A Study of Voice Change in Boys Between the Ages of 11 and 16.

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A STUDY OF VOICE CHANGE IN BOYS BETWEEN THE AGES OF 11 AND 16

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Speech

by

Charles P. Pedrey
B. A., Cornell College, 1951
M.A., State University of Iowa, 1954
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ABSTRACT

Introduction.

The phenomenon of voice change and voice break has long been the subject of speculation among psychologists, teachers of speech, and others interested in adolescent boys. It is surprising, therefore, to find that almost no systematic research has been done on the subject, but, rather, that writers have been satisfied with casual observations or with repeating what someone else has written.

Little has been known about the change of voice except that, from casual observation, it appears to occur between the ages of twelve and twenty years, that the pitch drops about an octave, that the length of time it takes for the voice to change from that of a boy to that of a man varies with the individual.

Only two objective studies pertaining to voice change are available. One study is by Eldon K. Jerome on the relationship between change of voice and chronological age, mental age, and skeletal age, respectively; the other study, by E. Thayer Curry, is concerned with the problem of finding the characteristic pitch level of boys in three age groups.

That there is need for more research in this phase of adolescent life is evident.
were noted. The so-called 'condition of the room' was used in determining the presence or absence of the day's development of events and the length of the story. At the end of each week, the story was read and the number of boys who had experienced breaks and (1) the number of boys who had not experienced breaks, and (2) the number of boys who had experienced breaks, were recorded for each week. The number of boys who had also experienced breaks was also recorded. After the story had been read, the subject was asked if he was aware of any events that had occurred during the week.

Note

The boys were sent into the room used by the investigator.

At the beginning, the boys were given a survey, and the following questions were asked:

1. How many boys were used in the study?
2. How many boys were used in the study?
3. How many boys were used in the study?

The boys were asked to describe their experience during the week.

Purpose of the Study

The study was undertaken to make an investigation of the

Proceedings
the stage of pubic development.

**Results.**

On the basis of the findings it was concluded that:

1. The onset of greatest change of voice depends somewhat on chronological age. The percentage of boys in the process of voice change rises from 60 per cent in the eleven-year-old group to 83 per cent in the thirteen-year-old group. It drops to about 56 per cent in the fifteen-year-old group.

2. Some boys (1.39 per cent) have adult voices at age eleven, but the first great shift in the direction of adult voice occurs at age 14, when the percentage jumps from 3.72 with mature voices in the thirteen-year-old group to 20.17 per cent in the fourteen-year-old group.

3. The onset of greatest voice change depends somewhat on pubic development. Almost 23 per cent of all the prepubescent boys observed still had childish voices, while slightly less than two per cent of them had changed voices. But 75.5 per cent of the prepubescent boys used in this study were in the period of voice change.

4. At the pubescent level, 89 per cent of the boys were in the process of voice change, while slightly more than five per cent still had childish voices and an equal per cent had mature voices.

5. Age and pubic development are about equally reliable as indices of the stage of voice development, the respective correlations being .85 and .88.

6. During the period of observation a surprisingly small number of voice breaks were noted. Only four breaks occurred in a total reading time of more than 84 hours for the 1,014 boys used in this study.
7. According to the reports of the boys themselves concerning the voice breaks they remembered having experienced, breaks may occur at any of the age levels investigated in this study. There is a gradual increase in the number of boys reporting voice breaks, consisting of from slightly more than 13 per cent in the eleven-year-old group to slightly less than 51 per cent in the fifteen-year-old group.

8. Memories of one or more breaks were reported by 5.52 per cent of the boys whose voices had not yet begun to change, by slightly less than 56 per cent of the boys whose voices were in the process of changing, and by almost 69 per cent of the boys whose voices had completed the change. The group of boys who reported the greatest percentage of frequent breaks (4.4 per cent) was the group whose voices had changed.

9. Of the prepubescent boys, 21.49 per cent reported that they recalled having experienced breaks, 37.52 per cent of the pubescent boys reported memories of breaks, and 51.47 per cent of the postpubescent boys remembered having experienced voice breaks. A greater percentage of the postpubescent boys reported frequent breaks (3.58 per cent) than either of the other two groups.

10. Undue embarrassment is not a frequent concomitant of voice breaks. Of 676 boys who reported having experienced breaks, 317 boys (47 per cent) testified that they remembered some feeling of embarrassment caused by voice breaks. Of the 317 reporting feelings of embarrassment, 91 said, "Yes, but not much"; 90 said, "Yes, I was a little bit embarrassed"; but only 5 boys reported extreme embarrassment.
The phenomenon of voice change and voice break has long been
the subject of speculation among psychologists, teachers of speech,
and those people interested in adolescent boys. It is surprising,
therefore, to find that so little systematic research has been done
on the subject, but, rather, that writers have been satisfied with
casual observations or with repeating what someone else has written.

A diligent search through speech and psychological literature reveals that little is known about the change of voice except that,
from casual observation, it appears the voice change occurs between
twelve and twenty years of age, the pitch drops about an octave, the
change is probably connected with pubic development, and the length
of time it takes for the voice to change from that of a boy to that
of a man varies with the individual.

Perhaps the first written observation of change of voice and

1. The following named sources were examined for research or
other information on voice breaks and voice change: The Quarterly
Arbor, Mich., 1924--); Archives of Speech (Iowa City, Iowa, 1934--);
The Journals of Speech Disorders (Columbus, Ohio, 1935--); Proceedings
of the American Speech Correction Association (1930--); The Laryng-
oscope (St. Louis, Mo., 1895--); Good Speech (London, England, 1932--);
Thomson, Fatherson, and Thomson, Bibliography of Speech Education
(New York: The H. H. Wilson Company, 1939); Psychological Abstracts
(Lancaster, Penna., 1925--); Biological Abstracts (Philadelphia, Penna.,
1927--).

In addition the available textbooks in speech and in adoles-
cent psychology were examined. Only two research articles were found.
voice break was made by Aristotle, who was a keen observer of many things.

When twice seven years old, in the most cases, the male begins to engender seed; and at the same time hair appears on the pubes, in like manner, as Alcmaion of Croton remarks, as plants first blossom and then seed. About the same time, the voice begins to alter, getting harsher and more uneven, neither shrill as formerly nor deep as afterwards, nor yet of any even tone, but like an instrument whose strings are frayed and out of tune; and it is called, by way of by-word, the blast of the billy-goat. Few this breaking of the voice is more apparent in those who are making trial of their sexual powers; for in those who are prone to instfulness the voice turns into the voice of a man, but not so in the continent. For if a lad strive diligently to hinder his voice from breaking, as some do of those who devote themselves to music, the voice lasts a long while unbroken and may even persist with little change. 3

Aristotle, then, definitely connected voice change with puberty, and going one step further, named a specific cause for voice breaks, although he fails to tell us how he arrived at this conclusion. Research as it is carried on today did not exist in the days of Aristotle and so he followed what must already have been a hallowed tradition: he quotes an authority, one Alcmaion of Croton.

With the publication in 1904 of G. Stanley Hall's two-volume Adolescence, interest in the problems of the adolescent was aroused. As yet the evidence consisted only of opinion, but with the focus of attention beginning to concentrate on the "teen" ages, there were seen to be students delving into the psychology of the adolescent, measuring height and weight, recording yearly increments in these

measures, and unearthed facts from which conclusions could be
drawn. Hall, like Aristotle, attributes the change of voice and the
break in voice to the maturation of the genital organs, or pubic
development. Like Aristotle, he too cites no experimental data upon
which to base his opinions.

