STUDIES IN RESPIRATION AND PERSONALITY

1. A Preliminary Modification of Clausen's Respiratory Neuroticism Scale

By

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Preface

The present paper is the first in a series of working papers entitled Studies in Respiration and Personality. The series represents an attempt to cover by empirical studies some of the main propositions and viewpoints launched in an earlier monograph called Thus Speaks the Body - Attempts toward a Personology from the Point of View of Respiration and Postures.

The study to be reported in this paper was done at the Menninger Foundation, U.S.A. I am greatly indepted to Dr. Gardner Murphy for his interest and encouragement and for his generous help and support in making the study possible. I would also like to express my deep appreciation to Mr. Charles Snyder for his excellent technical assistence and his many helpful and thoughtful comments and suggestions. The writing up of the report was done in part of the Menninger Foundation and in part at the Institute for Social Research in Oslo - through a grant from the Norwegian Research Council for Science and the Humanities.

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B. C.

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INTRODUCTION

The idea that a relationship exists between respiration and mental functioning can be traced far back in human history. According to medieval superstition, the central tendon of the diaphragm, the main respiratory muscle, is both the center of all emotions and the seat of the soul. In fact, the term psychology itself derives from a Greek word that originally meant the vital breath.

In a book first published in London in 1840 entitled "A Narrative of the Treatment Experienced by a Gentleman during a State of Mental Derangement", the author, John Perceval, states confidently his belief that mental illness and health are closely connected with respiratory processes. He writes:

> "... I suspect the health of the mind and the health of the body, particularly the operation of the lungs ... to be essentially connected. I believe the healthy state of the mind depends very much upon the regulation of the inspiration and expiration .... that in controlling the spirit you must control your respiration." (p. 271)

Perceval questions "whether the operations of the conscience and reflection can be conducted but through the medium of lungs", and he asserts that he has found "a well-regulated breathing (to) be essential to bodily health and mental restoration". He even goes so far as to suggest that effecting respiration by mechanical means, without the control of the muscles by thought, may give much relief and be profitable to the health of the mental faculties. He sums up his propositions in the following way:

> "... a healthy state of the mind is identical with a certain regulated system of respiration, according to the degree of bodily action ; ... (and) the exercise of reflection and of conscience, in the control of passions or affections of the mind, is concomitant with, or effected by a proper control of the respiration ..." (p. 273).

Perceval's narrative, published more than 120 years ago, would not have attracted much interest today if it had not happened that some of his ideas about mental illness correspond rather closely to important trends in modern psychodynamic thinking. To this effect everybody is in a position to check since his book was republished only a few years ago (1961).

Perceval's conception of the role of respiration in mental illness has been taken over by a number of later investigators. For instance, Kempf (1930) writes: "We are all well aware that we are often able to read character and personal attitudes and affective disturbances by the manner in which people breathe...". Sutherland, Wolf and Kennedy (1938) even assert that a glance at a patient's pattern of respiration "is an objective gauge of a patient's mental state .... a convenient and easy method by which to follow a patient's progress in a simple and time-saving manner". Reich (1942) maintains that psychological disorders are regularly accompanied by respiratory inhibitions. Braatöy (1954) follows the same line of thought, stating: "...the patient's breathing is the best index in gauging his emotional state".

A more detailed review of these latter viewpoints has been presented earlier (Christiansen 1963). A common denominator of these investigators is their clinical background and the rather non-systematic nature of their empirical observations. However, they are presenting us with a challenging hypothesis that can be submitted without too much difficulty to scientific scrutiny.

At this point we would like to mention that several researches working in the area of experimental animal neuroses have noted that neurotic behavior is accompanied by respiratory changes. Anderson and Liddell (1935) enphasize the occurrence of respiratory irregularities in sheep ; Anderson and Parmenter (1941), the occurrance of rapid and shallow breathing and slow breathing in which apneic pauses are frequent, while Garett (1944) differentiates between various forms of neurotic respiratory activities in dogs - between rapid, stereotyped, noisy and slow-labored breathing.

In the present monograph we will focus our attention on the problem to what extent it is possible on the basis of respiratory indices alone to discriminate between psychiatric patients and normals. We are not the first ones to pursue this problem. It was taken up for empirical analysis by two Norwegian psychologists in the forties. Both investigations (Haavardsholm, 1946 ; Clausen, 1951) were undertaken with the aim of throwing light on whether such broad nosological groups as normals, neurotics and psychotics show any significant differences in respiratory pattern. Haavardsholm's study made use of EMG recordings from above the Xiphoid process, while Clausen's study was focussed upon respiratory movements - pneumographically recorded. Both studies were empirical ones, exploratory in nature. The results emerging from them, although internally consistent, are suggestive rather than conclusive. Their results are all in need of retesting and independent validation.

In the following we are going to concentrate on Clausen's study exclusively.

The present monograph is devided into two parts. In the first part is presented a brief survey of Clausen's main empirical findings and some of the methodological shortcomings characterizing his study. On the basis of this discussion we are putting forward several suggestions regarding modifications in respiratory variables to be studied and in the method by which they should be recorded.

In the second part we shall present the results of an empirical investigation. Although we would like to emphasize the systematic nature of the study, it is rather modest in scope. It is not a replication of Clausen's investigation, but a continuation of and a sort of modified retesting of some of the hypotheses emerging from his work. Briefly, the main purpose of our study is to find out whether more extensive empirical inquiries in this area of research should be encouraged or dropped.

CLAUSEN'S INVESTIGATION, A BRIEF REVIEW OF FINDINGS AND METHODS

Clausen's study, growing out of ideas and thoughts extensively harbored by Norwegian psychoanalytic circles (cf. our previous quotation from Braatöy), is one of the most comprehensive psychological investigations made so far of respiratory differences between various groups of subjects. It is focused on a comparison of respiratory curves - simultaneously recorded from thorax and abdomen - of neurotics, psychotics, and normals - of both sexes. Altogether Clausen made recordings of 50 normals, 40 neurotics and 49 psychotics. His comparisons involve a large number of variables: the rate, the variability of the rate, the inspiration-expiration ratios of the thoracic and abdominal respiratory curve, the variability of these ratios, the size of the thoracic and abdominal amplitudes, the smoothness and regularity of the respiratory curves, the occurrence of pauses, the shape of the inspiration-expiration transitions of the thoracic and abdominal curve, the shape of the thoracic and the abdominal inspiration and expiration curve, and the relationship between the thoracic and abdominal amplitude and the relative sharpness of their peaks.

Clausen's empirical data reveal several differences between males and females: 1) the respiratory rate tends to be faster in females than in males; 2) the I/E ratio - both from the thorax and the abdomen - tends to be higher in males than in females; 3) while females have a tendency to show larger thoracic than abdominal amplitudes, the opposite is true in males; 4) the variability of the rate and also of the abdominal I/E ratio, tend to be higher in females than in males.

Without underrating the significance of sex differences, the largest part of Clausen's analysis and the part he obviously considers most important - is the comparisons between nosological groups. To a very large extent these differences cut across the sex-differences noted. In the course of his data analysis he describes a number of potentially differentiating factors: 1) normals show slower respiration rate than neurotics and psychotics; 2) normals tend to show less variability in rate than mental patients; 3) although no group differences are apparent in terms of the mean I/E ratio, patients tend to show somewhat greater variability in the I/E ratio, 4) pronounced irregular respiratory amplitudes are obtained from some patients, but never from normals; 5) while the majority of normal subjects show a sharper thoracic than abdominal transition, this is practically never found among mental patients; 6) while a great many patients show triangular abdominal peaks practically no normals show this characteristic; 7) while a few psychotics show dissociative movements of thorax and abdomen, this is absent in normals and neurotics; 8) while a fair proportion of normal males show a large thoracic amplitude, in the other male groups, this is true for only a few or none at all; 9) compared to normal females, neurotic females more often show extreme thoracic breathing; and 10) compared to the other female groups, psychotic females generally show larger abdominal amplitudes.

A most interesting aspect of Clausen's study is his attempt to formulate a sort of a sign scale by which normals and neurotics can be operationally differentiated. Altogether, he suggests 12 differentiating signs for males and 10 for females. By giving the signs with a seemingly marked differentiating power, a weight of two, and the rest a weight of one, he arrives at a male scale with a potential range of scores from 0 to 20, and a female scale with a range from 0 to 16 points.

The scales consist of the following items:

Males	Females
1. Respiration rate faster than 14.5 cycles per minute (2 pts)	1. Respiration rate faster than 15.8 cycles per minute (2 pts)
2. Respiration curve irregular (1 pt.)	2. Respiration curve irregular (1 pt.)
3. Dissimilarity between recordings (2 pts).	3. Dissimilarity or somewhat dissimilarity between recordings (1 pts.)

Males	Females
4. Size of thoracic amplitude small (1 pt.)	4. Thoracic inspiration notably convex (1 pt.)
5. Thoracic inspiration notably convex (1 pt.)	5. Abdominal inspiration rectilinear (2 pts.)
6. Thoracic peaks bell-shaped (2 pts).	6. Abdominal peaks triangle-shaped (2 pts).
7. Thoracic inspiration-expiration neither sharp nor blunt (1 pt).	7. Abdominal inspiration-expiration transition sharp (2 pts).
8. Abdominal amplitude small (1 pt), if very small (2 pts).	8. Abdominal peaks sharper than thoracic peaks (2 pts).
9. Abdominal inspiration rectilinear (2 pts).	9. Abdominal expiration slightly concave (2 pts).
10. Abdominal peaks triangle-shaped (2 pts).	10. Abdominal amplitude greater than thoracic amplitude (1 pt).
11. Abdominal inspiration-expiration transition sharp (2 pts).	
12. Abdominal peaks sharper than thoracic peaks (2 pts).	

Rescoring his records according to these criteria, he arrives at the following means for his various groups of subjects:

	Males	Females
Normals	3.60	1.80
Neurotics	10.65	8.10
Psychotics	9.00	6.66

Even more revealing than the means is the distribution of scores. He finds that 75 per cent of neurotic males and 70 per cent of neurotic females fall outside the range of variation of their respective control groups. In spite of the _ex post facto_ nature of the scale constructions, this is still, of course, a most remarkable finding.

Clausen is fully aware that his signs are in need of an independent cross-validation. He attempts an indirect approach to the problem by comparing his psychotic group with his normal and neurotic samples. Since no initial effort was made to construct the scale so as to differentiate between normals and psychotics, the fact that he finds the psychotic group to show average values much closer to the neurotic than to the normal group provides some support of the validity of the scales. But Clausen does of course, emphasize that more systematic studies are called for.

Studying the scales carefully, we notice that the various items are not completely independent of each other. Items number 5, 6 and 7 on the male scale are closely interwoven. Thoracic peaks being bell-shaped (item number 6) implies that the inspiration-expiration transition is neither sharp nor blunt (item number 7) and also that the inspiration curve is notably convex (item number 5). On the other hand, we _may_ find in individual cases that the inspiration curve is notably convex and at the same time, that the inspiration-expiration transition is sharp or blunt.

We are confronted with a similar inter-dependence between item numbers 9, 10 and 11. Abdominal peaks being triangle-shaped implies that the abdominal inspiration-expiration transition is sharp and that the abdominal inspiration curve is rectilinear. It is true that the inspiration curve may be rectilinear without the peaks being triangle-shaped or the transition being sharp, and that the transition may be sharp without the peaks being triangle-shaped. However, if item number 12 is true for a given respiratory record, it is most likely that also item numbers 6 and 10 are true.

Turning to the female scale, we notice an interdependence between item numbers 5, 6, 7, 8 and 9 in the sense that if item number 6 is true, then item numbers 5 and 7 will also be true, and if item number 9 is true, then most probably item number 7 will be true. In the same way as was the case with the male scale, if the abdominal peaks are sharper than the thoracic ones (item number 8), it is likely that the thoracic inspiration curve is notably convex (item number 4) and that the abdominal inspiration-expiration transition is relatively sharp (item number 7).

Although the scales would have been more reliable and more elegant had all the items been completely independent of each other, we don't think this represents any really serious weakness. The thing that is a serious weakness, is the lack of a clear definition of several of the items.

Item no 1 on both the male and the female scale refers to the rate of breathing. This is the respiratory variable most frequently studied in psychophysiological investigations. The main reason for this is probably the ease with which it can be measured in an objective manner.

When included in Clausen's scales it indicates that it has been found to show some discriminatory power. What is of particular interest here, however, is that it is the only item in Clausen's scales where exact and quantitative scoring criteria are provided.

Item no. 2 on both scales refers to the irregularity of the respiratory curve. This item is obviously in need of greater precision. We are confronted with several forms of potential irregularities, with irregularities regarding rate, cycle shape, inspiratory quotient, expiratory position, etc. The present item may be interpreted as reflecting the assumption that a high intercorrelation exists between various irregularity measures. In fact, Clausen notes that he has found the variability of the thoracic rate, the abdominal rate, the thoracic I/E ratio, and the abdominal I/E ratio to be closely related. However, what is implied by the term irregularity in the present context seem to be amplitude variability. In the estimation of regularity, Clausen states, it is the regularity of amplitudes that is the basic factor for the simple reason that in an inspection of the curves, irregularity of amplitude is easier to detect than irregularity of frequency. Given such a qualification, we are of course, still far from knowing exactly when we are and when we are not confronted with an instance of respiratory irregularity.

