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EMOTION, BREATHING AND SPEECH*

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THE LITERATURE on the variations of respiration in different emotional states is extensive. Yet few studies have examined respiration during actual speaking because methods of measurement interfere with the production of speech or preclude it altogether. Observations on nonspeaking respiration in different emotional states include work by Finesinger [1], Deutsch [2] and others. Stevenson [3] found increases in the frequency and amplitude and a more irregular pattern in states of anxiety and, at times, anger. Clausen [4], working with a pneumograph, discriminated between groups of normal subjects and neurotics, finding in the latter a higher breathing rate. Christiansen [5] has recently reported similar findings in certain types of 'excited' psychiatric patients as compared with controls.

Dudley [6], using a technique of direct alveolar gas exchange measurement, found that in action oriented states—anxiety, anger, as well as in exercise—there were increases of frequency, minute ventilation and oxygen consumption. Conversely in periods of non-action—deep relaxation or depression—the opposite was observed for oxygen consumption and minute-ventilation but surprisingly, almost no change in the other variables.

On the other hand, the extensive contributions of linguists and psychologists to speech and its disturbances have neglected for the most part what goes on below the glottis. An exception is the work of Goldman-Eisler [7–10], who indicated important relationships between breathing and language. Her insights were based upon correlations between verbal output and respiratory rate, measured by the audible sound of breathing in tape recorded interviews. They need to be supplemented by observation of respiratory tracings. Stetson [11], whose views were critically elaborated by Twaddell [12], attempted to isolate larger segments than phoneticists had dealt with before and to demonstrate their relationship to movements of the chest wall. Evidence, favoring the importance of the "breath group" as a basic segment, probably underlying the structure of the sentence in most languages, was also advanced by Lieberman [13]; but his own work, and his extensive review of that of others, showed the complexity of sub-glottal pressure regulation, which plays a crucial role in intonation. Lieberman concluded that: "all we can say at the present time, without knowing the idiosyncracies of a particular speaker, is that emotion is marked by a departure from the normal speaking habits of the individual" (p. 122). Evidently much remains to be established about the relationship between emotion, speech and breathing.

The present study attempts to observe various emotional states in speaking subjects and to relate these to variations in breathing. We felt that the forces governing emotional expression must interact with linguistic constraints and with the homeostatic mechanisms that regulate respiration.

Specifically we formulated the hypothesis that the rate and amplitude of breathing and the frequency of some major 'irregularities' of breathing movements would discriminate between the verbal expression of differing emotions and also speech that was emotionally neutral. As a provisional assumption we adopted the view of Engel [14, 15] which contrasts two basic physiologic states: 'flight–fight' and 'conservation–withdrawal.' Engel sees these contrasting states as corresponding to two primary biologic modes of responding to danger; they lead to the primal emotions of anxiety and depression–withdrawal. The latter is characterized by reduction of activity and protection of the organism against depletion; the former includes a variety of active modes of coping

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with stress. Along a different axis he also divides emotions into those marked by arousal and consummation of drive and those marked by anticipation, delay, preparation, and scanning the environment for vital information. 'Flight–fight' response thus may represent either active drive arousal or, in his terminology, 'signal scanning.' In line with these theoretical assumptions, as amplified below, we broke down a set of predefined emotions into different clusters, anticipating that they would show different respiratory patterns.

METHODS

Our subjects were four asthmatic patients in long-term psychotherapy. From the beginning they had agreed to participate in research procedures as partial compensation for their treatment. This also included careful medical supervision and management. They were observed during six to thirteen consecutive psychotherapy sessions, for a total of 39 interviews. The sessions were held in an 'experimental room,' different from the usual therapeutic office, though the therapist remained the same. All subjects expressed some concern over the change in room though they were not unfamiliar with it, having previously participated in other projects here. They were seated in a comfortable chair and were instructed not to smoke during the session.

A strain-gauge pneumograph* was placed around the chest of the subject at the level of the xyphoid process. It was tight enough to remain in place yet did not limit the breathing movement of the chest. The pneumograph tracing was recorded on a Grass Polygraph along with an EKG tracing obtained from chest electrodes and a tracing of the sound level of the room obtained through a regular microphone pick-up. This trace allowed us to differentiate speech from nonspeech periods. Because of the variability of the distance between the subject and the microphone no attempt was made to measure intensity levels. A synchronization signal to allow minute-to-minute comparison of the typescript with the pneumograph record was included. A technician, monitoring the recording, marked on the record those periods when the therapist was talking. Before and after the session the pneumograph tracing was calibrated by having the subject breathe through a closed system spirograph designed for precise measurement of respiratory volumes. The different components of the respiration which we measured are (1) amplitude (measured in millimeters); (2) rate (per minute); (3) their product, minute volume; (4) the variance of amplitude (in millimeters); and the number of (5) 'sighs' and (6) 'breath-holdings' (as defined below). Sighs and breath-holdings falling in the selected minute-samples were counted separately and not included in the determination of the variance of amplitude.

