# YAWNING AND ASSOCIATED PHENOMENA

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In the course of some studies (1) on the vasomotor activity in human fingers I noted that definite circulatory changes occur during spontaneous yawning. An attempt to correlate these observations with existing data on yawning revealed that the few pertinent studies of this subject have not found their way into British or American publications. Although yawning and its associated phenomena appear to be of minor importance they are not without interest, and it would seem worth while to make readily available the little that is known and the rather more that has been postulated on this subject. Such is the purpose of this paper.

LITERATURE. *Standard sources.* It is well to review the popular conceptions of yawning as set forth in the standard physiologic, psychologic and lay publications before turning to the special literature.

Of the well-known text-books of physiology eight (2, 3, 4, 5, 6, 7, 8, 9) contain no discussion of yawning. One of them (10), in a section devoted to "modified respiratory movements," defines it in the following terms:

> Various psychic or emotional reactions manifest themselves not only by facial expressions, but also by objective changes in respiratory acts. . . . Yawning is associated with a prolonged inspiration during which the mouth is stretched wide open, followed by a short expiration. (p. 386)

The larger text-book of Schäfer (11), in a discussion of "modified respiratory movements," does not go beyond stating:

> Yawning consists of a deep inspiration accompanied by a wide opening of the mouth and of the glottis, often attended by movements of the arms. (Vol. ii; p. 309)

Even the ponderous German hand-books on physiology treat the subject in cursory fashion. Thus in Hermann's *Handbuch der Physiologie* (12), under the heading "special forms of respiratory movements," yawning is defined and dismissed in these terms:

> [yawning is] a psychically or reflexly excited inspiration during which the vocal cords may be set in motion. (B. IV; H. 2; S. 234)

In Nagel's *Handbuch der Physiologie des Menschen* (13) the topic is introduced and concluded with the following remarks in a section devoted to "special forms of respiration":

> The yawn is a deep inspiration carried out with widely opened glottis and usually with opened mouth; it is frequently accompanied by movements of the arms, *etc.* It is caused by certain psychic influences, fatigue, *etc.* (B. I; S. 27)

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From the foregoing it is apparent that while none of these authors makes any conjecture as to the physiologic significance of the act, they have all focused their attention upon its respiratory component and have classified it as a respiratory phenomenon. It is hardly necessary to point out that the subject has not been developed beyond or even through the descriptive phase.

The psychologic literature appears to be equally barren. Yawning has been defined (14) as ". . . .a reflex usually induced by bodily fatigue," but critical studies in support of this conception are wanting. In a recent review of the psychologic aspects of the subject Moore (15) points out that nothing about yawning has been established beyond the notation that it appears very early in extra-uterine life.

Articles for lay consumption are more explicit and display less hesitancy in assigning a significance or purpose to the yawn. This is evident in the following excerpt from a recent *New York Times Magazine* (16):

> Boredom, hunger, overeating, drowsiness and bad ventilation have all been blamed for yawns, but the specific stimulus that starts the reflex is still obscure. The power of suggestion has a lot to do with it. Yawns are catching, as everyone knows, and they can even be self-induced. . . . A yawn has all the beneficial effects of a deep breath of fresh air. It is elaxing and refreshing. It tones up the muscles of the mouth, the chest, the back and even r he arms. Whether it has any other psychological or physical effects science doesn't say. t

The above views are essentially the same as those which Clarkson (17) submitted to the laity in *Hygeia*. They constitute a modern version of the Delsartean concept (18) which we will review in a later paragraph.

It is of interest to compare all of the foregoing descriptions with the dictionary definitions of the word *yawning* and its alleged synonyms, *pandiculation*, *oscitation* and *chasma*. Standard lay (19, 20) and medical (21) dictionaries agree that the word *yawning* is derived from the Old English verb *ganien* which has always denoted an "opening" in the sense of "to gape." The definitions of yawning given by the lay dictionaries (19, 20) are in such complete harmony that only one need be quoted:

> An involuntary act, excited by drowsiness, *etc.*, and consisting of a deep and long inspiration usually following several successive attempts at inspiration, the mouth, fauces, *etc.*, typically being wide open. (20)

Some medical dictionaries (21) conform to this restricted definition, but others have expanded the meaning to include the associated stretching of the limbs. Thus Dorland (22) offers the following definition of yawning:

> Pandiculation; a deep, involuntary inspiration with the open mouth, often accompanied by the act of stretching.

