

THE MAGNITUDE OF PITCH INFLECTION

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Pitch inflection here is intended to include any noticeable change in the frequency of the glottal tone during phonation. The change may be upward or downward, rapid or slow, and of greater or lesser extent. Specifically, the purposes of the investigation reported here were (a) to compare the impact of pitch inflections of two contrasting directions, extents, and durations or rates, and (b) to compare four procedures for evaluating this impact.

Procedure. Twenty university students served as listeners throughout the experiment. They responded to two sets of stimuli. Set One was extracted from recordings that Cowan made of a lengthy speech by the actor, Kenneth MacKenna. The speech was one of his lines in a then current play in New York City. Cowan determined the average fundamental frequency of successive $1/24$ second, and plotted the results graphically with the musical scale as the ordinate and time as the abscissa. This melody curve is illustrated in Figure 1.

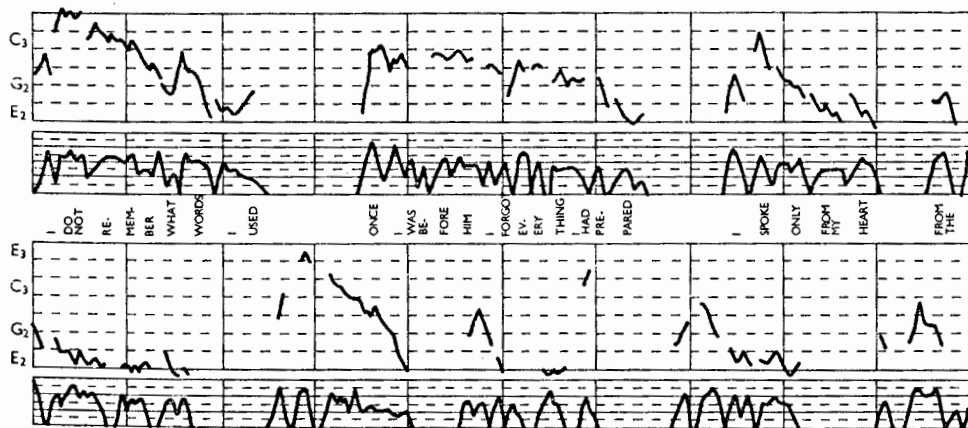


Figure 1. Melody curve from Cowan, "Pitch and Intensity Characteristics of Stage Speech", 1935.

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The materials of Set Two were borrowed from Takefuta who asked students to read sentences in manners appropriate to specified situational contexts, amazement, fear, indifference, etc. The vowel inflections were analyzed by a Trans Pitchmeter and photographed on an associated oscilloscope. The outcome is illustrated in Figure 2.