The tracing of the pneumograph is only an approximation of the air volumes exchanged, mainly because the abdominal volume changes are not directly represented and are not linearly related to chest volume changes. (Other sources of error are related to the flow and compressibility characteristics of air and need not concern us here.) Hence, the amplitude of the pneumograph tracing is not identical with the actual tidal volume but rather a function of it. Furthermore, since the coefficient of this function is determined in part by the position of the pneumograph on the lower chest and by the particular anatomy of the subject as well as by the tension of the belt, we could not directly compare different sessions for the same subject. These difficulties were met by comparing amplitudes only between different segments of the same sessions. In addition the calibration was done both before and after the session. It was assumed, rather arbitrarily, that the changes between the two calibrations were linear and intermediate points were placed on the slope.

When we refer to 'amplitude' and to 'minute volume' these considerations should be kept in mind. The measurement of respiratory frequency, or rate per minute, is straightforward, being based on the sharp inspiratory deflection of the pen. A sigh was operationally defined as causing the characteristic tracing of a deep inspiration and expiration, being also accompanied by the typical sound of a sigh, which the monitoring technician marked on the record as it occurred. A 'breath-holding' period was defined as a flat tracing, longer than a normal respiratory cycle, occurring above the base line, that is, at least, in partial inspiration, and briefly interrupting the flow of speech.

From the tape recording of the therapy session a typescript was prepared. The psychiatric variables were rated from this script by two psychiatric judges, one of whom was the therapist; each of them worked independently. They were instructed to select, in sessions with evidence of moderate-to-strong emotional expression, segments one minute in duration meeting the following criteria:

(1) An emotionally most neutral segment, at least one of these per session.
(2) Any number of segments presenting clearly and recognizably one of ten previously described emotions. These have been described and sample cues given, in previous publications [16, 17].

The major factor in selecting the segment was the natural occurrence of an 'emotion' as defined.

* Developed for us by Dr. E. P. Radford, Jr. Department of Physiology, School of Public Health, Harvard University.

The number of observations for each emotion was expected to be small. A condensation in clusters was made, to give finally the four different categories on which our predictions were made:

N—'Most neutral' emotional state of the session; the period could include mild degrees of pleasant or unpleasant affect.

D—Emotions expressing primarily strong 'distress': anxiety, guilt, shame, disgust-riddance. These are 'signal-scanning' emotions, in Engel's terminology [14, 15], indicating unpleasure leading to active attempts at the resolution of conflictual situation.

G—Emotions expressing mostly 'giving-up': fatigue–withdrawal, helplessness, hopelessness, sorrow. These are 'signal-scanning' emotions indicating unpleasure and associated with passive reaction to a conflict.

A—Emotions expressing predominantly 'drive arousal' or 'discharge': anger or erotic-sensuousness. These 'drive discharge' emotions are accompanied by a partial physiological arousal leading to some degree of climax and termination of the state.

The operational procedures were for the judges to select, without knowledge of the respiratory tracing, pertinent segments of an interview. For each segment selected, a technician, unaware of the hypothesis, measured the physiologic variables on the polygraph chart. A comparison was then made of each physiological value during different emotional clusters.

We tried to anticipate these relationships in specific working hypotheses. Using our four emotional clusters, we predicted their ordinal rank along each of the six physiologic parameters with

TABLE 1. HYPOTHESIS

Amplitude	Frequency	'Min. vol.'	Amplitude-variance	Sighs	Breath-holding
Arousal	Giving-up	Arousal	Distress	Distress	Distress
Distress	Distress	Distress	Arousal	Giving-up	Arousal
Neutral	Arousal	Neutral	Giving-up	Arousal	Giving-up
Giving-up	Neutral	Giving-up	Neutral	Neutral	Neutral

The relative position, higher or lower, of each emotion-cluster indicates the expected relative value.

which we were concerned. In states of 'arousal', involving active emotions, especially 'fight-flight,' we expected the largest increase in oxygen consumption and respiration, leading to high values of 'minute volume' and amplitude compared with neutral states. In 'distress' we anticipated respiratory changes in the same direction as 'arousal' but not as marked in degree. On the other hand, in 'giving-up', with the associated withdrawal from activity, we expected to find lower values for 'minute volume' and amplitude than in more neutral states. Frequency, the other factor contributing to minute volume', we expected would be highest in the shallow and rapid breathing of 'giving-up'; next highest in 'distress' where the stimulating effect of anxiety would raise frequency above normal values. Excitation in 'arousal', we felt, would have a similar effect on rate as 'distress', but due to deep inhalations (high amplitude) would not lead to as rapid a rate.

Those parameters measuring irregularities (amplitude variance, sighs, breath-holding) we expected to be most abnormal in conditions of 'distress' where smooth control of the physiologic function is disturbed. With less probability the excitation in 'arousal' we expected would lead to similar changes. 'Giving-up' emotions we expected to differ least from the 'most neutral' state in these parameters. Frequency of sighs, however, in moments of 'giving-up' would be closest to 'distress', for sighs also can become a means of expression and communication.

These anticipated rankings are summarized in Table 1. The actual predictions were worked out by one of us (E. H.), partly intuitively by extrapolation from non-speaking subjects, partly on the basis of pilot observations on one patient. Regarding them as preliminary, we still felt that it was heuristically valuable to make predictions as explicit as possible.