From this it also appears that Dorland regards pandiculation and yawning as synonyms.

Both lay (19, 20) and medical (21, 22) dictionaries agree that *pandiculation* is derived from the Latin verb *pandiculari*, meaning "to stretch oneself." Of these dictionaries only Dorland, as already noted, offers this word as a synonym

for yawning. The others are in agreement on a more narrow definition of which the following is characteristic:

A stretching and stiffening, esp. of the trunk and extremities, as when fatigued and drowsy, or after waking from sleep. (20)

All of these dictionaries (19, 20, 21, 22) offer the words *chasma* (from the Latin noun *chasma*. . . .a cleft or an abyss) and *oscitation* (from the Latin verb *oscitare* . . . .to open the mouth wide) as synonyms for the noun *yawn*.

From the above it is evident that the authorities, both lay and medical, have been aware of the complexity of the act under consideration and have been uncertain just how much of it to include under the designation "yawn." On semasiological grounds it would appear desirable to preserve a distinction between yawning and pandiculation, and to employ some such expression as "the yawn-stretch act" when the entire complex is intended.

*Special sources.* (Occurrence). Depending on the breadth of definition adopted, the occurrence of yawning throughout the animal kingdom is more or less widespread. Crämer (23) points out that the familiar gaping movements of fishes, amphibians and reptiles simulate the oral component of yawning in man, but most observers (24, 25, 26, 27) decline to read true yawning into this superficial resemblance. Whether or not the gaping of these lower forms is accompanied by the respiratory component of yawning and a generalized stretching is not known, and it is best to follow Peiper (27) in reserving judgment on the occurrence of yawning in these classes.

The data on birds are little more complete, although the gaping chicken beating its wings on tip-toe is an everyday spectacle. Here a generalized stretching is seen in conjunction with gaping, but the question of an associated respiratory effort has not been answered by critical observation. It is the impression of both Heinroth (25) and Crämer (23) that true yawning is practiced by birds, but Hauptmann (26) opposes this view.

It is generally agreed (23, 24, 25, 26, 27) that among terrestrial mammals true yawning and stretching are to be observed in primates and carnivores. The situation with regard to herbivora is not so clear, although most authors concede that these animals practice stretching. The failure of the herbivora to exhibit the gaping component of the yawn-stretch act constitutes an objection standing in the way of admitting them into the category of yawners, but Dumpert (24) has pointed out that since herbivora are exclusively nose-breathers, even under conditions of stress, it is unnecessary for them to add the oral component to the yawn-stretch act in order to effect its inspiratory phase.

Before leaving the subject of yawning in animals it is important to mention the possible relationship of its gaping component to the "automatic expressions" described by Darwin (28). The gaping movements of fishes, amphibians and reptiles may belong to this group of emotional expressions, and it appears certain that some of the anthropoids employ the mouth-act in question for emotional attitudinization. Finally, as we shall see, there are those who regard the complete yawn-stretch complex as but another example of the automatic expressions like laughing and crying.

In the case of man little can be added to the previously noted lay observations on occurrence. The idea that yawns are "catching" can be traced back to Mayer (29) who believes that in some individuals the threshold for this so-called psychically released yawning is exceptionally low, and that in such persons autosuggestion may constitute an effective stimulus. Crämer (23) and Schrijver (30) hold that yawning may normally be a symptom of hunger. They report that it is so regarded by some of the Continental laity, and Luciani (31) has been cited as supporting this view. It should be noted, however, that yawning was not among the symptoms of the fasting men observed by Carlson (32).

It has been remarked (24, 33) that among infants and children, as among many animals, yawning is more regularly attended by stretching than is the case among adults. Dumpert (24) looks upon the adult's yawn, without pandiculation, as a fractionation of a primitive yawn-stretch reaction, and he postulates that such a dissociation is the outcome of acquired voluntary inhibitions cultivated in accordance with the demands of "good company." As we shall see in a subsequent paragraph, this concept enjoys some support from the fact that man's ability to yawn without stretching can be lost in certain disorders of the central nervous system. There are other observations, however, which suggest that yawning and stretching are independent albeit frequently associated acts, rather than fundamentally conjoined responses. In the first place, infants under 1 year frequently yawn without stretching and it is hardly permissible to regard this as a fractionation of some basic physiologic pattern by voluntary inhibitions. Secondly, regardless of man's age he displays a tendency to yawn (without stretching) just prior to surrendering to sleep, and to stretch (without yawning) upon waking. This too intimates that factors other than voluntary inhibitions are active in determining whether pandiculation and yawning occur together or separately.

