# CHAPTER I

# INTRODUCTION

## Why Study Yawning?

### All People Yawn, But No One Knows Why.

Yawning provides an intriguing problem for human ethologists because though all people yawn, no one quite knows why. Relatively little research has been specifically devoted to yawn behavior in animals and even less has focused on yawn behavior in humans. There are certainly an abundance of popular 'folk' theories and culture-specific taboos explaining and concerning the behavior, yet the behavioral sciences have made relatively little progress in addressing this curious behavior. This thesis uses an evolutionary perspective to predict the design characteristics of human yawning, test these predictions, and analyze results. An adaptationist perspective allows us to explore how a behavior, which we share to some degree with other animals, developed functions and whether or not new functions have developed. Because yawning appears to perform a similar physiological function across the animal kingdom and may even serve as a social signal in some cases, it is an apt subject for comparative ethological and adaptationist analysis.  The key to understanding a human behavior is unpacking and analyzing its design in terms of adaptation and function, ancestral homology, and species-specific uniqueness. To this end, a brief overview of the issues addressed in this thesis is provided. The second chapter follows with an intensive literature review of research that underlies this study, the third chapter explains the rationale for the hypotheses to be tested, in the fourth chapter a description of the study and methods employed therein is provided, and the fifth chapter presents results of this study's investigations and a final discussion of these findings.

As yawning is an immediately recognizable and frequent act that occurs throughout the animal kingdom (Wimalaratna and Capildeo, 1988), it is not surprising that yawning is a common human behavior that is present throughout life and in all cultures (Provine, 1986). We know that yawns are easily triggered in humans by observed yawns and yawn-related stimuli, such as the sound of a yawn, features of a yawning face, reading of thinking about yawns (Provine, 1986). Yawns are also triggered in humans by watching uneventful stimuli, or by participating in repetitious, uninteresting tasks (Provine, 1986; Provine and Hamernik, 1986). Yawn frequency is relatively high among people who are waiting (Kataoka, 1975) or performing monotonous work (Kishida, 1973). Though these studies have investigated some possible effects of controlled mental and physical stimuli, previous studies (Schino and Aureli, 1989; Provine and Hamernik, 1986; Provine 1986, 1989, 1997; Baenninger *et al.*, 1996) have failed to adequately investigate the effects of dominance, sex, and hormones on contagious yawning.

# Yawning Is Not What It Seems.

Because few researchers have devoted themselves to the task of investigating yawning behavior, very little is known about it. We know that human yawning is indeed "contagious," that mere suggestion of a yawn serves as a contagion (Provine, 1986; Provine and Hamernik, 1986), and that contrary to common "folk" knowledge, yawning does not increase oxygen levels in the body or play a significant role in the respiratory process (Provine, Tate, and Gelmacher, 1987). Fish (Myrberg, 1972; Rasa, 1971; Baenninger, 1987) as well as normal, and high-risk human fetuses unexposed to the atmosphere (Petrikovsky, Kaplan, and Holsten, 1999) yawn. Yawning has been reported across the vertebrate species and has even been called a species-typical behavior for vertebrates (Deputte, 1994). Nevertheless, yawning contagion has only been reported in humans and ostriches. Contagious yawning remains a mystery of human nature (Chudler, 1999). Results from this literature review and study suggest that yawning contagion in humans may be a reflex action that developed as a result of our highly developed ability to infer the intentions, emotions, and physiological states of our conspecifics. The idea that yawning contagion might be based on a form of social communication seems strange and unlikely at first, but upon further consideration appears quite compelling.

This thesis argues that yawning first evolved as an internal physiological reflex action and later evolved in a few species as a social signal to the external world of physical features and social communication. Yawning signals a transition from activity to inactivity (in humans: Baenninger *et al.*, 1996; in rats: Anias *et al.*, 1984) or inactivity to activity (Baenninger *et al.*, 1996; Anias *et al.*, 1984). Bored people yawn, but so do anxious people such as Olympic runners on the starting blocks or paratroopers about to jump out of planes (Provine, 1997). It has been hypothesized that yawning is associated with change in activity because yawns serve to cleanse the brain of residual cerebrospinal fluid and neurotransmitters (Nolman, 2000). Yawning may originally have been selected for as a change-in-activity facilitator, since this is the common feature of yawning behavior across species. Because it involves facial motor processes, especially those related to circulatory/muscular arousal and sex hormones, yawning is an easily observable, useful indicator of physiological correlates of behavior that can be used to predict changes in others' activity.

## Yawning as a Social Signal.

In primates, yawning occurs in a variety of social contexts, suggesting that it has a communicative role (Deputte, 1994). Since yawning has been shown to signal a change in activity, and among social creatures it is often useful to be informed of a conspecific's disposition, it is plausible that monitoring yawns of conspecifics may have been selected for thus forming the basis for co-evolution of yawning as a social signal. If yawning while active is a cue that an individual is making the transition to inactivity and inattentiveness (e.g., sleep), then others can use this information. In the case of a subordinate individual it could be quite costly to signal such a transition in the company of dominant conspecifics. Only dominant individuals are likely to be able to "afford" the cost of signaling their transition to a restful, more vulnerable state while others are still active. Conversely, if yawning while previously inactive is correlated with transition to activity and alertness, yawning could also co-evolve to a social signal of arousal and movement (such as to a new feeding patch, or threat).

I hypothesize that contagious yawning is an adaptation that has been selected for because it is a “costly signal” as defined by Parker (1974) and Zahavi and Zahavi (1997). A costly signal is a trait whose value to the signaler is that it conveys honest information about the fitness of the signaler to those receiving the signal. The “cost” of the signal is derived from the cognitive or physical demand it makes upon the signaler. If there is no cost to a signal, nothing prevents unfit “cheaters” from using the signal, in which case the signal would not be reliable. Examples of costly signals abound in the animal kingdom. Peacocks are the most frequently sited example with their extravagant displays of plumage that demand time and energy to maintain. The tail feathers are grown during the months when little food is available. In order to develop and display the long feathers, which are held upright and spread out, shaken, and even rattled, considerable effort is required. Adversely, disease, malnourishment, and stress impact the symmetry and brightness of the tail. Peahens assess the relative fitness of peacocks by observing their demonstrations of plumage. A male who displays a perfect set of tail feathers demonstrates that he is in good health, has managed to find food during molt season, and may provide good genes which could, in turn, lead to successfully reproducing offspring (Petrie *et al.*, 1991). Various forms of threats in a many species also reliably convey honest information about the relative dominance of individuals and thus qualify as costly signals. Stretching behaviors, for example, have been considered threats, because they provide precise information about the threatener's size, but even more so show confidence (i.e. willingness to invest in fight) by exposing the body to attack Zahavi and Zahavi, 1997). Because threats can convey honest information, they are frequently displayed by various species and serve to resolve conflict and reinforce dominance hierarchy without attack. This thesis hypothesizes that the cost of yawning is derived from the information that it reveals. In addition to signaling change in activity, yawning sometimes serves as a display of canines. Canine size is correlated with dominance in many old world primates (Deputte, 1978) and canine display is associated with threat gestures. Review of the current literature confirms the correlation suggested by Deputte (1978): "threat yawns" featuring canine exposure occur more often amongst sexually dimorphic taxa, especially among males who frequently expose prominent canines.

In the event that canine display is associated with change-in-activity yawns, it would also be expected that subordinate individuals with relatively smaller canine size could convey their relative vulnerability (with respect to large-toothed individuals) whenever yawning. Thus, a display of inferior canines or a display of canines by subordinate individuals might be interpreted by dominant individuals as a threat.

## How to Study Yawning

### Using Multi-Disciplinary Ethology and the Evolutionary Paradigm

It may be that yawning behavior has been under-represented in studies of human and animal behavior because it requires cross-disciplinary inquiry. In order to investigate possible factors that influence yawning, one must examine psychological, physiological, and pharmacological aspects of yawning and their interface with the animal's social and physical environments. Deputte (1994: 243) notes, "yawning can be considered in an ethological paradigm because it can be elicited by internal metabolic events and by external social stimuli, both of which are modulated by the hormonal environment." Hormonal environments are best understood in terms of circular feedback loops between behaviors and external social environments. Such feedback loops make discussion of any particular effect, in isolation, difficult. This thesis, therefore, approaches the study of yawning holistically, considering psychological, physiological, social, and environmental factors in its analysis of this behavior.

Examining yawning behavior across non-human species can illuminate the adaptive origins of the current behavioral phenomenon in humans. Homologous behaviors between species share common evolutionary ancestry and developmental histories. The more detailed variations between homologous features, such as the differences in yawning behavior between various species or families of primates, are thus interpreted as evidence of evolutionary divergence from a common ancestry. The more widespread a behavioral feature is across the animal kingdom, the more likely it is to be an old feature and to have faced long histories of selective pressure (Alcock, 1998). It is thus useful for the purpose of this thesis to consider both similarities and differences in yawning behavior across species. By comparison with both our non-human primate relations and our closer primate relations we can identify both homologous and unique features of human yawning, and thus gain a better understanding of the evolutionary history and functions of yawning.

## Searching for a Homologue of the Human Yawn

Yawning generally refers to a stereotyped motor act characterized by a gaping mouth accompanied by a long inspiration followed by a shorter expiration. An ethological definition of the phenomenon should include the yawn as being a unitary action pattern performed at typical intensity. Yawns are thus recognized as a complete and stereotyped process with a temporally uniform progression: initiation, climax, and conclusion. Features of the primate yawn are rather straightforward and closely parallel the human yawn. (Redican, 1982; Hadidian, 1980.) The three main characteristics of a yawn isolated by Deputte (1978) are: (1) opening of mouth with progressive exposure and then reconcealment of both rows of teeth; (2) concomitant raising of the head as mouth is opened and then lowering as mouth is closed; (3)brief closure of the eyes in the first part of yawning and tight closure when the mouth is open maximally, then progressive opening when the head is lowering and the mouth is closing." (in Redican, 1982.) The gaping component, the most general feature of the yawn, is reported in fish (Myrberg, 1972; Rasa, 1971; Baenninger, 1987), reptiles (McCutchean, 1970), birds (Delius, 1967; Sauer and Sauer, 1967), and mammals (Altmann, 1967; Carpenter, 1940; Darwin, 1872; Schaller, 1972; Redican, 1982), but because of unclear information and limited studies it is debated whether yawn-like behavior is truly homologous in all of the above examples.

## Analysis of Yawn 'Design' in Humans and Between Species

According to Redican (1982) one of the foremost questions that should be asked in comparisons of facial expressions of primates of different taxanomic groups is whether an apparently similar expression in different taxa represents a common ancestry or simply a common function. Redican goes on to point out that the primary expressions of monkeys, apes, and humans are expected to be homologous, in view of the wide dispersal of very similar motor patterns and eliciting circumstances in both closely and distantly related taxa of primates and, indeed, other mammals. As we sample the primate taxa related to the ancestral groups from which we are believed to have diverged, we find "a continuity and progressive elaboration of facial expressions" (Redican, 1982: 215).

Though it has been suggested that primate yawns are all rather similar (Redican, 1982; Hadidian, 1980) there are also observable differences in yawning behavior exhibited across various species. Yawns may vary between the more basic stretching related forms, often interpreted as tired or disinterested yawns, and the impressive dental displays that are generally thought of as displays of weaponry (such as in baboons)(Darwin, 1872; Napier and Napier, 1967; Pellatt, Wright, and Levine, 1981; Deputte, 1994). A common feature reported across the animal kingdom is the relationship of yawns to changes in activity and social environment (Sauer and Sauer, 1967; Myer, 1972; Schaller, 1972; Deputte, 1994), yawns that serve as threat gestures are less frequent and found more often among the relatively aggressive social mammals (Troisi, *et al.*, 1990; Pellatt, Wright, and Levine, 1981)

As first proposed by Deputte (1978, in Redican, 1982) yawns fall into two general categories: “the yawn of inactivity” (i.e. the physiological yawn) and “the yawn of emotivity” (i.e. the tension yawn). This thesis hypothesizes that long ago in our evolutionary history yawning in human and non-human primates was emancipated through the process of ritualization from a non-communicative signal to a display. Yawns still serve, in part, among human and non-human primates, a purely physiological function having no communicative purpose. Yawning exhibits a dual purpose because the physiological component was selected for by hormonal pressures, while the expressive component was selected for by social pressures. As mentioned earlier we must remember that the hormonal and social characters of an animal are closely tied in a circular feedback loop.

## The Evolutionary History of Yawning.

Facial expressions in monkeys, apes and humans may be assumed homologous (Van Hooff, 1976). It is has long been suggested that facial expressions have their origins in ancestral reflex actions and that many homologues to human facial expressions are found within the animal kingdom (Andrew, 1965; Darwin, 1872). In comparison of facial gestures of various primates and other mammals, Charles Darwin came to the conclusion that the origins of these communicative displays could be traced back to primitive activities such as drawing back the lips for biting (Andrew, 1965). Tinbergen’s (1952;

Hinde and Tinbergen, 1958; Redican, 1982) use of the concept of emancipation explains that behavior can, over the course of evolution, be freed from the causal factors involved in the appearance of its phylogenetic precursor.

Two key possibilities that address the question “why yawn?” emerge from the information presented thus far: 1) a physiological function served by yawning, that does not have to do with air intake, is shared by all those creatures who do yawn, and 2) yawning, which exist across species, serves as an excellent candidate for having evolved into a behavioral signal in some species. The assumption in the second of the above observation is based on the hypothesis that signaling behavior has evolved through a process of “emancipation”, which is more likely to occur with behaviors that are obvious and shared between species. Ethologists speak of displays as having been derived or emancipated from behaviors not specifically functioning as communicative signals. According to Redican and others, displays tend to be specialized signals or patterns of motor activity with stereotyped characteristics because, over the course of evolution such stereotyped and often repeated behaviors were able to facilitated the process of communication (Andrew, 1964, 1972; Brown, 1975; Moynihan, 1970; Redican, 1982; Zahavi and Zahavi, 1997). A display is more likely to have been selected for as a communication-facilitating behavior if it demonstrates features promoting “evolvability”.

“Evolvable” features may be thought of in the following ways. “Clarity, precision, and strength of transmission are primary adaptive features of a signal, and they are achieved if the form and pattern of displays are exaggerated, emphatic, stereotyped, and distinctly different from other behavior patterns (Moynihan, 1970 in Redican, 1982: 216)

The adaptive formalization and canalization of emotionally motivated behavior selects for clear and distinct behaviors, so as to "(1) promote better and more unambiguous signal function, both intra- and inter-specifically; (2) to serve as more efficient stimulators or releasers of more efficient patterns of action in other individuals; (3) and to reduce intra-specific tissue damage" (Huxley, 1966: 250). Yawning behavior appears to meet all of these three criteria.

The literature on evolutionary ethology, primatology, and yawning provides strong evidence that yawning behavior serves both a physiological and signaling function. Specifically, it appears that yawning facilitates transitions between activity levels and communicates critical and potentially costly information between yawners and conspecifics (e.g. "I will be going to sleep", or "I am about to challenge my competitors"). By considering yawning behavior as a "costly signal" we are able to form hypotheses that account for some of the specific data reported on yawning behavior in the primate literature as well as make predictions regarding what might be expected in controlled laboratory situations.

# CHAPTER II

# REVIEW OF LITERATURE

## The Existence of Yawning Across the Animal Kingdom.

As mentioned in the introduction, yawning, characterized by a gaping mouth, has been shown to exist across the animal kingdom (Wimalaratna and Capildeo, 1988). Debate over whether this behavior is truly homologous has accompanied the above claim (Baenninger, 1987; Rasa, 1971; Schaller, 1972; Sauer and Sauer, 1967), with comparative studies of yawning behavior in distantly related species such as birds, fish, reptiles, and mammals (Baenninger, 1987). The status of yawning as a homologous behavior in rodents, carnivores, and non-human primates has gone unquestioned (Deputte, 1994). The one feature birds, fish, reptiles and mammals have in common in relation to their yawns is a change in activity or anticipated change in activity. This chapter reviews literature on yawning behavior in various animals, including humans, and concludes with a discussion and comparative analysis of the following studies.

### Yawning in Birds

Most of what we know about yawning behavior in birds derives from Sauer and Sauer's (1967) discussion of yawning as a maintenance activity in the South African ostrich (*Struthio camelus australis*). The term "maintenance behavior" is used to describe activities that help regulate the physiological state of an organism. In the case of the ostrich, yawning is also reported to act as a contagion. Sauer and Sauer eloquently explain that, when given in the presence of a conspecific, certain maintenance activities may have secondary, communicative effects through “sympathetic induction” that promote social facilitation. For example, some complex and derived maintenance activates, such as the collecting of food by individuals and groups for the benefit of all participants or their dependents, have become social events in both primary and ritualized contexts. According to Sauer and Sauer, a bird that yawns often is quite capable of making one or several neighbors yawn too, and in an Ostrich herd this can have a “snowball effect”. According to the authors, this contagious effect is beneficial to ostriches because at the beginning of a period of rest it allows members of a group to be assured of momentary safety or absence of danger. This is particularly significant in view of the fact that among ostriches the socially higher-ranking birds customarily relax and yawn before the lower-ranking and more nervous birds calm down to rest. Thus, yawning induces a general relaxation of tension in a group and triggers sleepiness. This mechanism for social cohesion prevents a scattering of the flock and disturbance of the group life, which is easily caused by lower-ranking birds that are not assured of safety by their dominant companions (as it has been observed that nervous ostriches will run from a harmless event if not assured of safety). The calming effect of contagious yawning functions regardless of whether previous tension had been building up through either intra- or inter-specific contacts. At the end of a period of rest, yawning (and also preening behavior) functions to stir up the group.

Yawning has been reported in both sexes and all ages of ostriches though it is most frequent in newly hatched ostrich chicks and adults. In general yawning was seen in communal areas when the birds rested or waited their turns at the water holes, and in their territories when they guarded their nests, when they incubated eggs or brooded chicks, when they settled for their nights sleep or awoke from it during a disturbance in the night or in the morning, or when they were disturbed during any of their short resting and sleeping periods in the day time. Yawning was not reported to have occurred when birds were active or alert. A dozing Ostrich suddenly disturbed by a passing companion or stranger would initiate an open-mouth threat (gular tissue pressed upward and tongue thrust upward and slightly forward as opposed to maximally lowered and tongue withdrawn as in yawn), and, becoming aware of the harmlessness of the situation, switch directly into a deep yawn before closing its mouth and eyes again. Because open mouth threats and yawns appear to be similar in various species it has been suggested that the two might be often be confused, misidentified, and or misinterpreted (Lambert, 2001; Provine, 2001; personal communication). However, Sauer and Sauer state clearly that open mouth threats cannot be mistaken for yawns, because the two differ significantly in appearance. Various acts of stretching were associated with yawning. Most frequently a stretching of the neck or the body was synchronized with yawning, while the unilateral stretching of wing and leg quite often immediately followed, but might also have preceded the act of yawning (Sauer and Sauer, 1967). Maintenance activities, such as yawning, are often grouped with or referred to as “displacement activities”. Displacement activities considered in the avian literature (e.g. preening, pecking, yawning) serve to regulate the physiological state of an organism by dissipating the effects of a stress response (Delius, 1967), which –if otherwise sustained- have known deleterious consequences (Uno *et al.*, 1989). Electrode stimulation of brainstems of herring and lesser black-backed gulls (*Larus argentatus* and *Larus fuscus*), was reported to cause an increase in displacement and maintenance activities including yawning (Delius, 1967).

A recent Internet search (http://google.com) for "yawning birds" revealed several professional and non-professional websites posting photographs and a video with titles or captions identifying other species of yawning birds. These Internet search results suggest that yawning has also been identified in the martin, snowy owl, barking owl, and cormorant, though this has not been verified by a process of peer reviewed scientific study. Sauer and Sauer (1967) also mention that they have documented yawning behavior in warblers of the genus *Sylvia*. In addition to being the only known study on yawning in birds, Sauer and Sauer's study is significant in that it describes the only known case of contagious yawning besides that of humans. Contagious yawning in ostriches is said to initiate and even help synchronize new activity cycles that are in the common interest of the group.

## Yawning in Fish

Yawning, defined as a slow opening of the mouth, maintenance of the open position for at least 3 seconds, then rapid closing of the mouth has been identified in several species of fish: *Betta splendens* or Siamese Fighting Fish (Baenninger, 1987), *Eupomacentrus partitus* or Bicolor Damselfish (Myrberg, 1972), *microspathodon* *chrysurus* (Rasa, 1971). A search of the Internet (http://google.com) suggests that yawning has also been identified (by several professional and non-professional websites posting photographs), though not by a process of peer-reviewed study, in goldfish, bass, groupers, Conies, and eels. Previous studies of fish yawning (Morris, 1954; Tugendhat, 1960; Barlow, 1964) have identified a correlation between feeding interruption and yawning, and between migration interruption and yawning. All observations of yawning in fish indicate that this behavior is associated with either a change in the stimulus pattern or the interruption or decrease in intensity of an ongoing response. Due to the similarities not only in morphology but in behavioral moderations and possible causes of yawning in fish, ethologists studying yawning in other taxonomic orders have come to agree that "indeed the so-called yawning in fish may be true yawning" (Sauer and Sauer, 1967: 584).

The results of Rasa and Rasa's experiments have shown that yawning in fish is associated with an increased excitement level, either endogenously or exogenously produced, and low levels of kinetic energy. This has led Rasa and Rasa to suggest that a reciprocal relationship between yawning and kinetic energy may exists. As with humans (Baenninger, Binkley, and Baenninger, 1996), activity in general has been shown to increase in fish after the performance of a yawn. Muscle contraction is known to increase blood flow to the muscle fibers, enabling oxygen transfer and heat expenditure, which in turn facilitate tension and thus "prime" the muscle for further action. One would therefore expect that, after strong muscle contraction, such as that which occurs during a yawn, the animal would be physically more capable of performing other behaviors. Yawning therefore is considered to be a behavior by which fish are able to regulate discrepancies between central nervous system excitation and body musculature tonus.

Yawning exhibited in *Eupomacentrus partitus* or Bicolor Damselfish (Myer, 1972) accompanied transitions between various social behaviors, particularly agonistic responses and nest entrances and exits. Similarly yawning exhibited in *Betta splendens* or Siamese Fighting Fish accompanied encounters with conspecifics and with mirror images but was not observed in solitary behavior, suggesting a yet unknown social component to fish yawns (Baenninger, 1987). As previous studies have correlated yawning in fish with transitions and interruptions in feeding activity, migration activity, and social activity, we can conclude that the gaping mouth component of yawning behavior that facilitates change in activity is a homologue of the yawning behaviors found across the animal kingdom. Yawning in fish has not been shown to coordinate or synchronize the behavior of schools and shows no “infectious” quality; thus contagious yawning in fish is said not to exist. (Rasa, 1971; Baenninger, 1987)

## Yawning in Reptiles

Yawning has been identified in amphibians and reptiles (McCutchean, 1970). Yawning has been specifically reported in lizards and geckos, and is also common in the Florida gopher tortoise (Sauer and Sauer, 1967), but no known behavioral studies have been devoted to the study of yawning in reptiles. A search of the internet (http://google.com) suggests that yawning has also been identified (by several professional and non-professional websites posting photographs), though not by a process of peer-reviewed study, in alligators, crocodiles, pythons, geckos, iguanas, and Monitor Lizards. From what little is known yawning in reptiles has not been shown to coordinate or synchronize the behavior of groups of reptiles or to have an “infectious” quality. Thus contagious yawning in reptiles is not currently known to exist.

## Yawning in Non-Primate Mammals

Aside from various primate species, felines, canines, and rodents are the only other known mammals in which yawning behavior has been documented. Deputte (1994) claims that the homologues status of yawning behavior in rodents and carnivores remains unquestionable, however, whether all or few rodents and carnivores exhibit the behavior remains a question. A search of the Internet (http://google.com) suggests that yawning has also been identified (by several professional and non-professional websites posting photographs), though not by a process of peer-reviewed study, in ferrets, hippos, elk, fur seals, otters, sea lions, koalas, and various felines, canines and rodents.