Before this period (puberty) the larynx of the sexes
differs but little, and from three to eleven the change in
both sexes is slight. Puberty, however, brings a sudden
enlargement of the glottis, which in the male nearly
doubles its proportions, and in girls enlarges in the ratio
of from five to seven. Its transverse diameter remains
more nearly the same for both sexes. . . .
The growth of double the length or more involves the
fall of an octave in the pitch of the voice and a more or
less prolonged period before fullness and quality are well
established on the new basis. The first symptoms of the
impending change is slight hyperemia of the larynx, which
causes the voice to become slightly raucous and hoarse.
This may vanish in a few days, when it is noticed that the
voice is a little lower but more uncertain. Often the
vocal cords and cartilages to which they are attached do
not grow in exact proportion the one to the other. The
tension is unsteady and the voice occasionally breaks to a
childish treble, often with notes higher than were normal
before the change began. Slowly phonation takes on a dis-
tinctly adult character. Those probably go too far who as-
sert that as the voice goes down in pitch it keeps exact
pace step by step with genital development, and that the
deeper it is the more complete the unfoldment of virility.
Eierent even goes so far as to think it a general rule, al-
though not without numerous exceptions, that a very robust
man with very abundant hair and well-developed sexual func-
tions usually has a bass voice, and that dark haired people
usually are basses or contraltos, and blonds are more likely
to have high voices.5

It is interesting to note here how close to the findings of
experimental data at least one of Hall’s observations is. He mentions,

3. G. Stanley Hall, Adolescence (New York: D. Appleton and
Company, 1904), II, 26-27.
in the above quotation, that the adult male voice has had a drop of about one octave from its characteristic prepubescent level, an assertion that has been shown to be experimentally correct in the laboratory by Curry, whose findings will be discussed later.

Hall's students and followers carried on his interest in the adolescent, but little objective research was done until comparatively recent years. Writers following Hall, and up to the last fifteen or twenty years, merely repeated his observations. Nor can one now find any study dealing with the rate of change in the adolescent voice, the psychological implications of the change, or the psychological and physiological concomitants of the voice break. In a recent book by Anderson we find this statement: "Let it be said in passing that at the present time too little is known of the voice of the prepubescent child, how it develops, how it should be used and trained, and what dangers may beset it, for any unnecessary risks to be taken."

Seth and Guthrie give some information about the physiological changes in the vocal cords during the period of pubescence, but they fail to mention where or how the measurements were made—whether made on living subjects or on cadavers. Nor are there any statistics to indicate the number of cases upon which these measurements are based.

About the age of fourteen years in boys, and twelve years in girls, the voice undergoes remarkable changes. The larynx then grows rapidly, so that the vocal cords become, in boys, 1 cm. longer, in girls 5 to 6 mm. longer, and the voice alters accordingly. In boys the lower limit falls a whole octave and the upper limit about a sixth. The change in voice may take from six to eighteen months to complete; in urban populations and in southern climates it develops earlier than in the country and in the North.

The lack of known facts does not deter many writers from making statements too often based upon superficial observation of a few isolated cases, or based upon the generalizations made by another writer after the observation of a few isolated cases. So far as can be found, no one has ever made an objective study of the embarrassment a boy experiences when his voice suddenly breaks into a squeaky falsetto, and yet a number of writers tell us that most boys are unduly self-conscious because of their squeaks. For example, Calkin writes:

There is an accompanying growth of the vocal cords and the often distressing change of voice. The girlish voice of the little boy gradually changes to the heavier voice of the adult male. All the world knows very well the amusing breaks of the voice which so often appear in the course of this change; but far too often the world fails to perceive the distress and embarrassment which these vocal mishaps bring. The boy may be proud of his new bass voice, but he is not proud of his inability to control it.

Or, to quote Earl C. Garrison, another well known author on adolescent psychology writing on the same subject:

It requires two or more years for the youth to achieve control of his voice in the lower register, and during that time he is often made self-conscious by the roughness of his own tones. He is mortified by the unexpected squeaks which punctuate his rumblings. Such whimsical "breaks" cause him to feel that he is making himself ridiculous—an opinion that is often confirmed, unfortunately, by the mirth with which others greet his vocal vagaries.

When presented with such statements we are immediately forced to ask: Upon what objective evidence is this conclusion based? What sampling of the population was questioned concerning the embarrassment felt?

In the following quotation from Hollingworth no mention is made of how often the voice breaks other than to state that it breaks easily and that it evades voluntary control. Neither does she state the number of boys whose voices were observed to break. So far as that is concerned, however, none of these writers mentions the number of observed cases of voice breaks, nor the number of cases of voice breaks with the alleged accompanying embarrassment.

In fact, the vocal cords of boys practically double in length between childhood and adulthood, and the voice drops in consequence. This involves also a marked increase in size of the larynx. During the years in which these changes take place, the voice breaks easily, and is often hoarse, evading voluntary control. For about two years a boy often has a strange and sometimes disagreeable voice, which may be a source of great embarrassment to him.9

But psychologists are not alone in insisting that voice breaks are an integral part of the period of voice change.

Raubiocheck makes this statement from the point of view of a teacher and textbook writer in Speech:

"Sometimes the vocal bands grow rapidly but unequally, in which cases the muscles that control them find it impossible to direct their delicate movements as precisely as is needed for producing voice. Thus we have the phenomenon of uncontrollable pitch and quality changes and of frequent breaks in resonance which are characteristic of what we call the "change" in the boy's voice."

Richmond has probably said as much as can be said with any real degree of confidence, since there is such a lack of objective data on the subject of voice change and voice break.

As puberty approaches, the boy becomes more lean and muscular, hair begins to grow in the pubic region, his voice becomes husky and uncertain and soon takes on a deeper tone.

It is now pertinent to observe that despite the lack of objectivity in the preceding quotations, there are actually two objective studies pertaining to the male adolescent voice.

In 1937, Eldon K. Jerome of the Mooseheart Laboratory for Child Research, making a study of the change of voice in adolescent males, used twelve boys in his research. He wanted to find out what relationship there is between change of voice and chronological age, mental age, and skeletal age. He came to these tentative conclusions:

1. Mental age is the least consistent age measure of children undergoing change of voice.
2. Skeletal age correlates more highly with chronological age than it does with mental age.

5. Boys undergoing change of voice who are of the younger chronological ages are, in general, older skeletally than they are mentally or chronologically.

6. Boys undergoing change of voice who are of the older chronological ages are, in general, younger skeletally than they are mentally or chronologically.

5. Skeletal age gives a more homogeneous grouping of boys undergoing change of voice than does mental or chronological age.

6. Skeletal age would seem to be more closely correlated with change of voice than the other criteria of age used. 12

Jerome feels that his most significant finding is that the skeletal age range in boys, within the period of voice change, is more restricted than either the chronological age or the mental age. He warns, however, that skeletal age may always be more restricted than either chronological age or mental age. He goes on to admit that "the smallness of the group under study prohibits them (the facts) from being statistically significant."

E. Thayer Curry, the other investigator credited with an objective study on boys' voices, set himself the problem of finding the characteristic pitch level of boys in three age groups. He selected six subjects at each of three different age levels: pre-adolescent (10 years), adolescent (16 years), and post-adolescent (18 years). He chose subjects which were as homogeneous as possible, within each age group, by controlling five factors: physical size, chronological age, reading comprehension, speaking ability, and intelligence. In the analysis of pitch he used the phonographic technique.

I. The Pitch Characteristics of the Adolescent

The results obtained agreed with the findings of other researchers who have previously studied the pitch characteristics of the adolescent. The data collected in this study showed that the pitch range of adolescent boys was similar to that of adult men. However, the mean pitch of adolescent girls was significantly lower than that of adult women.

II. The Effect of Age on Pitch

The pitch range of the adolescent group was found to be significantly wider than that of the adult group. This finding is consistent with previous research that has shown a decrease in pitch range with age. The mean pitch of the adolescent group was found to be approximately 250 Hz, while the mean pitch of the adult group was found to be approximately 190 Hz.

III. The Effect of Gender on Pitch

The pitch range of male adolescents was found to be significantly wider than that of female adolescents. The mean pitch of male adolescents was found to be approximately 275 Hz, while the mean pitch of female adolescents was found to be approximately 240 Hz.

IV. The Effect of Height on Pitch

There was no significant relationship found between height and pitch. The mean pitch of adolescents of different heights was found to be similar.

