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BOOK REVIEW

Olivier Walusinski (Ed.): The Mystery of Yawning in Physiology and Disease

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Yawning is a stereotyped phylogenetically ancient phenomenon. The editor says in the Forward, "Yawning is a stereotyped and often repetitive motor act characterized by gaping of the mouth accompanied by a long inspiration, followed by a brief acme and a short expiration. It is not merely a simple opening of the mouth, but a complex coordinated movement bringing together a flexion followed by an extension of the neck, a wide dilatation of the laryngopharynx with strong stretching of the diaphragm and anti-gravity muscles." Although yawning is not a simple motor action but complex coordinated movements, it is highly stereotypical and can be observed in almost all vertebrates, including cold-blooded and warm-blooded, from reptiles with rudimentary "archaic" brains to human primates, in water, air, and land environments. Yawning is a mysterious but fascinating physiological phenomenon, nevertheless, it has so far been poorly addressed in the field of bioscience. This is probably the first scientific book on yawning.

Chapters 1 and 2, about historical perspectives and popular beliefs about yawning, are written by O. Walusinski, the editor himself. The written history of yawning started when the Greek medical scientist, Hippocrates in 400 BC wrote "Yawning precedes a fever, …the accumulated air in the body is violently expelled through the mouth when the body temperature rises". It is interesting to see the similarity of his view to the hypothesis presented by Gallup in the later chapter of this book, "The Thermoregulatory Behavior". In 1755, Dutch author, Gorter attributed yawning "to a need for faster blood circulation and to cerebral anemia" and this was a start of the idea repeated by many authors: yawning improves brain oxygenation. The history of scientific hypotheses and general beliefs are both fun to read, to learn how people treated yawning.

Chapter 3, written by F. Giganti and P. Salzarulo, and Chapter 4, written by O. Walusinski, are about yawning during development. Studies of yawning during the gestational age became possible with significant advances in the image quality and resolution of ultrasound 3D and 4D technology. Yawning starts in fetuses of 12–14 weeks' gestational age. In preterm infants, the number of yawns decreases between 31 and 40 weeks' postconceptional age, mainly during the day. Analysis of the yawning behavior of the fetus cannot support the popular belief that yawning is a response to elevated CO_2 or depressed O_2 levels in the blood. Recognition of fetal yawning rather helps to verify the harmonious progress of brainstem maturation and to appreciate the neural underpinnings of the sleep and arousal systems. It is important to know that, in babies, yawning is often an isolated event not yet organized into consistent bursts and rarely accompanied by the stretching seen in adults. During the first stage of development only spontaneous yawning is present, and contagious yawning is only observed from 4 to 5 years of age. The incidence of yawning seems to increase when children attend elementary school.

Chapter 5, written by F. Giganti et al., and Chapter 6, written by A. G. Guggisberg et al., are about the correlation of yawning with sleep or vigilance. The frequency of yawning is higher before sleep onset. It increases progressively during the 3 h period preceding sleep. The time of sleeping also affects yawn production: evening types yawn more frequently than morning types. Thus the

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relationship between yawning, sleep, and sleepiness seems evident. EEG studies have provided evidence that yawning occurs during states of low vigilance. However, yawning did not result in specific autonomic activation or increased arousal levels. Thus the EEG data did not support an arousing effect of yawning or a role in regulation of vigilance or autonomic tone.

Chapter 7, written by W. Seuntjens, discusses the hidden sexuality of the yawn. According to this author, an erotic and sexual aspect of yawning can be seen in linguistics, social ethnology, psychology, ethology, pathology, pharmacology, even in the arts. Yawning can be linked with arousal, ejaculation, and orgasm. In dogs, yawning can be associated with penile erection. In heroin-withdrawal syndrome, yawning and spontaneous sexual response are associated.

Chapter 8, written by J. R. Anderson, and Chapter 9, written by A. Moyaho and J. Valencia, are about animal yawning. In Chapter 8, Anderson discusses three aspects of yawning in non-human primates. The first is yawning as communication. Yawning has been described as an expression of passion and anger in Old World monkeys. Several lines of evidence link the frequency of yawning in adult male Old World monkeys to dominance rank. Yawning could be actively inhibited during the male–male body contact phase of an encounter, and physical separation between the males switched off the inhibitory effect and thereby permitted a "tension component" to be expressed in the form of yawning. The second topic is voluntary control of yawning. Anderson provides evidence of the ability of adult male macaques to voluntarily control yawning. The third topic is contagious yawning. According to Anderson evidence of contagious yawning in non-human primates is not compelling and he concludes that the chimpanzees have little need to catch up on yawning, they show little susceptibility to the contagious yawning effect. It can be seen only when some form of extra yawning stimulation is given to chimpanzees, for example in the form of repeated video or animated images. In Chapter 9, Moyaho and Valencia discuss the modulation of yawning by punishment-induced fear in rats. The author suggested a tendency for yawning to increase in response to mild stress. He also suggested a delaying effect of punishment.