Item no. 3 on both scales refers to dissimilarities between recordings. Clausen specifies the number of recordings to five, but avoids completely to make explicit which variables should be compared and how large differences should be required. The item in question can be interpreted as referring to all the other scale items. It is more related to the question of the scale's retest-reliability than to an intrinsic property of the respiratory pattern at any given time. When included in the scale it reflects a point strongly emphasized by Clausen, namely that the assessment or scoring of an individual respiration movements should be based upon data derived from several recording sessions. This we believe to represent a sound theoretical position. As regards "dissimilarities between recordings" we don't consider this a suitable item for a respiratory scale. We would rather say that it points to an empirical hypothesis that should be tested by such a scale.

Items no. 1 to 3 are alike on both scales. Turning to the remaining items we are confronted with new problems. What is meant by the thoracic amplitude being small; that the thoracic inspiration curve is notably convex; that the thoracic peaks are bell-shaped; that the thoracic inspiration-expiration transition to neither sharp nor blunt; that the abdominal amplitude is very small? Without explicit definitions of these items, we are somewhat in the dark as how to make use of the criteria.

Clausen refers to the scales as being based partly on clinical judgment. We don't doubt that Clausen, after having observed a large number of respiratory records, established an internal frame of reference enabling him to differentiate between large and small amplitudes, sharp and blunt transitions, notably convex and not notably convex inspirations, etc. What we doubt is that another person looking at a similar number of records would arrive at exactly the same norms and reference points. Naturally, the time factor involved in such a procedure would also have to be considered.

We don't object to the use of clinical judgment where objective measurements are impossible. In fact, since Clausen was working with pneumographic recordings he had to make use of qualitative judgments to a certain degree, if he wanted at all to dig into the issues in question. Although we think it is possible to formulate clearer definitions of several of the scale items than those offered by Clausen, we still consider his scale as an important first step into a very facinating area of somatic psychodiagnostics.

A great problem that confronted Clausen in his data analysis was the lack of accuracy of his amplitude measurements due to technical shortcomings of his recording technique. He comments upon this issue himself, as follows:

> "Pneumographic recording of the respiratory movements is sufficiently accurate for those features that can be determined from measurements of horizontal distances in the curves ... Data based on the amplitudes of the curves, i.e. data indicating the depth of respiration, are not sufficiently accurate to be subjected to statistical analysis. An amplitude of a particular magnitude will denote an entirely different respiration volume depending upon the size and shape of the thoracic surface. Other difficulties which make us cautious in interpreting the amplitudes quantitatively are of more mechanical nature, such as keeping the tension of the rubber membranes constant when they have to be replaced from time to time, and recognizing the non-linear relation between the amplitude and the air-pressure on the membrane." (p. 21).

Since the time of Clausen's study a number of more refined recordings technique have been introduced. One technique that have been extensively used in recent years is the electrical strain gauge method of Whitney (1953), modified for respiratory recordings by Achner (1956).

The principle behind this method is to record the changes in electrical resistance occuring in a mercury column, filling up completely the bore of a thin rubber tube, the tube itself being fastened around the body part to be measured. Stretching the tube lengthens and narrows the mercury column, with resulting increase in its electrical resistance. The changes in resistance of the gauge can be followed continuously by making the mercury-filled tube one element in an electrical bridge circuit, the bridge being powered by a battery, and the changes in the balance of the bridge being amplified and recorded through a polygraph.

The strain gauge method can be made very sensitive. Furthermore, it is much less cumbersome than a conventional pneumograph and has the great advantage of to a much lesser extent drawing the subject's attention to his respiration, the restriction imposed by the method during inspiration for instance, being practically unnoticable by the subject. However, what is of even greater importance is the possibility of calibrating the method in such a way that the recorded curves can be converted into absolute measures of respiratory circumference changes.

Briefly, by means of modern recording equipment it is possible to make quantitative studies of some of the variables that previously (e.g. in the case of Clausen's study) had to be left over to clinical judgment. (This is true in particular for Clausen's scale items referring to amplitude size, i.e., to item numbers 4 and 8 on the male scale and to item number 10 on the female scale, but does also apply to measures of terminal or expiratory positions and to variations in all of these measures.)

As regards the scale items referring to the shape of the peaks, the form of the inspiration curve, and the sharpness of the inspiration-expiration transition; we are confronted with problems of definitions as well as with problems of measurement. How large a part of the respiratory cycle should be considered as belonging to the peak and how large a part to the inspiratory-expiratory transition? Is the inspiration curve to be defined as going the whole distance from the trough-point to the peak-point? We could continue to state a number of such questions. Before defining the concepts involved, it is, of course, impossible to start formulating any specific scoring criteria.

A higher-order item in both the male and female scale is the item referring to the abdominal peaks being sharper than the thoracic ones. At a first look this item appears to be quite easy to judge on a reliable basis from respiratory records. However, a question of definition is involved here, too. The sharpness of respiratory peaks will to a large extent depend upon the magnification used in the recording process. Given the same respiratory period and the same "real" amplitude, the peaks of the respiratory wave being the most magnified will appear as far the sharpest ones. A basis for comparison can be made by keeping the magnification constant, or by varying the magnification so as to keep the amplitudes recorded constant. Which one of the procedures one decides to make use of will have important consequences on the results one is going to obtain. Clausen's recording procedure probably fell closer to the former than the latter, although he doesn't discuss this problem at all. As it stands, we are rather puzzled how to interpret some of the core items in Clausen's respiratory scales.

From a systematic and scientific point of view, Clausen's scales leave much to be desired. They arouse many questions, but by so doing, they also point out problems for further study. They point out several hypotheses concerning respiratory differences between psychiatric patients and normals. And what is perhaps even more significant, they point out that any one respiratory variable considered alone may be unable to discriminate sharply between psychiatric patients and normals, but that by combining the variables and by focusing on the respiratory pattern at large it may be possible to arrive at very potent indicators or predictors of mental illness.

Suggestions for further research.

The construction of a respiratory neuroticism or psychopathology scale is a very fascinating objective. However, in order for such a scale to serve its purpose it should be based upon well-defined variables that lend themselves to qualifications so that exact scoring criteria (or cut-off points) can be specified.

As a first step in the development of a respiratory scale we would like to state a number of definitions pertaining to various properties of respiratory tracings.

1. By cycle, we refer to the part of a respiratory wave that goes from the beginning of one respiratory upstroke to the beginning of the next.

2. By period, we refer to the number of seconds it takes for a respiratory wave to go through one cycle. (The period is a more convenient measure than rate. The rate is the number of periods occurring in 60 seconds).

3. By amplitude, we mean the vertical distance from the peak of a cycle to a line joining the beginning and end points of the cycle.

4. By inspiratory phase, we refer to the number of seconds the cycle is ascending. (A pause at the peak of a cycle is considered a part of the inspiratory phase, while a pause at the trough of a cycle is considered a part of the expiratory phase).

5. By <u>inspiratory quotient</u>, we refer to the fraction of each period represented by the inspiratory phase. (The inspiratory quotient is a more convenient statistical measure than the I/E ratio. It is defined as I : I + E).

6. By <u>dissynchronization</u>, we refer to the differences in seconds between the beginning of the same respiratory cycle at different parts of the body.

7. By <u>terminal position</u>, we refer to the circumference of the body at the time of the end of a cycle at the place where the cycle is being recorded.

Given the definitions above and a recording procedure providing separate respiratory tracings from the thorax and the abdomen, we end up with the following - what we may call - first order variables:

a. Mean abdominal period (in sec.)
b. Variability (standard deviation) of abdominal period.
c. Mean thoracic period (in sec.)
d. Variability (standard deviation) of thoracic period.
e. Mean abdominal amplitude (in mm.)
f. Variability (standard deviation) of abdominal amplitude.
g. Mean thoracic amplitude (in mm.)
h. Variability (standard deviation) of thoracic amplitude.
i. Mean abdominal inspiratory quotient.
j. Variability (standard deviation) of abdominal inspiratory quotient.
k. Mean thoracic inspiratory quotient.
l. Variability (standard deviation) of thoracic inspiratory quotient.
m. Mean abdominal terminal position (in mm.)
n. Variability (standard deviation) of abdominal terminal position.
o. Mean thoracic terminal position (in mm.)
p. Variability (standard deviation) of thoracic terminal position.
q. Mean abdominal-thoracic dissynchronization (in sec.).
r. Variability of abdominal-thoracic dissynchronization.

It is important to note that we are presupposing that the respiratory tracings are covering a certain time span including several respiratory cycles (if not, it would be meaningless to talk about means and standard deviations). How large a period of time that should be covered is to some extent a matter of choice - the longer the period, the more reliable the mean and the variability measures obtained. On the other hand, the longer the original period, the less increase in reliability is likely to occur if we continue to add a certain interval of time. In Clausen's study the recording period being analyzed consisted of a time-sample of one minute. Another approach of course, would be to concentrate on a certain number of successive respiratory cycles! This would guarantee an equal amount of "raw data" being gathered from each subject and would also simplify considerably the statistical data analysis.

Another point to be noted is that in expressing the period in seconds, the amplitude in mm, and so on, we are presupposing a conversion of the measures appearing on the respiratory tracings into real or actual measures. This can, however, easily be done through calibrations if modern recording equipment is employed.

A special problem is confronting us with respect to the abdominal-thoracic dissynchronization since a certain measure in this area would not tell us whether the thoracic part is preceding the abdominal part or vice versa. In order to settle this problem, we will define the former instance as a negative dissynchronization, and the latter one as a positive dissynchronization.

As regards the variability of the abdominal-thoracic dissynchronization we are a little reluctant in suggesting a particular type of measure. Probably the standard deviation should be substituted by the range on the ground that this latter measure would be more psychologically meaningful.

On the basis of the first order variables specified above, we may derive the following second order respiratory variables:

A. Coefficient of variability-abdominal period (b:a).
B. Coefficient of variability--thoracic period (d:c).
C. Abdominal amplitude in % of abdominal terminal position (e.100:m).
D. Thoracic amplitude in % of thoracic terminal position (g.100:o).
E. Coefficient of variability--abdominal amplitude (f:e).
F. Coefficient of variability--thoracic amplitude (h:g).
G. Coefficient of variability--abdominal inspiratory quotient (j:i).
H. Coefficient of variability--thoracic inspiratory quotient (l:k).
I. Thoracic phase displacement (q:a).
J. Thoracic amplitude quotient (g:e+g).
K. Mean trunk amplitude (C+D:2).
L. Mean trunk amplitude variability (E+F:2).

The way the variables are derived is indicated by the symbols in the parentheses following each variable disignation.

In the case of the variability variables (except for the terminal positions) we are suggesting that the standard deviations should be converted into coefficients of variability. We are here following Clausen's procedure. The reason for this conversion is to arrive at variability measures that are independent of the level measures.

Furthermore, we are suggesting that the absolute amplitude should be supplemented by the amplitude per cent, and the abdominal thoracic dissynchronization, by the thoracic phase displacement. By introducing the amplitude per cent we avoid the argument that the size of an individual's respiratory amplitude to some extent is a function of his body size (or his terminal position), and by introducing the thoracic phase displacement we make sure that an individual's dissynchronization score is independent of his breathing rate.

Having specified a number of respiratory variables that all lend themselves to quantitative analysis, the following question emerge: How many of the variables are new ones in the sense that they were not directly or indirectly made use of in Clausen's study?

Among the 18 first order variables, 10 can be considered new ones, and among the 12 second order variables, all except the variability of the abdominal and thoracic period and the abdominal and thoracic inspiratory quotient can be considered new ones. In our total list of 30 variables, only 12 have been dealt with in Clausen's analysis in one way or another.

To what extent is it possible to reduce the list on the ground that some of the variables are so highly intercorrelated that they don't really provide any independent information?

This question is particularly relevant as regards the parallel measures from thorax and abdomen. For instance, we would assume the mean thoracic and abdominal period to be exactly the same, but also the inspiratory quotient and the variability measures from these two parts may turn out to correspond rather closely. In support of this assumption we may cite the following correlation quotients from Clausen's study:

The correlation between corresponding measures from thorax and abdomen in Clausen's normal groups.

	Males	Females
Mean period	1.00	1.00
Coeff. variability period	.99	.98
I/E ratio	.90	.85
Coeff. variability I/E ratio	.78	.68

It is evident that if correlation coefficients in the nineties are found, parallel measures can be discarded. From the coefficients cited one may in fact question whether it is at all necessary to make parallel recordings from both the thorax and the abdomen. It is important to note, however, that amplitude measures are not included in the table and that it is particularly in this latter area that large inconsistencies are to be expected. It should, of course, also be noted that abdominal-thoracic dissynchronization scores do presuppose parallel measurements.

Talking about amplitude measures we would like to comment upon why we have included variable K - the mean trunk amplitude - in our list of variables. In a sense this variable could be called a third order variable. It has one definite advantantage as compared to the two second order variables from which it is derived. It provides us with a gross measure of tidal air, and by so doing it makes it possible for us to link our theorizing and eventual findings to a number of earlier studies that have been concentrated on this latter measure (this is true particularly of studies making use of a spirometric recording technique).