V. The Effect of Vocal Fold Length on Pitch

The pitch range of adolescents with longer vocal folds was found to be significantly wider than that of adolescents with shorter vocal folds. The mean pitch of adolescents with longer vocal folds was found to be approximately 280 Hz, while the mean pitch of adolescents with shorter vocal folds was found to be approximately 240 Hz.
Another point that is not quite clear is the number of recordings made for each subject. He states: "Only recorded performances free from defects in pronunciation, word omission or substitution were used in the study. The reading material used was the 55-word passage used in the studies of Provoost, McIntosh and Smidser." One cannot determine from this information whether one or several perfect recordings were made for each individual. The recorded breaks may be from one or from several records of the same individual.

In his analysis of breaks, Curry found that:

4. Upward breaks occurred at a level approximately one octave below the respective median pitch levels, while downward breaks occurred at a pitch level very close to the median pitch levels. Both types of breaks are seen, time, to lie typically below the median pitch.

5. The mean, and likewise the mode, extents of breaks, both upward and downward, and for both ten-and fourteen-year-old groups, were found to approximate six tones, i.e., one octave.

We have just seen that much has been said about the period of voice change in the boy's life, but that little experimentation has been done upon it. That there is need for much more research in this phase of the adolescent period is evident. Information is needed about the length of the period of change; whether there is a strain on the larynx during the change; and what effects, if any, the breaks have on the personality. The textbook writers who touch

15. Ibid., 61.
on this subject would have us believe that this is a period of great strain and stress, that the transition from the treble of the child to the deeper tones of the adult is, at best, a hazardous period in the life of a boy.

Unanswered questions like these gave impetus to the present study. The problem that the investigator set for himself was: To make an investigation of the relationship of pitch level and voice breaks to pubic development and to age; to make a survey, both observational and retrospective, of the number of boys who experience breaks; and to attempt to determine the effects of voice breaks on the boy’s behavior.
PROCEDURE

A. Selection of subjects.

Boys who had passed the eleventh birthday but not yet attained the sixteenth birthday were used in this study. In setting
the age span from eleven to sixteen years it was felt that at the
eleven-year-old level the majority of boys would not yet be in the
period of voice change16 and that at the sixteen-year-old level most
boys would be past the period of voice change. These age groups
were determined upon after a study of the Jerome and Curry findings
previously cited. It will be noted that Curry found no boys at the
ten-year-old level to be in the period of change, and that he found
all boys at the eighteen-year-old level to be past the period of
change. Jerome found a mean chronological age of 166.75 months for
his "voice change" subjects. On the basis of these studies it has
appeared that the range between eleven and sixteen would very likely
give a good sampling of the boys in the process of voice change. The

16. Whenever the period of voice change is referred to it
means the period of greatest and most rapid change, occurring around
puberty. We all know that the voice changes from birth to death,
that there is a continuous modification of pitch level in the voice.
A child of ten does not have the same pitch he had at birth or when
he began to talk. The voice will not be the same when he is forty
as when he was twenty, and it will be different still when he reaches
sixty.
The boys studied were from the school systems (fifth grade and above) of Baton Rouge, Louisiana, and Greenville, Mississippi.

The number of boys included in the study was 1,014.

**Method of Interview.**

Each boy was interviewed individually. Each boy was asked to report to the room in the school building used by the investigator. When he was seated he was invited to read—with no explanation as to why he was asked to read and no opportunity to practice the material handed to him—the following story:

**THE COYOTE'S SENSE OF HUMOR**

To understand the coyote fully one must remember that he is simply a wild dog, getting his living by his wits and saving his life by the tireless use of his legs; so he has developed both these gifts to an admirable pitch of perfection. He is blessed further with a gift of music and a sense of humor.

When I lived at Yancey's on the Yellowstone, in 1897, I had a good example of the latter, and had it daily for a time. The dog attached to the camp on the inner circle was a conceited little puppy named Chink. He was so full of energy, enthusiasm, and courage that there was no room left him for dog sense. But it came after a vast number of experiences. A coyote also had attached himself to the camp, but on the outer circle. At first he came out by night to feed on the garbage pile, but realizing the peace of the park he became bolder and called occasionally by day. Later he was there everyday, and was often seen sitting on a ridge a couple of hundred yards away.

One day he was sitting much nearer and grinning in coyote fashion, when one of the campers in a spirit of mischief said to the dog: "Chink, you see that coyote out there grinning at you? Go and chase him out of that."

Burning to distinguish himself, that pup set off at full speed, and every time he struck the ground he let off a war whoop. Away went the coyote, and it looked like a good race to us and to the ground squirrels that sat up high on their mounds to rejoice in the sight of these, their enemies, warring against each other.

The coyote has a way of slouching along, his tail dangling and tangling with his legs, and legs, loose-jointed, mixing with his
tail. He doesn't seem to work hard, but oh, how he does cover the prairie! And very soon it was clear that in spite of his magnificent bounds and whoops of glory, Chink was losing ground. A little later the coyotes obviously had to slack up to keep from running away altogether. It had seemed a good race for a quarter of a mile, but it was nothing to the race which began when the coyotes turned on Chink. Uttering a gurgling growl, a bark, and a couple of screeches, he closed in with all the combined fury of night and right, pitted against unfair attack.

And Chink had a rude awakening; his war whoops gave place to yelps of dire distress as he wheeled and made for home. But the coyotes could run all around him, and nipped him here and there and when he would, and seemed to be cracking a series of good jokes at Chink's expense, nor ever stopped till the ambitious dog was safely hidden under his master's bed.

This seemed very funny at the time, and I am afraid Chink did not get the sympathy he was entitled to, for after all he was merely carrying out orders. But he made up his mind that from that time on, orders or no orders, he would let coyotes very much alone. They were not so easy as they looked.

The coyote, however, had found a new amusement. From that day he simply "laid" for that little dog, and if he found him a hundred yards or so from camp would chase him and race him back in terror to some shelter. At last things got so bad that even if we went for a ride, and Chink followed us, the coyote would come along too and continue his usual amusement.

At first it was funny, and then it became tedious, and at last it was deeply resented by Chink's master. A man feels for his dogs he wasn't going to stand still and see his dog abused. He began to grumble vaguely about "if something didn't happen pretty soon, something else would." Just what he meant I didn't ask, but I know that the coyote disappeared one day and never was seen or heard of again. I'm not supposed to know anything about it, although in those days the coyote was a protected animal.17

As the boy read the investigator judged the stage of development of the reader's voice: (1) was it a childish voice? (2) was it the voice of an adolescent in the process of changing? or (3) had it changed and acquired its adult characteristics?

In order to facilitate the keeping of records on each subject, a card was filled out for each individual. All items on the

card except weight, height, and pubic development were checked at the first interview. The subject's name, age in years and months, the answers to the questions concerning previous experiences with voice breaks and the embarrassment caused by breaks were filled in after the reading of the material. The stage of voice development and voice breaks occurring during the reading of the material were checked while the subject read.

Judgment of the stage of development of the voice was, of necessity, subjective, since the investigator had no way of knowing what the subject's voice was like previous to the day of the interview. The investigator had, however, had ample experience—eleven years—as a teacher of speech in the high school and junior high school level, and had worked with several hundred children under the age of ten years who had speech defects. He feels confident, therefore, that he can distinguish the three stages of voice development with considerable accuracy.

In order to check the reliability of the judgment of experienced observers it was decided that the experimenter and two other observers should listen to the voices of one hundred boys and should separately judge the stage of voice development for each boy. One observer was the head of the School of Music at Louisiana State University; as a student of vocal music and a teacher of voice he was well qualified to judge the pitch and the quality of the voice. The other observer had been a public school teacher for twelve years and had taught in the primary, elementary, junior and senior high school levels.
The results of the classifications showed that Judge A agreed with Judge B in 96 per cent of the cases; Judge A agreed with Judge C in 96 per cent of the cases; and Judge B agreed with Judge C in 94 per cent of the cases. There was unanimous agreement in 95 per cent of all the cases.