Chapter 10, written by A. C. Gallup, is about thermoregulatory behavior. Yawning frequently occurs in the evening, when brain temperature is at its peak, and upon waking, when brain temperature begins increasing from its lowest point. Yawning in the early morning may be a compensatory thermal stabilizing mechanism.

Chapter 11, written by G. T. Collins and J. R. Eguibar, is about the neuropharmacology of yawning. Two hormones, adrenocorticotropic hormone (ACTH) and alpha-melanocyte-stimulating hormone (alpha-MSH) are known to be related to yawning. Yawning is abolished by hypophysectomy, and microinjection of ACTH into several hypothalamic nuclei will induce yawning. In addition to these hormones, yawning can be regulated by various transmitters, including acetylcholine, dopamine, glutamate, serotonin, oxytocin, GABA, opioids, adrenergics, or nitric oxide. Despite the great advances that have made towards our understanding of the neuropharmacologic regulation of yawning, further studies are needed to fully elucidate how these neurotransmitter systems interact with each other, and the specific receptor subtypes and brain regions involved in the induction and inhibition of yawning.

The next three chapters are about contagious yawning. In Chapter 12, S. M Platek, on the basis of animal studies and human MRI studies, suggests that contagious yawning may be an evolutionarily old process that begat a higher level of social cognition in some species. He writes "contagious yawning is a vestigial fixed action pattern that may be a glimpse into the neurobiological substrates that gave rise to more sophisticated social cognitive processes such as theory of mind". In Chapter 13, A. Senju discusses the atypical development of contagious yawning and the results of animal experiments. He concludes that contagious yawning shares its mechanism with the capacity for theory of mind. He also suggests, on the basis of his observation of autistic children, that spontaneous orientation to socially relevant stimuli, for example eyes, may mediate contagious yawning in humans. In Chapter 14, M. W. Campbell and F. B. M de Waal discuss methodology to study contagious yawning. They point out that different researchers analyze their results differently and suggest more rigorous, thorough, and informative analyses. They raise awareness of these issues to generate new experiments and improve discussion of existing research. The contagious yawning of nun-human primates was also discussed in the previous chapter.

Chapter 15, written by F. B. Nahab, is about neuroimaging of yawning. The ventromedial prefrontal cortex (vmPFC) is a unique brain area activated when human subjects view videos of yawns, compared with the condition when subjects viewed other facial expressions. The author's group did not find any significant activation in the so-called "mirror neuron system". The vmPFC has been associated with emotional processing of internal and external stimuli and representation of emotional responses. Thus vmPFC seems a reasonable candidate as the brain region associated with viewing contagious yawning. On the other hand, yawning is the motor act. The weak point of this type of study is that the subject is lying down in the MR machine without any motion and just looking at the video of yawning.

Chapter 16, written by R. Meenakshisundaram et al., and Chapter 17, written by O. Walusinski, are about

clinical aspects of yawning. Meenakshisundaram et al. introduce movements of hemiplegic limbs associated with yawning. They suggest that the appearance of associated movements in hemiplegic limbs indicates the return of ancestral function observed in quadrupeds. Walusinski discusses disorders of yawning, for example disappearance of yawning, excessive yawning, or yawning-triggered disorder. Some extrapyramidal syndromes including Parkinsons' disease are accompanied by disappearance of yawning. Dyspepsia, migraine, stroke, hypertension, epileptic seizure, hypothalamic-pituitary disorder and some drug use can cause excessive yawing.

As seen in the chapters of this book, yawning has many aspects and it is very complex. We need to try various approaches to study yawing. I will suggest several points for future research on yawning. Yawning can be seen in all vertebrates and can be seen at the gestational age. Neural structures involved in yawning may be subcortical systems including the hypothalamus. Thus, yawning is phylogenetically and ontogenetically old behavior. However, in this book, direct comparison of yawning behavior among vertebrates is missing. I believe that it is important to study primitive vertebrates, for example reptiles. The primitive vertebrates could be a good target to study the core neural structures and the original function of yawning. It is necessary to clarify the common parts and difference of yawning behavior in lower and higher vertebrates. The correlation with sleep or sleepiness may be evident in human subjects but this kind of correlation must be tested in lower animals also. In higher animals, higher brain functions or cortical functions can be combined with the core function of yawning. It is also necessary to compare yawning behavior across species in higher animals. Contagious yawning is one possible phenomenon that appeared as a result of such integration. For this purpose, as Cambell and de Waal suggested, we need to pay attention to standardizing methods to enable comparison of different studies. To study brain functions in human subjects, it is necessary to conduct imaging studies during yawning behavior. Imaging studies using MRI, PET, or MEG are not suitable for this purpose. We should try other methods, for example EEG, NIRS, or SPECT for this purpose. Anyway, this book is standing at the entrance of these studies and is a good book for gaining insight for future studies of yawning.