

THE DEPENDENCE OF AUDITORY LOCALIZATION UPON PITCH.¹

BY F. L. DIMMICK AND E. GAYLORD

Hobart College

When Pratt offered the proposition that the designations 'high' and 'low' as applied to tones are based upon some fundamental spatial character of tones which varies with pitch,² he seemed to have settled a question which, as he pointed out, has been the source of much speculation. His solution affirms the very aspect of the problem which Stumpf, Wundt, and others had emphatically denied, namely, that "high tones are phenomenologically higher in space than low ones." Indeed, it was the apparently obvious negative of this which made necessary some explanation of the significance of the terms. Pratt submitted experimental data to substantiate his proposition. He presented to ten *O*s five pitches at the octaves from 256 d.v. to 4096 d.v. in five vertical positions and required them to locate the tones on a scale of fifteen points. The average vertical localizations of the tones followed exactly the order of their pitch numbers. When, however, we attempted to devise a simple demonstration based upon his results, we found ourselves in the difficulty of being unable to confirm them and, therefore, we undertook a more detailed experimental examination of the problem.

PROCEDURE I

In our preliminary work upon which we hoped to base a demonstration experiment, we adopted the thesis that if "high tones are phenomenologically higher in space than low ones," tones of various pitches coming from directly in front of *O* will be separated spatially, provided, of course, that *O* is

¹ Presented at the meeting of the American Psychological Association at Ithaca in September 1932.

² C. C. Pratt, The spatial character of high and low tones, *JOUR. EXPER. PSYCHOL.*, 13, 1930, 278-285.

not influenced by knowledge of the position of the stimulus. For this experiment, therefore, *O* was seated in a dark room facing at 3 meters' distance a loud speaker which was actuated from an oscillator in the control room. *O* was shown a scale 2 m long of ten steps, and instructed 'to localize each tone according to the direction from which it seems to come by reference to its position on the scale.' We used the same five pitches as did Pratt.

TABLE I
AVERAGE LOCALIZATIONS ON A VERTICAL SCALE WITH 10 STEPS, OF TONES OF VARIOUS PITCHES GIVEN AT POSITION 5

	H	W	C
4096.....	9.6 ± 1.1	7.7 ± 2.6	6.2 ± 1.5
2048.....	8.4 ± 1.1	7.1 ± 1.4	6.4 ± 1.5
1024.....	6.7 ± 1.2	5.2 ± 2.2	5.8 ± 1.9
512.....	5.9 ± 1.1	5.4 ± 2.6	6.0 ± 1.5
256.....	4.9 ± 1.1	5.5 ± 1.7	6.1 ± 1.5

The results of these preliminaries as shown in Table I are equivocal. The judgments from only one *O* (H) resemble those given by Pratt; those from the other two show no consistent relation between pitch and localization. In the main, all tones tend to be localized above the middle point, 5, at which they were given.

PROCEDURE II

Since the 'spatial character' of tones failed to spread out vertically tones of various pitches given at the same position, as it might be expected to do and as it is said to do in music, we attempted to approximate Pratt's original conditions. We counterbalanced a small speaker over noiseless pulleys to move vertically through a distance of 3.3 m. A chair with a head rest was placed on a platform at a distance of 3.6 m with *O*'s ear on a level with the middle position of the speaker. The scale consisted of 5 equidistant points whose radii to the ear as a center subtended angles with the horizontal of -25° , -13° , 0° , $+13^\circ$, $+25^\circ$. Six pitches at the octaves from 128 d.v. to 4096 d.v. were furnished by a beat-

frequency oscillator whose output deviated only slightly from the true sine curve.

O was given the typed instructions, "You will hear tones of various pitches which will be sounded from 5 different positions on the vertical scale. Indicate by reference to the numbers on the scale the direction from which each tone seems to come." Also, he was shown the moveable speaker and the positions from which the tones might come in order to emphasize for him the localization character of his task. He was then blindfolded and the tones presented in haphazard order with respect both to position and to pitch. Five series of 30 judgments were taken from 4 *O*s with the tones presented in the front median plane, 5 series in the back median plane, and 5 series at the right, 90° to the median plane.

RESULTS

Our results from this more carefully controlled work are in positive disagreement with Pratt's. Table II shows the average localizations of the several pitches by the 4 *O*s.

TABLE II
AVERAGES OF 75 LOCALIZATIONS ON A SCALE OF 5 OF EACH OF 6 PITCHES

	C	D	M	S
4096.....	2.80 ± 1.12	3.36 ± .65	2.79 ± .88	2.88 ± 1.12
2048.....	2.43 ± .99	3.53 ± .69	2.32 ± .92	3.07 ± 1.0
1024.....	2.37 ± .94	3.40 ± .68	2.52 ± 1.08	2.52 ± .94
512.....	2.83 ± .84	3.33 ± .77	2.33 ± 1.2	2.73 ± .79
256.....	3.15 ± .90	3.28 ± .85	3.7 ± 1.07	3.35 ± .99
128... ..	3.18 ± 1.03	3.08 ± .85	3.85 ± .96	3.55 ± 1.0

By no method of analysis could our results be made to indicate a relation between pitch and apparent position. For only one *O* (D) does localization parallel pitch with any consistency and his extreme spread is less than .5 of a scale division, about half of his M.V. Furthermore, this *O* was the only one who was aware of the significance of the results and of the possible relation between pitch and location. In the other cases the 'lowest' tones are localized higher than the 'highest' tones. In the main the *O*s tend to place tones at,

or just above, the horizontal so that the average localizations lie close to the value 3. The M.V.s are relatively large, however, and every average with its M.V. covers most of the mid-range of the scale, *i.e.*, 2-4. This middle tendency of the average localizations is due to two factors in the individual reports. In the first place, there was some tendency to avoid positions 1 and 5, as shown in Table III. In addition there