The 100 were distributed according to age as follows:

**TABLE I**

<table>
<thead>
<tr>
<th>Age group</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>14</td>
<td>27</td>
</tr>
<tr>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
</tr>
</tbody>
</table>

The cases of perfect agreement, distributed according to the stage of voice development were: 5 cases in the pre-adolescent stage; 77 cases in the adolescent stage; and 11 cases in the post-adolescent stage. In no case did the observers disagree by more than one stage; that is, there was never a judgment in which one subject was placed in the two extreme stages of voice development, pre-adolescent by one observer, and post-adolescent by another. It may be concluded from this experiment that the investigator's judgment is reliable in estimating the developmental stage of a boy's voice.

It must be taken into consideration that quality as well as
pitch enters into the judgment of the voice—even though pitch is the predominant characteristic of the three levels of development.

The following criteria were used in judging the voices:

1. Childish or pre-adolescent voice.
The voice of a child is characterized as having a comparatively high pitch. Tones are thin rather than round and resonant. Roughly, it corresponds in pitch and quality to the voice of the soprano. One gets the impression that the tones are relatively pure rather than complex.

2. Adolescent voice in the process of change.
A changing voice is characterized by some unsteadiness of tone, is somewhat lower in pitch than the child’s voice, and has in it a hint of harshness. It lacks the clearness of the child’s voice and has not yet attained the fullness of the adult’s voice.

3. The post-adolescent or male adult voice.
The male adult voice is about an octave lower in pitch than the voice of a pre-adolescent, and is usually full and round.

Upon completion of the reading material the subject was asked the following questions:

1. What is your name?
2. How old are you? When was your birthday?
3. Did you ever experience any voice breaks? By that I mean did your voice ever get out of control and go "way up" or "way down"?

If the answer to this last question was yes, he was asked:

4. How often did it happen? Does it break now? When did it break?
5. Did it ever cause you any embarrassment when it broke like that?

If the answer to this question was yes, he was asked:

6. Tell me about it. Can you remember specific instances when you were embarrassed? What happened?

Before leaving the method of interview it might be well to define the term "break" as used in this study.

Break is here defined to mean a sudden and uncontrollable rise or fall from the characteristic pitch of the individual, a rise
or fall which is definite enough to be heard by a listener. Ob-
viously, if the break cannot be heard, it can have no effect on the
auditor and we may question whether it has any effect on the speaker.
In short, listeners cannot laugh at or deride a speaker because his
voice breaks if they cannot hear the breaks, and one may well ask
how much embarrassment the speaker feels when there is no such
adverse reaction from his audience.

When the interview was ended, the boy was asked to return to
his room and send the next boy in.

The weighing and measuring were done in the gymnasium when
the boys used to their physical education classes. All boys inter-
viewed were required to strip before stepping on the scales. As a
boy stood on the scales to be weighed, his pubic development, using
the criteria first described by Crompton,13 was noted: if he had
no pubic hair he was classified as 1; if his pubic hair was straight
he was classified 2; if his pubic hair was kinky he went into
classification 3.

All data were later transferred to I.B.M. (International
Business Machine) punch cards, thus rendering it possible to make
all the tabulation of data on the I.B.M. machines. This phase of the
work was done in the Bureau of Statistical Service of Louisiana State
University.

13. C. W. Crompton, "Physiological Age," American Physical
Education Review (Springfield, Mass., 1879-), 1925, XIII, 244-164.
PRESENTATION AND ANALYSIS OF DATA

Before presenting the data on voice it is pertinent that the physical measurements and the physiological development of the boys in this study be presented and compared with the data of similar studies, so that it may be shown that the boys in this study are comparable to the average boys in the United States.

A. Heights and weights of the boys in this study.

Average heights and weights as well as the normal yearly increments in these two measurements have been rather thoroughly studied and recorded by various investigators. One may find many tables and charts pertaining not only to the heights and weights of boys and girls in general, but charts dealing also with different groups of boys and girls: racial stock groups, socio-economic groups, groups divided into chronological and skeletal ages, and groups divided into bodily types. A brief consideration of some of these collateral studies is necessary to throw the data of the present study into proper perspective.

One of the most comprehensive and most widely referred to compilations of child measurements is to be found in a monograph edited by Frank L. Shuttleworth.19

Table II is a partial reproduction of Table 45 from Shuttleworth. It must be remembered that Shuttleworth's table is one of generalized patterns of growth in average standing height and body weight. Shuttleworth smoothed his data by the rejection of erratic figures, by interpolation for gaps, and by adjustment for short intervals. Shuttleworth points out that the generalized increments were derived by adding and subtracting average accelerations and that the gross figures of Table 45 were derived in turn from the increments.

**Table II**

Generalized patterns of growth in average standing height and body weight (Shuttleworth 26)

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Height cm</th>
<th>Weight kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.50</td>
<td>701</td>
<td>155.08</td>
<td>30.95</td>
</tr>
<tr>
<td>10.30</td>
<td>705</td>
<td>157.51</td>
<td>32.49</td>
</tr>
<tr>
<td>11.50</td>
<td>705</td>
<td>159.30</td>
<td>33.99</td>
</tr>
<tr>
<td>11.30</td>
<td>707</td>
<td>162.57</td>
<td>35.61</td>
</tr>
<tr>
<td>12.50</td>
<td>707</td>
<td>144.66</td>
<td>37.31</td>
</tr>
<tr>
<td>12.30</td>
<td>707</td>
<td>147.14</td>
<td>39.16</td>
</tr>
<tr>
<td>13.50</td>
<td>707</td>
<td>149.92</td>
<td>41.58</td>
</tr>
<tr>
<td>13.30</td>
<td>707</td>
<td>153.54</td>
<td>44.35</td>
</tr>
<tr>
<td>14.50</td>
<td>707</td>
<td>158.15</td>
<td>48.03</td>
</tr>
<tr>
<td>14.30</td>
<td>707</td>
<td>162.30</td>
<td>52.01</td>
</tr>
<tr>
<td>15.50</td>
<td>691</td>
<td>166.39</td>
<td>55.57</td>
</tr>
<tr>
<td>15.30</td>
<td>668</td>
<td>168.68</td>
<td>58.52</td>
</tr>
<tr>
<td>16.50</td>
<td>619</td>
<td>170.52</td>
<td>60.44</td>
</tr>
</tbody>
</table>

In order to make the data from the present study comparable with Shuttleworth's data, the boys in this study were classified into half-yearly step intervals and all measurements changed from avoirdupois pounds to kilograms, and from inches to centimeters.

Figures I and II are comparisons of Shuttleworth's data from Table II and the data found in Table III pertaining to the boys used in this study.

**TABLE III**

Average height and weight of 1,014 boys used in this study

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Height</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.0 - 11.49</td>
<td>66</td>
<td>142.88</td>
<td>35.09</td>
</tr>
<tr>
<td>11.5 - 11.99</td>
<td>88</td>
<td>144.50</td>
<td>37.70</td>
</tr>
<tr>
<td>12.0 - 12.49</td>
<td>125</td>
<td>149.20</td>
<td>39.77</td>
</tr>
<tr>
<td>12.5 - 12.99</td>
<td>107</td>
<td>151.69</td>
<td>40.76</td>
</tr>
<tr>
<td>13.0 - 13.49</td>
<td>120</td>
<td>154.41</td>
<td>44.01</td>
</tr>
<tr>
<td>13.5 - 13.99</td>
<td>95</td>
<td>153.73</td>
<td>45.42</td>
</tr>
<tr>
<td>14.0 - 14.49</td>
<td>123</td>
<td>158.79</td>
<td>48.00</td>
</tr>
<tr>
<td>14.5 - 14.99</td>
<td>105</td>
<td>163.50</td>
<td>52.03</td>
</tr>
<tr>
<td>15.0 - 15.49</td>
<td>88</td>
<td>165.56</td>
<td>55.13</td>
</tr>
<tr>
<td>15.5 - 15.99</td>
<td>97</td>
<td>167.28</td>
<td>55.08</td>
</tr>
</tbody>
</table>

Figure I is the comparison of the weight patterns. The

![Figure I](image)

**Figure I.** Based on figures in Frank K. Shuttleworth.21

curves match fairly well until they get just beyond the fifteen-year-level, when the curve for this study flattens out. There may be several explanations to account for this difference in the two curves: (1) Shuttleworth's curve represents a greater number of boys; (2) Shuttleworth's curve is a smoothed curve which would not show variations so markedly; (3) at the time of this study spring practice in football was on, probably making many of the larger boys unavailable; and (4) a number of the larger boys may have been among those who dropped out of school to take employment in defense industries.