Although an analysis of variance would be the appropriate statistical tool, because of the small number of subjects and small and unequal numbers of observations, it was not applicable to our material. Instead, the somewhat less satisfactory technique (was used of serial *t*-tests for paired observations.) The significance of the results was further checked by an evaluation of the probability of correct predictions for each single physiological variable.

RESULTS

(i) *Quantitative considerations: comparison of emotional clusters*

The strong individual variations and the unequal numbers of experimental sessions produced considerable differences in the number of observations from one subject to the next. There were also differing numbers of segments representing the emotional clusters. The 'distress' cluster was most frequently observed; this is not surprising since the motivation for psychotherapy is closely related to the presence of unpleasant emotions and an active attempt at the resolution of a conflictual situation giving rise to them. In addition, sighs and breath-holding periods did not occur in one of the patients.

To test our hypothesis, we studied each physiological variable separately, and compared the

TABLE 2

Subject	Amplitude		Frequency		Min. vol.		Amplitude-variance		Sighs		Breath-holdings		No. of observations per subject
	N	*D*	*N*	*D*	*N*	*D*	*N*	*D*	*N*	*D*	*N*	*D*	
D. B.	6·9	8·3*	14·3	14·3	99·5	120·4	5·8	22·7*	—	—	—	—	8
S. D.	10.3	10.7	10·6	10·6	108·8	111·0	10·5	43·6	1	4*	1	4	5
P. L.	12·2	10·4	15·5	14·7	172·3	144·1	15·6	27·8	3	5	—	—	8
M. W.	13·1	14·0	12·6	11·9	152·8	163·5	45·8	75·4†	2·5	9*	1	5*	12
	N	*G*	*N*	*G*	*N*	*G*	*N*	*G*	*N*	*G*	*N*	*G*	
D. B.	6·0	6·4	13·4	12·4	81·4	77·0	4·5	5·3	—	1	—	1	8
S. D.	9·2	10·0	11·0	10·0	101·0	98·0	8·2	33·9	—	—	—	—	2
	N	*A*	*N*	*A*	*N*	*A*	*N*	*A*	*N*	*A*	*N*	*A*	
D. B.	5·7	6·4	12·7	12·6	73·1	82·0	3·5	7·8	—	—	—	—	7
S. D.	9·7	11·6	10·6	11·0	103·3	122·0	9·5	28·4	—	—	1	3	3
S. D. (s)	10·6	10·1	10·5	12·0	110·8	117·0	12·1	37·1	0	1	1	2	4
M. W.	12·0	14·4	13·0	12·0	142·4	179·2*	45·3	59·3	1	2	—	2·5	5
	D	*G*	*D*	*G*	*D*	*G*	*D*	*G*	*D*	*G*	*D*	*G*	
D. B.	7·6	6·4*	13·0	13·8	95·0	86·4	17·0	3·5	—	—	—	—	5
	D	*A*	*D*	*A*	*D*	*A*	*D*	*A*	*D*	*A*	*D*	*A*	
D. B.	6·8	7·5	14·0	13·3	95·0	103·0*	31·3	8·1	—	—	—	—	3
M. W.	14·0	14·4	11·4	12·5	165·4	179·2	79·1	59·3	0·5	1	2·3	2·5	5
	G	*A*	*G*	*A*	*G*	*A*	*G*	*A*	*G*	*A*	*G*	*A*	
D. B.	6·5	6·8	11·8	12·6	73·8	88·0	6·6	7·5					5
Total No. of comparisons	14		14		14		14		7		7		

Comparison of mean values for physiologic variables in different emotional states:
N = Neutral, D = Distress, G = Giving-up, A = Arousal.
A_s = 'Sex and arousal' in homosexual transference fantasies of one subject, S. D.
* = Significant at 0·05 level.
† = Significant at 0·01 level.

values obtained for any one emotional cluster with those obtained for each of the others during that interview. In any subject all the values obtained for a given physiological variable under two different emotion-clusters were pooled and used as one observed comparison.

The variable 'amplitude' will illustrate. The subject D. B. was observed on eight different occasions to display emotional clusters N (= neutral) and D (= distress) in the same interview. Average amplitude during the N segment was 6·9 mm and during the D segment was 8·3 mm. These two figures allowed one observed comparison (by t-test) between clusters N and D. In this instance the D was significantly greater than the N. Amplitude was then compared (always within this subject) under conditions D and G. Such a comparison was possible five times; the average value for D was 7·6 mm and for G 6·4 mm. Thus we had a second comparison of amplitudes, showing in this case a value for D greater than for G. If all four subjects had offered observations under all emotional conditions there would have been 24 comparisons for each physiological parameter. In fact there were many less.

Table 2 shows the observed comparisons for each physiological variable. It can be seen that

* We would like to thank Dr. Joseph L. Tecce for his statistical advice.

the 'variables', 'sighs' and 'breath-holdings' show differences between variables which appear significant. Values for 'variance of amplitude', 'sighs' and 'breath-holding' suggest differences among the various emotional categories.

These results must be interpreted cautiously. We made a large number of comparisons—70 in all; 26 of these (36%) were from one subject. Nevertheless it is not easy to attain levels of significance using a t-test on populations of less than 10 subjects. The fact that seven of these comparisons were significant at $p < 0.05$, one at $p < 0.01$, represents a strong trend.