Yawning in lions (*Panthera leo*), has been reported in captivity ( at the Philadelphia zoo) (Baenninger, 1987) and in the wild (Schaller, 1972). Schaller (1972: 85) describes the yawning face of a lion in detail: “the yawning lion raises its head and opens its mouth so widely that all teeth are exposed. Its eyes are closed and the tongue protrudes a little past the lips. Although the gesture is prominent, it is neither directed at a specific individual nor does it elicit a response, as it does in baboons, which use their exposed canines during yawns as a visual display in agonistic encounters (Hall and

Devore, 1965).” Yawning in wild lions is generally correlated with transitions to and from resting states (Schaller, 1972). In captive lions, time of day was found to be related to the frequency of yawning with a definite progressive increase in the hour before feeding time from 0.8 yawns/lion-hour to 1.8 yawns/lion-hour. (Baenninger, 1987) The sharp increase in yawning frequency observed near the hour of feeding for captive animals has also been noted in Pigtail macaques (Louboungou and Anderson, 1987), Mandrills (Baenninger, 1987), and Tonkean macaques (Anderson, and Wunderlich, 1988). Once again the correlates of yawning frequency with other behaviors suggest that yawning is related to a change or anticipated change in activity. It appears controlled feedings present regular changes in activity that are clearly anticipated by captive animals.

Just as in lions, yawning in rats is correlated with sleep and activity (circadian variation in activities or rhythm), which have an effect on the neurotransmitter systems postulated as subserving the central control and regulation of yawning. Light to dark transitions might be the “primary synchronizer” for the circadian rhythm of yawning, as the frequency of yawns noted around such transitions is significantly higher than the uniform distribution of yawns over the course of a day. The peak frequency of yawning seems to coincide with the time of day when cholinergic activity is highest, and dopaminergic activity the lowest. A decrease in dopaminergic activity is expected to liberate the cholinergic neurons exciting yawning from inhibitory control and thus facilitate the expression of this behavioral pattern (Anias *et al.*, 1984). Cholinergic neurons function to mediate the effects of stress by inhibiting the release of acetylcholine, which is known to play a role in the control of muscle tension. In another study investigating the cholinergic mechanism behind yawning, rats were injected with physostigmine salicylate, bilocarpine hyrochloride, neostigmine methylsulphate, and nicotine. Significant yawning was reported with administration of the first twoof these drugs, but not with the second two. . Results suggest that in the rat there is a central cholinergic mechanism, with 'muscarinic' receptors, underlying the act of yawning. Systematically injected cholinomimetic agents may eventually hinder the expression of yawning in older rats. (Urba-Holmgren, Gonzalez, and Holmgren, 1977) Based on these experiments (using rats specially bred for high-frequency yawning) it has been hypothesized that two sets of dopamine agonists and cholinergic neurons, are organized "in series" the former tonically inhibiting the latter, which exert a direct excitatory influence on the central pattern generator of yawning. (Anias *et al.*, 1984) Other studies (Gessa, Vargiu, and Ferrari, 1966) have also found pharmacological evidence for a cholinergic mechanism behind yawning.

As studies of laboratory rats and both captive and wild lions have correlated yawning with transitions or anticipated transitions in activity, we can conclude that the gaping mouth component of yawning behavior that appears to facilitate change in activity is a homologue of the yawning behaviors found across the animals kingdom. Yawning in non-primate mammals has not been shown to coordinate or synchronize the behavior of groups of conspecifics and shows no "infectious" quality, thus contagious yawning in non-primate mammals is not currently known to exist. (Baenninger, 1987)

## Yawning in Primates

### Which Species of Primates Yawn?

Though yawning behavior has been sparsely reported in non-primate mammals, a number of studies have considered yawning behavior in primates, often in association with other displacement activities. Data on yawning behavior in primates has been gathered primarily from the suborder of Anthropoidea and especially the infraorder of Catarrhini (Old World monkeys and apes). Among the Old World primates we have both field and laboratory observational data for yawning among the following taxonomic orders (See Table 1).

TABLE 1. Taxonomy of Primate Species for which Yawning Behavior Has Been Reported in the Literature

Suborder Anthropoidea (monkeys and apes):
    Infraorder Catarrhini (Old World monkey and apes)
        Superfamily Cercopithecoidea
            Family Cercopithecidae
                Subfamily Cercopithecinae:

- Black mangabeys *Cercocebus atterrimus* (Chalmers,1968; Deputte, 1978)
- Gray cheeked mangabeys, *Cercocebus albigena* (Deputte, 1994)
- De Brazza's Monkey, *Cercopithecus neglectus* (Rowe, 1996)
- Talapoin monkeys, *Cercopithecus (Miopithecus) talpoin* (Wolfheim and Rowell, 1972)
- Patas monkeys, *Erythrocebus patas* (Hall, 1962; Zucker, Gerald, and Kaplan, 1998; Rowe, 1996; Aureli and de Waal, 1997; Baker, and Aureli, 1997)
- Rhesus monkeys, *Macaca mulata* (Goy, and Resko, 1972; Baulu, 1973; Lagarde *et al.*, 1990)

TABLE 1 (Continued).

Suborder Anthropoidea (monkeys and apes):
- Infraorder Catarrhini (Old World monkey and apes)
  - Superfamily Cercopithecoidea
    - Family Cercopithecidae
      - Subfamily Cercopithecinae:
        - -Japanese macaques, *Macaca fuscata* (Hadidian, 1980; Troisi, Aureli, Schino, Rinaldi, and DeAngeli, 1990)
        - -Long-tailed macaques, cynomolgus monkeys *Macaca fascicularis* (Hadidian, 1980; Schino *et al.*, 1988; Troisi, Aureli, Schino, Rinaldi, and DeAngeli, 1990; Troisi *et al.*, 1990; Deputte, 1994)
        - -Bonnet macaques *Macaca radiata*(Rahaman and Parthasarathy, 1968; Rowe, 1996; Simonds, 2000)
        - -Pigtail macaques, *Macaca nemestrina* (Louboungou and Anderson, 1987)
        - -Celebes black-ape macaques, *Macaca nigra* (Barbiset, 1958; Hadidian, 1980; Bernstein and Baker, 1988)
        - -Tonkean macaques, *Macaca tonkeana* (Anderson, and Wunderlich, 1988)
        - -Savanna baboons *Papio cynocephalus* (Hall and DeVore, 1965; Pellatt, Wright, and Levine,1981)
        - -Wild olive baboons *Papio anubis* (Sapolsky, 1994; Castles, Whiten, and Aureli, 1999)
        - -Mandrills, *Papio sphinx* (Baenninger, 1987)
        - -Nilgiri langur, *Presbytis johnii* (Poirier, 1970)
        - -Drills, *Mandrillus leucophaeus* (Rowe, 1996)
        - -Gelada baboons, *Theropithecus gelada* (Mori, 1979)
  - Superfamily Hominoidea
    - Family Pongidae:
        - -Chimpanzees, *Pan troglodytes* (Goodall, 1965, 1968; Nishida, 1970; te Boekhorst *et al.*, 1991;
        - -Gorillas, *Gorilla gorilla berengei* (Schaller, 1963; Fosey, 1983)
    - Family Hominidae:
        - -Humans, *Homo sapiens*

The abundance of cercopithecine examples of yawning behavior may simply be due to the fact that these primates are more frequently studied. However, another possibility is that greater sexual dimorphism in canine size of many Old World primates and multimale group competition for status and resources has led to selection for more frequent display of yawning due to its effectiveness as a costly signal. The relative 'cost' of yawning in the case of cercopithecines is said to be increased as a result of the exposure of canines that function socially to produce a "secondary intimidating effect", sometimes interpreted as a threat gesture, on potential agonists (Darwin, 1872; Bertrand, 1969; Hall and DeVore, 1965; Altmann, 1967; Chalmers, 1968; Napier and Napier, 1967, 1985; Vine, 1970).

## What Types of Yawns Exists, and With What Relative Frequencies Do They Occur?

In order to gain a better understanding of the causal mechanisms of yawning, it is helpful to analyze trends reported in the yawning literature regarding who is yawning, under what circumstances they are yawning, and with what relative frequencies individuals are yawning in comparison to one another. The following sections will focus on the relations between yawning activity and age, sex, dominance, hormones, stress, and environment.

Among gray cheeked mangabeys and long-tailed macaques (*Cercocebus albigena* and *Macaca fascicularis*) studied by Deputte (1994), yawns generally occurred in two main contexts: during transitions from rest to activity (the "rest yawn") and following social interactions (the "emotion yawn"). The rest yawn represents 90% of yawns and is common to every age-sex group. By contrast the emotion yawn (10%) is more frequent in adult males. Yawns were usually performed by individuals in seated, lying or standing positions. Between 90 and 98% of yawns are performed by quiet individuals while seated or lying. In both mangabeys and long-tailed macaques there was a peak in yawning following waking and coincided with the "wake-up syndrome", urination, defecation, and erection in males. Between 90 and 98% of yawns are performed by quiet individuals while seated or lying. Thus, yawning is associated with a moderate to low level of muscular tonus. In both human and primate studies the pre- and post-waking peaks suggest that yawning is related to state changes. Outside pre- and post-waking periods, yawning occurs during transitions between loco-motor activity and rest, and the greater the postural instability, the higher the probability of yawning (Deputte, 1978; Deputte *et al.* 1994) In both human and primate studies the pre- and post-waking peaks suggest that yawning is related to state changes. Yawns were frequently followed by short periods of rest, so that, when triggered by a social interaction, they occurred at its end. The morphology of the yawning act did not vary in regard to context, age, and/or sex of yawner. (Deputte, 1994)

In their study on the expressive movements of the Bonnet Macaque, Rahaman and Parthasarathy (1968) note that "yawning behavior in the bonnet macaque suggests stress or apathy," however no explanation is given for why this is suggested. When bonnets settle down to rest, the dominant and aged individuals yawn. The juveniles and babies are never seen yawning. The mouth is open wide to bare the prominent teeth and when the yawn reaches the climax, the head is thrown backwards. The animal may yawn in a sitting position or lie down on the ground or on a branch and yawn. Though baboons may yawn as a visual signal, bonnets yawn in contexts that are non-aggressive. (Rahaman and Parthasarathy, 1968)

Baboons are considered the "most inveterate yawner in the animal kingdom" (Pellatt, Wright, and Levine, 1981:591) and their yawning behavior may be rather atypical compared to other primates. Where as cercopithecine individuals may yawn 10 times a day or less, captive male baboons may yawn at a mean rate of some 10 to 12 times per hour, and rates as high as 24 times an hour have been recorded. The frequency of baboon yawning may be directly related to social tension. Baboons' yawns are often interpreted visual signals (Hall and Devore, 1965) and as threat gestures, because they may indicate confidence and an honest measure of canine size when they are directed at antagonists (Pellatt, Wright, and Levine, 1981).

According to Schaller (1963) Yawning in gorillas, *Gorilla gorilla berengei,* varies depending on the intensity of the yawn. A high-intensity yawn is capable of exposing the entirety of the opened mouth, while less intense yawns are characterized by less-open mouths. An interesting behavior that follows some high intensity yawns is a vigorous shaking of the head in all directions. Yawning was observed as a result of uneasiness caused by the human observer and also in association with transition between rest and activity.

In a study of Patas monkeys based on 400 hours of ad libitum data collected on a free-ranging group (1 adult resident male, 22 adult females, 22 immatures) at La Parguera (between 1977-19780, Zucker, Gerald, and Kaplan (1998) found that for the resident male, 54 yawns (22% of total) were directed towards animate targets, suggesting an agonistic function (6% toward group members, 9% toward rhesus monkeys on island, 7% towards observers). The remaining displays occurred while scanning or approaching and using feeding/drinking areas. Four additional yawn displays occurred in sexual contexts. Adult females and immatures directed 40% of their total towards animate targets (7.5% toward group targets, 5% toward rhesus monkeys, and 28% toward observers). Thus, while the adult male emitted more gape yawn displays than did other age/sex class members, a significantly smaller proportion were directed towards specific targets ($z = 4.82$, $p<.01$) (Zucker, Gerald, and Kaplan, 1998).

Hadidian's (1980: 136) description of the black ape (*Macaca nigra*) yawn closely parallels description of the human yawn in that it denies any combination with other gestures (e.g., canine display) and it suggests a contagious nature. Hadidian claims that yawns do not receive responses that would be expected of threat gestures since they are not performed in the usual context of threat gestures, or with the intention of being perceived as threat gestures. The only notable effect of yawning on conspecifics is that they may be themselves prompted to yawn because of the yawns' "infectious effect". However, there is no data on the degree to which this effect has been observed and in what situations. Yawns were observed at times of rest prior to sleep or immediately following rousing from sleep. Yawns were observed with alert and responsive performers, and often followed or occurred during interruptions in fast-paced interactions or locomotor activities. When yawns occurred in association with a "demonstration" (e.g. shaking objects, creating noise or disturbance) they *always* occurred following the demonstration. Yawns that occurred during interactions were often preceded by a distinct movement of the performer to a short distance away from the other interactant, also called a “stepaway” (Hadidian, 1980: 143). This behavior appears to be an attempt to avoid the communicative aspect of a yawn.

Overall it seems that monkey and ape yawns more frequently serve as maintenance activities and dissipaters of stress and anxiety, than as social signals and threat gestures. It appears that at times primate yawns may serve as communicative signals (as in baboons and macaques) and occur mostly in males, and mostly as threats or signals of disinterest. This communicative value of a yawn is consisten withcostly signaling theory. The relative cost of a yawn lies in its display of canine size, its association with other behaviors (e.g. grooming, directed posture, stepaway, ), and the information it reveals regarding mental and physiological states (e.g. tensed musculature, reclining posture, “wake up syndrome”, upright posture). The more common examples of yawns as threat gestures tend to come from species which exhibit relatively large sexual dimorphism in canine size. However, it may be that overtly displayed yawns carry a cost even in species where yawns as threats are uncommon (as evidenced by the stepaway behavior in *Macaca nigra* prior to yawning).

As will be further seen in the discussion below, there is evidence suggesting that primates may have control over the frequency and timing of yawns (Louboungou and Anderson, 1987; Baenninger, 1987; Anderson, and Wunderlich, 1988), as well as the appearance of the display of yawns (Hadidian, 1980; Anderson, and Wunderlich, 1988; Bertrand, 1969; Deputte, 1994; Zucker, Gerald, and Kaplan, 1998). Control over one’s yawns suggests that the behavior may be more than simply an ‘autonomic reflex action’ as suggested by ethologists. It may be that yawns originate as autonomic reflex actions but because of their social significance, are modulated (whether consciously or not) by individuals in relation to multiple factors including age, hormones, drugs, dominance, sex, environment, and stress.

## Yawning Frequency Correlated With Age, Hormones, and Drugs

Yawning frequency across various species of primates shows strong correlations with age, hormones, and the presence of certain drugs. It is clear that sex hormone levels (e.g. testosterone) change through out the life of a primate, increasing greatly after puberty and waning again during old age, and also correlate with dominance status and sex. Anderson and Wunderlich (1988) have noted that Old World monkey yawns are distinctly designed to enhance the visual impact of canines and thus are strongly correlated with age, sex, serum testosterone levels, social context, and also show variance with regard to direction (towards opponent or not). Thus, dominant adult males with high testosterone levels yawn more frequently in agonistic social contexts. Within the two species studied by Deputte (1994) (*Cercocebus albigena* and *Macaca fascicularis*), males’ yawning frequency increased with age. Thus, sex hormones may modulate the physiological processes involved.

One means by which the correlation between hormones and yawn frequency has been measure is by introduction (via injection) of hormones, or by introduction of anti-androgens that decrease hormonal levels. Other studies have injected primates with psychoactive and non-hormonal drugs to investigate possible links between yawning and other neuro-chemical interactions. In either case, the injection of antiandrogens, androgens, or psychoactive chemicals should be expected to induce a change in physiology which, when significant enough, would, in natural conditions, correlate with a change in activities. Thus hormonal and chemical physiological changes created in laboratory conditions that would lead to a change in activity levels should be expected to increase yawning frequency.

After injecting adult rhesus macaque (*Macaca mulatta*) females with testosterone propionate (androgen), yawning occurrence increased twenty-fold (Goy, and Resko, 1972). Studies of male rhesus macaques show that injections of testosterone propionate increased yawning, and that injections of HydroxiFlutamide (anti-androgen) decreased yawning (Deputte, Johnson, Hempel, and Scheffler,1994; Deputte, Johnson, Hempel, Scheffler, and Eisele, 1994). Other studies on the effects of testosterone levels in primates have also reported that the only behavior found to have repeated significant correlations with testosterone levels in aging adult rhesus macaque males (at the Oregon Regional Primate Research Center over a 10-year period) is yawning (Phoenix and Chambers, 1984; Chambers, 1981; Phoenix and Chambers, 1986). Chair restrained rhesus monkeys given anxiety-increasing drugs yawn and chew more frequently than normal (Lagarde *et al.*, 1990; Mastripieri, Schino, Aureli, and Troisi, 1992).

Studies have shown peak yawning frequencies shortly after waking and before sleeping (Rahaman and Parthasarathy, 1968; Hadidian, 1980; Deputte, 1994) suggesting a cholinergic link in yawning. Previous studies have found that cholinergic drugs induce yawning in male rats (Anias *et al.*, 1984; Urba-Holmgren, Gonzalez, and Holmgren, 1977). Morphine withdrawal has been associated with yawning in monkeys and humans. Holmgren and Urba-Holmgren (1978) report that naloxone injected into ex-addict baboons elicited yawning. An injection of dimethyltryptamine (DMT) caused yawning as well, though DMT is a hallucinogen and not an opiate (Holmgren and Urba-Holmgren, 1978).

### Yawning Frequency Correlated with Dominance

As mentioned earlier, yawning frequency across various species of primates shows strong correlations with age and hormones. There is also a strong correlation between dominance status, age, and hormones, especially with male primates, where the dominant males tend to have relatively higher levels of androgens as compared to subordinate and juvenile males. This thesis argues that yawning was originally selected to serve a physiological function and may have later evolved to serve a socially communicative function in some species. A review of the literature shows strong correlations between an individual's yawning frequency and dominance status (Sauer and Sauer, 1967; Pelatt, Wright, and Levine, 1981; Zucker, Gerald, and Kaplan, 1998; Castles, Whiten, and Aureli, 1999; Hadidian, 1980; Troisi *et al.*, 1990; te Boekhorst *et al.*, 1991). Because of the physiological correlates of dominance, high yawning frequency by dominant adult male primates may be explained, parsimoniously, by both physiological and social signaling theories. Thus, as we have seen from review of the literature, an increase in androgen levels results in an increase in yawning frequency, but in so far as yawning is argued to be a costly signal, it is also expected that the behavior would be performed with respect to the relative cost of the performance per individual and social situation. The general trend reflected in the literature discussed below shows that alpha males tend to yawn the most with a steady decline in yawning frequency with respect to a decline in dominance status, and consistent with the costly signaling hypothesis that predicts dominant individuals are the most able to afford the cost of advertising both arousal and de-arousal (such as in threats and in transitions to vulnerable states such as sleep).

In a study of wild female olive baboons (*Papio anubis*)among whom yawns are associated with threat displays, the frequency of individuals' yawning may be not only affected by their own dominance status and androgen levels but by their neighbor's relative dominance status aswell. When a target individuals nearest neighbor was within 5 meters of a sexually mature female, and had higher status than the target individual, a combined measure of self-scratching, self-grooming, self-touching, body shaking and yawning increased by 40% over those times when the nearest neighbor (within 5 m) of a sexually mature female was a subordinate (Castles, Whiten, and Aureli, 1999). Displacement activities such as self-scratching, self-grooming, self-touching, body shaking and yawning are often measured together as a combined behavioral indication of stress and tension (Carpenter, 1940; Hinde and Rowell, 1962; Rowell and Hinde, 1963; Kaufman and Rosenblum, 1966; Bertrand, 1969; Redican, 1975; Hadidian, 1980; Baenninger, 1987; Schino *et al.* 1988, 1996; Troisi *et al.* 1990), as these behaviors are believed to be means by which primates displace the physiological stress that often results from social conflict.

A study of the Celebes black apes (*Macaca nigra*) reports that as status increases so does yawning frequency. Likewise, as status is lost, yawning frequency decreases. The highest-ranking adult male, the group alpha, yawned more frequently than any other group member, and he did so consistently during the entire time he was alpha. (Hadidian, 1980.) The same correlation between dominance status and yawn frequency was reported in long tailed macaques (Troisi *et al.*, 1990) and in chimpanzees (*Pan troglodytes*) (te Boekhorst *et al.*, 1991). However, no such correlation is found among Japanese macaques (*Macaca fuscata*) (Troisi *et al.*, 1990; Mastripieri, Schino, Aureli, and Troisi, 1992).

In general it has been said that Old World monkey yawns are distinctly designed to enhance visual impact of canines, being strongly correlated with age, sex, serum testosterone levels, social context, and showing variance with regard to direction (i.e., towards opponent or not) (Anderson, and Wunderlich, 1988). While keeping in mind the correlations identified between age, hormones, dominance and yawn frequency identified for Old World monkeys and apes, we will move on to consider correlations between sex, environment, and stress.

## Yawning Frequency Correlated with Sex

It has been reported that, regardless of context, yawning is displayed more frequently by nonhuman primate males than females (Redican, 1975; Bertrand, 1969; Deputte, 1978; Goy and Resko, 1972; Hadidian, 1980; Hall, 1962; Hall and DeVore, 1965; Redican, 1975; Wolfheim and Rowell, 1972; Schino and Aurelli, 1989; Deputte, 1994). It appears that this correlation with sex, which is based on respective androgen levels, is most clearly expressed in sexually mature, as opposed to pre-pubescent individuals. In long-tailed macaques, sex differences in frequency of yawning emerged only after sexual maturity; yawning rates increased significantly in both males and females as they approached sexual maturity; and, among males, dominance rank was positively correlated with frequency of yawning. In contrast, Japanese macaque males, both mature and immature, yawned more than same-aged females; sexual maturity was associated with an increase in yawning in males only, and male rank did not correlate with the frequency of yawning. Evidence suggests that social factors also influence the age-sex class distribution of yawning: long-tailed macaques are, in general, less agonistic with their daily behavior than Japanese macaques, which yawned much more than long-tailed macaques (Troisi, Aureli, Schino, Rinaldi, and DeAngeli, 1990).

Among the Celebes black apes (*Macaca nigra*) adult males account for between 68% and 92% of all observed yawns. Subadult males are the next most frequently yawning group, but differ little in frequency from adult and subadult female groups. Male yawning increases through adolescence and jumps dramatically as males enter early adulthood (when plasma levels of testosterone start to rise), whereas female yawning increases only slightly, if at all, after infancy. The highest-ranking male in the dominance hierarchy tends to yawn at a much higher rate than other group members (Hadidian, 1980). As mentioned earlier, it is likely that yawning frequency is influenced by the relative cost of the signal as well as the relative hormone levels of the signaler. Based on the literature, it appears that both of these factors are responsible for the unusually high rates of yawning in alpha males, however more detailed descriptions of the contexts in which yawns where performed and the nature of the yawn displays would help shed light on possible causes of the reported correlations.

Fortunately, some authors reporting on yawning behavior with regard to specific contexts have been able to differentiate between different types of yawns, such as directed or non-directed and emotive or non-emotive (Hadidian, 1980; Anderson, and Wunderlich, 1988; Bertrand, 1969; Deputte, 1994; Zucker, Gerald, and Kaplan, 1998). Among Deputte's (1994) mangabeys and macaques (*Cercocebus albigena* and *Macaca fascicularis*), yawns generally occurred in two main contexts: during transitions from rest to activity (the 'rest yawn') and following social interactions (the 'emotion yawn'). The rest yawn represents 90% of yawns and is common to every age-sex group. By contrast the emotion yawn (10%) is more frequent in adult males. One means of measuring whether a yawn is emotive or not is by observing whether the yawn is either directed or overtly displayed to observant neighbors. Hall (1962) studied the reaction of patas monkeys (*Erythrocebus patas*) towards mirror images of themselves. Hall reports that yawning or gaping responses by males were very frequently given in response to mirror images; however, adult females rarely yawned (Hall, 1962). Again, this information suggests that yawns serve as a communicative display consistent with costly signaling theory.