Figure II. Based on figures in Frank K. Shuttleworth. 22

Figure II is a comparison of the average heights as recorded in the two sets of data. In all probability, the numbers of subjects used at the various age levels would tend to make the discrepancies in the curves insignificant. Certainly we may agree that the boys used in this study are not very different from the boys investigated by Shuttleworth; at least, so far as height and weight are concerned.

B. Stages of pubescence at various age levels.

Table IV is a reproduction of a table found in Dimock, which gives the per cent of boys who are in the different stages of

**TABLE IV**

The pubescent status and chronological age of 1,406 boys  
(According to Dimock)

<table>
<thead>
<tr>
<th>Chronological age of boys between</th>
<th>Number of boys</th>
<th>Prepubescent Number</th>
<th>Per cent</th>
<th>Pubescent Number</th>
<th>Per cent</th>
<th>Postpubescent Number</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-11</td>
<td>106</td>
<td>104</td>
<td>98</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>11-12</td>
<td>227</td>
<td>188</td>
<td>83</td>
<td>32</td>
<td>14</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>12-13</td>
<td>347</td>
<td>215</td>
<td>62</td>
<td>86</td>
<td>25</td>
<td>46</td>
<td>13</td>
</tr>
<tr>
<td>13-14</td>
<td>280</td>
<td>112</td>
<td>40</td>
<td>80</td>
<td>29</td>
<td>88</td>
<td>31</td>
</tr>
<tr>
<td>14-15</td>
<td>240</td>
<td>32</td>
<td>13</td>
<td>52</td>
<td>22</td>
<td>156</td>
<td>65</td>
</tr>
<tr>
<td>15-16</td>
<td>115</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td>3</td>
<td>104</td>
<td>90</td>
</tr>
<tr>
<td>16-17</td>
<td>67</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td>17-18</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>100</td>
</tr>
</tbody>
</table>

physiological development at given age levels: prepubescent, pubescent, and postpubescent. 24

It is interesting to note that only 1 per cent of the ten-year-old group, and 5 per cent of the eleven-year-old group are postpubescent, while 100 per cent of his sixteen- and seventeen-year old groups are postpubescent.

Table V is the distribution of cases in the various stages of pubic development, distributed according to age levels, for the boys in this study.

**TABLE V**

<table>
<thead>
<tr>
<th>The pubescent status and chronological age of 1,014 boys used in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage of Pubescence</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Note: Age groups will hereafter be designated as 11 for those 11.0 to 11.99, 12 for those 12.0 to 12.99, etc.
Symbols

- Stage of pubescence
- 1 = prepubescent
- 2 = pubescent
- 3 = postpubescent

24. Dimock employed the "Crampton criteria" which will be discussed later.
It will be noted that the percentages in the study by Dimock and in this study are in fairly close agreement. That there are some differences in percentages may be due to the fact that Dimock made his study on a selected group of boys belonging to clubs and boys in summer camps, while this study includes all school boys within the given age ranges that were in school and available on those days when the survey was being conducted. There may also have been a slight difference in the interpretation of the criteria used for determining the stages of pubescence. In both studies the so-called "Crampton criteria" were used. Crampton25 had made a study of pubescence in 1908 and developed a technique which has been considered standard ever since. He outlined his criteria as follows: (1) the pre-pubescence period is the total period of life before there are any physiological signs of puberty; (2) puberty is marked by the appearance of pigmented hairs in the pubic region; (3) post-pubescence is marked by a kink or twist in the pubic hair, and by a wrinkled scrotum.

In Table VI we have a composite picture of the data from five investigators, in which are given the average ages of pubescent boys. The average ages found for the pubescent boys used in this study are in very close agreement with the average ages found by other observers. The average age for pubescent boys ranges from 14.4 years as reported by Baldwin to 15.00 years as reported by

The average age for the pubescent boys in this study is 13.72. In contrast to the average age of the boys in Crampton's study, the average age of the boys in this study is .32 of a year higher.

**TABLE VI**

The average age of pubescent boys as reported by several investigators

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Date of report</th>
<th>Number of boys</th>
<th>Average age of pubescents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crampton</td>
<td>1908</td>
<td>3,835</td>
<td>15.4</td>
</tr>
<tr>
<td>Baldwin</td>
<td>1916</td>
<td>3,600</td>
<td>14.4</td>
</tr>
<tr>
<td>Baldwin</td>
<td>1916</td>
<td>1,917</td>
<td>13.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(city boys)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(country boys)</td>
<td></td>
</tr>
<tr>
<td>Dimock</td>
<td>1937</td>
<td>1,486</td>
<td>15.08</td>
</tr>
<tr>
<td>This study</td>
<td>1945</td>
<td>1,014</td>
<td>13.72</td>
</tr>
</tbody>
</table>

Note: The data for this study were added to Dimock's table in order to facilitate comparison.

Figure IIII represents the percentages of boys in the three stages of pubic development as found by Crampton and Dimock, and as found for the boys in this study. Allowing for individual differences in the subjects studied, and for the aforementioned slight individual differences in the interpretation of the criteria by the various observers, it may be concluded that the slight variations in percentages are insignificant, and that the boys in this study are comparable in pubic development to boys elsewhere.

Figure III. Per cent of boys who are pre-pubescent, pubescent, and post-pubescent at various ages. Adapted from Dimock, *Rediscovering the Adolescent*, 211.
C. Voice change in relation to chronological age.

Table VII presents the data on the percentages of boys in the three stages of voice change for each of the indicated age groups. It will be noticed that, as in the stages of puberty, the period of voice transition is, in general, the one with the greatest population. Since no longitudinal study has yet been made to determine the length of time it takes for a boy's voice to change, we can only guess at the duration of the period in which the voice is between the child's treble and the man's bass. We may guess that, on the average, the time extends over several years, for at no time during the age ranges used in this study were there fewer than fifty-five per cent of the boys whose voices appeared to be in the period of changing voice, and in age group 13 there are as many as eighty-eight per cent in that transition period.

TABLE VII

<table>
<thead>
<tr>
<th>Age group</th>
<th>N</th>
<th>Stage of Voice Development</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per cent</td>
<td>Per cent</td>
<td>Per cent</td>
</tr>
<tr>
<td>11</td>
<td>164</td>
<td>Stage 1</td>
<td>38.21</td>
<td>60.36</td>
<td>1.29</td>
</tr>
<tr>
<td>12</td>
<td>232</td>
<td>Stage 2</td>
<td>19.39</td>
<td>78.01</td>
<td>2.58</td>
</tr>
<tr>
<td>13</td>
<td>215</td>
<td>Stage 3</td>
<td>8.57</td>
<td>87.90</td>
<td>3.72</td>
</tr>
<tr>
<td>14</td>
<td>228</td>
<td></td>
<td>1.75</td>
<td>78.07</td>
<td>20.17</td>
</tr>
<tr>
<td>15</td>
<td>186</td>
<td></td>
<td>5.54</td>
<td>56.67</td>
<td>43.78</td>
</tr>
</tbody>
</table>

Table VII reveals that of the 154 boys in the eleven-year-old group, 38.21 per cent were judged to have pre-adolescent or childish voices, 60.36 per cent had voices in the process of change, and 1.29 per cent had adult voices. It reveals also that it was a mistake to
assume that most boys aged sixteen years would be past the period of changing voices, for it is found that slightly fewer than forty-four per cent were judged to have changed completely.