As a next step we tested our hypotheses by assessing the direction of difference between the observed values, using the sign test. We assumed that the null hypothesis could be rejected when

TABLE 3

	Amplitude	Frequency	'Min. vol.'	Amplitude-variance	Sighs	Breath-holdings
No. of paired comparisons	14	14	14	14	7	7
No. of comparisons in the predicted direction	10	5	13	14	6	6
p	0·09	N. S.	0·001	0·008	0·062	0·062

the number of outcomes in the predicted direction was greater than expected by chance alone. The values obtained can only be regarded as approximations since this test requires independence of samples and our variables were obviously interrelated. Nevertheless, as shown in Table 3, the number of correct predictions was significant at below $p < 0.01$ for 2 out of 6 variables, at almost $p < 0.05$ another 2, and at $p < 0.10$ for a fifth. Only 'frequency' failed to follow anticipations (possibly revealing a flaw in predictions for this category). Again our preliminary hypothesis received support.

Another way to present this data is shown in Tables 4 and 5, where the total values for two variables, breath-holding and sighs, are compared between emotion clusters. Comparison is possible

TABLE 4. BREATH HOLDING: FREQUENCY IN THE DIFFERENT EMOTION CLUSTERS

Emotion clusters in predicted order	D >	A >	G >	N
No. of breath holding	80	29	8	24
No. of 1-min segments	33	19	10	47
Observed frequency	2·4 >	1·5 >	0·8 >	0·51

since these two variables are essentially independent of the pneumograph calibration. (So is breathing rate; but we have just seen this variable did not conform to our hypothesis.) Table 4 shows that the mean frequency of breath-holdings follows the order predicted by our hypothesis across all the clusters. Table 5 shows that the same is true for sighs, except for one cluster, 'neutral' which had been predicted to show the lowest and in fact shows the next highest frequency.

Because of the small number of subjects, it would hardly be meaningful to make a statistical evaluation of the probability of these findings; confirmation should come from replication on a larger number of subjects. These data do provide, we feel, a trend strong enough to justify further quantitative studies.

TABLE 5. SIGHS: FREQUENCY IN THE DIFFERENT EMOTION CLUSTERS

Emotion clusters in predicted order	D >	G >	A >	N
No. of sighs	168	8	14	59
No. of 1-min segments	33	10	19	47
Observed frequency	5·1	0·8	0·74	1·25

(ii) *Qualitative considerations: individual respiratory records*

Experience with a large number of speech–breathing records reveals a pattern fairly common among pneumograph tracings. A sharp inspiratory deflection is followed by an extended expiratory decline upon which are superimposed a number of smaller deflections like ripples. The decline coincides with a normal prolongation of expiration during speech and the ripples presumably with variations in the expulsive force during normal intonation (as well as with heart rate). "During talking expiratory resistance increases perhaps fifty-fold, while inspiration is produced in about one-fourth the time and hence at flows some four-fold those of spontaneous breathing" [18]. Taking this idealized picture as a starting point, one can see, however, marked inter-personal and intra-personal variation, particularly in patterns of respiratory movement.

It was striking to observe the individual constancy of breathing patterns in almost 40 interviews recorded with the four asthmatic subjects (range 6–13 sessions/individual). Although this was not

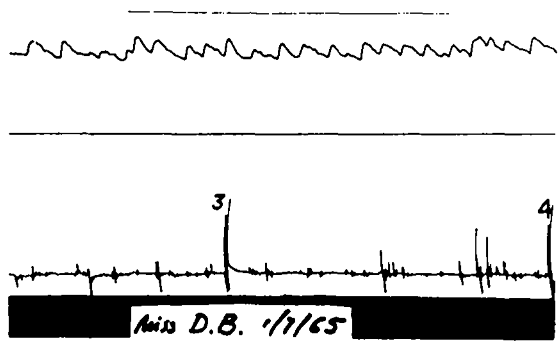

FIG. 1. The pneumograph tracing is characterized by steep inhalations and slow exhalations (interrupted by small deflections like ripples). Below: tracing of sound-intensity (interrupted by the synchronization-signal), which allows differentiation periods of speech from non-speech. In this subject (D. B.) the pneumograph tracing is very regular with almost no difference between speaking and non-speaking periods.

done as a strict experiment, recognition of the pneumograph records as belonging to the respective individuals on a blind basis did not appear to be difficult for a judge familiar with the records.

Describing the criteria necessary to do so, however, is a more formidable task. To some extent such judgments can be based on the measures already described. But further characteristics have to be included, such as the overall regularity of the breathing-pattern, distribution of sighs and breath-holdings, length of utterances, or 'breathing-units', each contributing to an overall rhythm of the speech breathing-pattern. Distribution of additional features, such as the following, would also have to be considered: coughing (sharp, long drop after deep inhalation—or forced additional exhalation from close to baseline, including air from the expiratory reserve volume); laughing (like coughing but with frequent short interruptions of exhalation); yawning (deep inhalation ending in plateau); crying (little to medium to deep inhalation with slow exhalation and prolonged breathing pauses); and whistling (irregular short sequence of inhalation–exhalation movements).

