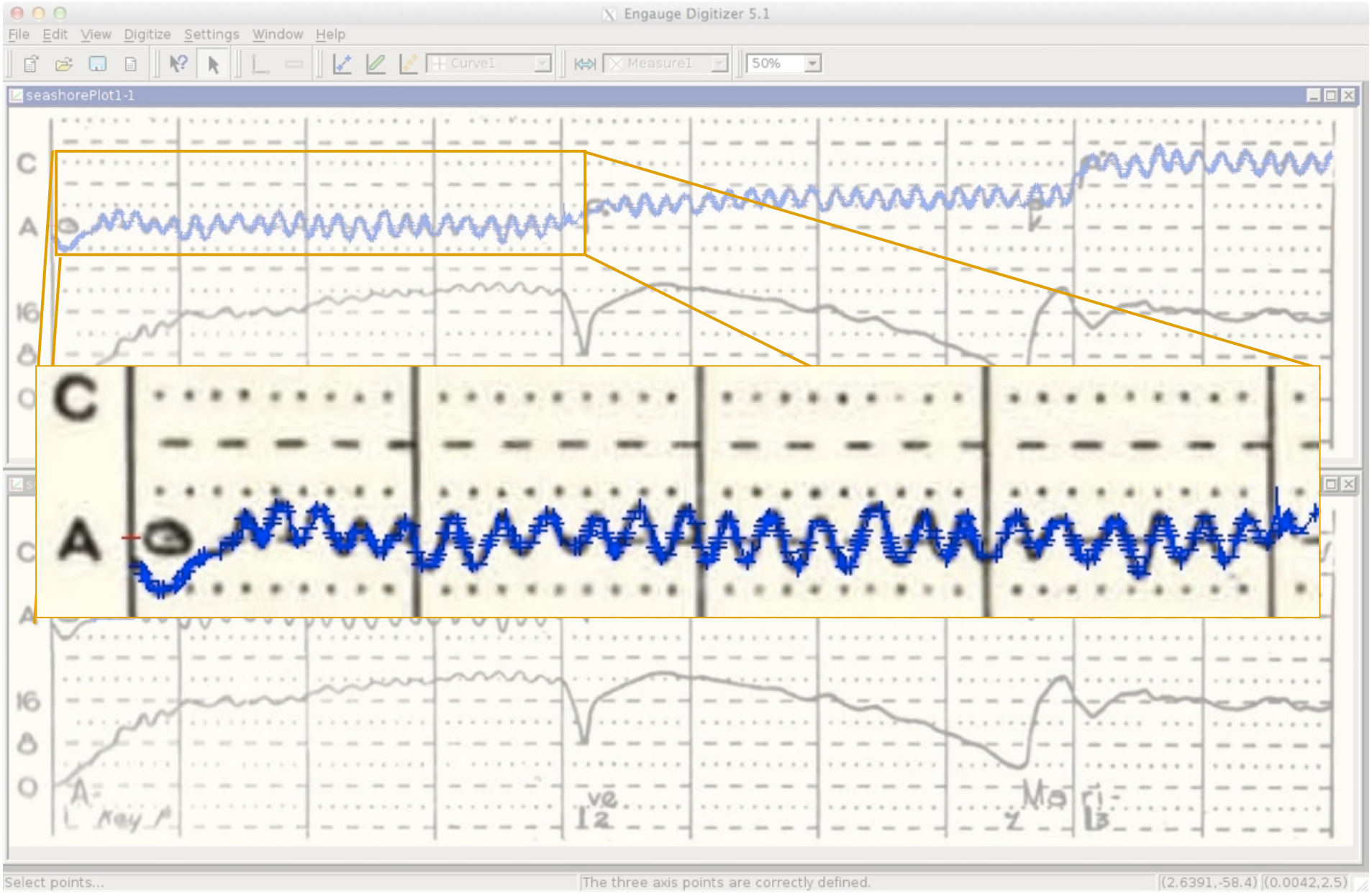
Performance Scores

Digitizing the data



Performance Scores

Digitizing the data



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An Objective Analysis of Singing

Singers studied

- **Baker - “**He shall feed His flock” from *Messiah* (Commercial) - *Figure 6*
- **Crooks -** “All through the night” (Commercial) - *Not reproduced*
- **Homer - “**Calm as the night” (Commercial) - *Not reproduced*
- **Kraft** - “Drink to me only with thine eyes” (Lab) - *Figure 3*
- **Kraft** - “All through the night” (Lab) - *Figure 4*
- **Marsh** - “Come unto him” from *Messiah* (Commercial) - *Figure 7*
- **Seashore** - “Come unto him” from *Messiah* (Lab) - *Figure 2*
- **Stark** - “Ave Maria” by Bach-Gounod (Lab) - *Figure 1*
- **Thompson** - “Phosphorescence” by Loewe (Lab) - *Not reproduced*
- **Tibbett** - “Drink to me only with thine eye” (Commercial) - *Figure 5*