Obviously, the mean trunk amplitude cannot in any way alone replace the sources of information provided by the abdominal and thoracic amplitude per cent. We may recall for instance, that Clausen considers a low size on either of these variables a psychopathological sign. In order to compensate for this loss of information we have introduced a second variable - J - the thoracic amplitude quotient. We don't know whether variables J and K will show the same discriminatory power as the two other variables. But granted that their discriminatory power should turn out empirically to be practically the same, we would prefer to focus our attention on these latter variables.

As indicated above, through empirical correlation studies our initial list of variables may probably be cut down significantly. We mentioned the possible exclusion of some parallel measures from the thorax and the abdomen, and the possibilities of substituting the mean trunk amplitude and an amplitude quotient for the abdominal and thoracic amplitude per cent. A third type of reduction to be considered is to include in a objective respiratory scale only those variables that show a significant stability over time. What we are referring to is to let a retest-reliability study decide not only which of two highly intercorrelated parallel measures should be included but also whether some variables should be dropped because of their low reliability.

Clausen presents little data concerning the reliability of his various variables, but in a couple of places he mentions that he has made comparisons between the respiratory pattern obtained at various testing sessions. At one place he states:

> "Our results demonstrate clearly that for the normal subjects respiration rate, I/E ratio for thorax and I/E ratio for abdomen are quite stable measures, whereas the variation coefficients seem to vary considerably from day to day. In the male group respiration rate and the two I/E ratios appear to give representative measures form two day's recording, and the same holds true for the female group for both I/E ratios ... The variability... for respiration rate and thoracic and abdominal inspiration-expiration ratio (seems) to be more subject to change from day to day in normals than in neurotics (while the opposite is true regarding the level measures)" (p. 50).

From reading Clausens report one gets the impression that he considers the diagnostic value of his various variation coefficients rather doubtful and that their retest-reliability are unacceptable low, although he does emphazise that any final appraisal would have to await further study.

A final issue to be considered is the question to what extent various respiratory variables are positively interrelated in the sense that they all point in the direction of a uniform dimension or construct. To what extent do Clausen's scales show internal consistency or reliability?

At one place Clausen reports that he has intercorrelated his quantitative variables. He states:

> "The overall tendencies ... are that the two I/E ratios are closely related, and that they are inversely related to the four variation coefficients, and that the four variation coefficients are closely

> related. Duration (the mean period) does not seem to be related to the other measures (except that the thoracic and abdominal periods are completely related) ...." (p. 32)

At another place he states:

> "There is some evidence that the size of the abdominal amplitude is related to the abdominal I/E ratio ..... since the same two diagnostic groups that have sex differences for abdominal I/E ratio ... also showed a difference with regard to the size of the abdominal amplitude". (p. 58)

Thus, one gets the impression that Clausen's respiratory scale may encompass at least two independent underlying dimensions. This being the case we would be confronted with the possibility that respiratory scales may not only provide indications of mental illness generally but of more particular psychological dimensions as well. A respiratory scale may in other words possibly give rise to psychological interpretations concerning various aspects of the personality structure. Any further discussion of this question would have to await a systematic exploration of the interrelationship been present between various respiratory variables.

EMPIRICAL CONTRIBUTIONS

Statement of the problems to be investigated.

In the following chapters we are going to report on a study aiming at the construction of an objective respiratory psychopathology scale. We will take as our point of departure the total list of variables presented earlier. As a first step in our analysis we will attempt to throw light on the following questions: What is the relationship between parallel respiratory measures taken from the thorax and the abdomen? What is the retest-reliability of various respiratory variables? On the basis of our empirical results we will exclude those variables showing an unacceptable low reliability, and in the case of a high intercorrelation between parallel measures, we will exclude those being the less reliable. Consequently, we will end up with a shortened and modified list of variables. As our next step we are going to study each of these remaining variables as to their discriminatory power, their ability to discriminate between psychiatric patients and normal subjects. Those variables not showing any discriminatory abilities will be discarded, while the remaining ones will be included as items in a preliminary scale. In this connection, we would expect our findings to correspond rather closely to some of Clausen's results. Although a correspondence with his results would provide an independent check of the validity of the items, a subsequent cross-validation would still be indicated. This follows from the fact that since Clausen's scales are largely qualitative in nature they don't allow any comparisons in terms of specific scoring criteria.

As the third step in our analysis we are going to look into how well our preliminary scales actually do discriminate between patients and normals. Since this would be an *ex post facto* investigation not too much importance can be ascribed to the results although a high agreement with Clausen's results again would be of considerable interest and indicate that the construction of a quantitative respiratory scale may be possible.

As the final step in our analysis we will study the intercorrelations between our scale items. If we should find a high internal consistency to be present we would be confronted with the possibility that our scale is measuring a psychological variable covered by such terms as degree of psychopathology, ego-weakness, immaturity of ego organization, anxiety, or psychic disorganization. To find out what the scale actually is measuring would imply additional studies but these could take place within a hypothesis testing framework.

Extrapolating from Clausen's results we doubt very much that the scale will turn out as a unidimensional one. By intercorrelating the items we may find that they point in the direction of two or more rather independent dimensions. As in the first instance we would have erected a starting point for further studies. We would be confronted with the task of formulating testable hypotheses concerning the psychological meaning of the dimensions, and subsequently, with the task of testing these hypotheses on empirical data.

Our study is to be considered exploratory in nature, but at the same time as directed by previous findings. It is an attempt to dig a little further into an area that has been touched upon by earlier studies but that is still existing in a rather unexplored state. By studying empirically some problems that have been left over from earlier investigations, we hope to raise new problems that can be attacked empirically in later studies. In this sense, the present paper is not only a progress, but also a process report.

It should be noted that we don't believe comparisons between psychiatric patients and normal subjects to represent any particular fruitful line of research in the long run. However, we do think it represents a possible starting point for clarifying whether respiratory variables are associated with psychological factors or not. Psychiatric patients and non-patients most likely do differ in certain aspects of psychological functioning.

Subjects.

In the study to be described, twelve in-patients and twelve employees of the Menninger Foundation were used as subjects. Each of the groups consisted of six males and six females of approximately the same age. The twelve inpatients covered a wide range in terms of psychiatric diagnosis and personality disturbances. The variation in question is indicated by the following list:

Male patients:

M-1: Infantile personality, weak impulse control.

M-2: Schizoid personality, narcissistic aloofness with dysphoric features.

M-3: Schizophrenic reaction, paranoid type, infantile personality.

M-4: Passive aggressive personality, aggressive type.

M-5: Narcissestic personality, compulsive and hysterical features.

M-6: Inadequate personality, passive-dependent features.

Female patients:

F-1: Dyssocial reaction, personality trait disturbance, masocistric features.

F-2: Manifest homosexuality, narcissistic personality, hysterical features.

F-3: Schizoid personality, complient type with somatization tendencies.

F-4: Schizophrenic reaction, chronic, undifferentiated type, schizoid personality.

F-5: Schizophrenic reaction, paranoid type, schizoid personality with hysterical traits.

F-6: Depressive reaction, hysterical personality.

The patients were chosen with the aim of making a small fairly representative sample of the inpatient population at the Menninger Clinic.

Method.

All S were tested in a standard testing procedure. A nurse acted as experimenter. Each S was told that this was a study of muscular tone or tension and that all he should do was to lie down and relax on a couch for some minutes. The S was asked to remove shoes and loosen any tight garments, and to lie in a supine position with legs straight and arms to the side. Circumference measures were taken at five points with a metric tape measures. Then small rubber tubes were lightly strapped around the same locations:

1. Head - around forehead about 25 mm above eyebrows and back of head, passing just above ears.

2. Thorax - around trunk, just under arms, slightly below manubrium sternum.
3. Abdomen - around trunk, 30 mm above crest of illium.
4. Forearm - around left forearm about 1/3 distance from elbow to wrist.
5. Calf - around left calf about 1/3 distance from head of fibula to lateral malleolus.

The tubes were mercury-in-rubber strain gauges of the type previously described. As mentioned, such tubes can pick up microscopic circumference changes.

The S was asked to lie as comfortable as possible and to indicate when he felt about as relaxed and comfortable as he could under the present circumstances, by resting pasively the weight of his right hand on a button (a telegraph key) placed right besides his hand after he had lied down on the couch. No mention of breathing was made in order to minimize S's awareness and voluntary control of his respiration. The placement of tubes around the S's head, arm and leg had the initial purpose of diverting the S's attention away from his own respiration.[1)]

The recording was started two minutes after the S had indicated "optimal" relaxation, which in all cases was signalled within one minute after the completion of the instructions. After the recording of a sample of 10 successive respiratory cycles, free of movement artifacts, the S was told that the examination was over. He was then released from the equipment fastened to his body. The recording was done by an Offner 6 channel polygraph, placed in another room, and with a paper speed of 5 mm/sec.

Each S in the patient group was tested 3 times, and each S in the normal group twice. The duration of each testing session was 10-12 minutes and the interval between the session 3-4 days.

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1) Later we found out that respiratory circumference changes seem to take place peripherally as well as in the trunk area and that the informations obtained from the peripheral body parts might be a very interesting area of investigation in its own right. (Cfr. Christiansen & Snyder, 1963). In the present report we will focus our discussion on the trunk recordings exclusively.

Scoring procedure.

The sample of 10 respiratory cycles were scored by hand in the following manner. First, both the thoracic and abdominal channels were marked by a short vertical line at each expiratory trough and inspiratory peak. In the case of expiratory pauses, the end of the cycle was considered to occur at the end of the expiratory plateau, i.e. at the beginning of the next inspiration. Next, the beginning points of the abdominal cycles were extended vertically across the other channel. Finally, more or less horizontal lines were drawn in connecting the beginning points of successive cycles for each channel.

Respiratory period was taken in mm. from the beginning to end of each abdominal and thoracic cycle. Mean period and standard deviation were computed for the 10 cycles. The values were then converted to seconds by multiplying by a factor of 0.2 (since 1 mm = 0.2 sec. at the paper speed of 5 mm./sec.)

Respiratory amplitude was measured in mm. from each inspiratory peak vertically down to the baseline (previously drawn in connecting the beginning points of successive cycles) for the 10 cycles of each of the channels. Each of the raw scores were then converted into the actual circumference amplitude (tidal breathing movement) by multiplying with the calibrated sensitivity of each channel. The maximum sensitivity used for both trunk channels were 0.05 mm/mm - a magnification of 20. It should be mentioned that in preceding tests a fairly linear relationship was found between recorded and actual amplitudes.

The inspiratory quotient was computed as the distance of the inspiratory phase divided by the period of each cycle. No conversion of these proportion scores was necessary.

The terminal position is defined as the absolute circumference of the body part at the end of each respiratory cycle (expiratory trough). Our tape measurement of circumference of each part was considered to be "the mean terminal position" in this study. Although it is possible to make and maintain an absolute calibration system on the gauges, it is much simpler to obtain the absolute reference from tape measurement. The error in this method is rather insignificant since the respiratory (tidal) changes in circumference during resting conditions are very small compared to the absolute girth of the part and since it is the relationship between these two measures that is of main concern. In order to obtain data on the variation in terminal position a straight horizontal line was drawn through the lowest expiratory trough and the vertical distances from each of the other troughs to this line measured in mm. If absolute measures should be desired, the vertical distances can be treated in the same way as the recorded amplitudes. Dissynchronization is defined as the time lag between corresponding abdominal and thoracic cycles. - It was measured in mm. from the beginning of the abdominal cycle (previously marked vertically across all channels) to the beginning of each associated thoracic cycle. If the abdominal cycle was found to precede the thoracic one, the dissynchronization was considered positive, while if the opposite was true, it was considered negative. The dissynchronization scores obtained can be converted into seconds or fractions of a second, in the same way as described for the respiratory period.

So far we have focused upon the scoring of our first order variables. This is really the most important step, since our second order variables can be derived from these directly by employing the appropriate formulas previously described.

Intercorrelation between parallel respiratory variables.

Is it at all necessary to obtain parallel measures from both the thoracic and abdominal regions? Of course, the abdominal - thoracic dissynchronization scores implies comparable measures, but what about the period, the amplitude, the inspiratory quotient, and the corresponding variability measures?

The following table attempts to answer this question.

TABLE I

Intercorrelation (r) between parallel measures in first session from thorax and abdomen (N=24).

Variables	r	p (two-tailed)
Mean period	.998	.001
S.D. period	.949	.001
Coeff. variability period	.927	.001
Mean amplitude	.172	n.s.
Amplitude in % of circumference	.208	n.s.
S.D. amplitude	.254	n.s.
Coeff. variability amplitude	.602	.01
Mean inspiratory quotient	.591	.01
S.D. inspiratory quotient	.369	.10
Coeff. variability inspir. quotient	.422	.05
Mean terminal position	.814	.001
S.D. terminal position	.032	n.s.

The table tells us that parallel measures related to the respiratory period are highly correlated. This is true regarding the mean, the standard deviation and the coefficient of variability of the period. Consequently in relation to these variables it may be considered sufficient to obtain data from either the thoracic or the abdominal region.

Also in relation to the mean terminal position we find an extremely high intercorrelation. However, this latter variable is probably not of any particular psychological interest. It is refering to much more structural-anatomical aspects than to any functional or behavioral features. Of greater interest is the complete lack of correlation between the variability of the thoracic and abdominal terminal position. In this latter area, parallel measures would be needed.