Illustration of the many factors contributing to the breathing-record during the interview situation will best explain our conclusion that one can speak of an individual 'style' of breathing in speech. A detailed description of life history and important events during time of observation of the subjects has been given in another paper [19]. Here we will characterize briefly the observed behavior as seen in the interviews and compare it with the pneumograph record.

Subject 1 (*D. B.—Female*, 38). In the therapeutic interview this subject sat rather tensely in her chair, barely ever moving, hardly ever allowing herself any emotional manifestation. She spoke fast, quite softly, always in the same flat tone of voice. She had no difficulty in verbal communication. Her speech was intelligible, coherent, and without long pauses.

The pneumograph (Fig. 1, 1/7, min 3) is very regular. Surprisingly, there is little difference between her speaking and non-speaking tracings. She does not show any reaction to the entrance of the therapist into the therapy room as the other subjects did. Sighs and breath-holdings are almost totally absent. This rigid control of her motor activity is present in all the records we made of her. Yet, in spite of this impressive regularity, we were able to discriminate between different effect clusters.

Subject 2 (*P. L.—Male*, 22). The interview behavior of this subject like that of the preceding one was exaggeratedly controlled. He allowed himself very little range of affective expression. He spoke in a rather monotonous voice, always very softly. He seldom showed any emotion on his face or in his manner. His communications were highly guarded and with him the judges had the greatest difficulty in finding periods of identifiable, contrasting emotions. However, the careful reading of his typescript showed that under stress, his intellectual thinking could subtly shift to the grandiose and disorganized.

In contrast to this picture of self-control was his breathing record. Although he would be breathing regularly before the interview, when the therapist entered the room his breathing would immediately become irregular, even in the absence of speech. He had the second highest variance of amplitude in the group. The most prominent feature of his record, however, is his very frequent sighs, occurring in bursts of two or three, most of them quite loud averaging in some interviews one per minute (Fig. 2, 12/3, min 16). Over the course of the observation period, his tracing became somewhat more regular, but again took its initial pattern in a later period of stress.

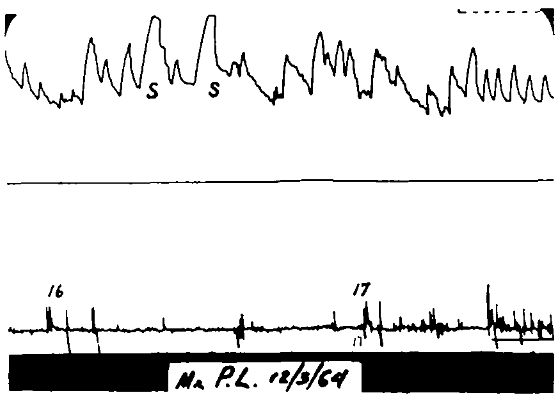

FIG. 2. In contrast to D. B. the tracing of P. L. is quite irregular with extremely frequent sighs (S).

Subject 3 (*S. D.—Male*, 27). In constrast to the two preceding subjects this young man displayed the widest—almost the wildest—range of use of his respiration in conjunction with his interview behavior. While sometimes he spoke with an educated fluency, at other times he could plunge into prolonged silence. Within minutes he could go from chuckles and laughter to pathetic moans and frank crying (S. D. 12/7, min) [19–21]. His reaction to the therapist entering the room was the most excessive of all. Once, for example, he greeted the therapist with five sighs within the first minute, all of them clearly audible (S. D. 12/17, min 0–1). Interestingly enough, the inspection of his tracings would suggest strongly that in most instances, the first half of the session was the dramatic one, while the second half tended to show a more regular breathing pattern. The change seems to have been related to greater activity of the therapist in the later part of the interview.

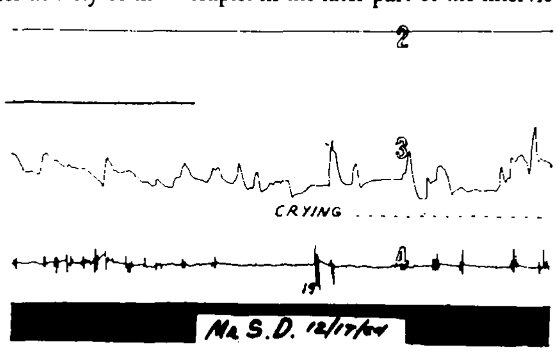

FIG. 3. A segment of irregular speech-breathing is followed by a period of spontaneous crying of subject. S. D.

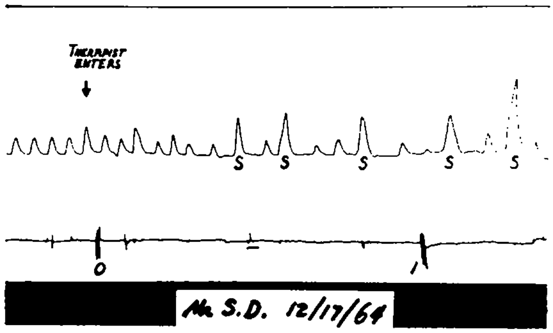

FIG. 4. Here the same subject (S. D.) responds to therapist's entering with a burst of sighs (S).

The problem for the judges was to evaluate what were the genuine emotions amidst the bizarre display. They were rather cautious and, indeed, later development in therapy proved them to have been right: much of the over-emotionality represented the patient's effort to fend off threatening feelings of depersonalization.