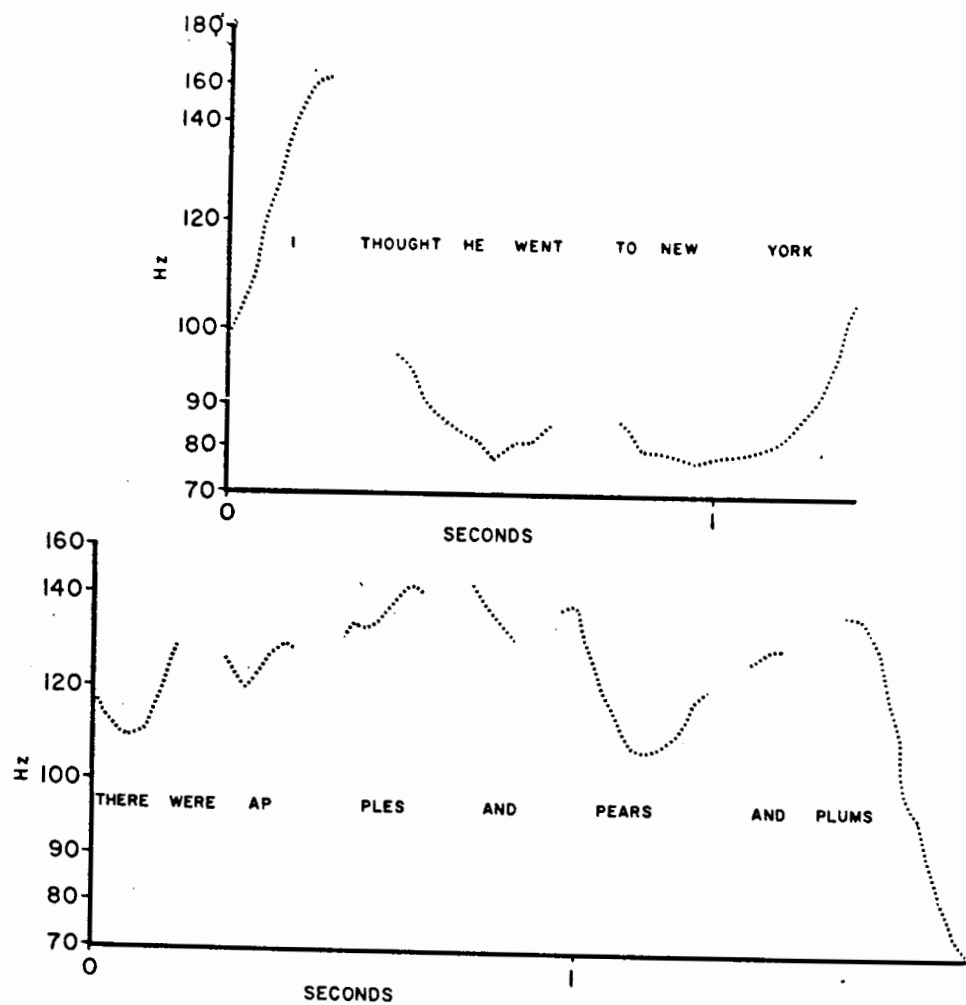


Figure 2. Display from oscilloscope of vocal inflections as analyzed by a direct-reading fundamental frequency instrument, the Trans Pitchmeter. Read-out on oscilloscope from a Trans Pitchmeter.

Insofar as possible, the 32 stimuli selected from Set One were matched by 32 stimuli selected from Set Two. These are summarized in Figure 3. There were four stimuli of each category listed in Figure 3. Thus there were four in the upward direction, relatively small in extent (3—5.5 semitones), relatively fast, i.e. short in duration (.10—.15 sec.). There were also four in the upward direction, of relatively great

extent (8—11.5 semitones), relatively slow, i.e. long in duration (.25—.40 sec.). The several permutations of these dimensions, upward and downward, are evident in Figure 3.

Category	(Cowan)		(Takefuta)	
	Extent (semitones)	Duration (sec.)	Extent (semitones)	Duration (sec.)
Up:				
Short-fast (✓)	5.0	.14	4.0	.10
Short-slow (✓)	4.0	.26	4.0	.30
Long-fast (✓)	9.0	.12	9.8	.20
Long-slow (✓)	8.0	.29*	10.0	.30
Down:				
Short-fast (✓)	4.0	.15	5.0	.10
Short-slow (✓)	4.0	.30	5.0	.40
Long-fast (✓)	9.0	.12	9.0	.15
Long-slow (✓)	9.0	.30	10.0	.30

* Median.

Fig. 3. Extent and duration of pitch inflections (modal values).

Listeners evaluated the stimuli on four separate occasions, using a different procedure each time: magnitude estimation, cross-modality matching, equal-appearing intervals, and paired comparisons. The salient features of the four procedures are evident in Figure 4. For *magnitude estimation* the subjects were asked to assign a num-

1.	<i>Magnitude Estimation:</i>	Assign a number; work in ratios.
2.	<i>Cross Modality Matching:</i>	Draw a line; work in ratios.
3.	<i>Equal-appearing Intervals:</i>	Encircle a value from 1—9.
4.	<i>Paired Comparisons:</i>	Answer—which is greater 1st or 2nd.

Fig. 4. Procedures.

ber to indicate the extent of the inflection of one segment and a number twice as large to indicate an inflection twice as great in extent. *Cross-modality matching* required the subjects to draw a line proportional to the extent of the inflection they heard. Again they were working in ratios. *Equal-appearing intervals* required the listeners to encircle a value from 1 to 9 on a previously prepared form. *Paired comparisons* required the listeners to answer the question: which is the greater inflection the first or second member of the pair?