TABLE III
PERCENT OF LOCALIZATIONS IN EACH VERTICAL POSITION

	O	C	D	M	S
Position 1.....		16	2	22	12
2.....		28	15	18	23
3.....		23	39	22	29
4.....		24	35	21	21
5.....		9	9	17	15

was an approximate balance of plus and minus errors; that is, any tone irrespective of pitch is as likely to be placed above its true position as below. 'Low' tones presented down were localized up and 'high' tones presented up were localized down as frequently as conversely. The correct localizations approximated 20 percent which is in substantial agreement with Seashore's results on localization in the median plane.³ The horizontal position of the tone, front, back, or side, had no noticeable effect on its apparent vertical localization.

At the end of every series we asked our *O*s to tell how they arrived at their judgments of location. All agreed that they had no satisfactory criteria of the vertical position of the tone, that to all intents and purposes the judgments were mere guesses. One *O* (M) remarked that he would have liked to take the 'high' and 'low' pitch of a tone and apply it to his judgment of position, but that he realized that in so doing he would not be localizing the tone, because a 'low' tone often seemed nearer the ceiling than a 'high' one. The other *O*s were accustomed to the terms 'bright' and 'dull' for pitch differences and did not use 'high' and 'low' either for pitch

³ C. E. Seashore, Localization of sound in the median plane, *Univ. of Iowa Studies in Psychology*, 1899, 11, p. 46.

or for position. They spoke, instead, of the position of the tone as 'up' or 'down.'

CONCLUSIONS

Our results, then, taken under conditions which we tried to make equivalent to Pratt's, contain no evidence that 'highness' and 'lowness' as applied to tones have a spatial significance, and deny his contention that "high tones are phenomenologically higher in space than low ones." The determinants of the divergent results must lie in the *O*'s *Aufgabe*. There may have been essential differences on the one hand in the instructions given to *O* either verbally or by the obvious experimental setting, and on the other, in the understanding of the problem and in the attitude taken by the *O*s observing in the two experiments. Pratt does not quote his instructions, but states that "observers were asked to locate on a numbered scale running from floor to ceiling the position of tones." In addition, "the observers were allowed to know that the receiver was being placed at different points up and down in the vertical scale." In these respects it does not appear that the two sets of conditions differed widely. However, we laid more emphasis on the localization aspect of *O*'s task than is evident in the bare statement of the instructions. These were re-presented at every rest period during the observation hour. *O* was allowed to see the speaker changed incidentally (but not in the course of the observations) from one position to another until it was evident from his reports that he had no doubt about the actual positional changes of the stimuli, or of our reasonableness in expecting him to indicate those positions. We adopted this procedure to preclude, if possible, the confusion of pitch-quality with either spatial or pitch localization. The results justify it. Spatial localization was difficult and inaccurate but pitch-quality certainly was not substituted as a secondary criterion of position. 'Pitch-location' did not intrude to modify the space judgments, either by raising high pitched tones presented down and conversely, or by increasing the correct judgments of 'high' tones presented up and 'low' tones presented down.

The *Aufgabe* that depends upon an *O*'s general and psychological background and specific training is, of course, difficult to evaluate, but in this case must form the major factor in the disagreement of results. Pratt tells us nothing about his *O*s and it would be absurd to speculate. The question is not in any sense one of better or worse observation. Three of our *O*s were free from any theoretical basis that could have affected the results. They were undergraduates who had had two years of laboratory training but who were unaware of the nature of the problem. One man was musically trained. The fourth *O*, on the contrary, is the senior author and as such planned and closely supervised the experiment. It is significant that his results somewhat resemble those of Pratt's *O*s.

Pratt states that "only at the outset did the observers experience any difficulty with the judgment. The tonal impression seemed at first to pervade the whole room, but as the attentional direction fell in line with the task imposed by the instructions this difficulty entirely vanished and the judgments were made easily and quickly, and with surprising consistency." Our *O*s always found the judgments difficult, the tone directionless, although in addition to several preliminary series every *O* made 75 judgments on 6 pitches, a total of 450 judgments against 10 judgments on 5 pitches or 50 judgments in all by each of Pratt's *O*s. Obviously their judgments of 'pitch-localization' were based upon a different perception from that of spatial localization and consequently do not demonstrate more than a figurative significance of the spatial terms as applied to tones. Pratt's statement that "as soon as one has his attention directed to the spatial property of a tone the phenomenon of pitch locality becomes very real and unmistakable" is a further indication that his spatial judgments do not reflect an ultimate spatial dimension of the tones but are based on perceptions of a somewhat higher order in which the spatial aspect has become figurative.

If 'pitch-location,' then, is a perceptual judgment, one that readily becomes implicit as so many perceptions do, but as such does not imply an ultimate dimension or attribute of

tone, its implications for the phenomenon of apparent auditory movement are somewhat different from those Pratt suggests. Musical 'movement' differs fundamentally from visual or cutaneous movement in as much as it is based not upon an attribute of extent but upon a spatial perception in which the implication of extent is figurative. Since, however, this figurative spatial perception so readily becomes ingrained or implicit and seems to *O*s to be immediately spatial, it is natural that musicians should easily acquire the perception of pitch-locality and hear temporal shifts of tone quality in music as 'movements.' It follows that such musical 'movements' would not be perceived by the musically untrained. Such, indeed, has been my own casual observation. To the uninitiated the term movement as applied to music is almost, if not quite, unintelligible.

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