Subject 4 (*M. W.—Female*, 27). This subject was very labile, colorful, and hysterical. During the interview she shifted a great deal on her chair, and gesticulated almost constantly. Her facial expression always reflected her constantly changing emotions. Her speech would fluctuate in a similar way, going from a low, halting hesitating murmur during moody, depressed states to a sharp, rapid and loud delivery when she was elated. The actual content of her verbal communication was often difficult to understand because of limited ability to tolerate for any length of time an abstract and intellectualized level of communication. This created some difficulty for the judges.

Her pneumograph tracing corresponds to her psychiatric picture: it is the most irregular of the group. She has the highest variance of amplitude, a very high number of breath-holding periods, numerous sudden pauses, abrupt inhalations and/or exhalations. She reacted very much to the therapist's entrance in the room—and did not in any of her records show any tendency to stabilize during the hour nor during the series of interviews. There seemed to be a tendency—opposed to patient number 3—to respond with more irregularities to the therapist's speaking—in particular by holding her breath.

A given session may exemplify the sudden shifts in her verbal material, along with occasional dramatic change of affects. In this particular session the patient was describing her disappointment at having spent New Year's Eve baby-sitting for her brother while her family was having a good time. This stirred up many old feelings of frustration, particularly since only a few days before, under pressure from her family, she had left her married paramour and returned to what she had hoped would be the protective harbour of her own family. In an overall rating of the session of a variable called "defensive–strain" [19] the psychiatric judges concluded the patient to have experienced maximal strain and high loss of defensive control.

As might be expected, there were difficulties in selecting a 'most neutral' segment from this generally disturbed interview. In this particular session it was felt that during minutes 5 and 6,

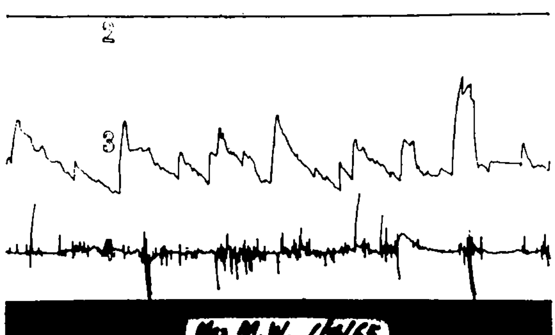

FIG. 5. Subject M. W. in a relative neutral period with moderately irregular tracing.

(Fig. 5 1/4) when the patient was describing her state of health and recent relapse into asthma, she was least 'emotional', although her total distress at the time suggested that she was far from being in a truly 'neutral' emotional state.

Speaking about New Year's events and experienced isolation and frustration, she grew more and more angry until reaching a peak of 'arousal' at about minute 16 (Fig. 6). Here she described an argument with her father who accused her physicians of not sufficiently helping the patient for her asthma. She responded to this rejecting accusation with expressions like "that just sort of sets like

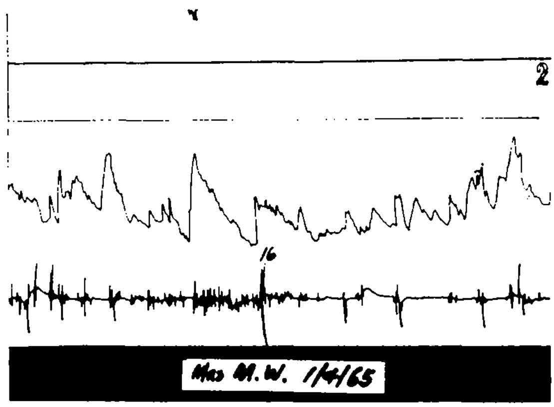

FIG. 6. Tracing shows increased irregularity and some deep inhalations, while subject (M. W.) verbally expresses intensive anger.

a bomb exploding in all directions . . . and I just got all—you know—up in arms at him". During the rest of the interview the theme shifted to her highly ambivalent and conflictual relationship with her married friend whom she had been missing during the New Year holiday. As the therapist confronted her with the intensity of her longing for him and her equal feelings of guilt, another peak of strain was reached. Her experiencing strong 'distress' around minute 50 is reflected in the typescript by a breakdown of intellectual control and a high level of confusion.

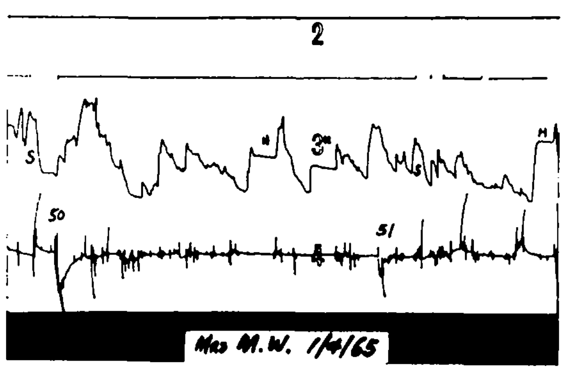

FIG. 7. Subject M. W. at a time of distress: There is wild and irregular breathing with frequent breath-holding (H) and some sighs (S).