Admittedly, because of the subjective manner of determining the stage of voice change, a few boys whose voices had completed the change may have been classified as having voices still in the process of change, but the percentage of boys in category 5 is so low that even if some errors in classification were made, the figure would still be low enough to force us to change the hypothesis that most boys at the age of sixteen are past the period of change.

D. Voice change in relation to pubic development.

We are now ready to consider the question inherent in the problem set up for experimentation at the beginning of this study: "Is there any relationship between change of voice and pubic development? If there is, how much relationship is there?" In order to answer these questions it is necessary to divide each age group into the three stages of puberty and to indicate the voice status of each of these groups. Table VIII is the result.

There is some highly interesting information in Table VIII. Inspection of Column 6, showing the percentages of boys whose voices have completed the change, reveals that the percentages for the pre-pubescent and pubescent boys is never as much as 9 per cent in any age group until we get into age group 15, where there are as many as 15 per cent of the pubescent boys whose voices have changed.

Column 5, showing percentages of voices in the process of
TABLE VIII

Voice change in relation to pubic development

<table>
<thead>
<tr>
<th>Age group</th>
<th>P.D.</th>
<th>N</th>
<th>Voice stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per cent</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>151</td>
<td>50.41</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>33.33</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>163</td>
<td>21.31</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>36</td>
<td>13.69</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>15</td>
<td>7.69</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>102</td>
<td>15.73</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>69</td>
<td>5.80</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>51</td>
<td>3.92</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>103</td>
<td>1.94</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>27</td>
<td>5.70</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>498</td>
<td>22.69</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>209</td>
<td>5.26</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>507</td>
<td>.98</td>
</tr>
</tbody>
</table>

P.D.: (1) prepubescent, (2) pubescent, (3) post-pubescent.

changing, shows something altogether different. In this column there is no per cent less than sixty until age group 15 is reached. There we discover that almost 48 per cent of the 147 boys are in the third stage of pubic development, while the voice is still in the process of changing. In other words, very few prepubescent and pubescent boys will be found to have adult voices.

From the totals it will be seen that a clear majority of the prepubescent and pubescent boys are still in the stage of changing
voice. Only 1.31 per cent of the prepubescent and 5.25 per cent of the pubescent boys had voices which had been judged as completely changed. While 40 per cent of the postpubescent boys had voices which had completely changed, a majority (59 per cent) are still in the process of change. Three boys have voices that have not yet begun to change, one in age group 12, and two in age group 14.

The totals for column 4 indicate quite clearly a relation between the process of change in the voice and the progress of physiological change. Slightly less than 23 per cent of prepubescent boys have voices that have not yet begun to change, but only a few more than 5 per cent of pubescent boys and 1 per cent of postpubescent boys have childish voices.

If change of voice in boys is not at all related to pubic development we should find no parallel changes in the periods of voice change and the periods of physiological development within restricted age groups. Conversely, if the two are directly related, then the percentages should be significantly parallel in all age groups.

Close study of Tables VII and VIII reveals that the relation between puberty and voice change is not one of perfect correlation, but it does show that there is some connection between the two phenomena. As has already been pointed out, this relation is especially evident in the totals of columns 3 and 4, where a sharp fall appears in the per cent of boys whose voices are still in stage one when they attain postpubescence, and a sharp rise in the per cent of boys whose voices have completed the change when they reach the postpubescent
In order to find whether the relation between pubic development and voice change is closer than the relation between age and voice change, the boys studied were divided into three age groups, and cross tabulations were drawn up for chronological age and voice change, and for pubic development and voice change.

**TABLE IX**

<table>
<thead>
<tr>
<th>Age group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>104</td>
<td>274</td>
<td>8</td>
<td>386</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>367</td>
<td>54</td>
<td>443</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>103</td>
<td>81</td>
<td>185</td>
</tr>
<tr>
<td>Total</td>
<td>127</td>
<td>744</td>
<td>145</td>
<td>1014</td>
</tr>
</tbody>
</table>

Age groups:
1 - 11 to 12.99
2 - 13 to 14.99
3 - 15 to 15.99

The three-by-three-fold tables here presented enable one to tell at a glance just how many boys in each category have childish voices, how many are in the stage of transition or changing voice, and how many have completed the change of voice. Table IX presents this information in relation to age groups and Table X shows it in relation to the physiological changes in the boys.
There is no reason why such a table could not be constructed to present the change of voice for a larger number of age levels, but the number of boys in each age group would then be so small that it would be more difficult to determine the meaningfulness of the resultant correlations.

TABLE XI

<table>
<thead>
<tr>
<th>Age group Theoretical Normal</th>
<th>(a-t)²/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>48.54</td>
</tr>
<tr>
<td>104</td>
<td>232.21</td>
</tr>
<tr>
<td>274</td>
<td>54.43</td>
</tr>
<tr>
<td>5</td>
<td>55.49</td>
</tr>
<tr>
<td>22</td>
<td>325.04</td>
</tr>
<tr>
<td>54</td>
<td>62.47</td>
</tr>
<tr>
<td>367</td>
<td>23.17</td>
</tr>
<tr>
<td>1</td>
<td>155.73</td>
</tr>
<tr>
<td>103</td>
<td>26.08</td>
</tr>
<tr>
<td>31</td>
<td>1013.26</td>
</tr>
</tbody>
</table>

To determine whether the relation between age and voice status could be due to chance, \( \chi^2 \) was computed, using the method recommended by Cauden. The resultant \( \chi^2 \) clearly demonstrates that one cannot interpret the distribution shown in the table to be a mere chance distribution. In a table yielding four degrees of freedom a \( \chi^2 \) of 13.26 will arise by chance only 1 in 100 times. The \( \chi^2 \) for Table XI is 275.47. The obvious conclusion is that our figures are definitely not chance distributions.

In Table XII the \( \chi^2 \) is again too large to allow the interpretation of the actual values as being due to chance.

**TABLE XII**

<table>
<thead>
<tr>
<th>Actual</th>
<th>Theoretical Normal</th>
<th>((a-t)^2/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>115</td>
<td>62.37</td>
<td>41.10</td>
</tr>
<tr>
<td>376</td>
<td>365.59</td>
<td>.50</td>
</tr>
<tr>
<td>9</td>
<td>70.23</td>
<td>55.58</td>
</tr>
<tr>
<td>11</td>
<td>26.17</td>
<td>8.79</td>
</tr>
<tr>
<td>137</td>
<td>155.54</td>
<td>7.38</td>
</tr>
<tr>
<td>11</td>
<td>29.47</td>
<td>11.57</td>
</tr>
<tr>
<td>3</td>
<td>50.45</td>
<td>32.68</td>
</tr>
<tr>
<td>181</td>
<td>225.26</td>
<td>8.69</td>
</tr>
<tr>
<td>123</td>
<td>45.29</td>
<td>( \chi^2 = \frac{146.77}{310.56} )</td>
</tr>
</tbody>
</table>

From the \( \chi^2 \) values derived in these two tables one can easily get a correlation of mean square contingency by the use of
Pearson's $r^2$ (c) formula, $C = \sqrt{\frac{\chi^2}{N + \chi^2}}$, where $N$ is the total number of observations (not the number of classes).

$$C = \sqrt{\frac{\chi^2}{N + \chi^2}} = \frac{2.7647}{\sqrt{1235.47}} = \sqrt{.42} = .6505,$$

which is the coefficient between age and voice status. Because the grouping giving $C$ is comparatively rough it is necessary to make a correction to allow for rough grouping. This correction is made by using the correction for index formula, $29C = \frac{C}{I^2}$, Kelley has prepared a series of values of $r_{x, \gamma}^2$ for varying numbers of categories and for different types of distributions. In this case the value for both $r$'s is .242 and the value of the corrected $C$ is $.6505 = .65$.

By using the same formula the corrected correlation for voice change and pubic development becomes .68.

A difference of .03 in the above correlations has no statistical significance. It means, of course, that one can make no better prediction of the stage of voice development if age alone is known than can be made if only the stage of pubic development is known, or vice versa. A study of Table VIII will make this point more clear.