Yawning under circumstances other than those already mentioned is probably always morbid.

*Special sources.* (Clinical.) Addressing clinicians in 1908 Geigel (34) lamented the fact that his teachers had never mentioned yawning and complained that nowhere could he discover observations elucidating its physiologic or pathologic significance. Similar conditions obtain today although morbid yawning is more common than our neglect of it would imply.

Geigel's contribution to the subject was quite limited. He emphasized the value of yawning as a favorable prognostic sign in certain acute illnesses and noted its occurrence in hysterics. Several observers (24, 27, 35, 36) have remarked the frequency of yawning after severe hemorrhage. Peiper (27) seeks to explain this on the basis of his theory (*vide infra*) of lowered excitability of the central nervous system, whereas Nash (36) attributes it to anoxia and/or arterial hypotension. There are no experimental data supporting either explanation.

Crämer (23) and Schrijver (30) have reported the frequency of excessive yawning in diseases of the gastro-intestinal tract, especially that of duodenal ulcer, wherein crises of yawning sometimes parallel exacerbations of symptoms. The association of deranged stools and flatus with morbid yawning so impressed

Crämer that he postulated an auto-intoxication by bacterial toxins arising from within the bowel as the causative agent. He reviews the rather meagre evidence supporting this view.

Neurologists have met with abnormal yawning rather more frequently than others. Oppenheim (37), Geigel (34) and Lewy (35) have encountered it in hysteria, and its occurrence as an aura in epilepsy has been remarked by Oppenheim (37), Lewy (35), Wilson (38) and Penfield (39). In Wilson's experience this aura has been associated with his so-called "peri-ventricular" or "visceral" epilepsy wherein the yawn is followed by voiding of urine, giddiness, headache and sometimes vomiting. He suggests that such cases depend on disorder of visceral centers in the third ventricle regulating sleep and fluid interchange, with subsequent spread to others on the floor of the fourth ventricle. Penfield (p. 110) gives the clinical details of such a case.

Among the manifold sequelae of epidemic encephalitis is that of paroxysmal yawning usually in conjunction with other, though varied, neurologic disturbances. Mayer (29), Wilson (38) and Sicard and Paraf (40) describe cases from their personal experience, but it has not been possible to ascribe the symptom to proven lesions at particular foci in the neuro-axis. In this connection it is of interest to record certain impressions which Yakovlev (41) has formed with regard to derangements of yawning and pandiculation in other disorders involving the basal ganglia. In his experience Huntington's Choreics exhibit a propensity for yawning and more especially for stretching which stands in sharp contrast to the behaviour of Parkinsonics who rarely yawn and never stretch. Yakovlev emphasizes that these impressions have been derived from a study of relatively few cases and stand in need of confirmation by a test on more material.

Excessive yawning is frequently seen in patients harboring expanding intracranial lesions, notably cerebellar abscess or tumor (35, 36, 37, 38, 42). When attended by abnormal drowsiness the sign is without localizing value (37, 38), but its occurrence in an alert patient suggests to some (38) that a thorough search be made for third ventricular and hypothalamic signs. Nash (36) hazards an explanation for the yawning seen in the usual run of brain tumor cases. He states:

> The occurrence of yawning, which is essentially an atypical respiratory act, in cases of brain tumor can be explained by irritation of the brain resulting in "afferent" impulses to the medullary respiratory center, which modify its rhythmic activity. (p. 92)

*Special sources.* (Investigative.) Mayer (29) alone has attempted a systematic investigation of the yawn-stretch act. By means of the roentgen-screen, laryngeal mirror and palpation of muscles he has analyzed the sequence of events in man when the complete complex, unmodified by inhibition, is allowed to develop. For convenience of description he divides the act into a number of phases:

I. Inspiratory Phase (duration: 4.4 to 6.8 sec.)
  A. Initial Part
  B. Acme (duration: 2.5 sec.)
II. Expiratory Phase

During the initial part of the inspiratory phase one observes a widening of the chest, a descent of the diaphragm and larynx, an elevation of the *ali nasi* and soft palate, a downward and backward displacement of the tongue, an abduction of the vocal cords and an opening of the mouth. This is occasionally attended by a subjective crackling in the ears which is thought (43) to be due to a contraction of the *M. tensor veli palatini* with jerking of its tendon in the bursa between it and the pterygoid hamulus.