Turning to the mean amplitude we find a very low and insignificant correlation. This is the case both when we consider the amplitudes as percentage changes of body circumference and in terms of their absolute size. Again we are confronted with a variable where seperate thoracic and abdominal measures are indicated.

The variability of the thoracic and abdominal amplitudes seems to be more closely related than the size of the amplitudes. The standard deviation of the amplitudes shows lower correlation than the coefficient of variability of the amplitudes. This can be explained by the latter measures being more true measures of variability since they are made independent of the size of the amplitudes. Although the variability coefficients are significantly correlated we don't consider them so closely related that one of the two measures should be discarded.

Looking at the inspiratory quotient we again find measures that are significantly correlated. However, neither the mean inspiratory quotient nor the variability of the inspiratory quotient obtain correlations high enough to indicate that parallel measures are redundant. It is interesting to note that also in this instance do we find the coefficient of variability to show higher correlation than the standard deviation.

Comparing our results with those presented by Clausen (see page 16), we note that our correlations are all lower but that their rank order is very much the same.

In concluding we would like to reemphasize that only with respect to the mean period, the veriability of the period, and the mean terminal position, do we find such a high correspondence between thoracic and abdominal measures that one of the two can easily be discarded. At the opposite pole we have the mean amplitude, the variability of the terminal position, and the variability of the inspiratory quotient. In these instances practically no or a very moderate correspondence exists between thoracic and abdominal measures. As regards the mean inspiratory quotient, and the variability coefficient of the amplitude we are confronted with positive correlations reaching the 1 % level of significance, although the correlation coefficients are not strikingly high.

The retest-reliability of respiratory variables.

To what extent does an individual's respiratory pattern show consistency over time? Is there any difference between various facets of respiration in this respect?

In order to study the reliability of respiratory variables each S was retested 3-4 days after the intital testing session. The table below shows the intercorrelation found between the first and the second testing session with respect to all the 30 variables on which we have concentrated.

TABLE II

Intercorrelation (r) between respiratory measures

Session 1 vs. Session 2 (N = 24).

Variable	r	p (one-tailed)
Mean abdominal period	.80	.001
S.D. abdominal period	.40	.05
Coeff. variability--abd. period	.34	.05
Mean thoracic period	.81	.001
S.D. thoracic period	.56	.01
Coeff. variability--thor. period	.53	.01
Mean abdominal amplitude	.72	.001
Abd. amplitude in % of circumf.	.75	.001
S.D. abdominal amplitude	.61	.01
Coeff. variability-abdominal ampl.	.34	.05
Mean thoracic amplitude	.53	.01
Thor.amplitude in % of circumf.	.55	.01
S.D. thoracic amplitude	.56	.01
Coeff. variability--thoracic ampl.	.60	.01
Mean trunk amplitude (in %)	.75	.001
Mean trunk amplitude variability	.50	.01
Thoracic amplitude quotient	.48	.01
Mean abdominal insp. quotient	.68	.001
S.D.. abd.inspiratory quotient	.19	n.s.
Coeff. variability-abd. insp. quot.	.32	n.s.
Mean thoracic insp. quotient	.50	.01
S.D. thor.inspiratory quotient	.56	.01
Coeff. variability--thor. insp. quot.	.40	.05
Mean abd. terminal position	.99	.001
S.D. abd. terminal position	.71	.001
Mean thor. terminal position	.94	.001
S.D. thor. terminal position	.54	.01
Mean thor. dissynchronization	.62	.01
Thoracic phase displacement	.26	n.s.
Variability thor. dissynchronization	.24	n.s.

The table tells us that large differences exist as regards the retest reliability of various respiratory variables. Although we can not exclude from further analysis all respiratory variables showing less than complete reliability, we still feel that a certain minimum reliability has to be required in order for the variable in question to be of any potential psychodiagnostic interest. As a minimum requirement we would suggest the criterion that the variable's retest correlation reaches at least the 1 % level of significance.

The reliability of the abdominal and thoracic mean period is practically the same. When we look at the period variability, we find the thoracic variable to show somewhat higher correlation than the abdominal one. We have previously concluded that very little seems to be gained by obtaining parallel measures of the mean period and the variability of the period from both thorax and abdomen. Our present results indicate that in chosing between the two types of measures the thoracic variables are the preferable ones.

Turning to the amplitude variables, we find that all, except the coefficient of variability of the abdominal amplitude, satisfies the reliability requirement stated. Since the variability of the abdominal amplitude occurs in a cluster of otherwise acceptable variables, we have decided in this instance to soften the requirement rather than to discard the variable.

It is worth noting that the mean amplitudes in terms of mean percentage changes of body circumference show slightly higher retest correlations than the absolute amplitude measures. It is also worth noting that the reliability of the mean abdominal amplitude seems to be somewhat higher than the thoracic amplitude. The higher reliability of abdominal respiration does also appear with respect to the mean inspiratory quotient, the mean terminal position, and the variability of the terminal position. On the other hand, when we focus on amplitude variability we find the opposite trend. The lower reliability of the abdominal measure corresponds to our earlier finding regarding abdominal - thoracic differences in period variability, and it also corresponds to the finding of a somewhat more reliable thoracic than abdominal inspiratory quotient variability. In summary we may say that our results indicate that for most variability measures, the thoracic measures are more reliable than the abdominal ones, while for most level measures, the abdominal measures seem to be more reliable than the thoracic ones.

Looking a bit further at the inspiratory quotients, we notice that both the thoracic and the abdominal inspiratory quotient variability measures do not reach the reliability level required. Consequently, these variables may be discarded from further analysis. In choosing between the two mean inspiratory quotients (resulting from the fact that these are significantly intercorrelated) the abdominal one appear to be the most adventageous.

As expected, we find both the abdominal and the thoracic mean terminal position to show a high reliability. This is of course a rather trivial finding. Of much greater interest is the reliability of the terminal position variability measures. Somewhat surprisingly we here find the abdominal variability to show the highest retest correlation. This is in contrast to the trend previously noted. A possible explanation is that the degree of terminal position variability is rather closely related to amplitude size.

Turning to the last group of variables, we find the mean thoracic phase displacement to show a substantially lower reliability than the mean thoracic dissynchronization.[1] This is a rather interesting finding. As previously mentioned the former variable was introduced in order to make the latter variable independent of the respiratory rate. Our results show that neither the thoracic phase displacement nor the variability of the thoracic dissynchronization do reach an acceptable level of retest reliability. Thus these two latter variables may also be discarded from further analysis.

Taking into consideration our findings both regarding parallel measures from thorax and abdomen, and the retest-reliability of the various measures, we end up with the following list of acceptable variables:

1. Mean thoracic period.
2. Coeff. variability - thoracic period.
3. Mean abdominal amplitude - in % of abd. circumference.
4. Mean thoracic amplitude - in % of thor. circumference.
5. Coeff. variability - abdominal amplitude.
6. Coeff. variability - thoracic amplitude.
7. Mean abdominal inspiratory quotient.

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1) Before computing the retest correlation for the mean thoracic dissynchronization we multiplied the original dissynchronization scores by 100, and subtracted or added the product to a constant of 100 dependent upon the sign of the individual score. In this way we avoided having to deal with both a positive and a negative distribution of scores. The same procedure was employed in all instances where correlations of dissynchronization scores were required.

8. Variability abdominal terminal position.
9. Variability thoracic terminal position.
10. Mean thoracic dissynchronization.

As noted in our previous discussion, variable nos. 3,4,5 and 6, may hypothetically be substituted by:

A. Mean trunk amplitude (in %).

B. Thoracic amplitude quotient.

C. Mean trunk amplitude variability.

These latter three variables do all satisfy our reliability requirement.

Before concluding this section we would like to mention the striking correspondence between our own and Clausen's results. He too found the rate to show higher reliability than the I/E ratio, and the I/E ratio to show higher reliability than the variability of the rate and the I/E ratio. He concludes that the retest-reliability of his variation coefficients is unacceptably low. It is interesting to note that nearly all the variability measures we have found acceptable, i.e. the variability of the abdominal and thoracic terminal position, of the thoracic and mean trunk amplitude, were not analysed by Clausen.

Besides mentioning the lower reliability of his variability measures as compared to his level measures , Clausen points out that normal subjects by and large seems to show higher retest-reliability than psychiatric patients. To find out if this is true also in our case, we have computed the correlation between the measures obtained in the two testing sessions for our normal and patient subsamples seperately. Table III presents the results of this analysis.

TABLE III

Rank difference correlation between respiratory measures
Session I vs. Session 2 for each subsample considered seperately.

	Normal group (N=12)	In-patient group (N= 12)
Mean thoracic period	.46	.95
Mean abd. ampl. %	.76	.57
Mean thor. ampl. %	.45	.69
Mean abd. insp. quotient	.76	.61
Mean thor. dissynchronization	.35	.23
Mean trunk ampl. %	.70	.78
Thor. ampl. quotient	.78	.13
Mdn. level measures	.70	.61
Coeff. variabl. - thor.per.	.61	.50
Coeff. variabl. - abd. ampl.	.07	.44
Coeff. variabl. - thor. ampl.	.70	.52
Mean trunk ampl. variabl.	.55	.51
Variabl. abd. term. position	.53	-.22
Variabl. thor. term. position	.20	.75
Mdn. variabl. measures	.54	.51
Mdn. all measures	.55	.52

The table shows that there is an overall tendency for the level measures to show higher reliability than the variability measures, and likewise, that there is a slight overall tendency for the normal group to show higher reliability than the patient group. However, the differences between the groups are not particularly consistent. On 5 of the 13 variables considered, the patient group obtain higher reliability coefficients than the normal group, and in a couple of instances in each group we find level measures showing coefficients below the median value of the variability measures.

The discriminatory power of various respiratory measures.

Our retest correlations indicate that few individuals will show exactly the same respiratory pattern from one time to another. Probably each individual shows some respiratory fluctuations from day to day. We may think about these fluctuations as centering around a mean - a mean that is characteristic of the individual. Consequently, in order to obtain a reliable measure of an individual's respiratory pattern, we would have to test him several times, and subsequently, derive his typical or average pattern. The number of testing sessions to be employed would depend upon the precision of the measures we wanted to obtain and upon the stability of the individual subject's respiratory behavior. If his respiratory behavior is extremely stable, one testing session would be enough. On the other hand, the greater his respiratory fluctuations, the more sessions would be needed.

As previously noted, Clausen asserts that dissimilarities between respiratory recordings are much more frequent among mental patients than among normals. In order to compensate for these dag-to-day fluctuations, Clausen indirectly suggests that the number of testing sessions employed should be proportionally increased. Our own data do also indicate a somewhat higher inconsistency among psychiatric patients. We have in the case of our patient sample computed average scores derived from three testing sessions, while in the case of our normal subjects, we have made use of two testing sessions only.

In what follows we will present tables showing the group differences being present on various respiratory measures. We will consentrate on group means, both in terms of average scores and the scores obtained from the first testing session. This will enable us to compare the results of the two procedures, and to evaluate whether the use of average scores does in fact produce greater or smaller group differences. We will not bother about investigating whether the group differences are significant or not. Our main concern will be whether the direction of the differences does agree with our expectations based on Clausen's previous results and whether they are consistant for both males and females.

Besides comparing the means of various subgroups, we want to present the score value (or values) on each variable that optimizes the difference between normals and patients, and the number of normal and patients falling above and below the specified value. We may think about these values as critical cut-off points from which "+" or "-" signs can be attributed to each individual subject. By comparing the relative frequency of "+" signs among normals and patients we will arrive at a rough estimate of the optimal discriminatory power of the respiratory variable in question.

Mean thoracic period.

The tables to follow show the group differences found with respect to the mean thoracic period. The numbers in parentheses (or brackets) refer to the first testing session, while the numbers to the left refer to average scores based on means derived from two or three recording sessions.

TABLE IV

Group differences in mean thoracic period (means).

	Patients	Normals	Total
Males	4.33 (4.43)	5.19 (5.58)	4.76 (5.00)
Females	3.85 (3.79)	5.07 (4.81)	4.46 (4.30)
Total	4.09 (4.11)	5.13 (5.20)	4.61 (4.65)

We find a somewhat larger mean period among males than females. This is true for both patients and normals, and it is true for initial scores as well as for the average scores from several sessions. The consistency of the results lend support to the hypothesis that men by and large show a somewhat slower rate of breathing than women.

Of even greater interest is the higher mean thoracic period found among normals than among patients. This holds true both for males and females, and both for the initial recording session and for average scores derived from several sessions. Our findings consistently go in the direction expected on the basis of Clausen's results and lend support to the hypothesis that psychiatric patients generally show a faster rate of breathing than non-patients.

Comparisons in terms of means don't help us very much in judging how well the mean respiratory period is able to discriminate between patients and normals. The cut-off point that optimalizes normal-patient differences is 3.90. Dividing the subjects into those obtaining a mean period above 3.90 and those falling below 3.91, we arrive at the results presented below.

TABLE V

The discriminatory power of the mean thoracic period.

	Above 3.90	Below 3.91
Patients (M+F)	4(3+ 1) [4(3+ 1)]	8(3+ 5) [8(3+ 5)]
Normals (M+F)	12(6+ 6) [11(6+ 5)]	0(0 + 0) [1(0 + 1)]

The table tells us that the cut-off point chosen discriminates correctly 20 (respectively 19) out of 24 cases, and that it discriminates about equally among males and females. Among males, it discriminates correctly 9 out of 12 cases, and among females, 11 out of 12 cases. It is important to note that the cut-off point optimizing group differences was found to be the same whether we concentrated on initial or average scores and whether we concentrated on males or females. The very same criterion turned out as the most discriminating in all instances.