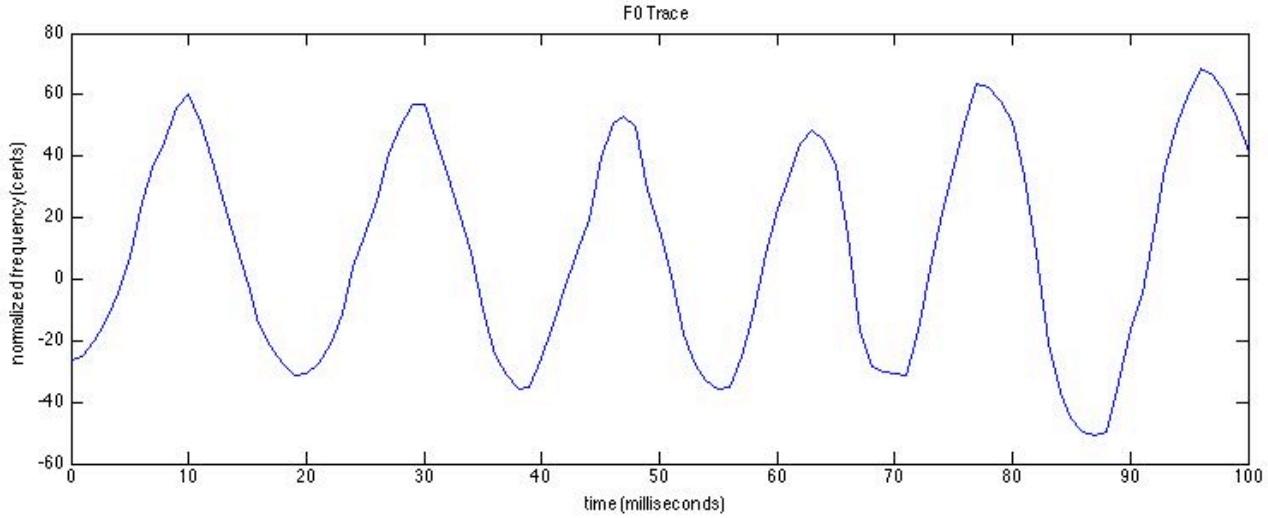
Modeling Extracted Data

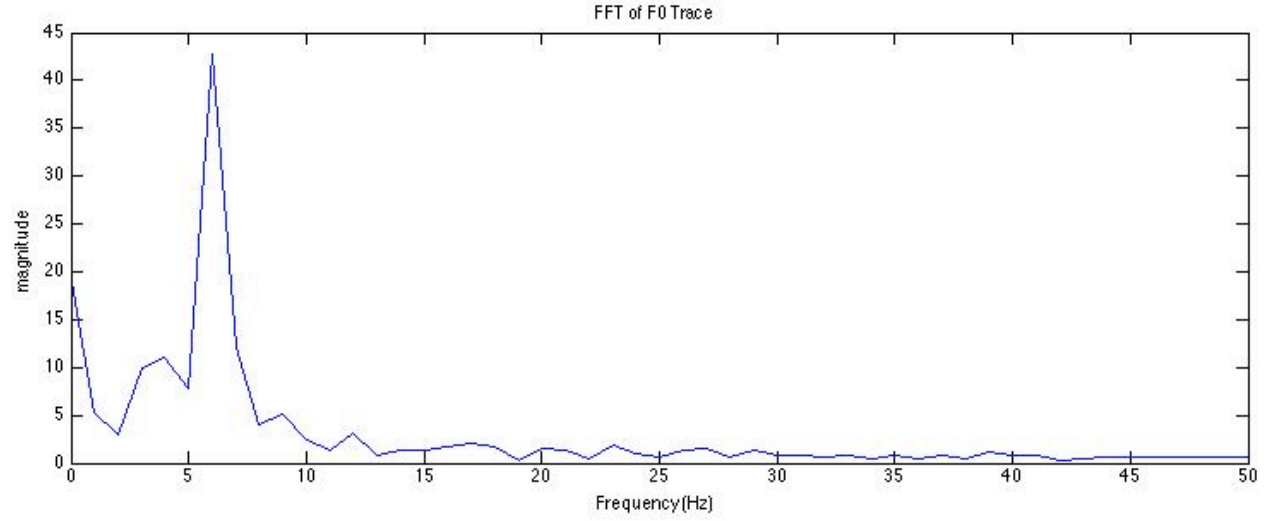
Vibrato

	H. Seashore	Computational
Vibrato rate	Manually counted in units of 0.5 cycles/ second	$\frac{\text{argmax } \lvert f(x)\rvert}{\text{length}(x)} * sr$
Vibrato extent	Distance from peak to trough	$\frac{\max \lvert f(x)\rvert}{\text{length}(x)} * 2$