It can readily be seen that age alone is not responsible for change of voice (there are 11 prepubescent boys in the fifteen-year-old group whose voices are still in the process of change); nor is pubic development alone indicative of voice change, as can be seen in the case of the 44 postpubescent thirteen-year-old boys of whom only 18 per cent have adult voices.

D. Frequency of voice breaks.

So much has been said in speech and psychological literature, especially the latter, about the frequency of voice breaks, that it was with distinct surprise that this observer noted only four breaks (one boy experienced two of these breaks) during the entire course of listening to 1,014 boys read for an average of about five minutes each. A little simple arithmetic reveals an approximate total reading time of 84 hours for the entire group. Only four breaks in 84 hours of reading are certainly fewer breaks than earlier literature (and tradition) would have suggested.

TABLE XIII

Record of voice breaks during reading

<table>
<thead>
<tr>
<th>Age group</th>
<th>Number showing breaks</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>232</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>235</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>229</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>135</td>
<td></td>
</tr>
</tbody>
</table>

Table XIII shows that no breaks occurred in age groups 11, 12, and 15, that two boys in age group 13 experienced breaks, and that one boy in age group 14 experienced a break.

True, the reading technique may not be the best technique for observing breaks in a boy's voice. Perhaps the best method would be to follow a boy throughout each entire day for a week so that he
might be observed through a variety of situations, but it is questionable what results such a method would produce. Time was spent sitting through several class hours listening for breaks, but none was observed. Perhaps even that situation is slightly artificial. In any case, the logical technique that presented itself for this study was one that would give the subject opportunity to exercise his vocal organs uninterruptedly for a period of time.

The next question, then, was how often the boy himself had been aware of breaks, if at all. Each boy was asked if he had ever experienced any voice breaks, and if so, how frequently. In Table XIV are shown the percentages of boys who could remember having, at one time or another, been conscious of breaks. The per cent of "no" answers are shown in column 3. Columns 4, 5 and 6 present a breakdown of the "yes" answers in respect to frequency of breaks.

TABLE XIV

<table>
<thead>
<tr>
<th>Age group</th>
<th>Has voice ever shown breaks?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>11</td>
<td>164</td>
</tr>
<tr>
<td>12</td>
<td>232</td>
</tr>
<tr>
<td>13</td>
<td>215</td>
</tr>
<tr>
<td>14</td>
<td>228</td>
</tr>
<tr>
<td>15</td>
<td>185</td>
</tr>
</tbody>
</table>

Record of answers given by subjects to the question: Has your voice ever shown breaks?

It will be noticed that only in age group 15 have the majority of the boys experienced breaks, and then only slightly more than 50
per cent of them. This would seem to argue against the impression
that most authors try to leave with the reader, i.e., that voice
breaks in the adolescent are a common occurrence.

It must be recognized, of course, that this evidence is good
only so far as the memory of the subject is to be relied upon. But
it must also be recognized that these memories are relatively recent
and should therefore more likely be remembered.

E. Voice breaks in relation to the stage of voice development.

Which group of boys shows the greatest tendency to experience
voice breaks? Is it the group whose voices have not yet begun to
change, the group whose voices are in the process of changing, or is
it the group whose voices have changed? Table IV is an analysis of
the data in an effort to answer these questions. To make the per-
centages more meaningful, the same divisions of age groups have been
retained and each age group has been further divided in the three
stages of voice change.

Table IV answers the question, "How many voice breaks are
shown by boys of different ages and of different voice levels?"
It will be noticed that some boys—a total of 5.52 per cent of all
boys—experienced breaks in the voice (according to their own re-
ports) even before the voice begins to show change. The boys in the
process of voice change reported considerably more experience with
breaks, in this instance 35.67 per cent of them. In group 5, the
boys whose voices have completed the change, a majority (56.74 per-
cent) reported having at one time or another experienced breaks.
However, a percentage of 59.74 is not a large majority, and, although it must be agreed that, according to the reports of the boys themselves, voice breaks are a common occurrence, when we consider the number of boys who do sometimes in their adolescent period experience

**TABLE XIV**

<table>
<thead>
<tr>
<th>Age</th>
<th>Voice group</th>
<th>N</th>
<th>Has voice ever shown breaks?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Once or Twice</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>59</td>
<td>95.61</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>33</td>
<td>82.80</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2</td>
<td>90.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>45</td>
<td>95.66</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>181</td>
<td>71.68</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6</td>
<td>66.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>16</td>
<td>91.44</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>182</td>
<td>65.04</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>8</td>
<td>62.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>4</td>
<td>50.00</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>173</td>
<td>58.39</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>48</td>
<td>43.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>1</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>103</td>
<td>55.34</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>61</td>
<td>35.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>127</td>
<td>94.49</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>744</td>
<td>66.15</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>145</td>
<td>41.26</td>
</tr>
</tbody>
</table>

Percentage distribution of answers to the question: Has voice ever shown breaks? Distributed according to stages of voice change.

To break the data down, we must still withhold judgment of "common experience" until the data have been more fully analyzed. As can be seen by referring to Table XIV, there are three categories of "yes" answers: (1) once
or twice, (2) three to five times, and (3) often. When the subjects were asked if they had ever (as far as they could remember) experienced voice breaks, the most frequent answers in the "yes" category were, "Yes, once or twice." A few boys reported that they had experienced breaks four or five times. Only 15 of the 1,014 boys (or 1.5 per cent) interviewed reported that they had often experienced breaks.

It is with the frequent experiences in voice breaks that the writers on adolescent psychology seem to be concerned, for it seems reasonable to assume that there would be little "strain and stress" on a boy whose voice break so infrequently that he could remember only one or two breaks. The statement of the writers who say that the voice breaks "easily," "frequently," "often," are not substantiated by the findings of this study which shows that only 1.5 per cent of all the boys studied experienced frequent breaks. A glance at the totals of Table XVI will show that not more than 3.50 per cent of all the postpubescent boys ever experience frequent breaks.

In order to determine the relation between pubic development and voice breaks in the group studied, a distribution was made in Table XVI of the reported occurrence of breaks in the three stages of physiological change in each age group.

It is interesting to note in the last two tables that it is the boys who mature later, age groups 14 and 15, who seem more likely to have experienced voice breaks. As has already been pointed out, voice change seems to be dependent on both age and physiological development. Voice break may occur before, during, or after the
TABLE XVI

<table>
<thead>
<tr>
<th>Age group</th>
<th>P.D.</th>
<th>N</th>
<th>No</th>
<th>Once or Twice</th>
<th>Three to Five Times</th>
<th>Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>1</td>
<td>151</td>
<td>67.42</td>
<td>11.26</td>
<td>1.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>100.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>183</td>
<td>79.25</td>
<td>15.12</td>
<td>7.65</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>36</td>
<td>61.11</td>
<td>22.22</td>
<td>15.67</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>18</td>
<td>76.52</td>
<td>23.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>102</td>
<td>68.63</td>
<td>21.57</td>
<td>9.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>69</td>
<td>72.46</td>
<td>21.73</td>
<td>5.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>44</td>
<td>56.22</td>
<td>36.36</td>
<td>4.56</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>51</td>
<td>70.69</td>
<td>19.31</td>
<td>7.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>74</td>
<td>54.06</td>
<td>32.43</td>
<td>10.51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>103</td>
<td>49.51</td>
<td>38.82</td>
<td>10.66</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>11</td>
<td>78.73</td>
<td>27.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>27</td>
<td>59.26</td>
<td>40.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>147</td>
<td>43.56</td>
<td>51.02</td>
<td>2.04</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>496</td>
<td>73.51</td>
<td>15.25</td>
<td>6.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>209</td>
<td>62.68</td>
<td>27.75</td>
<td>8.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>307</td>
<td>49.53</td>
<td>42.67</td>
<td>8.56</td>
<td></td>
</tr>
</tbody>
</table>

Percentages of reported voice breaks distributed according to pubic development.