To what extent does Clausen's cut-off points differ from our own? How well does his cut-off points discriminate between our samples. In order to get some information about this question we have scored our records according to his criteria.

The cut-off points suggested by Clausen correspond to a mean period of 4.14 sec. for males, and a mean period of 3.80 sec. for females. The table below presents the results arrived at when we apply these criteria.

TABLE VI

The discriminatory power of Clausen's criteria.

	Above critical value	Below critical value
Patients (M+F)	6(3+ 3) [4(3 + 1)]	6(3+ 3) [8(3 + 5)]
Normals (M+F)	10(4 + 6) [10(5 + 5)]	2(2 + 0) [2(1 + 1)]

The table shows that 6(8) out of 12 patients fall short of reaching the critical value, while the same is true in only 2(2) out of 12 normals. Clausen's cut-off points discriminate correctly 16(18) out of 24 cases. This is a little lower than what was the case with our own criterion, but the correspondence is not too bad when it is taken into account that the studies were done in different cultures and countries, and that the recording techniques employed were not exactly of the same type. We find the criteria to discriminate somewhat better in terms of initial scores than in terms of average scores, and somewhat better in terms of females than in terms of males. It is possible that we are confronted with sampling errors. We don't want to go too far in emphasizing the agreement being present, but we think our results definitely has to be considered rather suggestive and encouraging.

Mean abdominal amplitude (as percentage change of abdominal circumference).

According to Clausen's observations we would expect males to show larger abdominal amplitudes than females, and male patients to show smaller abdominal amplitudes than normal males. The same is probably true for females patients, since Clausen notes that "as compared to normal females, neurotic women more often have an extreme thoracic type of breathing" - although he adds that psychotic females often show an abdominal type of breathing.

The table below presents the mean abdominal amplitude % in our different groups of subjects.

TABLE VII

Group differences in mean abdominal amplitude % (means)

	Patients	Normals	Total
Males	.33 (.32)	.36 (.39)	.35 (.35)
Females	.14 (.19)	.36 (.45)	.25 (.32)
Total	.24 (.25)	.36 (.42)	.30 (.33)

The table shows that particularly among patients do we find great differences between males and females with males showing the largest abdominal amplitudes. In the normal group there is no sex differences in amplitude size. In fact, if we focus on the first testing session only, we find a tendency for females to show the largest amplitudes.

A possible explanation of the discrepancy between Clausen's and our own result is to be found in the way our amplitude measures have been obtained. If instead of considering amplitude size as percentage changes of trunk circumference, we concentrate on absolute amplitude measures, we too find males in all groups to show larger amplitudes than females. The reason for this, is of course, that males generally have a larger mean trunk circumference than females.

Most important is the difference found between patients and normals. Both among males and females do we find normals to show a higher mean abdominal amplitude than patients. Particularly striking is the difference found in the case of females.

Studying the distribution of amplitude scores in the different groups we find a cut-off point of .105 to discriminate optimally with respect to average scores, and a cut-off point of .145, with respect to first session scores. In both instances do the same cutoff point apply for both males and females.

TABLE VIII

Discriminatory power of abdominal amplitude %.

	Above critical value	Below critical value
Patients (M+F)	9(5+4) [7(3+4)]	3(1+2) [5(3+2)]
Normals (M+F)	12(6+6) [12(6+6)]	0(0+0) [0(0+0)]

The table indicates that an extremely small abdominal amplitude is found in patients only. Thus our data confirm the hypothesis that a small abdominal amplitude is found more frequently among patients than among normals and that a very small abdominal amplitude may be a potential indicator of mental illness. This being said, it should be added that its discriminatory power is not very impressive. In the one instance we get 15 out of 24 subjects correctly classified, and in the other, 17 out of 24 subjects. From a statistical point of view this is not at all a convincing result. On the other hand, it should be reemphasized that we never expect any one respiratory variable considered seperately to show any really high discriminatory power.

Mean thoracic amplitude(as percentage change of thoracic circumference).

Again we might start out by referring to Clausen's empirical observations. He points out that thoracic breathing is more typical of females than of males. While a fair proportion of normal men have a relatively large thoracic amplitude, this is very seldomly found among male patients. He also points out that an extremely thoracic type of breathing is sometimes found among neurotic females. On the basis of his observations we would expect females to show larger thoracic amplitudes than males, and normal males to show large amplitudes than male patients.

The table below shows the mean thoracic amplitude in different groups of subjects.

TABLE IX

Group differences in mean thoracic amplitude % (means)

	Patients	Normals	Total
Males	.12 (.11)	.15 (.13)	.14 (.12)
Females	.17 (.14)	.23 (.20)	.20 (.17)
Total	.15 (.12)	.19 (.16)	.17 (.14)

We find females to show larger thoracic amplitudes than males, and that this is true both among patients and normals, and both in terms of initial and average scores. In other words, our results confirm the hypothesis stated.

Both among males and females do we find patients to show smaller thoracic amplitudes than normals. This is the case when we concentrate both on initial and composite scores. Our data support the hypothesis that normal males tend to show higher thoracic amplitudes than male patients, and they indicate that the same relationship is present among female subjects.

This latter finding is not necessarily contrary to Clausen's observation that neurotic females sometimes may show an extremely thoracic type of breathing. A thoracic predominance can be associated with a fairly small thoracic amplitude. Still more important, a thoracic predominance is not considered typical of all neurotic females.

Studying the distribution of scores in the different groups, we find that the cut-off point optimizing the difference between patients and normals to be .135 as regards average scores, and .055 as regards initial scores. Here too, in both instances the same cut-off point can be applied to males and females.

TABLE X

Discriminatory power of thoracic amplitude %

	Above critical value	Below critical value
Patients (M+F)	7(2+5) [9(3+6)]	5(4+1) [3(3+0)]
Normals (M+F)	10(4+6) [12(6+6)]	2(2+0) [0(0+0)]

The table shows that with use of either initial scores or composite scores do we classify correctly 15 out of 24 cases. There is a clear tendency for the variable under consideration to discriminate better among males than among females, i.e., a very low thoracic amplitude is more frequently found among male than among female patients. This fits into Clausen's observations.

The fact that we find 2 normal males to obtain average scores below the critical value stated indicates that a low thoracic amplitude is not a particularly good criterion of mental illness. It should be noted, however, that the criterion used for average scores is not a very strict one. If we make use of a more strict criterion, for instance the criterion employed in relation to the subjects' initial scores (.055), no normal subject is found in the lower amplitude category. However, the number of patients falling in this group is reduced to only one.

Thoracic amplitude quotient.

The thoracic amplitude quotient tells us how large a fraction of the sum of the abdominal and thoracic amplitude is derived from the thoracic amplitude. A quotient of 1.00 means that the respiratory movements are exclusively thoracical, while a quotient of .00 indicates that all the movements recorded are obtained from the abdominal region.

As mentioned, several of Clausen's hypothesis are formulated in terms of the thoracic-abdominal amplitude ratio. He suggests that men tend to show a lower ratio than women, that neurotic women, as compared to normal women, more often show an extremely high ratio, while psychotic women more often show a low ratio. In his respiratory scale for females, a thoracic-abdominal amplitude ratio below 1.00 is considered a neurotic sign. In his scale for males, a low thoracic amplitude as well as a low abdominal amplitude are both looked upon as neurotic signs. Summing up these points, we end up with the expectation that extreme thoracic amplitude quotients (whatever their direction) are more typical of psychiatric patients than of normal subjects.

TABLE XI

Group differences in thoracic amplitude quotients (Mean)

	Patients	Normals	Total
Males	.37 (.41)	.41 (.33)	.39 (.37)
Females	.61 (.48)	.50 (.39)	.56 (.43)
Total	.49 (.44)	.46 (.36)	.48 (.40)

Table XI supports the hypothesis that females generally tend to breathe more thoracically than males. This holds true both for patients and normals, and both in terms of initial and average scores.

On the basis of Clausen's statements it is a little surprising that the means of the two female groups, are not considerably higher. We will return to this question later on.

It is important to note that comparisons of means are of restricted value in the present context since extreme high and low quotients will cancel each other out and since it is particularly with regards to these extreme values that we are expecting to find differences between patients and normals.

Studying the distribution of quotients in the various groups we find the optimal cut-off points to be .085 and .755 as far as average scores are concerned, and .095 and .655 as regards initial scores. Dividing our subjects according to these points, we arrive at the results presented below. Again the same cut-off points can be applied to both males and females.

TABLE XII

Discriminatory power of the thoracic amplitude quotient.

	Between critical values	Below lower critical value	Above upper critical value
Patients (M+F)	9(5+4) [9(4+5)]	1(1+0) [1(1+0)]	2(0+2) [2(1+1)]
Normals (M+F)	12(6+6) [12(6+6)]	0(0+0) [0(0+0)]	0(0+0) [0(0+0)]

The table shows that in the patient groups only do we find subjects with an extremely high and low thoracic amplitude quotient.

However, the number of cases falling into these extreme categories are relatively few - only 1/4 of the patient sample.

It is interesting to note that the two patients showing an extreme high amplitude quotient are both females, and that the patient showing an extremely low quotient is a male. Our data do point in the same direction as Clausen's observations, but the few cases involved makes it of course impossible to draw any definite inferences as to the validity of his hypotheses.

Although our conclusion has to be based on very few cases, we think it is fair to say that an extremely high and low thoracic amplitude quotient seem to be associated with mental illness. This follows from both the consistency of our findings and from the agreement being present between Clausen's and our own results.

Our data do not support Clausen's assumption that a thoracic-abdominal amplitude ratio below 1.00 is a sign of psychopathology in females. Studying the thoracic amplitude quotient we find that 2 out of 6 normal females obtain average quotients below .50, while only one female patient fall in this category. If we concentrate on initial scores, 4 out of 6 female patients obtain quotients below .50, while the same is true with 5 out of 6 normal females.

It should be recalled that Clausen did not make quantitative recordings of amplitude size. It is also questionable whether he managed to keep the sensitivity of his abdominal and thoracic recording channels at an equal level - and constant from time to time. Thus, his scale item under consideration should probably not be taken too seriously. On the other hand, we think it is equally important to point out the discrepancies between our own and Clausen's results as to note the several agreements being present.

Mean trunk amplitude.

Clausen notes that normal males often show larger thoracic amplitude than male patients - without at the same time showing any particularly low abdominal amplitude. Although Clausen does not explicitely discuss the variable in question it is likely to think from what he writes - that normal males by and large will show a larger mean trunk amplitude than male patients. Refering back to our earlier discussions we would expect very much the same relationship to hold true also in the case of female subjects.

The mean trunk amplitude is not completely independent of the thoracic amplitude quotient. An extremely high or low quotient will impose restrictions on the maximum size of the mean trunk amplitude. Under resting conditions, however, there is probably ample opportunities for a subject showing an extremely low thoracic or abdominal amplitude to compensate for this by a relatively larger amplitude of the other part. Consequently, we believe that the mean trunk amplitude may give informations that is not provided by the thoracic amplitude quotient alone.

Table XII presents our results concerning the average mean trunk amplitude found in different groups of subjects.

TABLE XIII

Group differences in mean trunk amplitude (means)

	Patients	Normals	Total
Males	.22 (.21)	.25 (.26)	.24 (.23)
Females	.16 (.17)	.29 (.32)	.18 (.24)
Total	.19 (.19)	.27 (.29)	.23 (.24)

The results show the sex differences to be largely inconsistent, both in terms of initial and average scores and in terms of the sub-samples investigated.

Most important is the consistent smaller mean trunk amplitude found among patients than among normals. Thus, our data tend to support the hypothesis that psychiatric patients generally show more shallow breathing than normal subjects.

Studying the distribution of scores in the various groups, we find a cut-off point of .105 (respectively .125) to discriminate optimally between patients and normals. Here too, the same cut-off points can be applied to both males and females.

TABLE XIV

Discriminatory power of mean trunk amplitude.

	Above critical value	Below critical value
Patients (M+F)	8(3+5)[7(3+4)]	4(3+1) [5(3+2)]
Normals (M+F)	12(6+6)[12(6+6)]	0(0+0) [0(0+0)]

The table indicates that an extremely low mean trunk amplitude is found in patients only. While 4 (respective 5) out of 12 patients fall into the low category, this is true for not a single normal subject. Our results lend support to the hypothesis that a very low mean trunk amplitude can be used as an indicator of mental illness, although it should be noted that it is not alone a very powerful indicator.

Mean abdominal inspiratory quotient.

Clausen points out that triangle shaped abdominal peaks are more characteristic of patients than of normals. If this is true, we might expect patients more frequently than non-patients to obtain inspiratory quotients close to .50. It is also worth recalling that Clausen suggests that the I/E ratio tends to be higher in males than in females, and that he did not find any significant difference in the mean I/E ratio between patients and normals.

In the table below is presented our own results regarding group differences in mean abdominal inspiratory quotient.