Figure 8 1/11, min 3, finally, represents a sample picked out of a period of sadness, related to the continuous struggle with her family a few days later.

It can be seen by inspection of the pneumograph tracings alone that the given examples of 'emotional peaks' differ considerably from the relatively 'neutral' segment for that particular session. Increase in amplitude and irregularity during 'arousal' in Fig. 6 is as much in accordance with the hypothesis as is the extreme increase of sighs and breath-holdings and equal irregularity (counted independently of sighs and breath-holdings) under 'distress'.

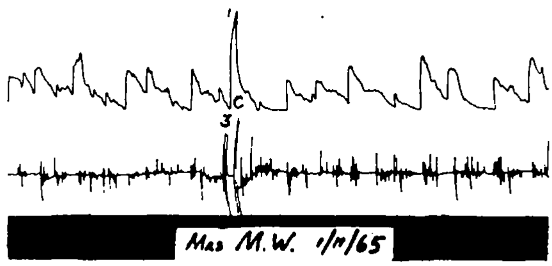

FIG. 8. Tracing of subject M. W. shows low, relatively constant inhalations with some irregularity in a period of sadness.

DISCUSSION

In contrast to many physiologic determinations, accurate assessment of respiration has until now been incompatible with a free, spontaneous and undisturbed interview situation. As we have mentioned, earlier attempts to observe breathing during speaking, particularly those of Goldman-Eisler, led to productive hypotheses; but they were hampered by insufficient techniques and were thus limited in the amount of precise information they could supply. Recent technological advances, particularly sensitive measures of air-flow, strain gauge pneumographs and various impedance measures [22–27], have permitted more precise assessment of respiration without the interference of complicated instrumentation. We have been struck with the possibilities of the 'magnetometer' developed by Mead and his associates [28]. This device, by using two magnetic fields, monitors the thoracic and abdominal *A–P* diameter changes; their algebraic sum is linearly related to the tidal volume over most of the vital capacity.

Our findings suggest that observation of speech and actual breathing patterns gives important information about inter-individual characterological features and intra-individual changes with changing emotional states.

The individual 'style' of breathing has been remarked upon by Christiansen [5] who reports success in differentiating normal from neurotic populations and various sub-groups within the neurotic population. He used samples of respiration obtained under conditions of maximum stability, while the subject was recumbent at rest. There is a need for us to attempt correlation of our speaking respiratory tracings with those from the same subjects at rest. However, our preliminary impression is that, just as the voice becomes highly idiosyncratic and individualized, so the speech-breathing pattern may come to acquire more of an individual stamp than does the breathing pattern alone. Ultimately there will be a need to study not only the aspects of rate, volume, and characteristics of the respiratory curve, but also to study the inter-relationship of these with loudness and other acoustic qualities of vocal expression.

Our population in the present study is obviously a small one and we must be cautious not to generalize prematurely. All of them were asthmatics. It will be important to get additional information about non-asthmatic subjects, some of which we are at present collecting. In an earlier, unpublished study by B. White, with one of us (P. H. K.), we found suggestive evidence that asthmatics in a closed breathing apparatus showed a higher proportion of 'irregularities' than a matched comparison group.

Ideally it would be desirable to get information from a tracing of speech and breathing with which to trace vicissitudes in the actual asthmatic state during interview. At present we lack a good method for assessing airway resistance in a freely communicating subject. The inspiration–expiration ratio, which earlier authors suggested might serve as an indicator of asthma, deserves further exploration but is inappropriate in speech–breathing studies. In the patients we have reported here there was little clinical evidence of asthma during the interviews we observed. Yet determinations of airway resistance before and after the interview [19] revealed frequent pathological values; and it was possible to correlate these with independent assessments of emotional state. Our ultimate hope is to find ways of extrapolating from precise measures of airway resistance to sensitive pneumograph measurements obtained close to them in time, in order to get a more accurate evaluation of the degree of asthma during periods of interview observation.

Our observations of intra-individual change over time in speaking individuals offer promise that this measurement may yield rich information about emotional vicissitudes. It was somewhat surprising to us that respiratory rate was the least sensitive measure in differentiating emotional clusters. This finding contrasts with that of other authors [4, 8, 9, 23] who have reported that respiratory rate appeared to be a valuable differentiating measure. In all of these workers, except for Goldman-Eisler, we are dealing with non-speaking respiration; and in her work the most important findings were not those of respiratory rate alone but respiratory rate in relationship to syllables per expiration. Further work will be necessary to distinguish the circumstances under which rate, as against amplitude, seems relevant in speaking subjects. Our preliminary observations suggest that amplitude was a more meaningful variable, and that even more significant was the product of amplitude x-rate, or our approximation of 'minute volume.'

It should be re-emphasized that these measures are interrelated. We may have been getting various samples of a factor that might be thought of as 'respiratory mobilization.' Similarly our estimate of 'variance of amplitude,' sighs, and breath-holding may well be interrelated and constitute another aspect of respiration, perhaps relative inhibition or interference with free and regular breathing. Both Goldman-Eisler [9] and Christiansen [5] have stressed in different ways the importance of inhibitory and excitatory factors, which may so readily reflect themselves in breathing behavior.