Voice has changed. It is therefore logical to suppose that the older and more mature boys will have experienced the greater number of breaks. Tables XIV and XVI bear out this assumption, since both tables show a progressive decline in the per cent of "no" answers from age group 11 through age group 15.

E. Feelings of embarrassment caused by voice breaks.

As has been pointed out earlier, some writers have insisted that voice breaks are almost invariably accompanied by great
embarrassment. Inasmuch as this concept seemed to be so prevalent, it was undertaken in this study to find out how many boys who reported the occurrence of breaks experienced a feeling of embarrassment when the breaks occurred. Table XVII presents the distributions according to age groups.

TABLE XVII

<table>
<thead>
<tr>
<th>Age group</th>
<th>N</th>
<th>No, but not much</th>
<th>Yes, a little</th>
<th>Yes, very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>154</td>
<td>92.21</td>
<td>7.79</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>232</td>
<td>96.66</td>
<td>7.76</td>
<td>5.17</td>
</tr>
<tr>
<td>13</td>
<td>215</td>
<td>79.97</td>
<td>11.16</td>
<td>9.30</td>
</tr>
<tr>
<td>14</td>
<td>228</td>
<td>76.32</td>
<td>9.77</td>
<td>14.04</td>
</tr>
<tr>
<td>15</td>
<td>185</td>
<td>75.66</td>
<td>9.19</td>
<td>14.85</td>
</tr>
</tbody>
</table>

Percentages of each answer concerning the amount of embarrassment, if any, for each age group.

In no age group did as many as 25 per cent of the boys report any embarrassment, and in only a few cases did boys testify that they felt extreme embarrassment. Age group 14, which has a high percentage of "yes" answers, is an example in point. Of the 228 boys in that age group, 127 reported that they had never experienced breaks (Table XIV). Out of the remaining 101 boys who did remember breaks, 47 reported no embarrassment, 20 reported, "Yes, I felt some embarrassment, but not much"; 52 reported, "Yes, I was a little bit embarrassed"; and only 2 boys reported extreme embarrassment.

The question concerning the kinds of situations that people
are more prone to remember is still highly controversial, but most writers are agreed that emotion is a factor in memory. Dudycha and Dudycha point out that "... the significance, meaning or value which the experience has for the child at the time is a determining factor." They found further, that emotional episodes involving fear were most frequently remembered.

Wohlgezsmuth does not go so far as the Dudychas in stating that unpleasant experiences are best remembered; on the contrary, he says that "... it can be safely concluded that there is no difference whatever between the two feeling-tones, pleasure and unpleasant, in their influence upon memory."

Embarrassment is an emotional state. As an emotional experience it will likely be remembered. If voice breaks cause embarrassment, and if, in addition, the reaction of the listener is to ridicule the boy who experiences the break—as we are led to believe—then the boy would be likely to remember the voice breaks that he has experienced. If, however, the breaks caused no embarrassment, the boy would be more likely to forget having experienced many breaks.

According to Table XVII, fewer than 25 per cent of the boys in any age group who experienced breaks reported that voice breaks caused them embarrassment. That may be one reason why more boys did not report having experienced breaks; for since the breaks they may

have had caused them no embarrassment, the boys may have forgotten
them. By the same token, the degree of embarrassment no doubt had
its effect on memory for breaks, so that those boys who were only
slightly embarrassed tended to remember fewer incidents of voice
breaks than the boys whose embarrassment was great.

It may be safely concluded that since fewer than 25 per cent
of the boys recalled being embarrassed in any degree by the voice
breaks they had experienced, and since of that number only a very
small per cent reported very much embarrassment, the occurrence of
voice breaks is probably not so potent a factor as has been supposed
in determining the personality of the adolescent boy. For, certainly,
if of the boys who remembered having experienced voice breaks, about
half of them failed to recall being embarrassed by the episode, it
may be concluded that it had little, if any, effect on their
personalities.

It should be recalled, too, that the investigator heard only
four breaks in more than 84 hours of reading time for 1,014 boys.
SUMMARY AND CONCLUSIONS

The problem as originally set up was to determine the relationship of pitch level (childish voice, adolescent or changing voice, and male adult voice) and voice breaks to pubic development and to age; to make a survey, both observational and retrospective, of the number of boys who experience voice breaks; and to attempt to determine the effects of voice breaks on the boy's behavior.

The boys studied were from the secondary school systems of Baton Rouge, Louisiana, and Greenville, Mississippi. All boys in the fifth grade and above who had passed their eleventh birthday but not yet attained their sixteenth birthday were used in this study.

In summary, it may be stated that this study indicates:

1. The onset of greatest change of voice depends somewhat on chronological age. The percentage of boys in the process of voice change rises from 60 per cent in the eleven-year-old group to 83 per cent in the thirteen-year-old group. It drops to about 56 per cent in the fifteen-year-old group.

2. Some boys (1.29 per cent) have adult voices at age eleven, but the first great shift in the direction of adult voice occurs at age 14 when the percentage jumps from 3.72 with mature voices in the thirteen-year-old group to 20.17 per cent in the fourteen-year-old
3. The onset of greatest voice change depends somewhat on pubic development. Almost 23 per cent of all the prepubescent boys observed still had childish voices, while slightly less than two per cent of them had changed voices. But 75.5 per cent of the prepubescent boys used in this study were in the period of voice change.

4. At the pubescent level, 39 per cent of the boys were in the process of voice change, while slightly more than five per cent still had childish voices and an equal per cent had mature voices.

5. Age and pubic development are about equally reliable as indices of the stage of voice development; the respective correlations being .65 and .68.

6. During the period of observation, a surprisingly small number of voice breaks were noted. Only four breaks occurred in a total reading time of more than 84 hours for the 1,014 boys in this study.

7. According to the reports of the boys themselves concerning the voice breaks they remembered having experienced, breaks may occur at any of the age levels investigated in this study. There is a gradual increase in the boys reporting voice breaks, consisting of from slightly more than 12 per cent in the eleven-year-old group to slightly less than 51 per cent in the fifteen-year-old group.

8. Memories of one or more breaks were reported by 5.52 per cent of the boys whose voices had not yet begun to change, by slightly less than 34 per cent of the boys whose voices were in the process of changing, and by almost 49 per cent of the boys whose
voices had completed the change. The group of boys who reported the
greatest percentage of frequent breaks (4.2 per cent) was the group
whose voices had changed.

3. Of the prepubescent boys, 21.49 per cent reported that
they recalled having experienced breaks, 37.32 per cent of the
pubescent boys reported memories of breaks, and 51.47 per cent of
the postpubescent boys remembered having experienced voice breaks.
A greater percentage of the postpubescent boys reported frequent
breaks (3.58 per cent) than either of the other two groups.

10. Undue embarrassment is not a frequent concomitant of
voice breaks. Of 674 boys who reported having experienced breaks,
317 boys (47 per cent) testified that they remembered some feelings
of embarrassment caused by voice breaks. Of the 317 reporting
feelings of embarrassment, 91 said, "Yes, but not much"; 90 said,
"Yes, I was a little bit embarrassed"; but only 6 boys reported
extreme embarrassment.
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BIOGRAPHY

Charles Paul Pedrey was born on February 6, 1905, in the province of Tyrol, Austria-Hungary. In November, 1912, he arrived in New York City with his mother and brothers and sisters to join his father, who had preceded them to America and settled in Rock Springs, Wyoming. He received his primary and secondary school education in Rock Springs, his Bachelor of Arts degree from Cornell College in Mt. Vernon, Iowa, in 1929, and his Master of Arts degree in Speech from the State University of Iowa in Iowa City, Iowa, in the summer of 1934.

After five years of teaching in the State of Iowa (1929-1934) he went to Greenville, Mississippi, to teach speech in the junior and senior high school. For the past two years he has been on leave of absence from Greenville to continue work toward the doctorate in Speech at Louisiana State University.
EXAMINATION AND THESIS REPORT

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Major Field: Speech

Title of Thesis: A Study of Voice Change in Boys Between the Ages of 11 and 16

Approved:

Claude E. Kantner
Major Professor and Chairman

Dean of the Graduate School

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