When the acme of the complex has been attained one notes that the chest, diaphragm, larynx, tongue, palate and mouth have maintained or accentuated their respective movements of the initial phase. There has, in addition, been a firm closure of the eyes and a rapid development of the stretch component. The number and distribution of muscles recruited for the stretch are subject to variation and may be modified by voluntary inhibition. Neck and arm muscles are most frequently recruited, but those of the legs, trunk and abdomen may participate. The probable influence of such widespread muscular activity upon the venous return, and secondarily upon cardiac filling, rate and output, has been recognized (24, 29), but no studies have been made to confirm this. At the close of this phase saliva occasionally spurts from the submaxillary and sublingual ducts, presumably due to a squeezing of these glands by the contracting oral musculature.

During the expiratory phase one notes a short sharp expiration with gradual relaxation of all previously activated muscles permitting the return of diaphragm, larynx, tongue, *etc.* to their resting positions. Lacrimation and swallowing may occur at this stage. The former is believed (44) to be due to an augmentation of secretion rather than to a simple compression of the lacrymal glands because the tightest possible voluntary blepharospasm cannot squeeze forth tears in an amount sufficient to overflow the conjunctival sac. The swallowing is presumed to depend upon the occurrence of the previously noted salivation. This final phase of the yawn is usually accompanied by some such subjective feeling as relief, satisfaction or refreshment.

Prior to Mayer's (29) fluoroscopic observations, which show the diaphragm to descend and remain relatively fixed in this position from the initiation until the expiratory phase of the yawn, Hauptmann (26) had arrived at a different opinion as to the behaviour of this organ. Using a kymographic method for recording thoracic and abdominal respiration, Hauptmann was led to believe that the rhythmic action of this muscle was but little, if at all, interrupted by yawning. His view must, of course, give way to that suggested by the more refined method of fluoroscopy. It is important to note, however, that Mayer and Hauptmann agree that yawning effects no ultimate increase in aeration of the lungs; they argue that the apneic period following the yawn (see fig. 1 and 2) more than compensates for any temporary increase in aeration afforded by a single deep breath.

The neural structures subserving the complicated yawn-stretch act may conveniently be thought of as comprising an integrative center played upon by diverse afferent elements and discharging over its several efferent channels. Evi-

dence at hand is insufficient, however, to establish the location or even the existence of a "yawn-center" in man or animals. Ellenberger and Scheunert (45) include yawning among the functions of the medulla oblongata in dogs, but they do not submit the evidence supporting this localization. In man a postulated center has been variously located in the *corpus striatum* (23, 35) and "subcortical ganglia" (24, 27, 29) on very unsatisfactory evidence. There are, however, two significant papers bearing on this question. Gamper (46) has seen the complete yawn-stretch act in what he describes as a mid-brain preparation (*Arhinencephalie mit Encephalocele*), and Catel and Krauspe (47) have observed it in a case where only the medulla oblongata and more caudal portions of the nervous system were