Results. Numerical summaries of judgments of magnitude estimation, cross-modality matching, and equal-appearing intervals are directly comparable. These differ from the typical and most appropriate representation of outcomes of a paired-comparison procedure. Table 1 shows the median values of the judgments in the three directly comparable procedures. The values of magnitude estimation are in *ratios*; in cross-modality matching, *millimeters*; and in equal-appearing intervals, in units of a *scale from 1 to 9*. Irrespective of the psychophysical method, slow inflections were of greater impact than fast ones of the same extent, and upward inflections were generally more powerful than downward ones of the same extent and rate. (These generalizations are especially applicable to the Cowan material.) Long inflections were generally judged to be of greater magnitude than short ones of similar rate. The effect of short-slow inflections was quite comparable to that of long-fast ones. These outcomes, along with the results of the paired-comparison responses, are summarized grossly in Figure 5. The inflections of different extents and durations are arranged

Direction of Stimuli	(Cowan)				(Takefuta)			
	Cross Modality Matching	Method of Judging			Cross Modality Matching	Method of Judging		
		Magnitude Estimation	Equal-appearing Intervals	Paired Comparisons		Magnitude Estimation	Equal-appearing Intervals	Paired Comparisons
Up:								
Minimum	SF	SF	SF	SF	LF	LF	LF	LF
↓	LF	SS	SS	SS	SF	SS	SF	SF
Maximum	SS	LF	LF	LF	SS	SF	SS	SS
↓	LS	LS	LS	LS	LS	LS	LS	LS
Down:								
Minimum	SF	SF	SF	SF	SF	SF	SF	SF
↓	LF	LF	LF	LF	SS	SS	LS	SS
Maximum	LS	LS	SS	SS	LS	LF	SS	LF
↓	SS	SS	LS	LS	LF	LS	LF	LS

Fig. 5. Rank order of the relative effect of four types of vocal inflection: short-fast (SF), long-fast (LF), short-slow (SS), and long-slow (LS).

top to bottom, in an order of increasing impact. Thus, with upward inflections, the long-slow ones carried the greatest impact in all instances. A second purpose of the study was to examine the relative effectiveness of the alternative psychophysical procedures. In the instances of magnitude estimation, cross-modality matching, and equal-appearing intervals, the reliability of the listening panel was tested by an

analysis of variance as developed by Hoyt. In the instances of paired comparison, the reliability was tested by the split-half procedure. The outcomes are summarized in Table 2. Five of the eight values of *r* exceed .90. Although the present data do not justify a ranking of the four procedures the relative effectiveness of magnitude estimation is apparent.

Conclusion. The relative magnitude of an inflection appears to be measurable. The impact is greater with a larger inflection than a smaller one and with a slower one than a fast one, within the dimensions of the stimuli that were studied. Further, and of greater interest, the impact of an upward inflection is greater than that of a downward inflection when the two are matched in extent and rate. The magnitudes of inflections of different dimensions are ordered similarly whether one or another of the commonly used psychophysical procedures is employed.

REFERENCES

- Cowan, J. Milton, "Pitch and Intensity Characteristics of Stage Speech," *Archives of Speech* [Supplement], December, 1936.
 Takefuta, Yukio, "A Study of Relative Efficiency of Acoustic Parameters in the Intonational Signal of American English," unpublished doctoral dissertation, The Ohio State University, 1966.

DISCUSSION

J. T. Hart:

Your result, that under the same conditions of length, slope and extent, a rise is more effective than a fall, seems to be well in line with our finding that in a well balanced set of rise and fall for Dutch the slope of the fall has to be about twice as steep as that for the rise, whereas in that case the duration of the fall has to be at least three quarters of that for the rise.

Sadanand Singh:

I would like to ask two questions to Prof. Black.

- 1) He said "the upward inflexion had greater impacts". I did not understand—on what? And what are the implications of such a distinct finding.
- 2) Whether Takefuta replicated the study by Cowan, i.e., did he control variable, including experimental materials, similarly as Cowan or whether he had introduced new variables and used different experimental materials.

Black:

The implications of the fact that an upward inflection is more potent per semitone per unit of time than a downward one are numerous. They relate to effective voices (Black, 1942), to effective reading of literature, to the teaching of second languages, and to sociolinguistics. The Takefuta and Cowan materials are unlike except that both have been *measured*. They permit replications of studies such as this one.