Clearly a functional relationship exists as a result of the feedback loop between hormones and behavior/environment. Yawning behavior has been shown to have a strong correlation with androgens, and thus may be affected by both social factors (e.g. challenges to dominance hierarchy, sexual competition) and physiological factors (e.g. sex, age).

Measures of male sexual activity and biochemical analyses in relation to injected androgens in cynomolgus monkeys (*Macaca fascicularis*) were made by Michael, Bonsall, and Zumpe (1987). The authors found a strong correlation between male sexual behavior and testosterone levels: old male rhesus macaques (and humans) display less sexual behavior than young and middle-aged males (also found by Phoenix and Chambers, 1984; Chambers and Phoenix, 1981). Among male rhesus macaques the only other behavior found to have repeated significant correlations with testosterone levels was yawning (Phoenix and Chambers, 1986).

A study of yawning behavior in patas monkeys (*Erythrocebus patas*) indicates a possible correlation between yawning and sexual behavior. The study reports that the resident male (of free-ranging patas monkeys) produced 75% of the gape yawns observed, with 69% of them in the birth season versus in the breeding season. Adult females accounted for 17% of total gape yawns observed, with 70% of those in the breeding season (Zucker, Gerald, and Kaplan, 1998). Another study (Scucchi, Maestripieri, and Schino, 1991) reports a correlation, though not significant at the 0.05 level, suggesting that stress affected displacement activities, such as yawning, increase as a result of the conflictual states associated with sexual behavior. The authors note that during the periovulatory phase of long-tailed macaques, male yawning and body shaking underwent insignificant increases, while male autogrooming and scratching increased significantly. The results suggest that the male conflictual state, but not the female one, is affected by female menstrual cycle (Scucchi, Maestripieri, and Schino, 1991). Deputte (1978) has also reported on yawning that occurred in mangabeys and macaques before and after interaction of a sexual nature. The yawning reported in these cases often showed either anxiety, conflict in desires, or disinterest as indicated by behavioral cues either preceding and/or following yawns (Deputte, 1978).

## Yawning Frequency Correlated with Environment and Stress

The social and physical contexts associated with high yawning rates tend to be stressful and relate to conflict, interactions with animals, or interactions with environment. As seen in correlations between yawning rates and sexual behavior, social and physical contexts associated with high yawning rates most commonly involve male primates (e.g. initiation of play, mounts, coercive gestures).

According to Deputte (1994), after an adult male gray-cheeked mangabey (*Cercocebus albigenus*) retrieves an infant and/or carries it, he often yawns. In macaques, play between an adult male and an infant sometimes induces a yawn in the adult, and according to Deputte (1978) shows possible disinterest in infants. Yawning is much more frequent after coercive gestures (e.g. threats, pushing away) than after open aggression (e.g. aggressive chase without actual contact). In macaques, adult male/female interactions, whether involving sexual or non-sexual contact, represented more than 52% of the social interactions inducing a yawn in males. Adult male/male mounts, play interactions and affiliative interaction, are reported to sometimes lead to yawning.

Mangabeys may yawn for 10 seconds after uttering an alarm call. Based on these examples of social contexts capable of inducing a yawn, Deputte concludes that the contexts can be characterized as leading to psychological tension, either as an increase in arousal or as a conflict of drives.

Deputte's conclusion above accords well with evidence reported in the literature, and is backed up by further study. During the formation of a group of captive Celebes black ape macaques (*Macaca nigra*) there was little aggression reported but much yawning, tense posturing and agitation. (Bernstein and Baker, 1988) When two unfamiliar female macaques are paIred in a relatively small cage, the delayed establishment of clear-cut dominance relationships brings about a sharp increase in the frequency of scratching, autogrooming and yawning over time (Schino *et al.* 1990; Rowell and Hinde 1963; Mastripieri, Schino, Aureli, and Troisi, 1992). All the social contexts of yawns described here are similar to those described by Hadidian (1980) in black apes, and confirm the widespread opinion that yawns are induced by psychological tension or mild stress (Redican, 1975; Deputte, 1994).

Another social context that shows evidence of inducing psychological tension as a possible product of arousal and conflict of drives is feeding behavior, especially when ritualized in captivity. Food reinforced yawning has been reported in several species. This is of particular interest to the study of yawning behavior because it demonstrates that yawning behavior can be modulated by primates in response to environmental cues.

In Pigtail macaques (*Macaca nemestrina*) yawning frequency is reported to increase when followed by food, with extinction and reconditioning procedures confirming the establishment of the conditioned response. The authors explain that these results were achieved by "conditioning" or rewarding yawning individuals with food (Louboungou and Anderson, 1987).

Another study reports a clear correlation between yawn frequency and time of day among Mandrills (*Papio sphinx*) observed at the Philadelphia zoo. This correlation increased progressively in the hour before feeding time from 1.5 yawns/mandrill-hour to 6.5 yawns/mandrill-hour. Yawn contagion was not apparent (Baenninger, 1987). Similarly, a study reported by Anderson and Wunderlich (1988) demonstrates that with conditioning, Tonkean macaques can learn to produce yawns for food and control the rate of yawning relative to the contingency of food reward on the behavior.

Chimps have been reported to yawn when frustrated, when they see a human observer, when approached by a dominant individual, or during agonistic interactions (Goodall, 1965, 1968; Nishida, 1970). A study of captive social groups noted that agonistic displays were often associated with yawns (te Boekhorst *et al.*, 1991). A captive study found increased rates of yawning and scratching under conditions of high population density (Aureli and de Waal, 1997). Captive chimpanzees exposed to an increased amount of incidents of neighbor vocalization engaged in more yawning (as well as scratching) than before (Baker, and Aureli, 1996).

Yawning often appears to be triggered by environmental stimuli that startle, disturb, alert, or appear to threaten the performer (e.g. noises, thunder, approach of strange humans, traffic on nearby service roads, agonistic behavior in group not directly affecting those yawning, change in relative proximity of group members). (Hadidian, 1980.)

The association between displacement activities and anxiety (which has been shown in macaques) has been investigated in chimpanzees, humans, apes and Old World Monkeys based on behavioral, pharmacological, and physiological evidence. Displacement activities considered in the literature include gentle and rough scratching, self-grooming, body shaking, and yawning. What researchers refer to as "displacement yawning" has frequently been reported (Carpenter, 1940; Hinde and Rowell, 1962; Rowell and Hinde, 1963; Kaufman and Rosenblum, 1966; Bertrand, 1969; Redican, 1975; Hadidian, 1980; Baenninger, 1987; Schino *et al.* 1988, 1996; Troisi *et al.* 1990). According to Bertrand, displacement yawning is distinguished from normal yawning by frequent repetition and clearer display of teeth. However, whether these types of yawning (displacement/normal) are synonymous with "emotive" yawning (preceding or following social interactions), as described by Deputte and others, is unclear. We will see in the upcoming discussion on physiological functions of yawning, that all yawns serve the function of "displacing" the neural and hormonal correlates of previous behavioral states, and thus it may be that all yawns are indeed "displacement yawns".

According to Castles and Whiten (1998), wild olive baboons suffered a clear stress response in the period following a conflict, as indexed by elevated rates of scratching, autogrooming, yawning and body shaking. The authors cite Sapolsky (1994), arguing that the "stress response" in this situation is an adaptive mechanism, which physiologically prepares the animals to respond to dangerous situations. In doing so, adrenal hormones rapidly mobilize stored energy and increase heart rate, blood pressure and breathing rate to allow the energy to be utilized. In addition, energy storage, growth, immune system and reproductive processes are inhibited. Sustained activation of the stress response is associated with a range of deleterious consequences including brain damage (Uno *et al.* 1989). In socially competitive environments, fellow group members are potential stressors (Dunbar, 1988) and chronic social stress can result in severe circulatory disorder and death in captive primates (Kaplan *et al.* 1991). Chronic stress is more likely to occur in environments in which it is impossible or extremely costly for stressed individuals to leave the group. Therefore, animals that form groups in response to predation pressures and are thus frequently exposed to social stress are expected to develop social mechanisms for attenuating its potentially destructive effects (Aurelli and van Schaik 1991; Castles, and Whiten, 1998). A variety of group behaviors that have been identified in social animals (e.g., group sexual behavior, group grooming, group yawning) are believed to be mechanisms for displacing the potentially destructive effects of stress. It has been argued that bonobo chimpanzees have developed highly sexualized behavior as a means of mediating social tension (Manson, Perry, and Parish, 1997) and that long-tailed macaques and other primates perform grooming to mediate social tension (Schino, Scucchi, Maestripieri, and Turillazzi, 1988). Schino *et al.* (1988) found that displacement activities, including yawning, were significantly reduced in frequency among caged heterosexual pairs of long-tailed macaques by grooming, and that displacement activity frequencies were proportional to the amount of grooming received. In the seconds immediately following the end of a grooming interaction, the frequency of male displacement activities increased (Schino, Scucchi, Maestripieri, and Turillazzi, 1988). In the event that yawns might serve as threats as hypothesized by costly signaling theory (and thus deter the appeasing efforts of a groomer), it may be that individuals receiving grooming intentionally suppressed their yawns so as not to jeapordize their ability to recieve grooming.

## The Relationship of Yawns to Canine Displays and Threat Gestures

In addition to signaling change in activity, anticipated change in activity, or general stress, tension, and unease, yawning sometimes serves as a display of canines (Napier and Napier 1967; Vine 1970). Yawns are an effective means of demonstrating relative canine size because they tend to be stereotyped within a species. Yawns associated with wake-up phases and yawns elicited in social interactions are morphologically similar (Redican, 1975). According to Hadidian (1980), yawns have the same form whatever the size of the canines, and do not change in form after the growth of the canines. Moreover, the change in yawning frequency during puberty occurs during the growth of canines, not after. Females possessing only short canines yawn in the same social contexts as males, although less often (Hadidian, 1980).

Canine display can therefore be a costly behavior, especially among species where canine size is correlated with dominance and canines are frequently displayed in the context of threats and used as weapons. The development of canine weaponry, and other forms of primate sexual dimorphism (behavioral, morphological, physiological), is commonly viewed as a product of male mate competition and sexual selection. It is argued that selection may favor the development of weaponry for display by reducing the risk of determining every contest through physical contact (Plavcan, 1999). In aggressive encounters, primates keep track of and constantly adjust their behavior to that of their antagonist. By contrast, when yawning, an individual stops his ongoing activity and, by raising his head and/or closing his eyes, loses track of a partner’s behavior. This risk or cost is the reason why yawning demonstrates confidence and willingness to invest in potential conflict. In such encounters, a yawning and inattentive primate, who also demonstrates inferior physical characteristics (associated with subordinate animals), is at risk. Thus, yawning in aggressive encounters is a costly behavior, and only dominant individuals should be able to afford the cost. According to costly signaling theory, once evolved, signals of fitness such as yawning are expected to be displayed by all. Should an individual not yawn in a social encounter, it may be that the individual is signalling concete, thereby “giving up” on the sexual competition that the display evolved as a signal for.

Whether the display of canines resulting from a yawn can be interpreted as a threat by conspecific observers is disputed, however. Hadidian (1980) noted that yawns failed to elicit direct responses from conspecifics, and thus were not threats. Moreover, duration and completion of “true” communicative facial expressions depend on the recipient’s response. Deputte and Fontenelle (1980) demonstrate that, unlike primary communicative signals such as the open-mouth threat and lip-smacking, the duration and degree of completion of a yawn are independent of external events; a yawn is ‘unfolded’ continuously, whereas, in the open-mouth threat, there is a plateau in the opening of the mouth, and its duration and intensity depend on the opponent's response. A yawner has little control over the completion of his yawn (Pellatt *et al.* 1981; Provine 1986) and even humans have difficulty stifling a yawn once initiated (Provine, 1986). Review of the current literature confirms the correlation suggested by Deputte (1978) that the occurrence of "threat yawns" featuring canine exposure is found more often amongst sexually dimorphic taxa, especially with males who frequently expose prominent canines.

A yawn is sometimes considered to be a mild threat gesture when the yawner faces his partner (Hall and DeVore, 1965; Altmann, 1967; Chalmers, 1968). Chalmers (1968) showed that, in black mangabeys, yawning while facing away from a partner is associated with a tendency to flee. Baboons have been often cited for their characteristic threat yawns that can often be seen repeatedly exchanged between two individuals in agonistic interactions (Darwin, 1872; Hall and DeVore, 1965). Baboons exchanging threat yawns in agonistic contexts may be using costly signaling: testing the strength of their oponent's confidence as opposed to testing each other's strength in the more direct manner, physically. The exchange of costly threats as a substitute for aggression has been identified among fish, birds, reptiles, and mammals (Zahavi and Zahavi, 1997). Analogies of costly threats come in many forms: vocal displays, aerial displays, electric pulses, chemical emissions, and posturing (Zahavi and Zahavi, 1997).

It may be that yawns do not and cannot qualify as true threat gestures for most animals, but as a result of the resulting canine display, there remains the possibility that yawns impose a social cost to their displayers. Socially costly yawning, which honestly indicates canine size, allows the more dominant individuals to display potentially intimidating confidence by casual and frequent yawning. Tellingly, it has been reported that yawning displays in males are more likely to be associated with social status than with canine size (Deputte, 1978).

## Yawning Contagion and the Communicative Value of a Yawn

In humans the puzzling question about yawning is its social infectiousness, a well-known but rarely studied phenomenon (Provine 1986, Provine 1989a,b). This contagious effect is absent in non-human primates (Depute, 1978, 1994). Only Hadidian (1980) has suggested that infectious yawning may exists in non-human primates, where the observer of a yawn may in turn be prompted to yawn. Contagious yawning is defined as non-emotive yawning that is provoked by the observed or suggested yawning behavior of conspecifics. It may be that with further primate observation we may find evidence of yawning contagion.

Contagious yawning differs from simple imitation, in that yawns cannot be imitated or contrived but, rather, are reflex actions that unfold in typical patterns and can be augmented only with difficulty (Pellatt *et al.* 1981; Provine 1986). Furthermore, when people yawn contagiously, it is not out of a conscious desire to imitate the yawner. The phenomenon in which observed yawns provoke yawns in the observer is called contagious because it is not imitated, but rather functions because of a triggering of a neurological stimulus feature detector (ethologically described as an "innate releasing mechanism") in the auditory and visual domain, that activates the species-typical, stereotyped ("fixed") action pattern of a yawn (Alcock, 1989; Provine 1986, 1989b).

Primate yawning occurring outside of the transition between sleep and waking phases may have a communicative function (Redican, 1975). Observers can integrate information available from the yawner’s previous and subsequent demeanor and thus infer mental and physiological states. Therefore, any yawn preceded by a social interaction, and not only the ‘averted tension yawn’ as Altmann (1967) proposed, could be considered as being secondarily communicative (Bolwig, 1959). This communicative value of the yawn (as an uneasiness indicator) is consistent with that proposed by several authors (Carpenter, 1940; Bolwig, 1959; Hall and Devore, 1965; Hall, 1968; Poirier, 1970; Hadidian, 1980; Maestripieri *et al.*, 1992; Deputte, 1994). If, indeed, contagious yawning exists in non-human primates, it will likely occur among species and individuals capable of interpreting secondarily communicative cues.

## Discussion of Non-Human Literature

In order to conclude that yawning in birds, fish, reptiles, and mammals is homologous and serves to facilitate a change in activities, we need evidence that yawning is physiologically tied to changes in activities as has been eloquently argued for humans. Until we gain a better understanding of animal physiology and can demonstrate with real-time technology (such as ultrasound video) the effects of yawning specific to a particular species we will not have conclusive evidence of its function. Given that examples of yawning behavior in the animal kingdom are limited to vertebrate species, and that all vertebrate species share remarkably homologous skeletal architecture, a strong possibility certainly exists that yawning behavior may have been selected for in even the earliest stages of vertebrate evolution to facilitate a change or anticipation of change in activities. The authors of one of the most rigorous behavioral studies of yawning to date agree: “It is conceivable that yawning is a phylogenetically old behavior pattern among vertebrates and common to most if not all of them” (Sauer and Sauer, 1967: 584).

When the behavior of four species -Siamese Fighting Fish (*Betta splendens*), Bicolor Damselfish (*Eupomacentrus partitus*), lions (*Panthera leo*), and Mandrills (*Papio sphinx*)- was compared, anticipation of major stimulus events appeared to be the one common factor associated with an increase in yawning (Baenninger, 1987). Herbivores have seldom been observed yawning (Barbizet, 1958; Heusner, 1946). It may be possible that carnivorous lifestyles, characterized by greater changes in activity levels, require greater variance or change in neurotransmitters and hormonal influence as associated with vigilance, aggression, defense, and especially competition for limited resources. In the review of bird, fish, reptile, and mammal literature we see that yawning is correlated with cases of either conflictual states, changes in activity, or anticipated changes in activity. In all of these cases it is plausible to expect an accompanying metabolic and physiological change (especially hormonal) correlating with the yawns. Without further information, however, it can only be suggested that yawning might be one of the consequences of the activation of arousal-regulating structures. In this capacity, yawning may help adjust the balance between general metabolism and arousal.

## Observation and Studies of Human Yawning

### Physiological Studies

A review of the studies of human yawning reveals that yawning behavior in humans is associated with displacement activities such as stretching and scratching. Displacement activities in humans tend to be associated with either change or anticipated change in activity, internal conflict, or motivational ambivalence. Findings suggest that human yawning is associated with changes in an individual's activity or arousal level (Baenninger, Binkley, and Baenninger, 1996). Conflict situations created in laboratory experiments have been known to produce a wide variety of autonomic responses in metabolism and physiology that often include the activation of displacement activities, including yawning (Holmgren and Urba-Holmgren, 1978; Lagarde *et al.*, 1990; Mastripieri, Schino, Aureli, and Troisi, 1992). Laboratory studies on the physiological effects of yawning have shown that yawning is associated with physiological changes activated by the autonomic nervous system. The proposed physiological changes associated with yawning include circulatory, respiratory, muscular, hormonal, and/or neuronal changes. A respiratory explanation for yawning has frequently been suggested; however in a study on human yawning by Provine, Tate, and Geldmacher (1987), no support was found for the popular hypothesis that yawning is a response to elevated $CO_2$ or depressed $O_2$ levels in the blood. Neither breathing 100% $O_2$ nor various $CO_2$ mixtures influenced the rate of yawning, although both increased simultaneous recorded breathing rate. Exercise was shown to have a significant effect on breathing rate, but there was no significant effect on yawning rate detected. Exercise that doubled breathing rate also had no effect on yawning (Provine, Tate, and Geldmacher, 1987).

Heusner (1946) has shown that heart rate increases with yawning and that vasoconstriction begins at 4 - 4.5 seconds after yawning with a maximum response at 9 – 10 seconds. The study shows that vasoconstriction subsides to the original level 45 seconds after yawning (Heusner, 1946). These findings weresupported by Arkenasy (1996), who reported an overall increase in blood pressure following a yawn. Increase in blood pressure and heart rate is often associated with arousal and supports the claim that yawning increases arousal initially, as measured by skin conductance (Greco and Baenninger, 1991). Another study measured activity in association with yawns by monitoring the wrist movement of six adult throughout their daily activities over a period of two weeks. An increase in wrist movement in the 15 minutes following yawning was found (Baenninger, Binkley, and Baenninger, 1996). Studies have shown that yawning is consistent in duration, that it occurs periodically, and that within-subject stability in yawn duration and frequency is maintained over intervals of several weeks (Provine, 1985; Baenninger, Binkley, and Baenninger, 1996). General arousal and increase in activity is associated with both stress responses and displacement activities. It has been argued that stress responses physiologically prepare animals to respond to dangerous situations (Sapolsky, 1994) and displacement activities allow the displacement of stress (Castles and Whiten, 1998), which, if sustained, could lead to deleterious consequences including brain damage (Uno *et al.* 1989). Yawning behavior as a displacement activity is a feature that humans share with other vertebrates.

Yawning is of medical importance because it is symptomatic of pathology such as brain lesions and tumors, hemorrhage, motion sickness, chorea, and encephalitis (Barbizet, 1958; Graybiel and Knepton, 1976; Heusner, 1946; Jurko and Andy, 1975; Provine, Tate, and Geldmacher, 1987; Argiolas and Melis, 1988; Arkenasy, 1996; Wimalaratna and Capildeo, 1988; Nolman, 2000). Neurological and pharmacological evidence suggests that yawning is a deep-brained activity, possibly controlled by the hypothalamus and medulla oblongata. Yawning is under the control of several neurotransmitters and neuropeptides. Among these the best known are dopamine, excitatory amino acids, acetylcholine, serotonin, nitric oxide, adrenocorticotropic hormone-related peptides and oxytocin (which facilitate yawning) and opioid peptides (which inhibit yawning). Of the above compounds, several interact in the paraventricular nucleus of the hypothalamus to control yawning (Argiolas and Melis, 1998).

Cases of neurological damage provide evidence demonstrating the involuntary nature of yawning behavior and its relation to stretching. One study reports that patients with brain damage have suffered from uncontrollable excessive yawning, that a stroke patient could move his hemiplegic arm during yawning, that another patient was able to move two hemiplegic arms while yawning, and that yet another patient with “locked in syndrome” could not open or close his mouth except while yawning (Wimalaratna and Capildeo, 1988).

As yawning is shown to be physiologically and behaviorally associated with stress responses and displacement activities in humans and other vertebrate species, the next question to be addressed is, “Why has yawning been so widely selected for as a common displacement activity?" It has been suggested by Nolman (2000) that yawning serves to "cleanse the brain" by aiding in the circulation, and transportation of cerebrospinal fluid (CSF). CSF is a clear liquid created by the choroid plexus found in the ventricles of the brain, and is believed to protect the brain from shock and to nourish the brain and remove brain waste products. It flows from the ventricles and surrounds the brain and spinal cord. Among the neurotransmitters and neuropeptides found in CSF, are those identified by Argiolas and Melis (1998) as having control over yawning behavior. Cerebrospinal fluid is known to be absorbed by the arachnoid villi / venous sinuses. Because we produce about a pint of CSF per day but only have the capacity to hold one fourth of that amount, our CSF is replaced several times per day during normal circulation (Nolman, 2000). The flow of CSF has much to do with cranial pressure, which is different from the blood pressure of the body. This cleansing of the fluid that occupies the cerebral environment and contains residuals (neurotransmitters, neuropeptides, hormones, and metabolites) from previous psycho/hormonal physiological states is assumed to refresh the brain for a change to arousal or de-arousal. Likewise, the effects of general anxiety, motivational conflict, and stress could conceivably be reduced by the refreshing of cerebrospinal fluid.

Circulation of CSF is achieved by a valve-like action that "normal" yawning creates (Nolman, 2001; Pellatt, Wright, and Levine, 1981). This is why subjects who were told to yawn in the "clenched teeth" position rated their yawns as highly abnormal (Provine, 1986). "The absolutely essential and ineradicable movement, the '*sine qua non'* of a yawn, is the depression, or better yet descent, of the larynx" (Pellatt, Wright, and

Levine, 1981:392). The “essential” effect described by both Nolman and Pellatt, Wright, and Levine can be best achieved with jaw gaping, chest expanded and raised, and larynx descended. When musculature and skelature are flexed by these movements, the effect is a valve like action at the base of the skull.

Nolman (2000) has described in detail the physiological action produced in association with the human yawn. He reports that at the deepest part of the breath when the lungs have the greatest force, the lungs fill and the ribcage is lifted, thereby lifting the spine and ultimately transferring force from the top of the spine to a bone of the skull called the occipital bone. This bone, accounting for most of the base of the cranium, is then pushed upward. At the same moment the fully expanded lungs push away from the ribs and the bronchi are forced apart from each other. The bronchi are attached to the bronchial tubes, causing them to pull down on the trachea. In so doing, the trachea pulls down on the thyroid. The thyroid is attached to the hyoid bone by the thyrohyoid membrane, and pulls evenly on the hyoid bone. The hyoid bone, which is being pulled downward, is attached to the skull by ligaments and muscle at two points called the styloid process of the temporal bones. The two temporal bones are on each side of the occipital bone. The styloid process is two thorn-like protrusions where muscles and ligaments attach from the hyoid bone to the temporal bones. The jaw, the tongue, and the hyoid bone together with many muscles work to pull down on the temporal bones during the deepest part of a yawn inspiration when the jaw is opened wide. While the temporal bones are being pulled downwards on each side of the occipital bone, the occipital bone is being pushed up between them. The occipital bone and the spine are like a piston pushing up between the temporal bones that are being pulled downward.