Modeling Extracted Data

Vibrato





Extent = 42 cents

Rate = 5.9 hertz

Modeling Extracted Data

Vibrato

	Rate (Hz)						Extent (Cents)					
	Seashore			Computational			Seashore			Computational		
	N	Mean	*SD*	N	Mean	*SD*	N	Mean	*SD*	N	Mean	*SD*
1	533	6.5	0.6	513	5.8	1.2	533	48	14	513	47	22
2	412	6.3	0.5	389	5.6	1.0	412	44	14	389	40	14
3	238	5.9	0.7	223	5.4	1.2	238	61	19	223	60	30
4	252	5.9	0.7	252	5.6	0.8	252	58	19	238	52	21
5	327	5.9	0.7	327	6.3	1.0	327	53	12	314	45	13
6	698	6.2	0.6	698	5.4	0.9	698	45	11	597	41	14
7	534	6.4	0.6	534	5.8	0.9	534	53	14	510	51	14
Avg	**2994**	**6.3**	**0.7**	**2784**	**5.8**	**1.2**	**2994**	**50**	**15**	**2784**	**47**	**19**

Modeling Extracted Data

Vibrato

	Rate (Hz)						Extent (Cents)					
	Seashore			Computational			Seashore			Computational		
	N	Mean	*SD*	N	Mean	*SD*	N	Mean	*SD*	N	Mean	*SD*
1	533	6.5	0.6	513	5.8	1.2	533	48	14	513	47	22
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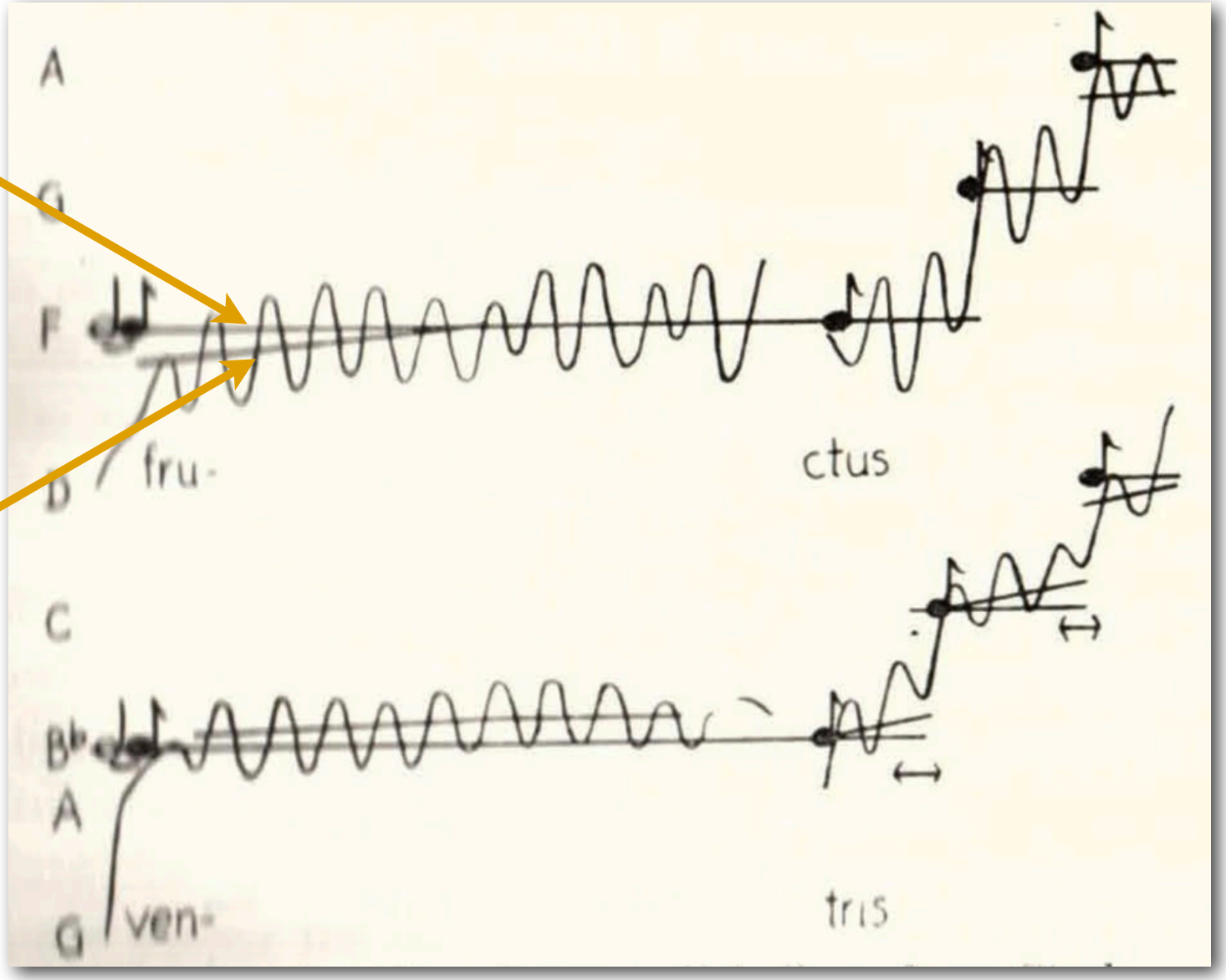
Modeling Extracted Data