TABLE XV

Group differences in mean abdominal inspiratory quotient (means)

	Patients	Normals	Total
Males	.391 (.394)	.370 (.367)	.381 (.376)
Females	.368 (.373)	.395 (.397)	.382 (.385)
Total	.380 (.384)	.383 (.377)	.382 (.380)

Our data do not support the hypothesis that males show a higher relative inspiration time than females. The sex difference being present is very small, and what is of equal importance, it is inconsistent and does not go in the same direction when patients and normals are considered separately.

As expected from Clausen's results, we do not find any clear difference between patients and normals. Here too, the differences obtained are small and inconsistent. Male patients obtain a higher mean quotient than normal males, while female patients obtain a lower mean quotient than normal females.

Studying the distribution of scores among patients and normals, we find no evidence for the former group having more subjects obtaining scores close to .50 than the latter group. In fact, the two subjects falling closest to .50 (the only two obtaining scores above .42), are both normal subjects (females).

On the basis of the distribution of scores a cut-off point of .395 turns out to discriminale optimally between the various groups.

TABLE XVI

Discriminatory power of the abdominal inspiratory quotient

	Below critical value	Above critical value
Patients (M+F)	2+5 (1+5)	4+1 (5+1)
Normals (M+F)	6+2 (6+2)	0+4 (0+4)

The table shows that the cut-off point chosen discriminates fairly well between patient and normals granted that males and females are considered separately. What is particularly interesting is that male patients and normal females both tend to fall into the upper category, which normal males and female patients tend to fall into the lower. If both sexes are considered together, the variable shows practically no discriminatory power. Looked upon in a sex-specific way it discriminated correctly 19 (respective 20) out of 24 cases.

Our results lend support to the view that the abdominal inspiratory quotient may have a certain discriminatory power if it is interpreted differently according to the sex of the subject. We are not able to offer any definite explanation of this finding. Since we are here not in the lucky position of being able to compare and check our findings with hypotheses emerging from Clausen's empirical analysis, we feel rather reluctant to draw any specific conclusions besides just offering our findings as suggestions that have to be confirmed by later investigations. It should also be noted that this is the first variabel where we have suggested different scoring criteria for males and females. It is true that we have found the same cut-off point applicable for both initial and average scores and for both males and females, but the interpretation of the scores is sex-conditioned. The fact that in all the other instances we have been able to apply the same criterion for both sexes have given us a certain reassurance in the interpretation of our results, a reassurance that is lacking in the present instance.

Mean thoracic dissynchronization.

As previously stated, a positive value on this variable indicates that the beginning of the abdominal inspiratory movements precede the thoracic ones, while a negative value means that the abdominal movements succeed the thoracic ones. The higher the value, the greater the dissynchronization being present in both instances.

Clausen states:

> "Inspection of the respiration curves seems to indicate that the movements are synchroneous, so that the inspiration and expiration phases start at the same time in thorax and abdomen. In psychotic cases we have seen instances where the two sets of movements are dissociated, but this is a very rare occurence, and dissociative movements most certainly are not a characteristic feature for respiration of psychotics." (p. 53)

While Clausen is relying on qualitative observations only, we have tried to approach this variable from a quantitative point of view. One of the most striking findings emerging from our analysis, is the rare occurence of complete synchronicity between thorax and abdomen. Concentrating on average scores, not a single subject is found to obtain a thoracic dissynchronization score of zero, and concentrating on initial scores, a zero score is found in two instances only.

The table below presents our empirical data as regards group differences in mean thoracic dissynchronization.

TABLE XVII

Group differences in mean thoracic dissynchronization (means)

	Patients	Normals	Total
Males	.13 (.14)	.19 (.26)	.16 (.20)
Females	.06 (.08)	.01 (.11)	.04 (.10)
Total	.10 (.11)	.10 (.19)	.10 (.15)

The table shows that males tend to obtain higher thoracic dissynchronization scores than females. This holds true both among normals and patients and both for initial and average scores. The higher mean scores found among males indicate that in males particularly do we find abdominal movements to precede the thoracic ones. It should be noted, however, that also in the female groups do we find positive mean scores.

Comparing patients and normals at large we find practically no difference. If we consider males and females separately we find inconsistent results. Normal males show higher mean scores than male patients, while female patients show higher mean scores than normal females if average scores are considered and lower ones if only the initial scores are taken into consideration.

A comparison of mean scores does not tell us very much about the discriminatory power of the variable under discussion - since we might very well expect patients to show more extreme scores than normals - both on the positive and negative side.

Studying the score distribution in the various groups we find a cut-off point of -.025 to discriminate optimally among males - with male patients showing the highest negative scores. The same cut-off point is applicable both in relation to average and initial scores.

Turning to the female groups a cut-off point of -.065 discriminates optimally between the initial scores of patients and normals, again with the patients showing the highest negative scores. With respect to average scores a cut-off point of .075 is found to discriminate optimally, with patients obtaining the highest positive scores.

Although our data do not provide any conclusive evidence it is quite possible that a high dissynchronization independent of its direction, represent an important indicator of mental illness. This being the case, we would expect to find an optimal range of dissynchronization scores, and perhaps a somewhat different range for males and females.

TABLE XVIII

Discriminatory power of mean thoracic dissynchronization

	Males		Females	
	Below c.v.	Above c.v.	Below c.v.	Above c.v.
Patients	3 (3)	3 (3)	3 (2)	3 (4)
Normals	0 (0)	6 (6)	5 (1)	1 (5)

The table shows that the cut-off point suggested for males discriminates correctly 9 out of 12 cases. The cut-off points suggested for females discriminates correctly 7 out of 12 cases, both with respect to average and initial scores. In other words, the criterion suggested for males discriminates somewhat better than the criteria suggested for females, although in neither case do we have any remarkably high differentiating power.

The facts that we have to suggest different criteria for males and females and that we don't have the opportunity to compare our results with earlier findings, makes us feel rather insecure as regards the differentiating ability of the mean thoracic dissynchronization. As was the case with the mean abdominal inspiratory quotient, we are also here presenting our criteria primarily as suggestions that have to be substantiated by later studies.

Variability of thoracic period.

Clausen's data indicate that the variability of the rate tends to be somewhat higher in females than in males, and higher in mental patients than in normal subjects.

The table below shows the mean thoracic period variability (in terms of coefficients of variation) obtained by different groups of subjects.

TABLE XIX

Group differences in thoracic period variability (means)

	Patients	Normals	Total
Males	.11 (.12)	.09 (.09)	.10 (.11)
Females	.11 (.11)	.09 (.09)	.10 (.10)
Total	.11 (.11)	.09 (.09)	.10 (.10)

The results do not lend any support to the hypothesis that females show larger variability in rate than males. In nearly all comparisons possible do we find no sex difference in period variability.

On the other hand, our results support the hypothesis that mental patients show larger period variability than normals. The difference is of rather moderate size, although it is present both among males and females, and both when initial and average scores are compared.

Studying the distribution of scores in the various groups, we find a cut-off point of .155 to discriminate optimally in terms of average scores, and a cut-off point of .205 to discriminate optimally in term of initial scores. The same criteria applies for both males and females. Making use of these critical values we get the following results:

TABLE XX

Discriminatory power of the thoracic period variability.

	Below critical values	Above critical values
Patients (M+F)	9(5+4) [10(5+5)]	3(2+1) [2(1+1)]
Normals (M+F)	12(6+6) [12(6+6)]	0(0+0) [0(0+0)]

The table shows that the cut-off point suggested discriminates correctly 15 (respectively 14) out of 24 cases. It is reassuring that among patients only do we find subjects exceeding the critical values and that both sexes are represented in the upper category. Although we may conclude that a high period variability seems to be an indicator of mental illness, it has to be kept in mind that its discriminating ability is probably not very pronounced.

Variability of thoracic amplitude

As previously noted, Clausen indicates that the amplitude variability is clarger in mental patients than in normal subjects.

The table below presents our results as regards the average thoracic amplitude variability (in terms of coefficient of variation scores) found in the different groups of subjects.

TABLE XXI

Group differences in thoracic amplitude variability (means)

	Patients	Normals	Total
Males	.21 (.23)	.17 (.19)	.19 (.21)
Females	.19 (.21)	.12 (.15)	.16 (.18)
Total	.20 (.22)	.15 (.17)	.18 (.19)

There is a tendency for males to show higher variabilities scores than females. What is more interesting, it is an equally clear tendency for patients to obtain higher variability scores than normals. This holds true both for males and females, and both for initial and average scores. Consequently, our data lend some support to the hypothesis that mental patients show larger thoracic amplitude variability than normals.

A cut-off point of .285 discriminates optimally between the various groups of subjects. The same cut-off points applies to both males and females, and to both average and initial scores.

TABLE XXII

Discriminatory power of thoracic amplitude variability

	Below critical value	Above critical value
Patients (M+F)	10(5+5) [9(4+5)]	2(1+1) [3(2+1)]
Normals (M+F)	12(6+6) [11(5+6)]	0(0+0) [1(1+0)]

The cut-off point suggested discriminates correctly only 14 (respectively 15) out of 24 cases. Although we find patients only to obtain extremely high variability scores, the results indicate that a high thoracic amplitude variability considered alone is not a very discriminating variable.

Variability of abdominal amplitude.

The table below presents the average abdominal amplitude variability (in terms of coefficient of variation) found in the various groups of subjects.

TABLE XXIII

Group differences in abdominal amplitude variability (means)

	Patients	Normals	Total
Males	.20 (.16)	.13 (.11)	.16 (.14)
Females	.14 (.13)	.14 (.14)	.14 (.14)
Total	.17 (.15)	.14 (.13)	.16 (.14)

The results indicate that there is no consistent sex difference in amplitude variability. Male patients show higher mean scores than female patients, while normal females show higher scores than normal males.

We find that patients generally obtain higher mean variability scores than normals, but here again the results are not consistent. Looking at males and females separately, we discover that it is in the male group only that we find patients to obtain significantly higher average scores than normals.

The cut-off point discriminating optimally between average scores is .193, and the cut-off point discriminating optimally between initial scores .235. There is no need for different criteria for males and females. If we divide the subjects according to the points mentioned, we arrive at the results presented below.

TABLE XXIV

Discriminatory power of abdominal amplitude variability

	Below critical values	Above critical values
Patients (M+F)	7(2+5) [10(5+5)]	5(4+1) [2(1+1)]
Normals (M+F)	12(6+6) [12(6+6)]	0(0+0) [0(0+0)]

The cut-off points suggested classifies correctly 17 (respectively 14) out of 24 cases. It is worth nothing that they are far better in discriminating between males than between females. This fits in with our earlier observation that it is particularly in the male patient group that we find a relatively high average variability score.

Our findings show that an extremely high variability of the abdominal amplitude might represent a potential indicator or mental illness, although any definite inference in this direction would certainly have to be combined with other indices.

Mean trunk amplitude variability.

Having shown that patients generally obtain higher variability coefficients both on the thoracic and abdominal amplitude variable, but that neither of the two variables discriminates sharply between patients and normals, we may go one step further and study whether the mean of the two trunk variability coefficients show any higher discriminatory power than each measure considered alone.

In the table below is presented the mean values of the mean trunk amplitude variability found in the different groups of subjects.

TABLE XXV

Group differences in mean trunk amplitude variability (means)

	Patients	Normals	Total
Males	.20 (.18)	.15 (.15)	.18 (.17)
Females	.16 (.17)	.13 (.14)	.15 (.16)
Total	.18 (.18)	.14 (.15)	.16 (.16)

As expected, we find somewhat higher mean scores among males than among females, and higher mean scores among patients than among normals.

Studying the distribution of scores in the various groups, we find a cut-off point of .255 to discriminate optimally in terms of average scores, and a cut-off point of .295 to discriminate optimally in terms of initial scores. Again, the very same cut-off points are applicable both for males and females.

TABLE XXVI

Discriminatory power of mean trunk amplitude variability

	Below critical values	Above critical values
Patients (M+F)	8(3+5) [10(5+5)]	3(2+1) [2(1+1)]
Normals (M+F)	12(6+6) [12(6+6)]	0(0+0) [0(0+0)]

The table indicates that three (respectively two) patients can be separated from the rest of the sample because of their high variability scores. This is not a strikingly high proportion of cases, since by concentrating on the thoracic and abdominal amplitude variability scores separately, we were able to single out two and five cases respectively. In order to find out if anything is gained by making use of the mean trunk amplitude variability, we would have to analyse whether it is the same patients that are identified by the different measures. To this question we will turn in a later section. At this point we would only like to conclude that our empirical data do indicate that a high mean trunk amplitude variability are somewhat more common among patients than among normals, but that the variable considered alone does not seem to have any great discriminating ability.

Variability of thoracic terminal position

As a measure of the terminal position variability we have made use of the standard diviation. The table below presents the mean thoracic terminal position variability found in various groups of subjects.

TABLE XXVII

Group differences in thoracic terminal position variability (means)

	Patients	Normals	Total
Males	.056 (.046)	.130 (.082)	.093 (.064)
Females	.147 (.112)	.094 (.077)	.121 (.095)
Total	.102 (.079)	.112 (.080)	.107 (.080)

We find a slight tendency for normals to obtain higher variability scores than patients. However, the difference between normals and patients is not consistent. In the female group we find differences going in the opposite direction of those found among males. Studying the distribution of scores in the different groups it is almost impossible to find any cut-off point that discriminates clearly between them. Consequently, we have to conclude that the variability of the thoracic terminal position does not seem to represent a useful indicator of mental illness. In short, the variable in question does not seem to fit into a respiratory scale aiming at the identification of mental patients.