As best as this can be observed by unaided subjective analysis of yawns in self and others, yawning does appear to put pressure on the basicranium. Nolman (2000) argues that the pressure that he believes is put on the brain within the skull has the effect of accelerating the normal CSF absorption and circulation process. Though the process has not yet been verified with real-time visual imaging techniques, it is believed that as a result of yawning the CSF is forced through its absorption pathways at an accelerated rate taking brain waste products with it. According to Nolman, some of the drained CSF finds its way to the lachrymal system. The eyes water because the CSF escapes from the cranial nerves and enters the lachrymal system. Some CSF enters the lymphatic system and causes the chest muscles to quiver, while most of it goes through the known, high-volume drainage pathway the arachnoid villi / venous sinuses.

Nolman (2000) observes that while people with brain lesions, tumors and certain kinds of epilepsy often yawn excessively, schizophrenics yawn very little. Nolman attributes the associations of these findings to the fact that brain lesions, tumors and certain kinds of epilepsy cause an increase in the CSF, thus creating a need to yawn more often. According to Nolman the reason schizophrenics yawn very little may be that people with schizophrenia have enlarged ventricles in their brains indicating that there may be an excess of CSF in the ventricles. People with schizophrenia are said to have an excess of neurotransmitters in their brains. CSF nourishes the neurons that produce neurotransmitters. Nolman suggests that perhaps an excess of neurotransmitters can cause an excess of CSF to feed the neurons to produce neurotransmitters, or else perhaps when the CSF gets too saturated or concentrated with neurotransmitters an excess of itself is produced in order to maintain or dilute the CSF to a lower percentage of brain chemicals per volume of CSF. Either way this would make schizophrenia an “incrementing cycle” in that excess neurotransmitters can cause excess CSF and excess CSF can cause excess neurotransmitters. Nolman suggest that yawning breaks the incrementing cycle of schizophrenia by reducing the CSF pressure and cleaning the brain of excess neurotransmitters and other potential contaminants.

## Behavioral Studies

Studies of yawning in humans indicate that human yawning behavior has much in common with yawning behavior found throughout the animal kingdom, yet has many unique characteristics that may be species-specific traits. A study exploring the relationship between self-reported yawning and subsidiary activities (chattering, looking around, changing positions, arranging hair) looked at several types of conveyor-line workers with both fixed and variable-tasks (Kishida, 1973). A correlation was found between yawns, subsidiary activities, and the self-report of boredom and/or fatigue, with higher frequencies of yawning in fixed-task employees. The authors of the study concluded that variable-task workers had better opportunities to displace stress associated with the task, afforded by the physical and cognitive stimulation resulting from more variation in activity, and that fixed-task workers suffered from great motivational conflict because they were restricted to repeating a fixed task, which, once automated, lacked cognitive and physical stimulation. These finding are in accord with Baenninger's (1987) in that they show higher frequencies of human yawning in situations with less physical and cognitive stimulation.

More yawning has been shown to occur during the week than during the weekend, though differences in yawning frequency between subjects were not correlated with sleep patterns (Baenninger, Binkley, and Baenninger, 1996). Yawning folklore carries some truth in that sleepy and bored people do yawn a lot. People yawn more in boring than in interesting situations (Provine and Hamernik, 1986). Yawning and stretching are frequently concurrent, especially near hours preceding and following sleep (Provine, 1986, 1987; Baenninger, Binkley, and Baenninger, 1996), when people are thought to be sleepy (Provine, Hamernik, and Curchack, 1987). In one study the probability of yawning was shown to increase during the four hours preceding sleep and following waking (Provine, 1986). A study that looked at yawning and stretching independently correlated stretching with morning yawning but not evening yawning (Provine, Hamernik, and Curchack, 1987). Steinen (1894) has been quoted for his ethnographic example of yawning behavior among the Bakairi of Central Brazil. He reports that "If they seemed to have had enough of all the talk, they began to yawn unabashedly. . . . That the pleasant reflex was contagious could not be denied. One after the other got up and left . . . [to go to sleep]" (in Eibl-Eibesfeldt, 1975: 135). This example is plausible, and interesting in that the contagion affected the group because, unlike in other species, human yawning is reported to occur more frequently in the relative absence of social, cognitive and physical stimulation (Baenninger, 1987; Baenninger and Baenninger; 1996). Human yawn frequency observed on a subway line was greater when fewer people were present: 0.24 yawns per hour were reported when less than 15 people were present versus the 0.006 yawns per hour reported when more than 15 people were present. The following rates of yawns per activity correlate similarly with respect to social, cognitive, and physical stimulation: for 45 minute college aerobic classes, average rates of 0.0012 yawns per hour were recorded; during lunches and dinners in dormitory cafeterias, average rates of 0.009 yawns per hour were recorded; at the campus library during mid-semester, average rates of 0.9 yawns per hour were recorded; during leisure activities observed in the dormitories (e.g. watch TV, casual conversation, beer drinking) average rates of 3.6 yawns per hour were recorded; and in math (calculus) classes the highest average rates of 24.6 yawns per hour were recorded. (Baenninger, 1987).

In all species of non-human primates for which data on sex differences in the frequency of yawning are reported, males yawn much more than females (Redican, 1975; Bertrand, 1969; Deputte, 1978; Goy and Resko, 1972; Hadidian, 1980; Hall, 1962; Hall and DeVore, 1965; Redican, 1975; Wolfheim and Rowell, 1972; Schino and Aurelli, 1989; Deputte, 1994). Of the 267 yawns recorded from 221 subjects (59.3% male, 40.7% female) collected on 94 subway journeys, 57.9% of the subjects who yawned were males and 42.1% were females. Thus the difference in relative distribution of yawns by sex was not significant. However, when yawns were coded by style (mouth covered or uncovered), 49.2% of male yawns were uncovered and 32.6% of female yawns were uncovered. Thus the distribution of types of yawns by sex was significant (Schino and Aurelli, 1989).

# Discussion of Human Literature

Yawning behavior observed in naturalistic and controlled behavioral studies reveals that, outside of socially influenced conditions, yawning tends to serve as a displacement activity much as reported in non-human behavioral literature. Human yawning behavior differs from non-human yawning behavior, in that contagious yawning is reported to exist, males yawn as much as females, and yawning appears to be inhibited by social factors and physical and cognitive stimulation. Theories of cerebrospinal fluid circulation, arousal, de-arousal, and stress displacement functions of yawning fit well with what we know about when we yawn and what effects yawning has on us.

The greatest mystery about human yawning centers around its contagious and socially mediated nature. Though yawning is performed by fetuses as early as 12 weeks after conception (Petrikovsky, Kaplan, and Holsten, 1999), yawning contagion develops in humans between the first and second years of life (Chudler, 1999). Yawning can be provoked with relatively little suggestion, yet not all people yawn when given the suggestion. Visually observed yawns were shown to be potent stimuli, as compared to visually observed smiles, for inducing yawns in observers. Twenty three of 42 subjects (55%) yawned while watching a video of yawns (usually within the first five minutes of watching), while only 5 of 24 (21%) yawned while observing smiles (Provine, 1986). Even reading about or thinking about yawning is sufficient stimulus to trigger yawning behavior (Carskadon, 1991 and 1992; Provine, 1986). This and other characteristics qualify yawning as both a stereotyped action pattern, and a releaser of the action pattern. In an attempt to discover the significant feature of a yawn that might serve as the releaser, Provine compared a motion picture of yawning man, a high resolution picture, a mouth only, a face with mouth omitted, the top part of a face omitted, the top part of face only, no face, and a smiling man. All stimuli were tested for their efficacy in producing yawns. The gaping mouth did not produce significantly more yawns than other variations of incomplete facial expression, whether yawns or smiles. Thus the author concludes that contagious yawning is provoked by the constellation of facial cues associated with yawns, not just the gaping mouth (Provine, 1997). Studies have demonstrated that trained yawners can stimulate college students in assemblies and libraries to yawn as well as church goers in both morning and evening services (Moore, 1942). Sound recordings of yawns have been shown to stimulate blind subjects to yawn (Moore, 1942). Motion pictures of a girl yawning stimulated yawning reflex in several students (Moore, 1942).

As suggested by Baenninger's (1987, 1996) studies, yawning frequency is affected by several factors including social ones. As discussed earlier, social factors have been shown to affect yawning frequency in primate studies, in that yawning has potential for being a costly signal where cost is a measure relative to the individual's position in the social hierarchy. It may be that the yawning behavior which we share as a homologue to the yawning behavior in other primates is also, in part, affected by the relative cost of the behavior with respect to social situations, and that the contagious yawning unique to humans may be based on the communication of a behavior that is a costly signal. In the next chapter predictions for contagious yawning in humans are developed, based on (1) the application of costly signaling theory and (2) suggestions of homologous design features that have emerged from comparative analysis of yawning across primate and vertebrate species.

# CHAPTER III

# PREDICTIONS

Yawning is a phylogenetically ancient behavioral pattern (Sauer and Sauer, 1967; Hadidian, 1980) as evidenced by its distribution across the vertebrate groups. A review of the literature shows that yawning serves as a displacement and maintenance behavior in all of its homologous examples across the animal kingdom, generally in association with stress or some sort of change or anticipated change in activity and accompanying physiology. Not only can yawns be clearly recognized by observers because of their conspicuous nature, it has been said that in some animals yawns have acquired a "secondary communicative value", by which information is communicated (Darwin, 1872; Carpenter, 1940; Hall and Devore, 1965; Hadidian, 1980; Deputte, 1994), and often at a cost. The "secondary" level at which information is communicated refers to an inferential level, wherein social animals can deduce the intentional state of yawning conspecifics by also considering the constellation of cues surrounding a yawn. Here a model of yawning contagion is developed based on the findings these findings and the adaptive logic of costly signaling theory. The following chapter describes methods used to test these predictions, and finally Chapter V reports the results of these tests. The predictions that have been developed are organized into two categories for simplicity: Pharmacological and Physiological Influences, and Psychological and Social Influences. It is this author's belief that all of the predicted influences on yawning contagion are interrelated and must ultimately be considered with respect to one another. As mentioned earlier, previous studies (Schino and Aureli, 1988; Provine and Hamernik, 1986; Provine 1986, 1989, 1997; Baenninger et al., 1996) have failed to adequately investigate the effects of drugs and hormones, dominance, social perceptions, and sex on yawning contagion. It is predicted that each of these factors affects the frequency with which yawns are evoked under controlled circumstances previously demonstrated to have elicited contagious yawning. In order to test for the predicted effects of previously untested factors, this study is closely modeled after the methodology of Provine's (1986) study: "Visually Observed Yawns as Stimuli."

## Pharmacological and Physiological Influence

Primate and animal yawns are often correlated with a change in androgen levels, with higher-testosterone individuals exhibiting higher frequency of yawns (Goy and Resko, 1972; Lagarde et al., 1990). Higher-testosterone individuals, who are often more dominant, are more likely to display both costly signals and displacement activities. Yawning may, in part, be a displacement activity that results from the stress response caused by testosterone surges (Dabbs, 2000) identified in males. Though a stress response may benefit an individual (Sapolsky, 1994) in preparing for the danger associated with sexual competition, the sustained activation of a stress response is known to have deleterious consequences (Uno *et al.* 1989). By means of temporary metabolic and muscular arousal as well as CSF circulation, yawning is believed to displace the effects of stress that arise in response to abnormally high levels of testosterone in both men and women. Therefore, this study predicts that those subjects with high levels of testosterone will show higher than normal frequencies of yawning when observing yawn stimuli in a controlled setting. Stress responses provoked in subordinate or lower-testosterone individuals will not result in elevated yawning frequencies, conversely, due to the cost entailed in yawn display. Furthermore, yawns provoked in subordinate or lower-testosterone individuals by dominant individuals are expected to be accompanied by both displacement and "hiding" activities (e.g. rubbing face, covering mouth).

The occurrence of primate and animal yawns has also been linked with the presence of drugs. In addition to the correlation between yawning and androgen-increasing, anti-androgen, and cholinergic drugs (Anias et al., 1984; Urba-Holmgren, Gonzalez, and Holmgren, 1977), yawning has also been reported in relation to opiate-withdrawal and the presence of anxiety-increasing and psychoactive drugs (Holmgren and Urba-Holmgren, 1978). Across the animal kingdom, yawning is believed to be a deep-brained activity under the control of several neuropeptides and neurotransmitters. These substances include dopamine, excitatory amino acids, acetylcholine, serotonin, nitric oxide, adrenocorticotropic hormone-related peptides and oxytocin (Argiolas and Melis, 1998). As suggested by Nolman (2000), serotonin-uptake related and MAO-inhibiting drugs may also affect yawning frequency. Nolman also observes that while people with brain lesions, tumors and certain kinds of epilepsy often yawn excessively, schizophrenics yawn very little. According to Nolman, these cases abnormal yawn frequencies are a result of abnormal CSF pressure or abnormal neurotransmitter levels. Though an in-depth understanding of the neuropharmacology of yawning is beyond the scope of this study, the above evidence suggests that a variety of drugs and neurological pathologies interacting with neurotransmitters, neuropeptides, and CSF may be correlated with abnormal yawn frequencies.

Changes in activity and activity levels, which have been associated with yawning, may be correlated with changes in energy levels and changes in metabolism as affected by food, caffeine, and rest. Following a large meal it is not uncommon to experience a decrease in arousal accompanied by a change in activity level. It is predicted that large meals and caffeine, consumed within the hour preceding participation in this study, could change the energy levels of subjects such that the change in activity, associated with their transition from non-participation to participation, would be experientially different than as for those subjects not under the influence of large meals and caffeine. Yawning has been correlated with tiredness and fatigue, but not sleep patterns (Kishida, 1973; Baenninger, Binkley, and Baenninger, 1996; Provine and Hamernik, 1986). Amount of prior sleep is also known to affect energy levels, with tiredness associated with relatively little prior sleep. Relative amounts of sleep can be measured by comparing prior sleep with average sleep. It is predicted that yawning will be correlated with subjects' reporting of having received relatively little sleep the night before their participation in this study and with subjects' reporting of relatively higher levels of tiredness before and during participation in this study.

## Psychological and Social Influence

Though yawning has been correlated with changes in activity and identified as a displacement activity in primates (including humans), it is clear that, in humans, yawning can also be triggered by observing yawns or yawn-related stimuli. Previous studies have used self-reporting of yawns by subjects as a method for obtaining data on the frequency of yawns elicited as a result of observing yawns (Provine, 1986). However, this method for measuring yawns is confounded by the fact that thinking about yawns has been demonstrated to affect the triggering of yawns (Provine, 1986, Provine and Hamernik, 1986). In Provine's (1986) study, subjects may likely have been influenced by the experiment briefing that described the objective of the study, which was "to measure yawning frequency in subjects" (Provine, 2001, personal communication). Though designed as a study of yawning contagion, as provoked by visually observed yawning stimuli, the results obtained were confounded by the thought of yawning, first by its mention in the briefing preceding the experiment, and secondly through the self-reporting design of the study.

This thesis predicts that in a study of yawning contagion provoked by visually observed yawns, objectively measured yawns will be lower in frequency than self-reported yawns. Furthermore, a study similar in design to Provine's (1986) but that makes absolutely no mention of "yawning" or "contagious behavior" to subjects is expected on average, to elicit significantly less yawns in response to visually observed stimuli than would a similar study that was preceded by mention of these words.

This study is largely based on the hypothesis that contagious yawning is an adaptation that has been selected for because it is a "costly signal," as defined by Parker (1974) and Zahavi and Zahavi (1997). Yawning serves as a display of canines, which are associated with threat gestures and whose size is correlated with dominance in many primate species (Deputte, 1978). Displaying canines in the presence of a dominant individual could be quite costly to a subordinate individual, at most provoking an attack and at the very least revealing the subordinate's lesser physical formidability. Therefore, this study predicts that subordinate individuals will initiate yawns in the presence of dominant individuals less often than dominants will initiate yawns in the presence of subordinates. Likewise, subordinate yawners should be more likely than dominant yawners, on average, to elicit yawns from conspecifics.

Yawning also signals a transition from activity to inactivity (in humans: Baenninger et al., 1996; in rats: Anias et al.) or inactivity to activity (Baenninger et al., 1996; Anias et al.). It has been hypothesized that yawning is associated with change in activity because yawns serve to cleanse the brain of residual cerebrospinal fluid and neurotransmitters (Nolman, 2000). An individual may convey its vulnerability by signaling a transition to inactivity and inattentiveness. Once again, it could be quite costly for a subdominant individual to signal such a transition in the company of dominant conspecifics. Signaling one's transition to a restful state may indicate one's vulnerability (while asleep, for instance). Conversely, only dominant individuals are likely to be able to "afford" the cost of signaling their transition to a restful, more vulnerable state, while others are still active. Yawning has been identified in association with stretching, maintenance, and displacement activities in humans. It is a common practice of yawning people to cover their mouths while yawning and touch their heads at a greater frequency than non-yawners. It is therefore predicted that yawning subjects in this study will display high frequencies of displacement and maintenance activities near their heads. It is also predicted that of those subjects yawning, individuals ranking themselves as more dominant than the actor shown in the stimulus video will be less likely to yawn with their mouths covered.

Whereas yawning behavior in primates is costly among species where males have larger canines because it may signal motivational conflict, anxiety, relative dominance status, and/or change in activity, yawning behavior in humans is hypothesized to be a costly signal because -in combination with body posture and gaze- it signals change in activity, anxiety, and disinterest in stimulus. Primates often display costly signals and yawns at a higher frequency among males than females (Hall, 1962; Redican, 1975; Zucker et al., 1998), with high-frequency yawning males having the largest canines. Humans display yawns at equal frequency among males than females and exhibit little or no sexual dimorphism in canine size. It is frequently suggested in academia, especially by feminists, that when patriarchal ideology is abolished, relative dominance status in humans is independent of sex. It is predicted that yawning in humans is correlated with dominance but not sex, because while there is no significant difference in yawn frequency between men and women, dominant individuals yawn more than submissive individuals. Contagious yawning frequency in humans is hypothesized to be correlated with the relative cost of yawn behaviors and social dynamics between yawner and respondent. Thus, factors that signal dominance, dominance perceptions, and interpersonal relationships may all affect frequencies of yawns elicited by subjects when observing yawn stimuli in a controlled setting.

Among non-human primates, high-ranking individuals tend to yawn more than lower-ranking individuals (in black apes: Hadidian, 1980; in long tailed macaques: Troisi et al., 1990; in chimpanzees Boekhorst et al., 1991; in patas monkeys: Zucker et al., 1998, in bonnet macaques: Simonds, 2001 personal communication). It is hypothesized that dominance rank affects yawning in primates because of both androgen levels and costly signaling. It is unclear from previous studies whether dominance perceptions have had any effect on contagious yawning. This study predicts that dominance manipulation in a controlled experiment testing for contagious yawning will result in a significant correlation between difference in observer-target relative dominance and frequency of yawns in observer, such that higher frequencies of contagious yawning will be correlated with relatively little difference in subjects' perceptions of dominance in self and perceptions of dominance in actor. Because yawning does not reveal canine sexual dimorphism, it is not considered an overt threat in humans, although it may have been so in our hominid history. The relative cost of yawning in humans is associated with the information it reveals concerning physiological and motivational states as well as its interpretation by many people as an insult or disrespectful behavior. When two individuals are of equivalent dominance status there is minimal anxiety or stress producing stimulus. Thus, between two individuals of equivalent dominance status, contagious yawning would be expected to not be the result of intimidation behavior, but would be associated with the relative lack of social, physical, and cognitive stimulus that has been correlated with yawning in humans (Baenninger, 1987; Baenninger and Baenninger; 1996). It is predicted that larger differences in perceived dominance status between self and actor will be associated with a stress response and an increase in social, physical, and cognitive stimulation, and thus represented by lower frequencies of contagious yawning in this study. Though this appears to contradict data on animal yawning that shows yawning increases with social stress, this is in accord with the reviewed data that human yawning decreases with social stress. Human yawning, which might be more capable of signaling an insult than a threat, is seen as a more costly behavior between individuals of different dominance status than between individuals of equivalent dominance status. Though it has not been tested, it appears that among humans, verbal insults are more affective (i.e. insulting) between individuals of different dominance status than among individuals of equivalent dominance status. This study predicts that cases where subjects perceive themselves as being of lower status than the actor will be associated with a stress response in subjects, and an increase in social, physical, and cognitive stimulation, and thus represented by lower frequencies of contagious yawning in this study.

Several variables of appearance (see below) that have been proven to have significant effects on the perception of dominance will be manipulated in this study. It has been demonstrated that human faces are reliably judged by raters to look dominant or submissive, with remarkable agreement across cultures (Keating et al., 1981). Variables shown to have significant effect on the perception of dominance include; direction of gaze (Exline, 1972; Strongman and Champness, 1972), confidence of gestures (Daily and Wilson, 1983), position and cant of head (Key, 1975; Daly and Wilson, 1983), position of eyebrows (Keating, 1977; Senior et al., 1999), type of smiling or facial gesture (Dabbs, 2000; Exline, 1972; Senior et al., 1999), and position or posture of body (Morris, 1977; Ginsburg, Pollman, and Wauson, 1977). Seven-point Likert scales will be included in the questionnaire for the purpose of evaluating the effectiveness of manipulated variables previously demonstrated to affect the overall perception of dominance. Subjects will rate the actor in the videos, and then later themselves, on the following adjective pairs: "subordinate—dominant," "humble—proud," "passive—assertive," "insecure—self-confident," "insignificant—important," and "likely to follow the initiative of others—likely to initiate action" (see Appendices A and B). The above system of rating perception of dominance was derived from theoretical developments stemming from several published studies (Speigel and Machotka, 1974; Wiggins, 1979; Moskowitz, 1990; Keating 1981; Mazur et al., 1994; and Dabbs, 2000). It has been demonstrated that the above system of self-report measures and measures of perceived dominance in others has had high convergence (Moskowitz, 1990), so that it should be possible to later assess correlations between subjects' dominance and actors' dominance from experimental data. In this study's experimental manipulation of dominance perception, consistent biases in the perception of dominance, as reported by previous studies (Ellyson and Dovidio, 1983; Porter and Geiss, 1981; Schwartz, Tesser, and Powell, 1982; and Halberstadt and Saitta, 1987), are expected: that males are rated as significantly more dominant than females, regardless of their nonverbal behaviors, and female raters perceive others as more dominant than male raters. By controlling for gender of both subjects and actors, as well as type of video, and performing an analysis of covariants, the degree of the above biases can be statistically determined and assessed for significance.

It has been suggested that yawning and contagious yawning behavior may be greatly affected by inhibitions specific to subjects' psychologies (Provine, 2001 personal communication). It was thus predicted that an obvious presence of video-taping equipment would result in increased inhibitions among some subjects, while a more covert and less-obtrusive presence of such equipment would result in significantly less inhibitions. In general, physical, social, and cognitive stimulation (not associated with yawning) appear to inhibit yawning behavior in humans (Baenninger, 1987; Baenninger and Baenninger; 1996).

Of greatest curiosity to this study are the possible inhibitory effects of various social dynamics and perceptions on yawning contagion in the laboratory. Provine's (1986) study used mostly college freshman whose averaged 19.1 years of age, and measured their responses in yawns to a yawning 41-year-old male actor (who happened to be Provine himself). As the releaser of yawns was old enough to be the father of most of the subjects and thus of potentially higher dominance status (as correlated with age), it is suggested that the difference in relative dominance status between target and subjects affected the results of the study. Subjects' perceptions of differences in dominance status between self and target are predicted to be larger intra-generationally than inter-generationally, thus affecting the social dynamics predicted to affect yawning contagion. Differences in dominance status are likely to lead to increased social and cognitive stimulation. Because, unlike non-human primates, humans yawn more frequently in the relative absence of such stimulation, intra-generational yawning stimulus is predicted to elicit more yawns than inter-generational yawning stimulus. In an attempt to test for differences between inter-generational and intra-generational yawning contagion, this study chose to use an intra-generational design: videotaped targets were 22 and 23 years of age, and subject averaged 19- 25 years of age. In the interest of conducting a comparative study of inter-generational and intra-generational visually observed stimuli with relation to yawn frequency, the author and principal investigator of this study contacted Provine, asking permission to view and use the video-tape stimulus from his 1986 study for both replicative and comparative purposes. Permission was denied, lending doubt to the credence of scientific integrity in studies carried out by the most prolific researcher on yawning and contagious behavior in humans.