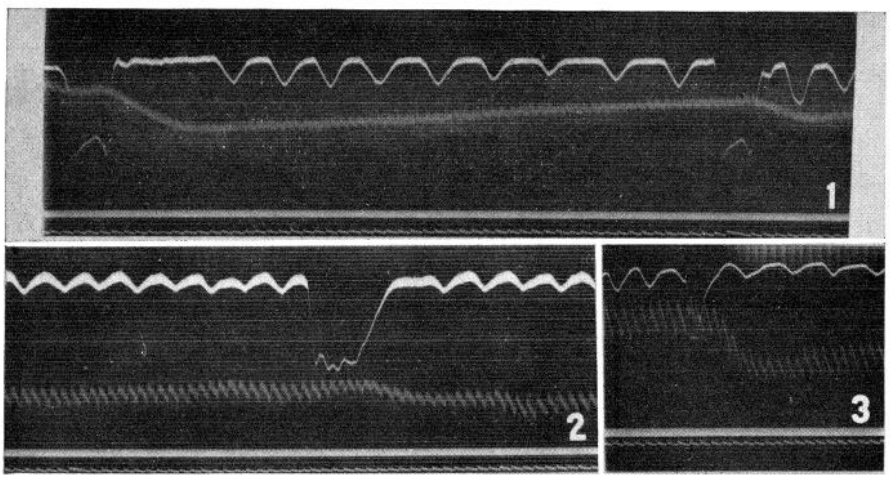


Fig. 1. Record of vasoconstriction in normal finger accompanying yawning.
Fig. 2. Record of vasoconstriction in sympathectomized finger accompanying yawning.
Fig. 3. Record of vasoconstriction in normal finger accompanying deep breath. The tracings from above downward are: (a) respiration by stethograph, (b) digital translucency, (c) signal magnet and (d) time in one second intervals.

completely formed (*Meroanenzephalie mit Meroankranie*). These observations suggest that if a yawn-center exists it is to be found in the medulla oblongata, possibly in the immediate vicinity of the respiratory and vasomotor centers.

The so-called psychically released yawning, or yawning as an apparent consequence of suggestion, implies that the act can be initiated by influences emanating from the highest cerebral levels. Inhibition of the act by influences arising at these levels is confirmed by the behaviour of hemiplegic patients who have lost the ability to fractionate the yawn-stretch act. Both Dumpert (24) and Lewy (35) have noted yawning in such patients attended by stretching movements confined to the affected (*i.e.*, "paralyzed") extremities. . . .doubtless to the amazement of the patient if not the doctor. Dumpert emphasizes that although this phenomenon is not to be seen in all hemiplegics it is consistently present in given cases.

Activation and possibly inhibitory modification of yawning by neural elements below the telencephalon is of course attested to by the observations of Gamper (46) and of Catel and Krauspe (47) on their cases of cerebral malformation. The involuntary nature of most yawns and their occasional occurrence in comatose patients (29) likewise argue for activation from so-called "sub-conscious levels," but nothing further is known about the afferent influences exciting this act.

Information regarding the centrally located efferent pathways subserving the yawn-stretch act is limited to deductions suggested by the involuntary activation of paralytic limbs during yawning. This stretching of limbs deprived of corticospinal control appears to indicate that the so-called "extra-pyramidal" pathways play a significant rôle in the uninhibited act.

*Special sources.* (Theories.) Numerous hypotheses concerning the mechanism and significance of yawning and stretching have appeared, and existing data do not suffice to show which of these are tenable. They are not mutually exclusive and it is possible that each contains a grain of truth.

The first theory to find its way into print, that of the Delsarteans, appeared in Russell's monograph (18) of 1891. This little book, which remains the most exhaustive account of yawning in the English language, defies description and should be consulted in the original by anyone interested in whimsical physiology. Suffice it here to say that yawning is presented as an "automatic impulse" caused by "bad air in the lungs," designed by Nature as a "gymnastic," and intended both to "awaken the respiratory organs into activity" and to "effect a stimulation of the brain through increased activity of the circulation." Although this concept enjoys no supporting evidence it appears to be the fore-runner of present day lay belief (16, 17) and it is not without current favor among clinicians. Within the past decade Otto (33) and Seeligmüller (48) have reiterated the notion that yawning is a gymnastic the practice of which should be cultivated as a means of toning up the body or relaxing mental tension.

Hauptmann (26) appears to have been the first clinician to attempt an interpretation of the yawn-stretch act. Writing in 1920, he suggested that this complex is a means of combating the loss of muscle tone which, along with tedium, develops as a consequence of enforced inactivity of the higher cerebral centers. He emphasized that this augmentation of muscle tone and metabolism, rather than the deep inspiratory effort, is the main purpose of the yawn-stretch act. We have already noted his contention that any temporary improvement in aeration due to this inspiratory effort is more than offset by the period of apnea which follows the expiratory phase. By this process of reasoning, but without recourse to precise measurements, Hauptmann rejects the notion that yawning bespeaks an anoxia of cerebral tissue. This conclusion has been widely accepted (24, 27, 29, 35) without confirmatory evidence.