Mean Pitch

“Correct” pitch

Mean pitch calculation



Seashore (1936)

Modeling Extracted Data

Pitch

	H. Seashore	Computational
Mean Pitch *Max/Min Deviations*	Deviations of mid-point in vibrato cycles from equal tempered pitch	–
“Perceived Pitch”	–	Robust mean
Intervallic Size	Distance between the points of most accurate mean-pitch measurement	Difference between perceived pitch calculations

Meta-analysis example

Comparative analysis of Seashore and contemporary data

	H. Seashore *N = 418*	Devaney et al. 2011 *N = 3981*
Ascending semitones	96 (*SD* = 24)	**96** **(*SD* = 20)**
Descending semitones	99 (*SD* = 24)	93 (*SD* = 18)
Ascending whole tones	192 (*SD* = 23)	198 (*SD* = 18)
Descending whole tones	197 (*SD* = 20)	201 (*SD* = 19)

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Summary

Where we have been

- **This talk has**
  - Described the information contained in Seashore's performance score
  - Detailed a method for extracting and analyzing performance score data

Future Work

Where I am going

- **Refine and expand computational analyses of performance score data**
- **Source the recordings corresponding to the performance scores**
- **Investigate whether the original phonophotograms still exist in the Seashore Archive at the University of Iowa**
- **Digitize more performance scores**

Thank you!

References

Cary, H. December 1922. Are you a musician? Professor Seashore's specific psychological tests for specific musical abilities. *Scientific American.* 326–327

Devaney, J., M. Mandel, D. Ellis, and I. Fujinaga. 2011. Automatically extracting performance data from recordings of trained singers. *Psychomusicology: Music, Mind and Brain* 21 (1–2).

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An Objective Analysis of Singing

H. Seashore's Schema of the Study of Singing

THE SINGER	THE SONG	THE LISTENER
Production	*Performance*	*Reception*
(Psychophysiology)	(Sound Waves)	(Psychophysiology)
Vocal apparatus	Pitch (frequency)	Auditory system
Neurophysiology	Loudness (intensity)	Neurophysiology
Sensitivity	Timbre (wave form)	Sensitivity
Motor skills	Duration (time)	
Interpretation	*Interpretation*	*Interpretation*
(Psychology)	(Analysis)	(Psychology)
Perception	Norms	Perception
Cognition	Individual differences	Cognition
Emotion	Variability	Emotion
Action	Laws of artistry	Action
	Musical form	

Seashore (1936)

Focus of H. Seashore's Study

Meta-analysis example

Exploratory comparative analysis of Seashore and contemporary data

	H. Seashore		Devaney et al. 2011	
	a cappella	accompanied	*a cappella*	accompanied
Ascending semitones	98 (*SD* = 24)	95 (*SD* = 25)	95 (*SD* = 20)	97 (*SD* = 17)
Descending semitones	99 (*SD* = 27)	100 (*SD* = 23)	93 (*SD* = 19)	94 (*SD* = 18)
Ascending whole tones	194 (*SD* = 20)	192 (*SD* = 25)	199 (*SD* = 20)	198 (*SD* = 19)
Descending whole tones	**201 (*SD* = 22)**	194 (*SD* = 19)	201 (*SD* = 18)	202 (*SD* = 17)

Mean-Pitch Deviations

Percentage of minimum values within thresholds

	Seashore				Computational			
	N	<0.1	<0.2	<0.3	*N*	<0.1	<0.2	<0.3
1	107	57	22	14				
2	109	72	23	5				
3	69	84	13	3				
4	52	85	15	0				
5	69	84	13	3				
6	117	81	13	1				
7	109	81	13	2	6.4	534	6.4	534

Mean-Pitch Deviations

Percentage of minimum values within thresholds

	Seashore					Computational				
	N	<0.1	<0.2	<0.3	<0.4	*N*	<0.1	<0.2	<0.3	<0.4
1	107	57	22	14	1					
2	109	72	23	5	0					
3	69	84	13	3	0					
4	52	85	15	0	0					
5	69	84	13	3	0					
6	117	81	13	1	0					
7	109	6.4	534	6.4	534	6.4	534	6.4	534	6.4