Another possible social dynamic that may affect studies of yawning contagion may be found between the sexes. As has been mentioned the yawning stimulus in Provine's 1986 study was himself. This study uses both male and female stimuli. Costly signaling theory hypothesizes that for signals that are true signs of fitness, individuals who are more able to "afford" production of the signal (in this case dominant individuals) are more likely to initiate the display of costly signals than those for whom the marginal cost of display is higher (in this case subordinate individuals). Costly signals should therefore be honest displays seen in dominant sexual competitors and absent in submissive sexual competitors (Zahavi and Zahavi, 1997). It is essential to ask whether humans qualify as sexual competitors who use costly signals. According to "male show-off" theory and costly signaling theory (Dabbs, 2000; Miller, 2000; Bird, Smith, and Bird, 2000), costly signaling behavior has been reported in human males potentially competing for sexual access to choosy females. Because males display risky behavior (resulting in stress responses) to compete against other males for the favor of females, but females are not reported as exhibiting equally high frequencies of such costly displays, it is expected that females would experience less cognitive, physical, and social stimulation as a result of a stress response provoked by observing potential sexual competitors. Based on the hypothesis that yawns are costly signals, and the observation that humans yawn more frequently in the relative absence of cognitive, physical, and social stimuli, it is predicted that, on average, contagious yawning in males will be more frequent when evoked by a female (as opposed to a male) yawner. Conversely contagious yawning in females will be as frequent when evoked by a yawning male as when evoked by a yawning female.  It is expected that the difference between male and female subjects' yawns will be such that female subjects' yawns will be more closely associated with same-sex evoked yawns than male subjects' yawning will be. The higher frequency of yawns predicted to be provoked by same-sex "yawn contagion" for females may be explained by a greater within-group sex competition for males than for females.

# CHAPTER IV

# “WHY IS YAWNING CONTAGIOUS?”

## Study Description

### Introduction

This study investigates why and under what circumstances human observation of conspecifics’ yawns elicits yawns from the observer. Little is known about the variables that affect contagious yawning. This study predicts that dominance, sex, and circulating testosterone concentration all affect the frequency of yawns evoked under controlled circumstances previously demonstrated to have elicited contagious yawning. The experiment sampled saliva from subjects (for later determining salivary testosterone concentration), asked subjects to watch a short video where they either saw one of two actors yawning repeatedly (in either a dominant or submissive pose) or a simple colored bar pattern, and asked subjects to fill out a short questionnaire. While the subjects watched the short video they were videotaped for the purpose of collecting data on possible yawning behavior. The questionnaire data was used to assess the possibility of confounding variables, as well as to assess the effectiveness of manipulated factors believed to affect dominance characteristics.

The study was conducted in the Hill Center Lobby (Straub Hall) and adjacent rooms (177 and 178 Straub). Yawning stimuli were presented without audio in room 178, a sound-attenuated room. This study employed advanced video-surveillance equipment to observe yawns elicited by subjects in order to avoid the confounding variable of having subjects consciously preoccupied with their yawning frequency. Though subjects gave consent to having themselves videotaped throughout the experiment, the videocameras were hidden within ceiling-mounted tinted plastic domes, approximately 1 foot in diameter, located outside of the subjects' direct field of vision (when facing the stimulus as instructed). When needed, the focus and angle of the video cameras was controlled from remote locations, so as not to draw attention to the equipment or data-collection process.

The study was conducted by the Principal Investigator, Eric Schniter, with the help of two researcher assistants, Jessica Brower and Ida Madsen. A team of independent raters was used for stimulus development.

## Stimulus Development

In order to manipulate effects of dominance and sex, two actors were used: one male and one female ages 23 and 22, respectively. Each actor was instructed on how to manipulate their appearance to appear dominant and submissive, as described in the literature (see below).. Actors were asked to think about yawning and produce "authentic yawns" while adopting dominant and submissive facial and body positions. Each actor produced a series of real yawns in each of two contrived and controlled positions. The series of recorded yawns were viewed twice by a team of five independent raters, who then ranked the yawns and respective dominance-appearance manipulations on a scale of

1-10, indicating the degree to which the yawns appeared stereotypical and authentic. The best ranking yawn stimuli were selected after being scored by the team of independent raters, for each of the four categories of yawn stimuli: dominant female, dominant male, submissive female, submissive male.

## Dominant Yawn Stimulus

The male and female actors were instructed in how to carry themselves with dominant facial expression and body posture and videotaped emitting yawns from this positions. The dominant stimulus videos feature the actor shown seated in a chair, leaning back confidently. The actor's shoulders are drawn back, not hunched forward. The chin is up, so as not to give the impression of a head bowed forward. The head is not canted, such that the line drawn from the center of the forehead down the nose to the chin is perpendicular with the shoulders. The actor's gaze is directly into the camera, not looking away. The actor is not smiling. The actor has lowered eyebrows, not raised eyebrows, nor eyebrows in the normal position. The eyebrows were not be lowered to their maximum potential, however, so as not to exaggerate the lowering of the eyebrows.

The actor is shown from the shoulders to the top of the head, filling the video frame. During the 300 seconds of each dominant video, the actor yawns 15 times, once every 20 seconds for an approximate duration of 4 seconds. After 300 seconds the video scrolls an announcement from bottom up reading, "This video is now over."

## Submissive Yawn Stimulus

The male and female actors were instructed in how to carry themselves with submissive facial expression and body posture and videotaped emitting yawns from these positions. The submissive stimulus videos feature the actor seated in a chair, sitting slightly forward and not confidently. The actor's shoulders are hunched forward, not drawn back. The chin is down, with the head bowed slightly forward, and body posture is slumped or hunched. The head is canted, such that the line drawn from the center of the forehead down the nose to the chin is not perpendicular with the shoulders, but rather forms an obtuse angle of approximately 40 degrees. The actors gaze is away from the camera, not achieving direct eye contact. The actor smiles gently such that there is noticeable zygomatic major activity (movement of the corners of the mouth upward and outward) but little orbicularis oculi activity (raised upper cheeks, producing crinkling around the outer corner of the eyes). The actor has raised eyebrows, not lowered eyebrows, nor eyebrows in the normal position. Eyebrows were not raised to their maximum potential, however, so as to not exaggerate the raising of the eyebrows.

The actor is shown from the shoulders to the top of the head, filling the video frame. During the 300 seconds of each submissive video the actor yawns 15 times, once every 20 seconds for an approximate duration of 4 seconds. After 300 seconds, the video scrolls an announcement from bottom up reading, “This video is now over.”

## Null Yawn Stimulus

The null yawn stimulus video shows a constant multi-colored test-bar pattern for a duration of 300 seconds. The test bar pattern resembles those traditionally used by television stations after they go off the air.

## Description of Subject Population

The subject population used in this study was not restricted by age, gender, or ethnicity, and was comprised mostly of male and female students at the University of Oregon who volunteered to participate. Subjects were recruited from “Paid Experiments” postings at the Department of Psychology and from Department of Anthropology undergraduate classes. Students in these pools typically range from 18 to 30 years of age and are of mixed gender and ethnicity; no vulnerable populations were used. A total of 110 subjects participated in the study over the course of three months. All subjects (as defined by criteria below) were accepted and assured that their participation was voluntary as explained by the recruitment flyer and consent forms (see Appendices C, D, and E). Subjects received a payment of $5.00 for their volunteered time of one half-hour and were given the opportunity to learn more about yawning behavior and scientific inquiry during the debriefing portion of the experiment.

# Methodology

## Activities Involving Subjects

Subjects were greeted by the principal investigator in the Hill Center Lobby of Straub Hall. Consent forms (see Appendices D and E) were read and offered to the subjects, briefing them on the nature and purpose of the experiment for which they were volunteering. Those who gave informed consent by signature then rinsed their mouths and chewed gum for one minute.  After chewing gum, the gum was removed and subjects were asked to "collect" a bit of saliva in their mouths. A standard amount of approximately 0.5 ml. of saliva was drooled or spit into a 1.2 milliliter test tube such that it filled about half way. The tube was immediately sealed, coded, and dated. The investigator transferred all tubes to a cold storage receptacle. Next, subjects were escorted to room 178, where the television set and video-surveillance system were located. The television set was approximately 50 centimeters in diagonal width and located approximately 1 meter from the seat where subjects were asked to sit. Subjects were shown to the seat facing the television set and asked to sit down and wait for the video to begin. After activating the video, the investigator left the room, closed the door, entered the control room (room 177), and began monitoring and videotaping the subject. Each subject was shown one of five stimulus videos Twenty subjects watched the dominant female stimulus video, 20 subjects watched the dominant male stimulus video, 20 subjects watched the submissive female video, 20 subjects watched the submissive male video, and 30 subjects watched the control video (test-bar pattern). No subject was allowed to see more than one video or participate more than once. This independent-subject design provides for a more robust analysis of various yawning stimuli than would a repeat-subjects design.

Following the showing of the video, subjects were asked to fill out a short questionnaire (see Appendices A and B). Subjects were then compensated with a payment of $5, debriefed as to the purpose of the experimental design, and allowed to ask questions. An approved experiment protocol prepared for the Committee for the Protection of Human Subjects was at hand and also available for further information.

The whole experiment took, on average, 25 minutes: 10+ minutes were allotted for greeting, briefing, receiving informed consent, and producing a saliva sample; 6 minutes were allotted for yawning stimulus, video taping, and observation; 5+ minutes were allotted for the questionnaire; and up to10 minutes were allotted for debriefing.

## Method of Data Collection

### Saliva Sample

A minimum of only 0.25 ml. of saliva per test is needed to provide a sample for reliable assay of relative testosterone levels. Subjects were given gum to chew for one minute and asked to spit or drool into a test tube. Saliva samples were immediately sealed, coded, and dated before being transferred by the Principal Investigator to a cold storage device. The time at which the samples were taken was recorded. This study has attempted to standardize and restrict the time of day during which the experiments took place, so as to control for diurnal variation in salivary testosterone.

## Videotaping and Observation

During the time subjects watched the five-minute video tape and in the seconds following, while they waited for the Principal Investigator to return with a questionnaire, subjects were monitored and videotaped by an in-house surveillance system. Videotapes were assigned code numbers corresponding to subjects, times, and dates. As many as three raters (Principal Investigator and two Assistant Researchers) recorded the number of yawns elicited by subjects over the course of five and a half minutes; 48 of 110 subjects were rated by more than one rater in a completely independent manner (at separate times and not in each other's company); the other 62 subjects were rated by researchers simultaneously. Inter-rater reliability of the number of yawns expressed was calculated and found to be high (48/48 identical independent codings) for both complete and incomplete yawns. "Complete yawn" and "incomplete yawn" count for each subject was based on fully and incompletely expressed yawns, respectively, as defined by Provine's (1986, 1987) description of yawns as a reliable and consistent "stereotyped action pattern." Behaviors that did not meet all the qualifications for a complete yawn but that demonstrated many, but not all, of its components, qualified as incomplete yawns. In the few instances when raters did not agree, yawn counts were scored as the average of the three raters' counts of yawn frequency for each subject. In addition to yawning, displacement and maintenance activities seen near the head, including rubbing eyes, scratching face, scratching neck, scratching scalp, and touching hair were coded for during the five and a half minute observation of yawning subjects. The covering of the gaping mouth component of a yawn by subjects' hand(s) was also coded for separately.

### Questionnaire

Subject's questionnaires were assigned a code number corresponding to the saliva sample and entered into a database for statistical analysis. Questionnaires (see Appendices A and B) included questions concerning date, age, sex, ethnicity, sexual preference, use of medication, contents and time of last meal, prior sleep, average sleep, desire to yawn during experiment, self report of yawning during experiment, self report of tiredness before and during experiment, self assessment of dominance, excitement or lack there of caused by viewing video, and assessment of actor dominance (based on appearance in video). No subjects' names were recorded nor can subjects' names be linked to code numbers. Coding was used to distinguish data from videotapes, saliva samples, and questionnaires.

## Data Disposition

High-8 digital videotape was used for visual recording of original yawn stimuli and transferred digitally to computer for editing. Edited yawn stimuli were transferred to VHS for experimental playback. VHS was used for recording of video surveillance of subjects exposed to yawn stimuli. Freezer-safe antiseptic polystyrene test tubes were used for collecting saliva samples. Questionnaires for recording responses were printed and filled out by hand (in pen). Data from the above three sources has been entered into a database and analyzed using an SPSS statistics package. All data has been kept in the security and sole access of the Principle Investigator and will be kept for possible future analysis. Subject videotapes will not be shown publicly, and the saliva samples will be disposed of following analysis.

# CHAPTER V

# RESULTS

## Introduction

Of 110 subjects, of which seventy-four (67.3%) were female and 36 (32.7%) male, 20 were exposed to each of the four stimulus videos depicting a yawning human actor while 30 subjects were exposed to the colored test-bar control video.

Subjects' complete yawns, incomplete yawns, and yawn related activities were coded by researchers. Inter-coder reliability for complete and incomplete yawn frequencies shows high accord (100% or 48/48 independent-codings identical). Inter-coder reliability for complete and incomplete yawn duration also shows high accord (96% or 48/50 independent-codings identical) with insignificant error ($p<0.05$); the two sets of non-identical scores have a difference of 1 second, suggesting raters were coding the same yawns with a high degree of accuracy.

The average duration of complete yawns observed in this study is 5.2879 seconds, with the longest complete yawn 17 seconds and the shortest 2 seconds (std. dev. 2.53447, variance 6.424). The range of 15 seconds for yawn duration in this study is significantly greater than the 5.5 second range reported in Provine's (1986) study of yawn duration among 37 subjects, and is of importance because it demonstrates that human yawns, though stereotyped, show a variety of intensity levels ranging from small quick yawns (showing all the signs of long inspiration, drop in larynx, gaping of mouth, and short expiration but no vigorous or extraneous stretching) to vigorous slower yawns (including the stretching of muscles throughout the body and long durations). Of those subjects who yawned, average frequency of complete yawns was 4.25 yawns/person (range of 12, std. dev. 3.99166, and variance 15.933), average frequency of incomplete yawns was 1.5 yawns/person (range 3), and the combined measure of yawn frequency was 5.75 yawns/person (range 13). For all subjects the average combined measure of (complete and incomplete) yawns was 0.8818 yawns/person (range 14, std. dev. 2.50039, variance 6.252).

## Study Effects

### Effects of Stimulus vs. Control Condition

In contrast to Provine's (1986) study in which 23 of 42 human subjects (55%) self-reported yawning in response to watching 5 minute videos of a conspecific yawning, only 15 of 80 subjects (18.75%) exposed to 5 minutes of videotaped yawns in this study emitted complete yawns in response. Nevertheless, only one of thirty subjects in this study emitted complete yawns in response to the control condition. Thus, as predicted, significantly fewer subjects emitted complete yawns in response to the control condition than to videotapes of conspecifics yawning (Fisher's one tailed $\chi^2$=4.172; df=1; *p*=.032). Further, while overall the average number of complete yawns emitted by subjects in response to control and stimulus conditions does not significantly differ (*F*=3.229; df=1; *p*=.075), when only subjects who yawned are considered, those exposed to conspecifics yawning emitted significantly more complete yawns than subjects who yawned in the control conditions (*F,*(1,108) = 4.258, $p<.05$). Similar results are seen when a combined measure of both incomplete and complete yawns is considered. 2 of 30 subjects in the control condition and 18 of 80 in the stimulus conditions emitted either complete or incomplete yawns (Fishers one tailed $\chi^2$=3.677; df=1; $p$=.044). Combined measure of complete and incomplete yawns shows that average number emitted per subject was also significantly higher in the stimulus vs. control conditions ($F$=4.149; 1,108; $p$=.044).

## Differences in Yawns Elicited Across Experimental Yawn Conditions

This study predicted that overall, dominant individuals would elicit less contagious yawning than submissive individuals, such that higher frequencies of contagious yawning were predicted in response to actors in the submissive vs. dominant condition. Analysis of variance indicates that this is not the case (Table 2). There is no significant difference between average total number of yawns (complete and incomplete) elicited in response to dominant vs. submissive videos ($F$=1.290, $p$=0.28). Sex of the target actor in the video cannot account for this ($F$=1.929, $p$=0.168), and there is no sex of actor by dominance condition interaction ($F$=0.316, $p$=0.730).

TABLE 2. Multivariate Analysis of Variance for the Combined Measure of (Complete and Incomplete) Yawns by Target Dominance Condition, Sex of target, and Target Dominance Condition by Sex of Target

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Target Dominance Condition | 15.775 | 2 | 7.887 | 1.290 | .280 |
| Sex of Target | 11.793 | 1 | 11.793 | 1.929 | .168 |
| Target Dominance Condition * Sex of Target | 3.865 | 2 | 1.932 | .316 | .730 |

Taking account only of complete yawns does not change this conclusion (Table 3).

TABLE 3. Multivariate Analysis of Variance for Only Complete Yawns by Target Dominance Condition, Sex of Target, And Target Dominance Condition by Sex of Target

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Target Dominance Condition | 12.137 | 2 | 6.069 | .316 | .735 |
| Sex of Target | 2.209E-03 | 1 | 2.209E-03 | .000 | .992 |
| Target Dominance Condition * Sex of Target | 10.518 | 1 | 10.518 | .548 | .475 |

## Verification of Video Dominance Manipulation

Six factors associated with dominance in the literature were used to assay subjects' perceptions of the dominance of the four yawn stimulus video conditions on a seven-point Likert scale: dominant, proud, assertive, self confident, important, initiative of action. In addition, an overall (averaged) measure of dominance was computed as a composite of these scores. Yawn stimulus video conditions were: submissive male, submissive female, dominant male, and dominant female. As expected, subjects rated actors in the dominant conditions higher on average than in the submissive conditions on variables associated with dominance. This difference is significant for the dominance (*F*=4.513 (1,78); *p*=.044) and assertive ratings (*F*=7.813 (1,78); *p*=.032) but not significantly so for all other measures [proud (*F*=1.9 53, *p*=0.240); confident (*F*=1.8, *p*=0.253); important (*F*=0.613, *p*=0.538); initiative (*F*=3.403, *p*=0.184); averaged dominance *(F*=2.939, *p*=.077)]. The same actors were used in both dominant and submissive conditions with all variables controlled except postural cues of dominance, thus reducing the degree to which visual cues of dominance could be manipulated and increasing the degree to which they could be controlled. As expected averaged dominance scores were grouped around the central score of 4 on a scale from one to seven, with 14/80 (17.5%) scoring exactly 4 (neither dominant nor submissive). Nevertheless, the experimental manipulation of dominance appears to have been at least partially successful. In addition to the significant effects on the individual dominance and assertiveness ratings, subjects' composite scores show effects in intended directions: dominant male and female targets were scored higher than 4 on average, and submissive male and female targets were scored lower than 4 on average. Analysis of variance in composite dominance scores shows this difference approaching significance (*F*=(1,78) 3.207, *p*=0.07). Table 4 presents summary statistics for these values. Testosterone analysis is still pending.

TABLE 4: Actor-Dominance Ratings by Target Dominance Condition

| Source | Dependent Variable: Actor-Dominance | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Dominance Condition | Dominant [a] | 4.513a | 1 | 4.513 | 4.191 | .044 |
| | Proud [b] | 1.953b | 1 | 1.953 | 1.401 | .240 |
| | Assertive [c] | 7.813c | 1 | 7.813 | 4.772 | .032 |
| | Confident [d] | 1.800d | 1 | 1.800 | 1.326 | .253 |
| | Important [e] | .613e | 1 | .613 | .384 | .538 |
| | Takes Initiative [f] | 3.403f | 1 | 3.403 | 1.797 | .184 |
| | Ave. Dominance [g] | 2.939g | 1 | 2.939 | 3.207 | .077 |

a R Squared = .051 (Adjusted R Squared = .039)
b R Squared = .018 (Adjusted R Squared = .005)
c R Squared = .058 (Adjusted R Squared = .046)
d R Squared = .017 (Adjusted R Squared = .004)
e R Squared = .005 (Adjusted R Squared = -.008)
f R Squared = .023 (Adjusted R Squared = .010)
g R Squared = .039 (Adjusted R Squared = .027)

When comparisons are made across all the four video stimulus experimental conditions, ratings of factors associated with dominance do not significantly differ between them (Table 5). Similarly, no overall effects of sex of target, or interaction effect of sex of target by dominance condition of target are found for any of the ratings of dominance (Table 6). Thus dominance manipulation is shown to be effective by at least two central measures of dominance, and manipulated cues of dominance appear to be more powerful than sex of target as cues to dominance.

TABLE 5: Effect of Video Condition on Ratings of Actor-Dominance Related Measures

| Source | Dependent Variable | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Video Condition | Dominant [a] | 6.038a | 3 | 2.012 | 1.855 | .144 |
| | Proud [b] | 8.109b | 3 | 2.703 | 2.002 | .121 |
| | Assertive [c] | 8.875c | 3 | 2.958 | 1.776 | .159 |
| | Confident [d] | 4.712d | 3 | 1.571 | 1.159 | .331 |
| | Important [e] | 3.437e | 3 | 1.146 | .715 | .546 |
| | Takes Initiative [f] | 4.159f | 3 | 1.386 | .717 | .545 |
| | Ave. Dominance [g] | 3.973g | 3 | 1.324 | 1.429 | .241 |

a R Squared = .068 (Adjusted R Squared = .031)
b R Squared = .073 (Adjusted R Squared = .037)
c R Squared = .065 (Adjusted R Squared = .029)
d R Squared = .044 (Adjusted R Squared = .006)
e R Squared = .027 (Adjusted R Squared = -.011)
f R Squared = .028 (Adjusted R Squared = -.011)
g R Squared = .053 (Adjusted R Squared = .016)

TABLE 6. Multivariate Analysis of Variance for Reports of Actor-Dominance by Sex of Target, Dominance Condition of Target, and Sex of Target by Dominance Condition of Target

| Source | Dependent Variable | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Sex of Target | Dominant [a] | 1.250E-02 | 1 | 1.250E-02 | .012 | .915 |
| | Proud [b] | .903 | 1 | .903 | .669 | .416 |
| | Assertive [c] | 5.000E-02 | 1 | 5.000E-02 | .030 | .863 |
| | Confident [d] | 2.112 | 1 | 2.112 | 1.559 | .216 |
| | Important [e] | 2.812 | 1 | 2.812 | 1.756 | .189 |
| | Takes Initiative [f] | .378 | 1 | .378 | .196 | .660 |
| | Ave.Dominance [g] | 5.868E-02 | 1 | 5.868E-02 | .063 | .802 |
| Dominance Condition | Dominant [a] | 4.513 | 1 | 4.513 | 4.159 | .045 |
| | Proud [b] | 1.953 | 1 | 1.953 | 1.447 | .233 |
| | Assertive [c] | 7.813 | 1 | 7.813 | 4.689 | .033 |
| | Confident [d] | 1.800 | 1 | 1.800 | 1.328 | .253 |
| | Important [e] | .613 | 1 | .613 | .382 | .538 |
| | Takes Initiative [f] | 3.403 | 1 | 3.403 | 1.760 | .189 |
| | Ave.Dominance [g] | 2.939 | 1 | 2.939 | 3.171 | .079 |
| Sex of Target * Dominance Condition | Dominant [a] | 1.513 | 1 | 1.513 | 1.394 | .241 |
| | Proud [b] | 5.253 | 1 | 5.253 | 3.891 | .052 |
| | Assertive [c] | 1.013 | 1 | 1.013 | .608 | .438 |
| | Confident [d] | .800 | 1 | .800 | .590 | .445 |
| | Important [e] | 1.250E-02 | 1 | 1.250E-02 | .008 | .930 |
| | Takes Initiative [f] | .378 | 1 | .378 | .196 | .660 |
| | Ave.Dominance [g] | .975 | 1 | .975 | 1.052 | .308 |

a R Squared = .068 (Adjusted R Squared = .031)
b R Squared = .073 (Adjusted R Squared = .037)
c R Squared = .065 (Adjusted R Squared = .029)
d R Squared = .044 (Adjusted R Squared = .006)
e R Squared = .027 (Adjusted R Squared = -.011)
f R Squared = .028 (Adjusted R Squared = -.011)
g R Squared = .053 (Adjusted R Squared = .016)

## Effects of Dominance Perceptions

### Subject Self-Reports of Dominance

### Reports of Self-Dominance and Actor-Dominance

Six factors associated with dominance in the literature were used to assay subjects' self-perceptions of dominance. Subjects rated their own dominance, pride, assertiveness, self confidence, importance, and likelihood of initiating action on a seven-point Likert scale. An overall (averaged) measure of dominance was computed as a composite of these scores. These measures are used to assess effects of own dominance on ratings of dominance of targets and on measures of yawning. Table 7 provides overall descriptive statistics for ratings of self-dominance associated factors by sex of subject.