Mayer (29) concluded that the yawn-stretch act is an automatic expression of cerebral fatigue in the sense that crying and laughing are expressions of sorrow and happiness. In this conclusion he has been joined by several subsequent writers (10, 27, 35). Mayer goes on to suggest that the act accomplishes im-

portant but as yet undefined physiologic adjustments in the state of the circulation and in the metabolism of the recruited muscles.

Of all hypotheses advanced that of Dumpert (24) is by far the most elaborate. The salient features of his concept are as follows:

1. Yawning (the mouth act attended by a deep inspiration) is but part of the larger yawn-stretch complex which occurs in many animals, in infants and in children. This larger reaction is first regularly dissociated into its respiratory and stretching components in adult man, and even here the ability to fractionate the act can disappear following certain lesions of the central nervous system.
2. The yawn-stretch act is believed to occur whenever the cerebral circulation is not favorably adjusted for maintenance of the waking and alert states.
3. The yawn-stretch complex or even yawning alone is thought to effect an augmentation of the venous return to the heart by means of:
   a. The "milking action" of the striated muscles upon the veins of the limbs;
   b. The compressing action of the contracting abdominal muscles and the descending diaphragm upon the veins of the splanchnic bed; and,
   c. The aspirating effect of the lowered intra-thoracic pressure upon blood entering the *venae cavae* during the inspiratory phase of the act.
4. This presumed increase in venous return is thought to effect an increase in the rates of cardiac filling and output (Bainbridge's reflex), thereby providing a generalized improvement in the supply of arterial blood to the tissues.
5. A differential distribution of the supposedly augmented arterial flow is presumed to occur for the especial benefit of the cerebral circulation. This selective redistribution is believed traceable to the effects of centripetal impulses arising in the stretched muscles and serving to:
   a. Produce a widespread systemic vasoconstriction by their action on the vasomotor center (a la Bayliss); and,
   b. Effect a cerebral vasodilatation by their action on Weber's center.
6. Thus the yawn-stretch reaction and, less effectively, the yawn alone are able to combat cerebral circulatory states unfavorable to the maintenance of the waking and alert conditions.

Although much that Dumpert postulates is probable and my own observations (*vide infra*) confirm the occurrence of the systemic vasoconstriction he predicted, his theory is without support at its crucial points. Thus it is unjustifiable to assume that the cerebral circulation is diminished during sleep; indeed, the only reliable information (49) we have on the state of the cerebral circulation prior to, during and after sleep fails to disclose any significant variations. Further, there are no observations confirming an increase of the venous return during yawning. Finally, Dumpert invokes the aid of a cerebro-dilatory center the existence of which is open to question.

Peiper (27) looks upon yawning as a purely respiratory act which represents a transient disorder of the respiratory center. He believes that as a result of fatigue the excitability or sensitivity (*erregbarkeit*) of the higher respiratory centers (50) is depressed whereupon a lower lying yawn-center is released. He thus explains the occurrence of an automatic expression of fatigue and does not postulate that it accomplishes any physiologic adjustments. His theory is attractive but rests upon purely hypothetical considerations.

One further theory concerning the yawn has come to my attention. It has been suggested that as the nuchal muscles are recruited in the stretch they squeeze

upon the thyroid gland, express thyroxine into the blood stream and thereby accelerate the metabolism. The literature has been searched in vain for the origin and subsequent reference to this idea.

NEW OBSERVATIONS. *Methods and material.* My observations on yawning were made while studying the vasomotor activity in the digits of adult humans some of whom were "normal" and others of whom were victims of either Raynaud's or (early) Buerger's diseases. The diseased group was studied both before and after therapeutic pre-ganglionic sympathectomy. None was aware of my interest in yawning.

The subject, comfortably seated, placed one finger or toe, without restraining device, on a simple rest between a photo-electric cell and a constant light source. Current set up in the cell by light passing through the digit was led to a 2-stage amplifier, whence it emerged to activate a DuBois oscillograph. A mirror mounted on the latter directed a beam of reflected light onto a moving strip of bromide paper. The electrical circuit employed was such that a downward deflection on the photographic record was produced by an increase in the amount of light (and decrease in the amount of blood) traversing the digit.