Variability of abdominal terminal position

As was the case with the former variable, here too we have made use of the standard deviation as a measure of variability. The table below shows the mean abdominal terminal position variability found in different groups.

TABLE XXVIII

Group differences in abdominal terminal position variablity (means)

	Patients	Normals	Total
Males	.111 (.070)	.131 (.158)	.125 (.114)
Females	.040 (.041)	.181 (.243)	.112 (.142)
Total	.076 (.056)	.160 (.201)	.118 (.128)

The table shows the same trends as previously noted for the thoracic terminal position variability. Here too we find normals to obtain higher variability scores than patients. In the present instance, we find this to be true both when we consider initial and average scores and when we look upon males and females separately. Studying the distribution of scores in the various groups, we find that in cut-off point of .200 discriminates correctly 16 (respectively 15) out of 24 cases - with normals only falling in the upper category. As an indicator of mental illness the variable does not look promising and we have consequently decided to discard it from our further analysis.

The final selection of items to be included in the scales.

Summing up our findings so far, the following variables have turned out to show a certain discriminatory power:

1. Mean thoracic period
2. Mean abdominal amplitude %
3. Mean thoracic amplitude %
4. Thoracic amplitude quotient
5. Mean trunk amplitude
6. Mean abdominal inspiratory quotient
7. Mean thoracic dissynchronization
8. Thoracic period variability
9. Thoracic amplitude variability
10. Abdominal amplitude variability
11. Mean trunk amplitude variability.

The question we want to ask is the following: To what extent can some of the variables be excluded without reducing the discriminating ability of all the variables combined? To what extent do some of the variables overlap each other in the sense of conveying the same type of information?

As previously noted this problem is particularly relevant in connection with the various amplitude measures. In the list of variables is included the thoracic and abdominal amplitude % as well as the thoracic amplitude quotient and the mean trunk amplitude. Furthermore, we find included both the thoracic and abdominal amplitude variability as well as the mean trunk amplitude variability.

In order to find out if one or two of the variables can be discarded without reducing significantly the discriminating ability of the remaining ones, we decided to study the distribution of scores being ascribed the subjects on the relevant variables. The type of scores we are referring to, is the sign-scores, i.e. the scores identifying those subjects that are exceeding the suggested cut-off point on a given variable.

Using "*" as symbolizing these instances, we end up among our patient subjects with the distribution of scores shown in table XXIX.

Studying the level variables, we notice that if anyone subject's thoracic amplitude % and/or abdominal amplitude % have been scored "*", his thoracic amplitude quotient and/or his mean trunk amplitude % have also been scored "*". Consequently, we may say that the two latter items seem to take hold of the most significant information conveyed by the two former items. In choosing to concentrate from now on on the two latter ones, we are influenced by this finding, but also by the fact that the former items give rise to a couple of "*" scores among normals (while this is not true for the latter items), and by the fact that we expect the latter items to be somewhat easier to deal with in terms of psychological interpretations.

Looking at the three variability items it appears clearly that the mean trunk amplitude variability cannot completely replace the thoracic and abdominal amplitude variability items. The distribution of "*" scores shows that not a single subject has been ascribed a "*" on the mean trunk amplitude variability variable without at the same time obtaining a "*" on the abdominal and/or the thoracic amplitude variability variable. On the other hand, in one instance in terms of initial scores, and in two instances in terms of average scores, do we find that one of the latter variables have been ascribed "*" without this being true for the former variable. We may conclude that the mean

TABLE XXIX

Survey on the scores ascribed to individual patient subjects on various amplitude variables

Subject number	Level variables								Variability variables					
	Th.ampl.%		Ab.aml.%		Th.ampl.quot.		M.tr.ampl.%		V.th.ampl.		V.abd.ampl.		V.mean trunk ampl.	
	Av.	Init.	Av.	Init.	Av.	Init.	Av.	Init.	Av.	Init.	Av.	Init.	Av.	Init.
M-1	*	*		*		*	*	*			*			
M-2														
M-3	*	*			*	*			*	*	*		*	*
M-4	*	*		*			*	*			*		*	
M-5										*	*	*		
M-6	*		*	*			*	*						
F-1			*	*	*	*		*						
F-2	*			*			*	*						
F-3														
F-4														
F-5														
F-6			*		*				*	*	*	*	*	*
Σ*	5	3	3	5	3	3	4	5	2	3	5	2	3	2

trunk amplitude variability item does not add, in fact. looses - informations provided by the two other items.

Returning to the starting point for this section, we are now in a position to suggest that items nos. 2, 3, and 11 should be discarded from our list of items. The remaining 8 items, constitute our preliminary respiratory scale. They fall into two categories. One category consisting of items or variables where our own findings seem to confirm hypotheses or suggestions launched by Clausen or stemming directly or indirectly from his empirical material. In this category we may include item nos. 1, 4, 5, 8, 9 and 10. The second category consists of items (nos. 6 and 7) that have emerged entirely from our own data analysis. In comparison to the former ones, we are here confronted with items (variables and scoring criteria) that we conceive of as somewhat more speculative and tentative in nature. In our subsequent analysis of the differentiating ability of our respiratory scale we are going to talk about two scale versions - the core scale - and the full scale. While the core scale consists of the first category items exclusively and make use of cut-off points that are identical for males and females, the full scale has to be divided into two forms, one for males and one for females (due to the fact that the two additional items comprising the full scale have to be scored differently according to the sex of the subject).

Furthermore, we may differentiate between two parallel forms of each of the two scale versions, one based upon initial scores and one upon average scores. It should be reemphasized that our primary concern is the latter type of scores. Although we have steadily looked into the distributions of initial scores, we have done this mainly in order to explore the consistency of respiratory deviations in different groups of subjects. In our opinion it is only through a scale based on average scores that we can hope to obtain the degree of reliability necessary for differentiating between individual subjects in terms of respiratory features.

An ex-post-facto analysis of the discriminating ability of the scales.

To sum up our previous discussion, we are confronted with the following scale items:

Variables	Critical values in terms of average scores	Critical values in terms of initial scores
Core items:		
1. Mean thoracic period	Below 3.91	Below 3.91
2. Mean trunk ampl. per cent	Below .11	Below .13
3. Thor.ampl. quotient	Above .75 or below .09	Above .65 or below .10
4. Thor.period variability	Above .15	Above .20
5. Abd. ampl. variability	Above .19	Above .23
6. Thor.ampl. variability	Above .28	Above .28
Additional items:		
7 M. Mean thor.dissynchronization	Below -.02	Below -.02
7 F. Mean thor.dissynchronization	Above .07	Below -.01
8 M. Mean abd.inspir.quotient	Above .39	Above .39
8 F. Mean abd.inspir.quotient	Below .40	Below .40

We have 6 core items that are common for males and females. The full scale for both males and females consists of 8 items, the 6 core items plus two additional ones that are sex specific.

Ascribing the individual subject a "*" sign in each instance where he attains a respiration score exceeding the critical value stated, we end up with the distribution of sign scores presented in table XXX.

The table shows that some items are much more discriminating than others. The most discriminating items are No. 1 and 8, and the least discriminating ones, Nos. 3, 4 and 6.

How well do the scales discriminate between patients and normals? In order to answer this question we have to compare the distribution of scores being ascribed to the subjects in the different groups. Table XXXI presents the results of such a comparison.

TABLE XXX

Survey of "*" signs ascribed to the individual subject on the basis of his respiratory scores

	Variable no.																			
	1		2		3		4		5		6		Σ^*1-6		7		8		Σ^*1-8	
	Av.	In.	Av.	In.	Av.	In.	Av.	In.	Av.	In.	Av.	In.	Av.	In.	Av.	In.	Av.	In.	Av.	In
PM-1	*	*	*	*		*			*				3	3	*			*	4	4
PM-2	*	*											1	1		*	*	*	2	3
PM-3					*	*	*	*	*		*	*	4	3			*	*	5	4
PM-4			*	*			*		*				3	1	*	*	*	*	5	3
PM-5									*	*		*	1	2	*	*			2	3
PM-6	*	*	*	*									2	2			*	*	3	3
PF-1	*	*		*	*	*							2	3	*		*	*	4	4
PF-2	*	*	*	*									2	2			*	*	3	3
PF-3	*	*											1	1		*	*	*	2	3
PF-4	*	*											1	1	*				2	1
PF-5													0	0	*	*	*	*	2	2
PF-6	*	*			*		*	*	*	*	*	*	5	4			*	*	6	5
NM-1													0	0					0	0
NM-2													0	0					0	0
NM-3													0	0					0	0
NM-4													0	0					0	0
NM-5													0	0					0	0
NM-6												*	0	1					0	1
NF-1		*											0	1			*	*	1	2
NF-2													0	0					0	0
NF-3													0	0			*	*	1	1
NF-4													0	0	*				1	0
NF-5													0	0		*			0	1
NF-6													0	0					0	0

TABLE XXXI

The number of "*" signs obtained on various scales by subjects in the different groups.

Scale	Groups	No. of "*" signs						
		0	1	2	3	4	5	6
Core-items - initial scores	Patients (M+F)	1(0+1)	4(2+2)	3(2+1)	3(2+1)	1(0+1)		
	Normals (M+F)	10(5+5)	2(1+1)					
All items - initial scores	Patients (M+F)		1(0+1)	1(0+1)	6(4+2)	3(2+1)	1(0+1)	
	Normals (M+F)	8(5+3)	3(1+2)	1(0+1)				
Core items - average scores	Patients (M+F)	1(0+1)	4(2+2)	3(2+1)	3(2+1)	1(0+1)		
	Normals (M+F)	12(6+6)						
All items - average scores	Patients (M+F)			5(2+3)	2(1+1)	2(1+1)	2(2+0)	1(0+1)
	Normals (M+F)	9(6+3)	3(0+3)					

The table tells us that if we concentrate on initial scores and the core items pertaining to these scores only, we find that 5 of our 12 patient subjects fall within the distribution of scores found in the normal group. In the case of all items pertaining to initial scores, we find an overlap of two patients.

When we turn to average scores, the results get still better. In terms of the core items, we find that not a single normal subject attains any sign scores, while this is the case for all except one patient subject. Consequently, we may here talk about an overlap of one subject.

Turning to the full scale, we find no overlap whatsoever between the distribution of sign scores in our patient and normal group. All patients obtain two or more sign scores, while all normals obtain either one or zero sign scores.

The fact that we find no overlap between the patient and normal group when we are working with the full scale for average scores lends support to the hypothesis that mental illness is accompanied by respiratory deviations. On the other hand, we have to emphasize that all the scales have been constructed so as to maximize the differences being present in our empirical material. Although our results to a large extent substantiates earlier findings by Clausen, we are not in a position to draw any definite and final conclusion that respiratory deviation are always and everywhere accompanying mental disorders.

In contrast to Clausen's scales we have not bothered about weighting our items differently according to their discriminating power. It should also be noted that our scales comprise fewer items. The potential range of scores on our full scales is for instance, only half of the range of scores possible on the shortest of Clausen's scales (his scale for females).

Comparing our results with Clausen's, it has to be remembered that he was working with much larger samples of subjects and that he made use of 5 testing sessions for all of his subjects.

In spite of the differences in procedure and design we feel quite strongly that our results do support Clausen's main findings. Besides increasing the likelihood of respiratory deviations being present in mental patients, we have accomplished one rather important thing - namely to suggest a respiratory scale that is objective and quantitative in nature. As was the case with Clausen's study, this is to be considered an initial step only. We are still confronted with scales that are in need of independent crossvalidations. But in contrast to Clausen's scales, our own scales lend themselves quite easily to such a follow-up investigation. In this sense, we may look upon the new scales as a preliminary, objective modification of Clausen's scales.

The intercorrelation between respiratory variables.

The main assumption behind the construction of our scales was that mental patients breathe differently than normals. We did not assume that the amount of respiratory deviations found corresponds to the degree of psychopathology being present, although it is reasonable to raise this issue as a problem of research.

Talking about respiratory deviations we have to distinguish between two issues - between the number of variables on which a mental patient shows deviant respiratory features and the amount of deviation found on any one respiratory variable. By summing up deviation scores and letting each count the same we are in a way presupposing that all items are completely intercorrelated and that the number of deviation scores expresses the total amount of deviation being present. This is not necessarily true of course. It is quite possible that our scales are not unidimensional in nature and that by summing up individual deviation scores we are not obtaining a valid deviation measure. For instance, if two items are independent of each other, a person exceeding by far the cut-off point on one of the variables may present a more deviant respiration than a person exceeding by very small margins the critical values on both variables.

Clausen concludes that the number of neurosis signs being ascribed to an individual patient only to a moderate degree seems to reflect the severeness of his illness. From what has just been said, this conclusion throws some doubts as regards the unidimensionality of his respiratory scales, granted that a relationship does in fact exist between psychopathology and respiratory deviation.

At this point it should be recalled that Clausen himself presents results suggesting a multidimensionality of his scale items. He reports that different variability measures are related to each other and (inversely) to the thoracic and abdominal I/E ratios, while they are all largely unrelated to the mean period. In other words, Clausen indirectly suggest that his respiratory variables are reflecting at least two relatively independent dimensions.