TABLE 7: Descriptive Statistics for Ratings of Self-Dominance by Sex of Subject

| Subj. Sex | Ratings of Self | N | Minimum | Maximum | Mean | Std. Deviation | Variance |
|---|---|---|---|---|---|---|---|
| Female | Dominant | 74 | 2 | 7 | 4.48 | 1.127 | 1.270 |
| | Proud | 74 | 1 | 7 | 3.97 | 1.208 | 1.458 |
| | Assertive | 74 | 1 | 7 | 4.53 | 1.437 | 2.064 |
| | Confident | 74 | 1 | 7 | 4.67 | 1.335 | 1.783 |
| | Important | 74 | 1 | 7 | 5.27 | 1.234 | 1.522 |
| | Takes Initiative | 74 | 2 | 7 | 4.86 | 1.315 | 1.730 |
| | Average Dominance | 74 | 2.67 | 6.67 | 4.6306 | .84951 | .722 |
| Male | Dominant | 36 | 3 | 6 | 4.85 | .800 | .640 |
| | Proud | 36 | 2 | 6 | 4.26 | 1.105 | 1.221 |
| | Assertive | 36 | 1 | 7 | 4.50 | 1.498 | 2.243 |
| | Confident | 36 | 1 | 7 | 4.94 | 1.580 | 2.497 |
| | Important | 36 | 2 | 7 | 5.10 | 1.281 | 1.640 |
| | Takes Initiative | 36 | 2 | 7 | 4.99 | 1.251 | 1.564 |
| | Average Dominance | 36 | 2.50 | 6.25 | 4.7731 | .94041 | .884 |

Comparisons of self-dominance rated characteristics across experimental conditions reveal no significant differences, indicating that the experimental condition did not affect rating of self-dominance for any of the dominance related variables (Table 8). A multivariate analysis of variance for reports of self-dominance finds no significant effects of sex of target, dominance condition of target, or sex of target by dominance condition of target (Table 9). Thus there is no significant effect of sex (target and/or subject) on self-dominance rating overall.

TABLE 8. Comparison of Average Self-Dominance Ratings by Experimental Condition

| Source | Dependent Variable: Self -Dominance | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Exp.Condition | Dominant [a] | 4.421 | 4 | 1.105 | 1.018 | .402 |
| | Proud [b] | 2.972 | 4 | .743 | .526 | .717 |
| | Assertive [c] | 16.293 | 4 | 4.073 | 2.009 | .099 |
| | Confident [d] | 2.649 | 4 | .662 | .321 | .863 |
| | Important [e] | 12.425 | 4 | 3.106 | 2.080 | .089 |
| | Takes Initiative [f] | 3.338 | 4 | .834 | .492 | .742 |
| | Ave.Dominance [g] | 3.194 | 4 | .798 | 1.036 | .392 |

a R Squared = .037 (Adjusted R Squared = .001)
b R Squared = .020 (Adjusted R Squared = -.018)
c R Squared = .071 (Adjusted R Squared = .036)
d R Squared = .012 (Adjusted R Squared = -.026)
e R Squared = .073 (Adjusted R Squared = .038)
f R Squared = .018 (Adjusted R Squared = -.019)
g R Squared = .038 (Adjusted R Squared = .001)

TABLE 9. Multivariate Analysis of Variance for Reports of Self-Dominance by Sex of Target, Dominance Condition of Target, and Sex of Target by Dominance Condition of Target

| Source | Dependent Variable: Self -Dominance | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Sex of Target | Dominant [a] | .528 | 1 | .528 | .487 | .487 |
| | Proud [b] | .112 | 1 | .112 | .080 | .778 |
| | Assertive [c] | 3.612 | 1 | 3.612 | 1.782 | .185 |
| | Confident [d] | .200 | 1 | .200 | .097 | .756 |
| | Important [e] | 1.653 | 1 | 1.653 | 1.107 | .295 |
| | Takes Initiative [f] | .378 | 1 | .378 | .223 | .638 |
| | Ave.Dominance [g] | .542 | 1 | .542 | .703 | .404 |
| Dom. of Target | Dominant [a] | .703 | 1 | .703 | .648 | .423 |
| | Proud [b] | 2.113 | 1 | 2.113 | 1.496 | .224 |
| | Assertive [c] | .200 | 1 | .200 | .099 | .754 |
| | Confident [d] | 2.113 | 1 | 2.113 | 1.024 | .314 |
| | Important [e] | 2.278 | 1 | 2.278 | 1.525 | .220 |
| | Takes Initiative [f] | .378 | 1 | .378 | .223 | .638 |
| | Ave.Dominance [g] | .719 | 1 | .719 | .933 | .336 |
| Sex of Target * Dom. of Target | Dominant [a] | 2.628 | 1 | 2.628 | 2.421 | .123 |
| | Proud [b] | .200 | 1 | .200 | .142 | .707 |
| | Assertive [c] | 1.013 | 1 | 1.013 | .499 | .481 |
| | Confident [d] | .313 | 1 | .313 | .151 | .698 |
| | Important [e] | 5.253 | 1 | 5.253 | 3.518 | .063 |
| | Takes Initiative [f] | 1.653 | 1 | 1.653 | .975 | .326 |
| | Ave.Dominance [g] | 1.445 | 1 | 1.445 | 1.874 | .174 |

[a] R Squared = .037 (Adjusted R Squared = .001)
[b] R Squared = .020 (Adjusted R Squared = -.018)
[c] R Squared = .071 (Adjusted R Squared = .036)
[d] R Squared = .012 (Adjusted R Squared = -.026)
[e] R Squared = .073 (Adjusted R Squared = .038)
[f] R Squared = .018 (Adjusted R Squared = -.019)
[g] R Squared = .038 (Adjusted R Squared = .001)

Table10 presents summary statistics for actor-dominance factor ratings by experimental condition. Analysis of variance for reports of actor-dominance finds no significant effects of sex of target or dominance condition of target (Table 11). Similarly, no significant interaction was found between these factors (Table 11).

TABLE 10. Summary Statistics on Actor-Dominance Ratings by Experimental Condition

| Exp. Condition | Rating | N | Minimum | Maximum | Mean | Std. Deviation | Variance |
|---|---|---|---|---|---|---|---|
| Dom. Female | Dominant | 20 | 2 | 7 | 3.88 | 1.213 | 1.470 |
| | Proud | 20 | 2 | 7 | 3.78 | 1.153 | 1.328 |
| | Assertive | 20 | 1 | 7 | 3.93 | 1.417 | 2.007 |
| | Confident | 20 | 2 | 7 | 4.32 | 1.340 | 1.797 |
| | Important | 20 | 2 | 7 | 4.60 | 1.353 | 1.832 |
| | Takes Initiative | 20 | 1.67 | 7.00 | 4.0708 | 1.18447 | 1.403 |
| Sub. Female | Dominant | 20 | 2 | 5 | 3.68 | .693 | .481 |
| | Proud | 20 | 2 | 6 | 3.98 | 1.057 | 1.118 |
| | Assertive | 20 | 1 | 5 | 3.53 | .939 | .881 |
| | Confident | 20 | 2 | 6 | 4.22 | 1.032 | 1.065 |
| | Important | 20 | 3 | 6 | 4.40 | .754 | .568 |
| | Takes Initiative | 20 | 2.17 | 4.83 | 3.9083 | .66166 | .438 |
| Dom. Male | Dominant | 20 | 1 | 6 | 4.13 | 1.122 | 1.260 |
| | Proud | 20 | 1 | 6 | 4.50 | 1.318 | 1.737 |
| | Assertive | 20 | 1 | 6 | 4.20 | 1.196 | 1.432 |
| | Confident | 20 | 1 | 6 | 4.85 | 1.268 | 1.608 |
| | Important | 20 | 1 | 6 | 4.20 | 1.399 | 1.958 |
| | Takes Initiative | 20 | 1.17 | 6.00 | 4.3458 | 1.06454 | 1.133 |
| Sub. Male | Dominant | 20 | 1 | 5 | 3.38 | 1.062 | 1.128 |
| | Proud | 20 | 2 | 6 | 3.68 | 1.104 | 1.218 |
| | Assertive | 20 | 1 | 6 | 3.35 | 1.531 | 2.345 |
| | Confident | 20 | 2 | 6 | 4.35 | .975 | .950 |
| | Important | 20 | 1 | 7 | 4.05 | 1.432 | 2.050 |
| | Takes Initiative | 20 | 1.67 | 5.00 | 3.7417 | .85622 | .733 |

TABLE 11. Two Way Analysis of Variance of Actor-Dominance Rating by Sex of Subject and Dominance Condition of Target

| Source | Dependent Variable: Actor -Dominance | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Dom. of Target | Dominant [a] | 2.005 | 1 | 2.005 | 1.681 | .200 |
| | Proud [b] | 1.612 | 1 | 1.612 | 1.064 | .307 |
| | Assertive [c] | 6.687 | 1 | 6.687 | 3.878 | .054 |
| | Confident [d] | .134 | 1 | .134 | .095 | .759 |
| | Important [e] | .370 | 1 | .370 | .199 | .657 |
| | Takes Initiative [f] | 2.477 | 1 | 2.477 | 1.303 | .258 |
| | Ave.Dominance [g] | 1.698 | 1 | 1.698 | 1.717 | .195 |
| Sex of Subject | Dominant [a] | 1.516E-02 | 1 | 1.516E-02 | .013 | .911 |
| | Proud [b] | 1.712E-02 | 1 | 1.712E-02 | .011 | .916 |
| | Assertive [c] | 1.405 | 1 | 1.405 | .815 | .371 |
| | Confident [d] | 1.377 | 1 | 1.377 | .976 | .327 |
| | Important [e] | 2.738 | 1 | 2.738 | 1.476 | .229 |
| | Takes Initiative [f] | 4.159E-02 | 1 | 4.159E-02 | .022 | .883 |
| | Ave.Dominance [g] | 6.739E-03 | 1 | 6.739E-03 | .007 | .935 |
| Dom. of Target *Sex of Subject | Dominant [a] | .970 | 1 | .970 | .814 | .371 |
| | Proud [b] | 2.538 | 1 | 2.538 | 1.675 | .201 |
| | Assertive [c] | .418 | 1 | .418 | .242 | .624 |
| | Confident [d] | .151 | 1 | .151 | .107 | .745 |
| | Important [e] | 2.161 | 1 | 2.161 | 1.165 | .285 |
| | Takes Initiative [f] | 4.279E-03 | 1 | 4.279E-03 | .002 | .962 |
| | Ave.Dominance [g] | .531 | 1 | .531 | .537 | .467 |

a R Squared = .037 (Adjusted R Squared = -.013)
b R Squared = .039 (Adjusted R Squared = -.011)
c R Squared = .078 (Adjusted R Squared = .030)
d R Squared = .021 (Adjusted R Squared = -.030)
e R Squared = .043 (Adjusted R Squared = -.007)
f R Squared = .022 (Adjusted R Squared = -.028)
g R Squared = .034 (Adjusted R Squared = -.016)

Analysis of variance for reports of actor-dominance finds no significant effects of sex of subject, and sex of target. Similarly, no significant interaction is found between these (Table 12). Thus no significant effects of sex of subject are found on overall dominance ratings for either same sex or different sex targets.

TABLE 12. Two Way Analysis of Variance of Actor-Dominance Rating
By Sex of Subject and Sex of Target

| Source | Dependent Variable: Actor -Dominance | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Sex of Subject | Dominant [a] | 3.585E-02 | 1 | 3.585E-02 | .029 | .865 |
| | Proud [b] | 1.336E-04 | 1 | 1.336E-04 | .000 | .993 |
| | Assertive [c] | 1.655 | 1 | 1.655 | .905 | .345 |
| | Confident [d] | 1.407 | 1 | 1.407 | 1.033 | .314 |
| | Important [e] | 2.579 | 1 | 2.579 | 1.456 | .232 |
| | Takes Initiative [f] | 1.761E-02 | 1 | 1.761E-02 | .009 | .924 |
| | Ave.Dominance [g] | 2.310E-02 | 1 | 2.310E-02 | .023 | .881 |
| Sex of Target | Dominant [a] | .488 | 1 | .488 | .398 | .531 |
| | Proud [b] | 3.448E-03 | 1 | 3.448E-03 | .002 | .963 |
| | Assertive [c] | .660 | 1 | .660 | .361 | .550 |
| | Confident [d] | 2.444 | 1 | 2.444 | 1.795 | .186 |
| | Important [e] | 6.103 | 1 | 6.103 | 3.447 | .068 |
| | Takes Initiative [f] | 8.551E-07 | 1 | 8.551E-07 | .000 | .999 |
| | Ave.Dominance [g] | .170 | 1 | .170 | .167 | .684 |
| Sex of Subject * Sex of Target | Dominant [a] | 6.292E-02 | 1 | 6.292E-02 | .051 | .822 |
| | Proud [b] | .152 | 1 | .152 | .096 | .757 |
| | Assertive [c] | 4.280E-03 | 1 | 4.280E-03 | .002 | .962 |
| | Confident [d] | 1.265 | 1 | 1.265 | .929 | .339 |
| | Important [e] | 1.995 | 1 | 1.995 | 1.127 | .293 |
| | Takes Initiative [f] | 8.977E-02 | 1 | 8.977E-02 | .046 | .831 |
| | Ave.Dominance [g] | 1.212E-02 | 1 | 1.212E-02 | .012 | .914 |

a R Squared = .009 (Adjusted R Squared = -.042)
b R Squared = .002 (Adjusted R Squared = -.050)
c R Squared = .022 (Adjusted R Squared = -.028)
d R Squared = .055 (Adjusted R Squared = .006)
e R Squared = .086 (Adjusted R Squared = .039)
f R Squared = .001 (Adjusted R Squared = -.051)
g R Squared = .003 (Adjusted R Squared = -.048)

## Female vs. Male Rating of Dominance

Consistent biases in the perception of dominance experimentally manipulated in this study, as reported by previous studies (Ellyson and Dovidio, 1983; Porter and Geiss, 1981; Schwartz, Tesser, and Powell, 1982; and Halberstadt and Saitta, 1987), were expected. Biases are found in the expected directions: male targets were rated more dominant than female targets, regardless of their nonverbal behaviors, and female raters perceived others as being more dominant than did male raters. However when averaged male and female actor-dominance ratings are compared between male subject and female subjects, neither is found to be significant ($F(1,78)=0.062$, 0.059, respectively, and for both $p>0.05$).

The average composite rating of self-dominance for female subjects was 4.667, with a standard deviation of 0.82086, variance of 0.674, and range of 3.83 (on a scale of 1-7: submissive-dominant). The average composite rating of self-dominance for males was 4.681, with a standard deviation of 0.96338, variance of 0.928, and range of 3.67 (on a scale of 1-7: submissive-dominant). An analysis of variances of rating of self-dominance by subject sex shows no significant differences for this ($F=(35,74)1.068$, $p=0.397$) or any of the measures of self-dominance. Furthermore, a multivariate analysis of ratings of self-dominance for both male and female subjects finds no effect by sex of subject, sex of target, or interaction between sex of subject and sex of target on self-dominance ratings (Table 13).

TABLE 13. Multivariate Analysis of Variance: Rating of Self-Dominance
By Sex of Subject and Sex of Target

| Source | Dependent Variable: Self-Dominance | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Sex of Subject | Dominant [a] | 4.326 | 1 | 4.326 | 4.011 | .048 |
| | Proud [b] | 2.393 | 1 | 2.393 | 1.681 | .198 |
| | Assertive [c] | .138 | 1 | .138 | .067 | .796 |
| | Confident [d] | 1.982 | 1 | 1.982 | .950 | .332 |
| | Important [e] | .377 | 1 | .377 | .246 | .621 |
| | Takes Initiative [f] | 1.037 | 1 | 1.037 | .612 | .436 |
| | Ave.Dominance [g] | .938 | 1 | .938 | 1.196 | .277 |
| Sex of Target | Dominant [a] | 1.853 | 2 | .926 | .859 | .427 |
| | Proud [b] | .913 | 2 | .456 | .320 | .727 |
| | Assertive [c] | 14.619 | 2 | 7.310 | 3.561 | .032 |
| | Confident [d] | .313 | 2 | .156 | .075 | .928 |
| | Important [e] | 1.927 | 2 | .963 | .629 | .535 |
| | Takes Initiative [f] | 2.134 | 2 | 1.067 | .629 | .535 |
| | Ave.Dominance [g] | 1.524 | 2 | .762 | .971 | .382 |
| Sex of Subject * Sex of Target | Dominant [a] | 1.525 | 2 | .762 | .707 | .496 |
| | Proud [b] | .147 | 2 | 7.326E-02 | .051 | .950 |
| | Assertive [c] | .612 | 2 | .306 | .149 | .862 |
| | Confident [d] | .125 | 2 | 6.244E-02 | .030 | .971 |
| | Important [e] | 3.715 | 2 | 1.857 | 1.212 | .302 |
| | Takes Initiative [f] | 3.162 | 2 | 1.581 | .932 | .397 |
| | Ave.Dominance [g] | .891 | 2 | .446 | .568 | .569 |

a R Squared = .053 (Adjusted R Squared = .007)
b R Squared = .021 (Adjusted R Squared = -.026)
c R Squared = .069 (Adjusted R Squared = .024)
d R Squared = .010 (Adjusted R Squared = -.037)
e R Squared = .058 (Adjusted R Squared = .013)
f R Squared = .028 (Adjusted R Squared = -.019)
g R Squared = .030 (Adjusted R Squared = -.017)

## Effects of Relative Dominance on Contagious Yawning

This study predicted that controlled dominance manipulation in an experiment of contagious yawning would result in a significant correlation between relative dominance (between subject's self and target ratings) and frequency of yawns, such that higher frequencies of contagious yawning correlate with relatively little difference in perceptions of self-dominance and perceptions of actor-dominance. Of these individuals showing significant difference in perceptions of self-dominance and perceptions of actor-dominance, it was predicted that individuals would emit yawns in the presence of others perceived as more dominant more often than in the presence of individuals perceived as subordinate. To separate out "smaller" from "greater" differences, relative dominance scores were separated into two categories for analysis: one category represents relative difference scores within one point of zero, and the second category represents relative difference scores more than one point from zero. Figure 1 shows the average number of complete yawns by subjects reporting little or no difference in perceived dominance between self and target.

FIGURE 1. Number of Yawns by Subjects with Small Relative Dominance Scores

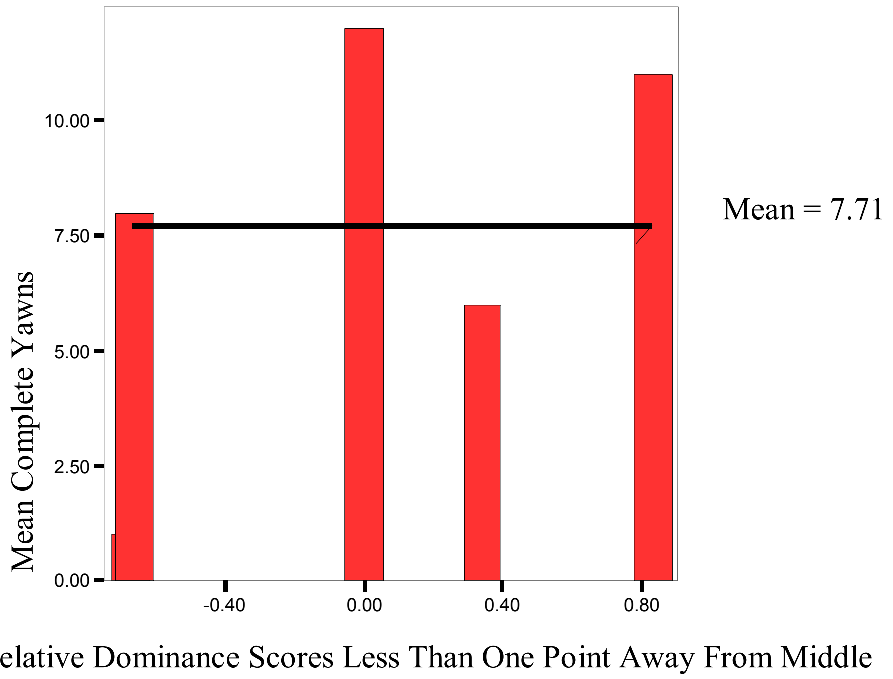


Figure 2 shows the average number of complete yawns by subjects reporting a difference greater than one in perceived dominance (scored on scales of 1-7) between self and target. Results confirm the predictions that higher frequencies of contagious yawning would occur between individuals of equivalent dominance status, as contagious yawning in such a case is likely associated with the relative lack of social, physical, and cognitive stimulus (Baenninger, 1987; Baenninger and Baenninger; 1996). Figure 3 demonstrates that larger differences in perceived dominance status between self and target correlate with less frequent contagious yawning means. It is suggested that the perception of dominance difference is associated with an increase in social, physical, and cognitive stimulation, and thus lower frequencies of contagious yawning.

FIGURE 2. Number of Yawns by Subjects with Larger Relative Dominance Scores

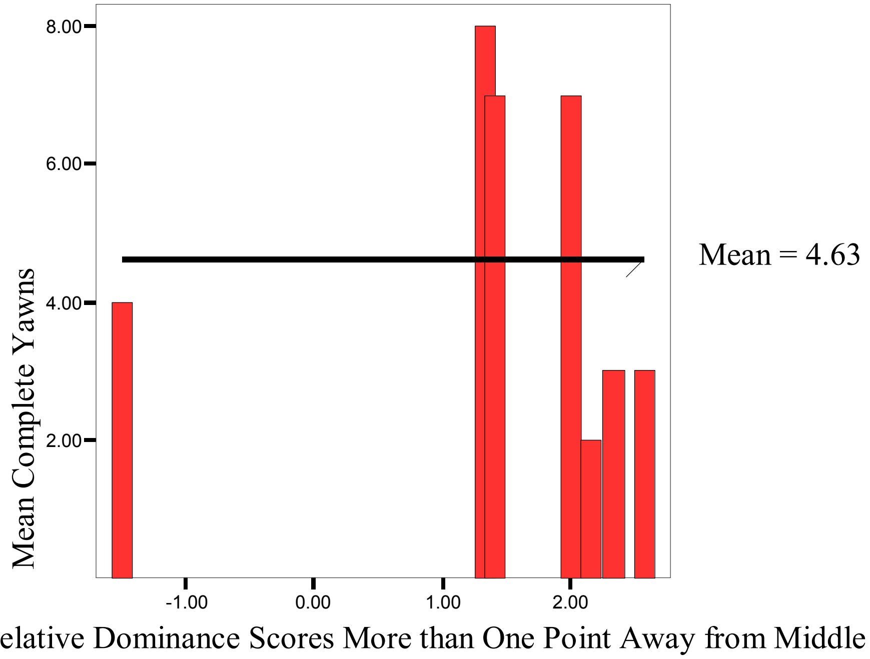
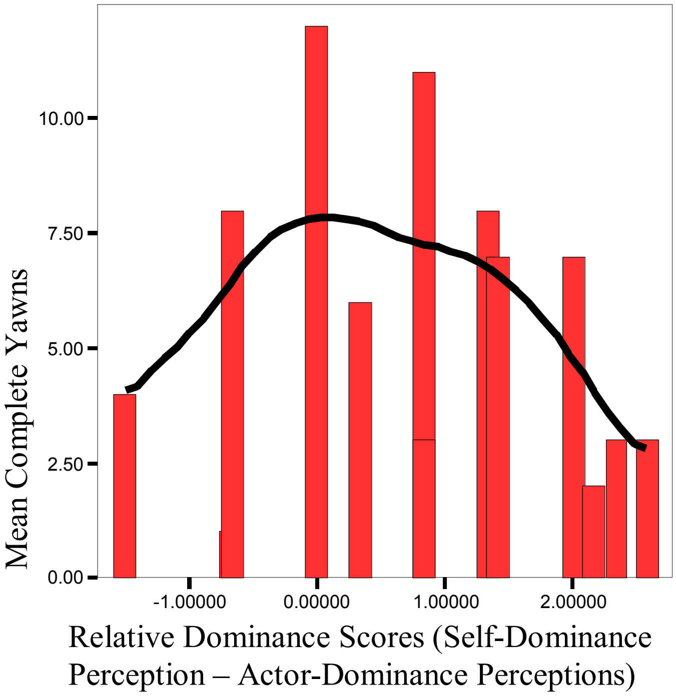


FIGURE 3. Distribution of Yawns by Subject in Relation to Relative Dominance



Because of small number of subjects who exhibited complete or incomplete yawns, results from this study are not conclusive with respect to the prediction that subordinate individuals should initiate yawns in the presence of dominant individuals less often than dominants will initiate yawns in the presence of subdominants, however results are in the predicted direction. While mean frequency of yawns by relatively dominant individuals (positive scores) is not significantly different than the mean frequency of yawns by relatively submissive individuals (negative scores), individuals perceiving themselves as more dominant than the target yawned more frequently than those who rated themselves as less dominant (Figure 3). Complete yawns were observed in only one subject with a score less than negative one, while six subjects with scores greater than one, and four subjects with scores greater than two showed complete yawns.