We are impressed with the possibility that some of the non-lexical features referred to by linguists [21, 29], such as speech disruptions and hesitation noises, may be closely related to breathing disturbances. They appear to represent an accentuation of the tendency for breathing to fluctuate more in speaking than in non-speaking subjects. The extent of irregularity in breathing during speech may reflect the intrusion of conflicting impulses into a spontaneous and habitual function. Careful attention to the temporal patterns of interference with smooth speech appear to be both a simple and fruitful avenue to explore in understanding the relationships of speech to emotion, as Goldman-Eisler [21] and Lieberman [13] have shown.

Spontaneous holding of breath, often for many seconds, seems a particularly clear example of how disturbing emotion may disrupt normal speech–breathing. At times it seems to mark off pausing before starting a new statement. At other times, for example, when a patient suddenly stops breathing as a therapist speaks, it seems as though a major influence in the inter-personal situation has intruded itself on the normal ebb and flow of speech and language.

Similar observations may be made about sighs, which have been ascribed to unpleasant effects, particularly in neurotics [1, 4]. Our study showed that the total number of sighs for two subjects was double the number published by Bendixen for normal subjects at rest [24]. Again we noted great fluctuation within sessions, indicating the apparent relationship of sighs to emotional factors. It should not be forgotten that sighs may also play a physiologic role, namely, to re-open atelectatic air spaces; this aspect may also interact with emotional factors. As Wright [30] remarked, postural variations, in which a subject rigidly restricts his lung for a period of time, as he becomes absorbed by one or another attentive task, may lead to just such transient collapse of small lobules within his lung and the need for a sigh. This pattern of miniature 'air hunger' and its relief, may then become caught up in other learned patterns.

Our major speculation about respiration received some support from these preliminary results, namely, that orientation toward 'flight–fight' in emotional disturbance tended to increase the respiratory volume, as if the organism were anticipating and preparing for activity and actual expenditure of energy, a finding that Dudley also reported in studies measuring gas exchange [6, 31]. Though rare, our instances of arousal confirm the observation that excited people frequently hyperventilate. Finally, we obtained some evidence that 'giving up' led to a noticeable reduction of the speech respiratory volume, again a finding reported by Dudley, as the organism anticipates withdrawal from action and less need for energy.

Obviously our sketchy findings do little more than illustrate the potentialities of this method of approach. Much remains to be done, such as distinguishing erotic from angry affect. Another possible distinction is that of true 'sorrow' with an active urge to weep from other depressive elements.

Indeed, it may have been the confusion of these two that made 'giving up' less discriminating than some other clusters in our explorations. Still another possibility is that 'distress', characterized by anxiety, tension, and conflict may lead to hyperventilation with much evidence of irregularity, whereas arousal and expression of drive and emotion processes, unhindered by conflict, may lead to more regular, though still overactive ventilatory patterns.

We feel that these observations are important in helping us work toward a meaningful classification of emotional processes. Emotions can obviously be sub-divided almost infinitely. Yet, it is important to remember that the repertoire of the organism to respond biologically is far more limited. Felt emotions may shade into one another and be difficult to differentiate, but all nuances may not be so crucial for the physiologic investigator. In general, we continue to believe that it is important to try to isolate 'families' or, as we call them in this study, 'clusters' of emotions. Whether or not the simple scheme we used here will eventually prove the best remains to be seen. (For an alternative and slightly more complex model the reader is referred to additional studies by one of us [32, 33].)

Lastly, we call attention to the importance of observing respiratory movements in microscopic analysis of interview behavior. Breathing may segment language into meaningful behavioral units, in Scheflen's term [34], and lend itself well to careful methods of analyzing communication. In a pilot investigation we had some success in showing a relationship between lexical content and breathing patterns in an audio-visual recorded interview with one asthmatic patient. Not only can asthmatic fluctuations be studied in immediate context, but also there is a fruitful area for linking speech–breathing behavior with linguistic-kinesic studies of intonation, and body movement.

SUMMARY

Four perennial asthmatics were observed in different emotional states which arose during psychotherapeutic interviews. Respiration was monitored with a strain-gauge pneumograph during a total of 39 sessions. The respiratory record allowed us to select various one minute samples of the interview and measure the following variables: (1) respiratory rate; (2) mean amplitude; (3) variance of amplitude; (4) minute volume; (5) sighs; (6) periods of breath holding.

The typescript of the tape-recorded interviews was independently studied by two psychiatric judges who selected 'emotional peaks' as well as a reference 'neutral' period in each interview. These were all segments during which patients were speaking. The 'emotions' were operationally defined in advance and condensed in four clusters chosen to reflect different psychophysiologic states: (1) 'distress' (encompassing anxiety, guilt, shame), (2) 'giving-up' (encompassing sorrow, helplessness, hopelessness), (3) 'drive arousal' (anger or sexual excitement), and (4) 'neutral emotion' referring to the moments when the subject was judged to be in his least intense emotional phase for that hour.

Predictions were made about the relative level of each physiological variable under the differing emotional conditions. Predicted outcomes were observed at a significant level for four of the six variables. Individual consistency of breathing patterns in the interviews suggested that there were individual 'styles' of speech–breathing.

Observation of speech–breathing patterns gives important information about inter-individual personality features and intra-individual change with changing emotional states.

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