A stethograph of the air-transmission type was applied to the chest and its indicator made to cast a second shadow on the sensitized paper. A downward excursion of this indicator was produced by an inspiratory movement.

Tracings of a time-marker and a signal magnet also appear on the photographic records.

Subjects were routinely observed over periods of 30 to 60 minutes in a warm darkened room. Under these conditions spontaneous yawning was frequent.

*Observations.* In the digits of normal adults a vasoconstriction was regularly observed to follow a spontaneous yawn. Figure 1 is a characteristic record of the development and subsidence of this phenomenon in a finger. From this tracing it can be seen that the vasoconstriction begins to appear after a latency of about 4 to 4.5 seconds as measured from the inception of the inspiratory phase of the yawn. The response is maximal within 9 to 10 seconds after the onset of the yawn and then gradually subsides during the ensuing 45 seconds. In a large number of such observations the latent period was regularly found to be between 3.5 and 5 seconds. The magnitude of the response and the time required for its complete development and subsidence were subject to considerable variation even in the same individual. In general these values were roughly proportional to the depth and duration of inspiratory movement. Maximal response was nearly always evident within 7 to 12 seconds and subsidence was usually complete within 30 to 60 seconds.

It was also observed that yawning in normal adults is regularly attended by a transient cardiac acceleration. This speeding of the heart was found to develop and subside *pari passu* with the vasoconstrictor response. The subject in figure 1, whose resting pulse is 80/min., shows an acceleration to 90/min. This degree of cardiac acceleration is fairly representative of many similar observations but it is subject to variation among different individuals and even in the same individual according to the depth of the yawn.

That the observed changes in the translucency of digits during a yawn are truly vasoconstrictor responses dependent upon the integrity of the autonomic innervation of the part is clearly shown by studies on sympathectomized extremities. Prior to surgical intervention the digits of such limbs exhibited responses equal to or even greater than those observed in normal parts. Following sympathectomy they show a greatly diminished or no vasomotor response depending upon the completeness of the denervation. Figure 2, a tracing from the finger of a Raynaud patient after sympathectomy, shows no appreciable vasoconstriction following a deep yawn. It is interesting to note, however, that the cardiac acceleration is not abolished. This subject's resting pulse rate of 70/min. is raised to one of 80 to 85/min. during the inspiratory phase of the yawn.

Results in every way comparable to those depicted for fingers were obtained from the toes of normal and sympathectomized subjects.

Discussion. Although Dumpert (24) and Mayer (29) predicted that circulatory alterations would be found to accompany yawning, there has been, to my knowledge, no previous demonstration of such changes. The phenomena under consideration are, however, closely related to or identical with the circulatory changes which Bolton *et al.* (51) describe as following a deep inspiration.

In a series of experiments on man Bolton *et al.* showed that following a deep voluntary inspiration a vasoconstriction occurs in the digital vessels. Its reflex nature was conclusively established by experiments on denervated and sympathectomized limbs, and some evidence was adduced in favor of the afferent stimulus arising from the expansion of the chest wall. Figure 3 is a recording by our apparatus of the vasomotor reflex they describe.

In the discussion of their observations Bolton *et al.* make no mention of their reflex being accompanied by a cardiac acceleration. Careful scrutiny of their figures 2 and 3 suggests, however, that this did occur in their experiments. The subject of my figure 3 exhibited a resting pulse rate of 70/min. This rose to 80/min. during the 10 seconds following the initiation of the deep inspiration and is typical of the behaviour of the pulse in many such observations.

## SUMMARY

The literature on yawning and stretching has been reviewed. The descriptive phase of the subject is essentially complete for man. The experimental phase is barely begun with the demonstration that circulatory changes consisting of transient cardiac acceleration and digital vasoconstriction attend spontaneous yawning in man. Aspects of the problem remaining completely unexplored include:

a. The behaviour of the cerebral circulation;
b. Measurements of cardiac filling and output;
c. The chemistry of the respiratory component;
d. The nature of the motor discharge in the stretch component; and,
e. The possibility of endocrine (*e.g.*, thyroid) changes.

Until such observations are completed, any formulation of the physiological significance of this act will rest upon an insecure foundation.

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