The finding that more females yawned than males may be accounted for by the smaller differences between females' self- and actor-dominance perceptions. Individuals who reported smaller differences between self-dominance and target-dominance tend to yawn more often than subjects who report larger relative differences. Females report a relative absolute difference of 1.1340 points and a directional difference of +0.5558 points, while males report a relative absolute difference of 1.3578 points and a directional difference of +0.6548. The difference between measures of absolute self-video dominance perception differences for males and females is found to be insignificant ($F(1,78)=1.040$, $p>0.05$), as are the differences between measures of directional difference ($F(1,78)=0.059$, $p>0.05$). Thus, significant differences found by sex for the likelihood of emitting both complete and incomplete yawns cannot be accounted for solely by differences in relative dominance perceptions (where females report smaller differences between self-dominance and target-dominance), though this may be a contributing factor.

## Effects of Sex Differences

### Sex Differences in Yawning

While Schino and Aureli (1989) found no sex differences in yawn frequency under natural conditions, in this study -across all stimulus conditions- fourteen out of seventy-four (18.91%) females emitted complete yawns, whereas only 2 out of 36 (5.5%) of males yawned completely. Thus females were more likely to emit complete yawns than males across all conditions, but not significantly so by conventional standards ($\chi^2$=3.48; df=1; $p$=.062). However, the critical prediction in this study was that higher testosterone and dominance would both be correlated with higher levels of yawning. While some females have high testosterone and rate high on dominance, on average males tend to have higher levels of testosterone (Dabbs, 2000). Thus, one should expect that just as in many other primates, males on average would yawn more than females in response to social stimuli. The opposite appears to be found here; males are significantly less likely than females to emit both complete and incomplete yawns, whether across all stimuli condition ($\chi^2$=3.854; df=1; $p$=.5) or with only yawn stimuli (Fisher's exact test (one-sided) $p$=.042) Cross tabulation and chi-square statistics for the combined measure of complete and incomplete yawns by sex of subject is shown across all stimuli in Table 14, and between stimuli conditions (yawns or control) in Table 15. Further, on average females emitted more complete yawns than did males accounting for 86.76% (59/68) and 13.24% (9/68) of all completed yawns, respectively. An analysis of variance between male and female yawning frequencies (complete, incomplete and combined measures) in this study shows no significant difference ($F$(1,78)=1.637, 0.893, and 1.867, respectively; all with $p$>0.05).

TABLE 14. Subject Sex by Combined Measure of (Complete and Incomplete) Yawns: Cross Tabulation and Chi-Square Statistics

| Sex: | | Yawn: | | Total: |
|---|---|---|---|---|
| | | No Yawn | Yes Yawn | |
| Female | Count | 57 | 17 | 74 |
| | Expected Count | 60.5 | 13.5 | 74.0 |
| | % within Sex | 77.0% | 23.0% | 100.0% |
| | % within Yawn | 63.3% | 85.0% | 67.3% |
| | % of Total | 51.8% | 15.5% | 67.3% |
| Male | Count | 33 | 3 | 36 |
| | Expected Count | 29.5 | 6.5 | 36.0 |
| | % within Sex | 91.7% | 8.3% | 100.0% |
| | % within Yawn | 36.7% | 15.0% | 32.7% |
| | % of Total | 30.0% | 2.7% | 32.7% |
| Female and Male | Count | 90 | 20 | 110 |
| | Expected Count | 90.0 | 20.0 | 110.0 |
| | % within Sex | 81.8% | 18.2% | 100.0% |
| | % within Yawn | 100.0% | 100.0% | 100.0% |
| | % of Total | 81.8% | 18.2% | 100.0% |

Chi-Square Tests for Subject Sex Differences of All Yawns

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | 3.489 | 1 | .062 | | |
| Continuity Correction | 2.574 | 1 | .109 | | |
| Likelihood Ratio | 3.894 | 1 | .048 | | |
| Fisher's Exact Test | | | | .070 | .050 |

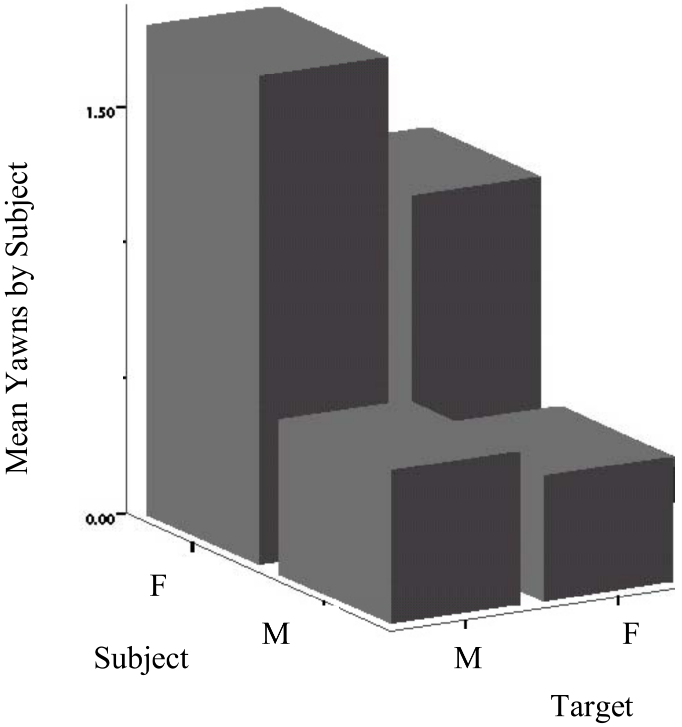
Computed only for a 2x2 table

## Differences by Video and Sex in Yawning

It was also predicted that, on average, contagious yawning in males would be more frequent when evoked by a female (as opposed to a male) yawner, as a result of greater within-group sex competition for males than females, such that female subjects yawn more frequently when observing same-sex yawns than do male subjects. Figure 4 below shows mean complete and incomplete yawns by sex of subject and sex of target:

no significant differences are found between contagious yawning in males as evoked by watching female as compared to male targets. Likewise, female subjects were not more likely than male subjects to show contagious yawns associated with same-sex evoked yawns, nor by opposite-sex evoked yawns.

FIGURE 4. Mean Complete and Incomplete Yawns by Sex of Subject and Target



## Sex Differences by Target Differences in Yawning

Table 15 shows means of the combined measure of (complete and incomplete) yawns by sex of subject in relation to stimulus condition (yawn stimuli or control stimulus): no significant differences are found between male and female mean contagious yawns (complete and incomplete) as evoked by control stimulus. However, as mentioned earlier, female subjects were more likely than male subjects to show contagious yawns (complete and incomplete) associated with yawn stimuli.

A multivariate analysis of variance for reports of averaged actor-dominance ratings by sex of target, sex of subject, and sex of target by sex of subject shows no significant effects for any of these (Table 16). Likewise, an analysis of variance (Table 17) for averaged actor-dominance shows no effects by different stimulus videos (4 yawning stimuli and 1 control).

# TABLE 15. Sex of Subject by Combined Measure of (Complete and Incomplete) Yawns by Stimulus Condition: Cross Tabulation and Chi-Square Statistics

| | | | | Yawn: | | Total |
|---|---|---|---|---|---|---|
| Stimulus Condition: | | | | No Yawn | Yes Yawn | |
| Control | Sex of Subject | Female | Count | 21 | 2 | 23 |
| | | | Expected Count | 21.5 | 1.5 | 23.0 |
| | | | % within Sex | 91.3% | 8.7% | 100.0% |
| | | | % within yawn | 75.0% | 100.0% | 76.7% |
| | | | % of Total | 70.0% | 6.7% | 76.7% |
| | | Male | Count | 7 | 0 | 7 |
| | | | Expected Count | 6.5 | .5 | 7.0 |
| | | | % within Sex | 100.0% | .0% | 100.0% |
| | | | % within yawn | 25.0% | .0% | 23.3% |
| | | | % of Total | 23.3% | .0% | 23.3% |
| | Total | Male and Female | Count | 28 | 2 | 30 |
| | | | Expected Count | 28.0 | 2.0 | 30.0 |
| | | | % within Sex | 93.3% | 6.7% | 100.0% |
| | | | % within yawn | 100.0% | 100.0% | 100.0% |
| | | | % of Total | 93.3% | 6.7% | 100.0% |
| Yawn Stimuli | Sex of Subject | Female | Count | 36 | 15 | 51 |
| | | | Expected Count | 39.5 | 11.5 | 51.0 |
| | | | % within Sex | 70.6% | 29.4% | 100.0% |
| | | | % within yawn | 58.1% | 83.3% | 63.8% |
| | | | % of Total | 45.0% | 18.8% | 63.8% |
| | | Male | Count | 26 | 3 | 29 |
| | | | Expected Count | 22.5 | 6.5 | 29.0 |
| | | | % within Sex | 89.7% | 10.3% | 100.0% |
| | | | % within yawn | 41.9% | 16.7% | 36.3% |
| | | | % of Total | 32.5% | 3.8% | 36.3% |
| | Total | Male and Female | Count | 62 | 18 | 80 |
| | | | Expected Count | 62.0 | 18.0 | 80.0 |
| | | | % within Sex | 77.5% | 22.5% | 100.0% |
| | | | % within yawn | 100.0% | 100.0% | 100.0% |
| | | | % of Total | 77.5% | 22.5% | 100.0% |

TABLE 15 (Continued).Chi-Square Tests for Female vs Male:
All Yawns by Stimulus Condition

| Stimulus Condition: | | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|---|
| Control | Pearson Chi-Square | .652 | 1 | .419 | | |
| | Continuity Correction | .000 | 1 | 1.000 | | |
| | Likelihood Ratio | 1.106 | 1 | .293 | | |
| | Fisher's Exact Test | | | | 1.000 | .582 |
| | N of Valid Cases | 30 | | | | |
| Yawn Stimuli | Continuity Correction | 2.838 | 1 | .092 | | |
| | Likelihood Ratio | 4.224 | 1 | .040 | | |
| | Fisher's Exact Test | | | | .057 | .042 |
| | N of Valid Cases | 80 | | | | |

Computed only for a 2x2 table

TABLE 16. Multivariate Analysis of Variance for Reports of Averaged
Actor-Dominance Ratings by Sex of Target, Sex of Subject,
And Sex of Target by Sex of Subject

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Sex of Target | 1.271E-03 | 1 | 1.271E-03 | .001 | .971 |
| Sex of Subject | 5.620E-04 | 1 | 5.620E-04 | .001 | .981 |
| Sex of Target * Sex of Subject | .949 | 1 | .949 | .982 | .325 |
| Total | 1365.097 | 80 | | | |

R Squared = .014 (Adjusted R Squared = -.025)

TABLE 17. Analysis of Variance of Averaged Actor-Dominance Ratings by Video

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power |
|---|---|---|---|---|---|---|---|---|
| Video (1-5) | 3.973 | 3 | 1.324 | 1.429 | .241 | .053 | 4.287 | .365 |
| Total | 1365.097 | 80 | | | | | | |

Computed using alpha = .05
R Squared = .053 (Adjusted R Squared = .016)

## Self Reported Statistics of Yawning

### Self Report of Yawns

Self-reports were compared with objective-reports for yawn behavior. Fourteen out of 90 (15.55%) subjects reported yawning “a little bit” or more when no complete yawns and no incomplete yawns were recorded by the researchers, thus subjects self-report that they had yawned when, according to the standard behavioral definition, they didn’t. Scores indicating the degree to which subjects “felt like yawning” indicate a desire to yawn in association with the relative absence of actual yawns as recorded from both objectively-reported and self-reported methods. Forty-seven out of 79 (59.49%) subjects who reported not having yawned indicated they “felt like yawning” a little bit or more. Fifty eight out of 90 (64.44%) subjects who showed neither complete nor incomplete yawns (as objectively coded by researchers) indicated they “felt like yawning” a little bit or more, thus some desire to yawn was present even in subjects who did not yawn.

## Differences by Video and Sex for Feels Like Yawning

### Control vs. Yawn Condition for Feels Like Yawning

An independent samples Mann-Whitney U analysis of “felt like yawning” scores (1-7 on a Likert scale) for yawn stimulus versus control conditions shows a significant difference between the desire to yawn while watching yawn stimulus, and the desire to yawn reported in association with watching the control condition. Significantly higher scores for “felt like yawning” were reported for watching yawning stimuli than for watching control conditions ($Z_{\text{Mann-Whitney}} = -2.911$, $p$(two-tailed)$<0.01$).

### Female vs. Male for Feels Like Yawning

Table 18 reports summary statistics for subjects’ reports of “feel like yawning” by sex of target and control conditions. Across stimuli and control conditions, the average report for “felt like yawning” by female subjects was 3.358, with a standard deviation of 1.9906, variance of 3.985, and range of 6 (on a scale of 1-7: “no- yes, more than a little bit”). Across all stimuli conditions the average report for “felt like yawning” by male subjects was 2.958, with a standard deviation of 1.8608, variance of 2.970, and range of 6 (on a scale of 1-7: “no- yes, more than a little bit). An analysis of variances of all feels like yawning reports by sex of subject shows no significant differences ($F$=0.79, $p$=0.376).

Table 18. Descriptive Statistics for Feels Like Yawning by Sex of Subject
And Sex of Target (Male, Female, or Control)

| Sex of Subject | Sex of Target | Mean | Std. Deviation | Number of Subject Reports |
|---|---|---|---|---|
| Female | control | 2.283 | 1.7699 | 23 |
| | female | 3.440 | 1.8046 | 25 |
| | male | 4.231 | 1.9557 | 26 |
| | Total | 3.358 | 1.9906 | 74 |
| Male | control | 3.000 | 2.5166 | 7 |
| | female | 2.933 | 1.3741 | 15 |
| | male | 2.964 | 2.0890 | 14 |
| | Total | 2.958 | 1.8608 | 36 |
| Both Male and Female | control | 2.450 | 1.9447 | 30 |
| | female | 3.250 | 1.6564 | 40 |
| | male | 3.788 | 2.0690 | 40 |
| | Total | 3.227 | 1.9496 | 110 |

## Sex Differences by Target Differences for Feels Like Yawning

Table 19 shows analysis of variances of feels like yawning scores by sex of subject, sex of target, and sex of subject by sex of target. No significant effects are found for sex differences of subject, target, or both. Thus, neither males nor females were more likely to report they felt like yawning in response to male targets, and likewise neither males nor females were more likely to report they felt like yawning in response to female targets.

Table 19. Analysis of Variance for Feels Like Yawning by Sex of Subject, Sex of Target, and Sex of Subject by Sex of Target

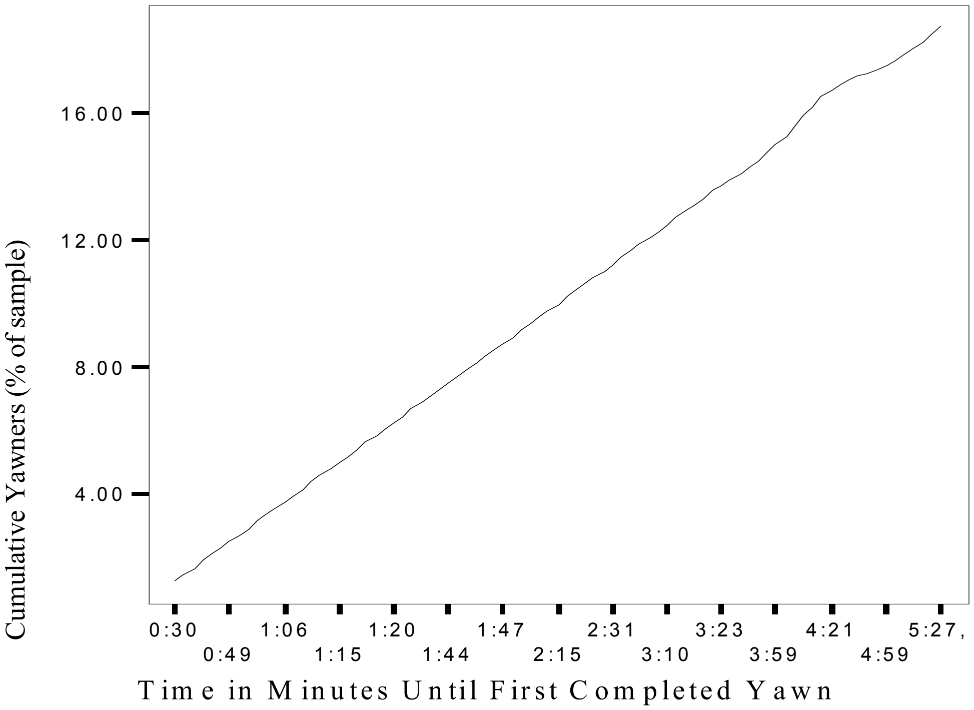
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Sex of Subj. | 2.767 | 1 | 2.767 | .791 | .376 | .008 |
| Sex of Target | 12.419 | 2 | 6.209 | 1.775 | .175 | .033 |
| Sex of Subj. * Sex of Target | 13.290 | 2 | 6.645 | 1.899 | .155 | .035 |
| Total | 1560.000 | 110 | | | | |

R Squared = .122 (Adjusted R Squared = .080)

## Latency and Yawn Contagion

The latency of contagion until first yawn is shown in Figure 5; the proportion of subjects that emitted complete yawns while viewing yawning gradually increased over the course of five and a half minutes of observation.

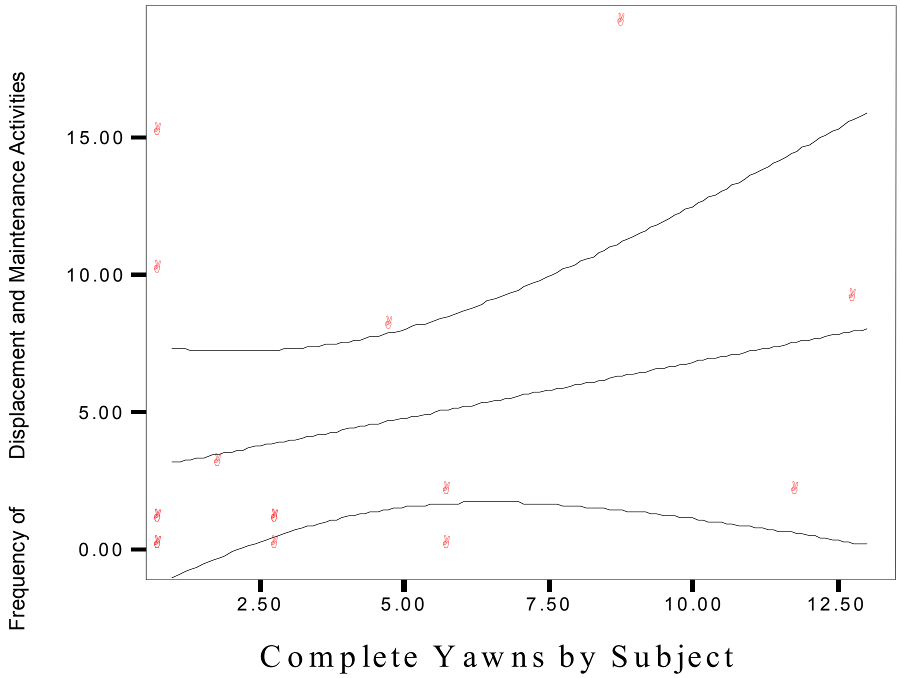
FIGURE 5. Contagious Yawn Latencies: Latency to First Yawn
By Subjects Watching Yawning



## Yawn Related Activities

It was predicted that yawning subjects would display high frequencies of displacement and maintenance activities near their heads. It was also predicted that of those subjects yawning, individuals ranking themselves as more dominant than the actor shown in stimulus video would be less likely to yawn with their mouths covered. Of those subjects who yawned, 75% (14/16) showed yawns accompanied by maintenance or displacement activities on or near the head, including rubbing of eyes, scratching face, scratching nose, scratching neck, scratching scalp, and touching hair. The frequencies of separate maintenance activities in yawning subjects scored during the five-and-a-half minute observation period range from 0-19, with an average of 4.5 maintenance activities per yawning subject. An overall linear correlation between number of maintenance activities and number of yawns is noted for subjects, with more displacement and maintenance activities being associated with more yawns (see Figure 6). Of those yawns elicited by subjects, 55.88% (38/68) were "covered yawns", in which subjects' hand(s) were brought to the level of the mouth during the time that the gaping component of the yawn was displayed. Unlike Schino and Aureli's (1989) findings that females account for significantly more covered yawns than males, an analysis of variance of covered and uncovered male and female yawns in this study shows no significant difference in type of yawn by sex ($F$=(1)0.003, $p$>.05). Of those subjects who yawned, only three out of 16 showed only uncovered yawns. Those showing only uncovered yawns were all in the top 37.5 percentile of scores of relative dominance (a measure of actor-dominance subtracted from self-dominance perceptions). As predicted, subjects ranking themselves as more dominant than target were the only individuals who showed only uncovered yawns.

FIGURE 6. Maintenance and Displacement Activities Correlated with Complete Yawns.



Displacement and Maintenance Activities = 2.78 + 0.41Complete Yawns;

F=1.128, R squared= 0.361, p=.011

## Confounding Factors

It has been predicted that subjects with abnormally high levels of testosterone would show higher than normal frequencies of yawning when observing yawn stimuli in a controlled setting, as explained by both costly signaling and displacement activity theories. Because testosterone analysis is still pending at the time of this report, no comment is made on the correlations between yawners, non-yawners, and testosterone levels, nor between distribution of individuals by reported dominance ratings, dominance status relative to self-target perceptions, and testosterone levels.

It is well known that caffeine and alcohol can affect activity levels and alter one's inhibitions. Because yawning has been correlated with changes in activity and yawn frequency may be affected by inhibition, it was predicted that the presence of caffeine and alcohol, when significant, would affect the results of this study. It has also been predicted that drugs and neurological pathologies affect yawning frequencies as elicited by visually observed yawn stimuli in a controlled setting. An analysis of observational data in relation to information obtained from the questionnaire (see Appendices A + B) used in this study finds no significant effects from drugs, alcohol, or caffeine.