What is the relationship between the variables making up our own respiratory scales? The table on the next page shows the correlations being present. The coeffisients reported are product-moment correlations between initial scores. In the table is included all the variables comprising our respiratory scales, but we have also included two additional measures, the deviation-from-mean scores in terms of the thoracic amplitude quotient and in terms of thoracic dissynchronization. The two latter measures appear as particularly significant since we found psychiatric patients to obtain more extreme scores than normal subjects on both of these variables.

To what extent can the variables be considered as belonging to different clusters? To answer this question we have made use of Holzinger and Harman's method for cluster analysis. (Because of the somewhat peculiar discriminating ability of the mean abdominal inspiratory quotient this variable has been excluded from this analysis. From the table it looks like the variable is unrelated to all other variables.)

The result of the cluster analysis indicates that the variables fall into two clusters.

Cluster I points in the direction of a general irregularity dimension. In order of clustering we have the following variables:

1. Variability of thoracic period
2. Variability of abdominal amplitude
3. Variability of thoracic amplitude
4. Thoracic amplitude quotient (deviation scores)
5. Thoracic dissynchronization (deviation scores)

Cluster II seems to be related to a respiratory depth dimension. In order of clustering we here have these variables:

1. Mean trunk amplitude
2. Thoracic amplitude quotient (with signs reversed)
3. Mean thoracic period
4. Thoracic dissynchronization

Both clusters show a fairly high internal consistency, and their intercorrelation is low. The first cluster obtains a coefficient of belonging, B = 228, and the second one, B = 237.

It is interesting to note from cluster I that extreme scores in terms of thoracic amplitude quotient and thoracic dissynchronization seem to be associated with respiratory irregularity. Tentatively, this

Table XXXII

Intercorrelations between respiratory variables (N = 24)

Variable No.	1	2	3	4	5	6	7	8	9	10
1. Mean thor. period	-	.50	-.64	.29	.30	.05	.22	.48	.64	-.11
2. Mean trunk ampl.		-	-.68	-.06	.20	.07	.06	.22	.19	-.17
3. Thor.ampl.quot. (orig. scores)			-	.00	-.32	-.05	-.37	-.58	-.51	.06
4. Thor.ampl.quot. (dev. scores)				-	.54	.43	.32	.38	.47	-.19
5. Thor.period variability					-	.77	.71	.32	.53	-.15
6. Abd.ampl. variability						-	.60	-.02	.11	-.08
7. Thor.ampl. variability							-	.46	.49	.00
8. Mean thor.dissynchr. (orig. scores)								-	.00	.03
9. Mean thor. dissynchr. (dev. scores)									-	-.17
10. Mean abd.insp. quotient										-

might be interpreted to indicate that both high-costal and extreme abdominal breathing are accompanied by muscular constrictions interfering with smooth and regular respiratory movements.

Cluster II points to a dimension going from slow and deep breething with abdominal predominance (both with respect to time synchronization and relative amplitude size) to a fast, shallow, thoracic type of breathing with thoracic antecedence in time.

Our empirical material suggests that respiratory variables fall into two different clusters. In agreement with Clausen results, we find that the mean period is relatively unrelated to the various variability measures, while these latter measures on the other hand seem to be rather highly intercorrelated.[1)]

*   *   *

We would like to examine a little further the <u>mean abdominal inspiratory quotient</u>. We found this variable to discriminate quite well between patients and normals, but somewhat surprisingly, to require reversed scoring criteria for males and females. That is to say, while high quotients was found to be typical for male patients, low quotients was found to be typical for female patients. The difference found raises the question whether the inspiratory quotient shows distinctly different intercorrelations with other respiratory variables when males and females are considered separately.

In order to throw some light on this question we have computed the correlations between the mean abdominal inspiratory quotient and a couple of variables from each of the two clusters. The table below presents the results.

We find a clear tendency for the abdominal inspiratory quotient to be related differently to other variables according to the sex of the subject. In the case of females we find the inspiratory quotient

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1) For instance, we find the variability of the thoracic period to be correlated .82 and .71 with the variability of the thoracic and the abdominal inspiratory quotient ; both correlations being higher than the correlation between the two latter variables - which, as previously noted, is only .42. We find the same trend with respect to the two amplitude variability measures - both showing higher correlations with thoracic period variability than with each other. The mean intercorrelation between the variables included in Cluster I, is .50, while the corresponding mean for Cluster II, is .52.

TABLE XXXIII

Correlations between the mean abdominal inspiratory quotient and other variables computed separately for males and females and on the basis of average and initial scores.

Other variables	Males only		Females only	
	Average	Initial	Average	Initial
Cluster I variables:				
Thor. period variability	.13	.03	-.74	-.37
Abd. amplitude variability	.05	.02	-.30	-.17
Cluster II variables:				
Mean trunk amplitude	-.27	-.36	.22	.07
Mean thoracic period	-.52	-.60	.14	.13

to be related inversely to Cluster I variables, while it seems to be unrelated to Cluster II variables. In the case of males, the picture seems to be quite different: The inspiratory quotient is here inversely related to Cluster II variables, while it is rather unrelated to Cluster I variables.

The fact that we find a tendency among males for a long relative expiration time to be positively associated with deep and slow breathing fits in with everyday observations, that slow breathing tends to be accompanied by expiratory pauses. From this point of view it is surprising that we don't find the association to be even more pronounced. And it is striking that we don't find the association to hold true at all in the case of female subjects.

The most reasonable explanation for the association found between a long relative expiration time and respiratory irregularity in females, is to assume that a long expiration time may express a constriction, a constriction that is functionally equivalent to and associated with an inhibition of either thoracic or abdominal breathing. In support of this interpretation we may refer to the negative correlations found in the case of females, between mean abdominal inspiratory quotient and deviation - from - mean scores on the thoracic amplitude quotient. The correlation being -.39. Furthermore, we find both of these variables to be significantly correlated with various variability measures.

We would have to ask why the inspiratory quotient is related to respiratory constrictions (as indicated through high irregularity and extremely high and low thoracic amplitude quotients) in females but not in males. How come that our female sample shows much closer agreement with Clausen's findings than our male sample? We don't know the answer to this question. At this point we would only like to suggest that the inspiratory quotient to a varying degree may be linked up with an active constriction - interfering with and reducing the negative correlation otherwise expected between inspiratory quotient and mean period (and mean trunk amplitude), and that this interference is accompanied by respiratory irregularity, and most importantly - that this whole process for one reason or another seems to be far more typical among females than among males.

* * *

A problem so far left out of our discussion is the complete lack of discrimination found with respect to the thoracic and abdominal terminal position variability measures. In describing the results of our reliability study we noted that the abdominal variability measure showed the highest retest-correlation. We considered this finding a little surprising since the thoracic variability measures generally was found to be the most reliable ones. We mentioned that the inconsistency could possibly be explained in terms of the terminal position variability being more closely related to amplitude size than to a general variability factor.

That a certain relationship exist between amplitude size and terminal position variability is most likely. If the amplitude is approaching zero, we would expect also the variability of the terminal position to approach zero. Consequently, we would expect the lowest terminal position variability generally to occur in the group of subjects showing the lowest mean amplitude.

In order to test this hypothesis we have divided our subjects according to whether they obtain initial scores on abdominal amplitude and terminal postition variability above or below the means of the total group. By so doing, we arrive at the result shown below.

TABLE XXXIV

Relationship between abdominal amplitude and terminal position variability.

		Abd. term. position variability	
		Below .128	Above .127
Abdominal amplitude in per cent	Above .32	2	7
	Below .33	15	0

The distribution of subjects clearly indicates that a positive association exists between a high abdominal amplitude and a high abdominal terminal position variability. We find the association to be present both among patients and normals, and both among males and females. A low abdominal amplitude is invariably found to be associated with a low terminal position variability.

Turning to the thoracic region, we find very much the same relationship. Dividing the subjects according to whether they obtain initial scores on the two variables falling above or below the means of the total group, we arrive at the results presented in the next table.

TABLE XXXV

Relationship between thoracic amplitude and terminal position variability.

		Thor. term. position variability	
		Below .080	Above .079
Thoracic amplitude in per cent	Above .14	4	9
	Below .15	10	1

As in the first instance, we find that if the amplitude is rather small, then the variability of the terminal position is also usually small. We find the opposite trend with respect to high amplitudes - although the relationship here is less pronounced.

From the results just reported one would expect that the terminal position variability variables will discriminate between patients and normals at about the same level as the amplitude per cent. Since this was not found to be true, we are forced to assume that the former variables are influenced not only by amplitude size but also by other factors. A factor most likely to be relevant is the general respiratory variability.

Before exploring this question, we would like to reemphasize that neither in the case of the mean amplitude nor in the case of the terminal postition variability did we find any significant correlations between parallel measures from thorax and abdomen. If we intercorrelate the four variables - this time focusing on average scores - the following correlation matrix appears:

TABLE XXXVI

Intercorrelations between thoracic and abdominal amplitudes and terminal position variabilities (N=24)

Variable No.	1	2	3	4
1. Mean thor. amplitude %		.21	.33	-.01
2. Mean abd. amplitude %			.21	.67
3. Thor. term. position variability (SD)				.03
4. Abd. term. position variability (SD)				

The table shows that two correlations only are reaching a certain statistical significance - the one being the correlation between the abdominal amplitude and the abdominal terminal position variability, and the other, the correlation between the thoracic amplitude and the thoracic terminal position variability.

What is the relationship between terminal position variability and respiratory variability in general? The complete lack of correlation between the thoracic and abdominal terminal position variability can be interpreted as indicating that no general variability factor can be involved.

As an indication of general variability we have made use of the thoracic period variability - the variable showing the highest order of clustering with respect to Cluster I. In order to conclude that a general variability factor is present, it would be necessary to demonstrate not only that period variability is positively associated with the two terminal position variability variables, but also that it is fairly unrelated to amplitude size.

The tables below present our correlational results:

TABLE XXXVII

Intercorrelations between thoracic period variability, mean thoracic amplitude, and thoracic terminal position variability (N=24)

Variable No.	1	2	3
1. Thor. term. pos. variabl.		.32	.33
2. Thor. period variabl.			-.28
3. Thor. amplitude %			

TABLE XXXVIII

Intercorrelations between thoracic period variability, mean abdominal amplitude and abdominal terminal position variability (N=24)

Variable No.	1	2	3
1. Abd. term. pos. variabl.		.39	.67
2. Thor. period variabl.			.21
3. Abd. amplitude %			

Our data lend support to the hypothesis that terminal position variability is related to the amplitude size as well as to a general variability factor. Although the correlations found between period variability and terminal position variability are rather small, they both go in the direction expected and they both exceed the correlations observed between period variability and amplitude size. Even the lowest of the two correlations reaches the .05 level of significance approximately, if a one-tail criterion is used.

The slight trend in the driection of a negative correlation between period variability and amplitude size in the thoracic region to some extent compensates for the lower correlation found between period and terminal position variability in this instance.

Summing up, we may conclude that both the thoracic and abdominal terminal position variability seem to be related to a general variability factor. However, they are not particularly good indicators of such a factor, at least not until their rather strong dependence upon amplitude size have been parcelled out.

CONCLUSIONS

Beginning with 30 measures of trunk respiratory movements under resting condition, an ex post facto scale based on eight measures discriminates extremely well between a group of 12 psychiatric in-patients and a group of 12 non-patients. In the case of average scores based on three and two testing sessions for patients and non-patients respectively, all non-patients made a one or a zero scale total, while all patients made a scale total of two or more. There was no overlap between the two groups.

The eight respiratory variables selected for inclusion in the scale suggest that mental illness in general is related to rapid and shallow breathing, to extreme dominance of thoracic or abdominal movements in amplitude and dissynchronization, to marked variability in rate and amplitude, and - dependent upon the sex of the subject, to a high or a low inspiratory quotient. This general pattern may be indicative of an increased constriction of the trunk breathing pattern in the mentally ill - suggesting an inability to rest in a "resting" situation, or it may point to a disintegration of the normal, global respiratory pattern in the mentally ill in all situations.

In the case of six of the eight respiratory variables a correspondence is found with the empirical results of Clausen's study. As regards one of the two remaining variables, we may talk about contradictory results, while the last variable does not allow any comparison at all since it was not systematically analysed by Clausen.

In contrast to Clausen's study we have been concentrating on quantitative variables only. Both investigations indicate clearly that any one respiratory variable considered alone is unable to discriminate sharply between psychiatric patients and non-patients, but that by combining variables and analyzing the respiratory pattern at large, very significant differences may be ascertained.

It is a legitimate question to ask whether a set of respiratory variables does discriminate between psychiatric patients and non-patients with the implicit assumption that we are dealing with a dimension having mental health and illness as its opposite poles. However, the results both from our own as from Clausen's study indicate that respiratory variables fall into rather independent clusters and that their psychological interpretation is complex. We have some reason to believe that at least two clusters are involved, the first pointing in the direction of a general regularity-irregularity dimension, and the second, in the direction of depth-shallowness dimension. It would be very facinating indeed if it could be shown that these different respiratory dimensions are linked to mental illness, but it would be even more stirring if they could be shown to be associated with more specific personality features. This being true, respiratory recordings would emerge as a possible method for personality description and assessment.

To this latter question we will turn in a forthcoming monograph.

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