It was predicted that subjects who had consumed large meals prior to the experiment or who were sleep deprived or very tired would experience the experimental procedure in a significantly different state of arousal: the change in activity associated with their transition from non-participation to participation might be experientially different from that of other subjects, thus affecting results of this study. All subjects were told not to eat large meals prior to the experiment and to eat no later than an hour before the experiment. A survey of "time of last meal" and descriptions of "last meal" from subjects' questionnaires indicates that none of the 110 subjects reported eating large meals in the hour prior to their participation in the experiment. Subjects' reports of "tiredness" before experiment showed some correlation with yawn frequency. The Pearson correlation coefficient between tiredness before experiment and yawn frequency approaches significance ($r= 0.138$ df=108 $p$(one-tailed)=.075). Relative amounts of sleep as measured by “missed sleep” (the difference between prior sleep from average sleep, when prior sleep was less), also shows no strong correlation with complete yawns or all yawns (the combined measure of complete and incomplete yawns), as the Pearson correlation coefficients are insignificant ($r$=-0.065 df=108 $p$(one-tailed)=.25; and $r$=-0.050 df=108 $p$(one tailed)=.303, respectively).

It was predicted that changes in activity affect yawn frequency and that participation in this experiment may have been perceived as a transition to a more boring activity. The experience of watching an experimental video was rated by all subjects on a scale of 1-10 (see Appendices A and B), from boring to exciting, and received an average rating of 3.43 (std. dev. 2.307, variance 5.323): more boring than exciting. A measure of perceived change of activity or arousal associated with subjects’ transition from non-participation to participation (in a relatively boring activity) was made by subtracting reports of “tired during experiment” from reports of “tired after experiment.” Spearman’s correlation between perceived change in activity/arousal and complete yawn frequency approaches significance ($r$= 0.146 df=108 $p$(one-tailed)=.064). Spearman’s correlation between perceived change in activity/arousal and yawn frequency (as a combined measure of complete and incomplete yawns) is significant ($r$= 0.157 df=108 $p$(one-tailed)=.050). It appears that the transition to a state of increased tiredness during the course of this experiment, as reported by subjects, is correlated with yawn frequencies as observed in a controlled study of yawn contagion.

# CHAPTER VI

# SUMMARY OF FINDINGS AND CONCLUSIONS

## Findings and Conclusions

Visually observed yawn stimulus were shown to be contagious and elicit more yawns among observers than among observers of the control condition. On average, a significantly greater frequency of yawns was elicited from videos showing actors yawning than from a colored test-bar pattern video. A desire to yawn (as indicated by high scores on “felt like yawning” reports) was found to be dependent on visually observed yawning stimuli.

In comparison with similar studies (i.e. Provine, 1986) this study shows a significantly lower frequency of evoked yawns ($F$=(1, 40) 33.929, $p$<0.01). Inter- versus intra-generational design differences, as measured by the average age difference between subjects and actors ($p$=0.013), and different data-recording methods may account for differences in contagious yawning frequencies between the studies. Because Provine (1986) did not attempt to control for dominance interactions, and in using himself (41-years-old at time of 1986 study) as the target for yawn stimulus videotapes, an inter-generational interaction between subjects (average age of 19.1 years) and stimulus was created in his study. It is likely that significant dominance interactions resulted from this inter-generational design, such that subjects yawned more frequently as a result of perceiving a yawning actor (more than twice their age on average) as more dominant. In this study the same two actors, male and female, (from the same age group as subjects) were used in both dominant and submissive conditions with all variables controlled except for postural cues of dominance, thus reducing the degree to which visual cues of dominance could be manipulated and increasing the degree to which they could be controlled. Subjects' perceptions of actor-dominance show effects in intended directions: dominant male and female targets were scored higher than 4 on average, and submissive male and female targets were scored lower than 4 on average. Thus dominance manipulation was shown to be effective and analysis of variance in scores of target dominance grouped by intended dominance shows a difference approaching significance ($F$=(1,78) 3.207, $p$=0.07). Sex differences were also observed with yawning frequency: males were significantly less likely than females to emit both complete and incomplete yawns, whether across all stimuli condition ($\chi^2$=3.854; df=1; $p$=.5) or with only yawn stimuli (Fisher's exact test (one-sided) $p$=.042). The finding that more females yawned than males may be accounted for in part by the smaller differences between females' self- and actor-dominance perceptions. Individuals who reported smaller differences between self-dominance and target-dominance tend to yawn more often than subjects who report larger relative differences. Thus, this study finds no strong evidence against the hypothesis that age, sex, dominance conditions and dominance perceptions all affect contagious yawning frequency in a controlled setting. In almost all cases, lack of statistical significance is at least partially a function of low number of subject yawns in this study. Large effects sizes of sex, dominance, and/or relative dominance would be necessary for the critical tests to reach statistical significance at conventionally accepted levels ($p<0.05$).

Subjects self-report that they had yawned when, in actuality, they didn't: self-reports were compared with objective-reports for yawn behavior. Fourteen out of 90 (15.55%) subjects reported yawning "a little bit" or more when no complete yawns and no incomplete yawns were recorded by the researchers. Higher rates of self-reported yawn behavior may be accounted for by confusion between a felt desire to yawn during the five minutes of stimulus, and the actual display of complete or incomplete yawns by subjects.

Scores indicating the degree to which subjects "felt like yawning" show a desire to yawn in association with the relative absence of actual yawns as recorded from both objectively-reported and self-reported methods. Forty-seven out of 79 (59.49%) subjects who reported not having yawned indicated they "felt like yawning" a little bit or more. Fifty-eight out of 90 (64.44%) subjects who showed neither complete nor incomplete yawns (as objectively coded for by researchers) indicated they "felt like yawning" a little bit or more. This evidence of a "desire" to yawn despite the absence of actual yawning may be explained by inhibition which suppressed the manifestation of a behavior that the subjects, otherwise, "felt like" performing.

Inhibitions caused by subjects' awareness that they were being videotaped might also have been a contributing factor to the lower frequency of evoked yawns. As mentioned earlier, yawns may be considered impolite or even insulting. Thus, subjects may have felt inhibited from revealing yawns, while videotaped and watched by researchers, because to do so may have been impolite. Other studies with higher frequencies of evoked yawns differ in that they lack the presence of videotaping equipment, and that they measure subjective data as reported by the subjects. The results of self-reported behavior in Provine's (1986) study may be confounded by a triggering of the behavior by the process of reporting it, or subjects' tendency to report having yawned more than they actually did. Thus Provine's (1986) reports of contagious yawning behavior in a controlled setting are confounded by several factors (sex interactions, age interactions, postural cues of dominance, and self reporting methods) shown to have significant effects by this study, and therefore cannot be easily replicated and (because of a lack of design rigor) should not be considered trustworthy descriptions of contagious yawn behavior.

## Discussion

### Considerations for Future Studies

Future controlled studies of contagious yawning behavior should attempt to gather and code for more data that may serve as a measure of relative inhibition. During debriefing, subjects in this study gave verbal feedback indicating that their awareness of being videotaped some how suppressed their willingness to act on the desire to yawn.

Other measures of social comfort/discomfort besides the dominance scale could be used to test for predictions of correlations between status and contagious yawning frequency. Possible questions that might be added to the questionnaire following experiments such as these might include more questions based on appearance: “How comfortable would you feel in the close company of the actor shown in the video?” “Does the person in the video seem like they would be interested in the same romantic or sexual partners that you might be interested in?” “Does the person in the video seem like a possible romantic or sexual partner to you?” “Did the yawns you observed in the video look threatening?” “Did the yawns in the video make you feel anxious?” “How comfortable did you feel with the knowledge that you were being videotaped and watched?”

Future studies of yawn contagion could pretest dominance conditions with yawning actors such that only highly dominant and highly submissive actor videos are used. By selecting different actors based on visual cues of dominance (preferably extreme), and assigning these dominant and submissive actors to dominant and submissive conditions, the manipulation of visual cues of dominance could be increased, however the degree to which they could be controlled would decrease. A naturalistic study of yawning and contagious yawning that included a measure of yawners’ perceptions of conspecific and self-dominance could also serve as a helpful contribution to the study of human yawn phenomena.

## Final Discussion

The purpose of the study, “Why is Yawning Contagious,” is to investigate why and under what circumstances human observation of conspecifics’ yawns elicits yawns from the observer. Based on a literature review and analysis of results from this study, it is concluded that yawning contagion is a byproduct of both the act of yawning (as a refresher of CSF and facilitator of transitions between activities) and socially adapted minds capable of inferring and experiencing (empathizing) conspecifics' mental and physiological states, yet moderated by the relative cost of displaying the signal. As humans empathize, they attend to cues revealing mental and physiological states of other humans. Human empathy requires an internalization of others' mental and physiological states, such that both thoughts and feelings may be shared. It is because of the adaptation allowing empathy, or a theory of mind, that over time shared in the company of a conspecific, a mere suggestion (in the absence of stress and stimulation) of yawning may serve as no more than a reminder (at a deep-brained level) to activate the reflex action of a yawn.

There is no convincing evidence for yawning contagion as an adaptation, though the hypothesis has been suggested by others (Provine, 1986; Weller, 1988; Aurelli and van Schaik, 1991; Castles and Whiten, 1998; Sauer and Sauer, 1967; Deputte, 1978, 1994). Among humans it is unlikely that, as suggested for ostriches (Sauer and Sauer, 1967), it is designed to help social groups attenuate the potentially harmful effects of inter-specific social stress (possible inability to hunt in packs or protect selves in herds) thereby synchronizing the physiological as well as behavioral state of the group.

It need not be a mystery why the phenomenon of contagious yawning exists, when it does not appear to be an adaptation. Clearly, it is natural, common, and healthy to yawn. And clearly, humans are quite adept at empathizing and internalizing the inferred mental and physiological states of fellow humans. In the absence of stimulation caused by differences in dominance (when yawning might be seen as an insult or sign of impoliteness), and in conjunction with empathetic abilities shared by all humans, a phylogenetically ancient adaptation –the yawn- is capable of contagiousness transmission among humans. Based on the conclusion of this study it is predicted that in addition to laughter and yawning, many other distinct (but less obvious) mental/physiological states (and displacement activities) are contagious. Furthermore, it is likely that future discovery of behavioral and experiential contagion will be illuminated by costly signaling theory.

# APPENDICES A & B AVAILABLE UPON REQUEST

# APPENDIX C

## RECRUITMENT FLYER

(The following statement used in the “Why is Yawning Contagious?” study, has been formatted and printed to appear as it did when seen by subjects in the study.)

You are invited to participate in a research study conducted by Eric Schniter, a graduate student from the University of Oregon Department of Anthropology. I hope to learn what the effects of various videotaped stimuli are on different subjects. Results from this research will contribute to my thesis. If you decide to participate, the experiment will be run as follows: you will be asked to rinse your mouth with water, given a stick of sugar-free gum to chew for one minute, and then asked to drool through a straw into a test tube. Next you will be asked to watch a short five-minute video during which time your reactions will be videotaped, and last you will be asked to fill out a short questionnaire. The video you will be watching will contain nothing offensive or shocking in nature. When you sign up for an experiment you are agreeing only to show up at a certain place and time and listen to what the researcher would like you to do. At the time of the experiment the procedures will be explained in further detail. It is asked of all subjects to avoid eating or drinking alcoholic beverages during the hour preceding the experiment. All experiments have been extensively reviewed by the Anthropology Department and the University and are completely safe and relatively stress-free. If at any time you do not like what is happening or simply want to stop, you are NOT obligated to continue. There are many good reasons to take part in experiments such as this. First, it is a great way to learn first-hand about how psychological, and anthropological research is done. At the end of each experiment you will be given a written description of the experiment and will be given the opportunity to talk to the experimenter about the purpose of the research and how he or she is hoping to learn from the data you provided. **Second**, participation enables you to meet the researchers at the University of Oregon and find out about their areas of investigation. One of the great things about attending a major research university, such as the University of Oregon, is that there are professors and graduate students doing research, which may wind up in your textbooks in a few years. If you find any of the research topics you learn about particularly interesting, be sure to let the researcher know and don't be shy about asking questions. **Third**, you can even get involved with this project! As the principal investigator I need undergraduate assistants and this is a great way to learn even more about anthropology and psychology and to get helpful letters of recommendation. **Fourth**, you'll be taking part in a long tradition of advancing humankind's knowledge of human behavior and psychology. As long as behavior and psychology have been studied (and maybe even longer) professors, graduate and undergraduate students have been learning from one another. Professors and graduate students help students understand what is already known about psychology. In return, students help professors and graduates learn about things which are still unknown. This continual exchange of information is what makes the human sciences such an interesting and rapidly expanding field of study. **Fifth**, and finally, experiments have the potential of being lots of fun. This experiment will not necessarily be as fun as a Friday night party, but should be a better experience than having dental work done! Participation in this experiment might add an experience outside of the mundane and ordinary experiences of the average school day. Sign up and have the opportunity of a unique experience that will also serve as a contribution to Science!

If you have any questions or wish to become an assistant on this project feel free to contact Eric Schniter at 346-4139. As a graduate student I would also like to include the number of my advisor Dr. Sugiyama 346-5142 in case you should care to direct any questions or concerns towards him.

# APPENDIX D

## CONSENT FORM

(The following consent form used in the "Why is Yawning Contagious?" study, has been formatted and printed to appear as it did when seen by subjects in the study.)

Consent Form for Research including videotaping and collection of saliva samples.

You are invited to participate in a research study conducted by Eric Schniter, from the University of Oregon Department of Anthropology. I hope to learn what the effects of various videotaped stimuli are on different subjects. Results from this research will contribute to my thesis. You were selected as a possible participant in this study because you are capable of participating and responding to the questionnaire.

If you decide to participate, the experiment will be run as follows: You [the subject] will be asked to rinse your mouth with water, given a stick of sugar-free gum to chew for one minute, and then asked to drool through a straw into a test tube. The purpose of collecting a sample of your saliva is to later supply me with data concerning your circulating testosterone concentration. When you are done giving the saliva sample you will be asked to go into the next room to watch one of five short five-minute videos. During this time you will be video taped. The purpose of you being video taped is so that the investigator can verify that you are actually watching the video, and later observe your reaction to the video. The video you will be watching will contain nothing offensive or shocking in nature. After you are done watching the video we would like you to exit the room and fill out a short questionnaire asking you about yourself, your thoughts about the video, and your experience watching the video. Following the questionnaire there will be a 5 to 10 minute debriefing period during which the experiment will be further explained to you and you will be free to ask questions. The whole experiment should take no more than 30 minutes. There are no risks, discomforts, or inconveniences that we expect you to experience. As a participant you should expect to receive payment of 5 dollars following successful completion of all parts of the experiment. Other benefits might include educational exposure to issues of human behavior, scientific inquiry and investigation. However, I cannot guarantee that you personally will receive any benefits from this research.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Subject identities will be kept confidential by a coding procedure that will identify your data without use of your name. I will personally keep the data safe and secure and no one other than myself will have access to it. There will be no master code list or any other means by which codes will be able to be identified with subject names. Saliva samples will be released to a scientific laboratory for analysis, but will be coded for identification and no personal information will accompany them. Your participation is voluntary. Your decision whether or not to participate will not affect your relationship with the University of Oregon or any of its faculty or alumni. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time without penalty. If you have any questions, please feel free to contact the principal investigator, Eric Schniter at 171 Straub, telephone #346-4139 . As a graduate student I am also providing my advisor as a contact: Dr, Lawrence Sugiyama telephone #346-5142. If you have questions regarding your rights as a research subject, contact the Office of Human Subjects Compliance, University of Oregon, Eugene, OR 97403, (541) 346-2510. You have been given a copy of this form to keep.

Your signature indicates that you have read and understand the information provided above, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation without penalty, and that you are not waiving any legal claims, rights or remedies.

Print Name_____________________________________________

Signature _____________________________________________

Date____________________

# APPENDIX E

## CONSENT FORM #2

(The following consent form used in the “Why is Yawning Contagious?” study, has been formatted and printed to appear as it did when seen by subjects in the study.)

# CONSENT AGREEMENT FOR VIDEOTAPING

I have received an adequate description of the purpose and procedures for videotaping sessions during the course of the proposed research study. I give my consent to allow videotaping during my participation in the study, and for those videotapes to be viewed by persons involved in the study, as well as for other professional purposes as described to me. I understand that all information will be kept confidential and will be reported in an anonymous fashion such that there will be no means by which video tape recordings will be identifiable with subject names, and that the videotapes will be erased after an appropriate period of time after the completion of the study. I further understand that I may withdraw my consent at any time.

Print Name________________________________________

Signature _____________________________________Date________

# BIBLIOGRAPHY

Alcock, J

1998. Animal Behavior. Sinauer Associates, Inc.; Massachusetts.

Altmann, SA

1967. The structure of primate social communication. In: Social Communication among Primates. University of Chicago Press; Chicago, pp.325-362

Anderson, JR; and Wunderlich, D

1988. Food reinforced yawning in *Macaca tonkeana*. American Journal of Primatology 16:165-169

Andrew, RJ

1964. The displays of primates. In. J. Buettner-Janusch (Ed.), *Evolutionary and genetic biology of primates* (Vol. II), pp. 227-309. Academic Press: New York

Andrew, RJ

1972. The information potentially available in animal displays. In R.A. Hinde (Ed.), *Non-verbal communication*, pp. 179-206. Cambridge University Press.

Andrew, RJ

1965. The origins of facial expressions. Scientific American. 213(4): 88-94

Anias, J; Holmgren, B; Urba-Holmgren, RU; and Eguibar, JR

1984. Circadian variation of yawning behavior. Acta Neurobiologiae Experimentalis 44:179-186

Argiolas, A and Melis MR

1998. The neuropharmacology of yawning. European Journal of Pharmacology. Feb., 343(1):1-16

Arkenasy, JJ; et al.

1996. Inhibition of muscle symapthetic nerve activity during yawning. Clin. Auton. Res. Aug., 6(4): 237-239

Aureli, F; and van Schaik, CP

1991. Post conflict behavior in long-tailed macaques (*Macaca fascicularis*): II. Coping with uncertainty. Ethology 89: 101-114

Aureli, F; and de Waal, FBM

1997. Inhibition of social behavior in chimpanzees under high-density conditions. American Journal of Primatology 41:213-228

Baenninger, R

1987. Some comparative aspects of yawning in *Betta splendens, Homo sapiens, Panthera leo,* and *Papio sphinx*. Journal of Comparative Psychology. 101(4):349-354

Baenninger, R, Binkley, S; and Baenninger, M

1996. Field observation of yawning and activity in humans. Physiology and Behavior. Mar., 59(3):421-425

Baker, KC; and Aureli, F

1997. Behavioural indicators of anxiety: and empirical test in chimpanzees. Behaviour 134:1031-1051

Barbizet, J

1958. Yawning. Journal of Neurological Psychiatry. 21, p. 203-209

Barlow, GW

1964. Ethology of the Asian Teleost *Badis badis*: V. Dynamics of fanning and other parental activities with comments on behaviour of the larvae and postlarvae. Z. Tierpsychol. 21, p. 99-123

Barlow, H

Unpublished. Chapter draft of The Inevitability of Consciousness. In Ridley, 1993

Baulu, J

1973. Responses of rhesus monkeys (*Macaca mulata*) to motion picture stimulation: A preliminary study. M.S. thesis, University of Georgia, Athens.

Bell, L

1980/1981. Boredom and the Yawn. Rev. Existent. Psychol., Psychiat. 17:91-100

Bell, Q

1976. On Human Finery. (Second edition.) Hogarth Press, London.

Bernstein, IS; and Baker, SC

1988. Activity patterns in a captive group of celebes black apes (*Macaca nigra*). Folia Primatologica 51:61-75

Bertrand, M
1969. The behavioral repertoire of the stumptail macaque: a descriptive and comparative study. Karger, Basil. In Deputte, 1994.

Bolwig, N
1959. A study of the behavior of the chacma baboon, *Papio ursinus*. Behaviour, 14; 136-163

Brown, JL
1975. The Evolution of Behavior. Norton Publishers: New York

Caldecott, JO
1986. Mating patterns, societies, and the ecogeography of macaques. Anim. Behav., 34: 208-220.

Carpenter, CR
1940. A field study in Siam of the behavior and social relations of the gibbon (*Hylobates lar*). Comp. Psychol. Monogr. 161-212

Carskadon, MA
1991. Yawning elicited by reading: Effects of sleepiness. Sleep Research, 20; 116.

Carskadon, MA
1992. Yawning elicited by reading: Effects of sleepiness. Sleep Research, 21; 101.

Castles, DL; and Whiten, A
1998. Post-conflict behaviour of wild olive baboons. II. Stress and self-directed behaviour. Ethology 104:148-160

Castles, DL; Whiten, A; and Aureli, F
1999. Social anxiety, relationships and self-directed behaviour among wild female olive baboons. Animal Behaviour 58:1207-1215

Chalmers, NR
1968. The visual and vocal communication of free living mangabeys in Uganda. Folia Primatologica, 9; 258-280

Chambers, KC
1981. Diurnal patterns of testosterone, dihydrotestosterone, estradiol, and cortisol in serum of rhesus males: relationship to sexual behavior in aging males. Hormones and Behavior 15:416-426

Chudler, EH
1999. Web Page. *Yawning: why do we yawn and why are yawns contagious?* http://faculty.washington.edu/chudler/yawning.html

Cowan, A
1978. Cholinergic link in yawning. Nature 271:187-188

Dabbs, JM
2000. Heroes, Rogues and Lovers: testosterone and behavior. McGraw-Hill: New York.

Daly, M; and Wilson, M
1983. Sex, Evolution, and Behavior. (Second edition.) Wadsworth: Belmont, California.

Darwin, C
1872. Introduction, Afterword, and Commentaries: 1998 (Paul Eckman).
The Expression of the Emotions in Man and Animal. HarperCollins Publishers: London

Delius, JD
1967. Displacement activities and arousal. Nature. 214:1259-1260

Deputte, BL
1978. [Study of yawning in two species of Cercopithecidae, *Cercocebus albigena albigena* GRAY and *Macaca fascicularis* RAFFLES: Research on causal and functional factors; A consideration of socio-bioenergetic factors.] These presentee devant l'Universite de Rennes, France, pour obtenir le titre de Docteur en Troisieme Cycle, February 1978. v+111pp.]Dissertation (in French)

Deputte, BL; and Fontenelle, A
1980. Threat and yawn in Macaca fascicularis: Interest of compared electromyographic technique. Biology of Behavior 5:47-54 ((French w/English summary) Abstract: Biological Abstracts 70: #34713, 1980.) UI103186

Deputte, BL
1994. Ethological study of yawning in primates. I. Quantitative analysis and study of causation in two species of old world monkeys (*Cercocebus albigena* and *Macaca fascicularis*). Ethology 98: 221-245

Deputte, BL; Johnson, J; Hempel, M; Scheffler, G; and Eisele, S
1994. Behavioral effects of an antiandrogen in adult male rhesus macaques (*Macaca mulatta*): a pilot study. Folia Primatologica 62(4):195

Deputte, BL; Johnson, J; Hempel, M; and Scheffler, G

1994. Behavioral effects of an antiandrogen in adult male rhesus macaques (*Macaca mulatta*). Hormones and Behavior 28:155-164

DeVore, I (Ed.)

1965. Primate Behavior: field studies of monkeys and apes.

Dunbar, RIM

1988. Primate Social Systems. Croom Helm: London

Eckman, P (Ed.)

1982. Emotions in the Human Face. (2nd Edition) Cambridge University Press: New York

Eibl-Eibesfledt, I

1975. Ethology, the Biology of Behavior. (2nd ed.) Holt Rinehart and Winston: New York.

Ellis, H

1992. The Evolution of Sexual Attraction: evaluative mechanisms in women. In *The Adapted Mind* (see Barkow).

Falk, D

2000. Primate Diversity. W. W. Norton and Co.

Fossey, D

1983. Gorillas in the Mist. Houghton Mifflin Company: Boston, Massachusetts

Gessa, GL; Vargiu, L; and Ferrari W

1966. Stretchings and yawning induced by ACTH. Nature 221: 426-427

Goodall, J

1965. Chimpanzees in the gombe stream reserve. In: Primate Behavior: field studies of monkeys and apes. DeVore (Ed.) Holt, Rinehart, and Winston: New York

Goodall, J

1968. A preliminary report on the expressive movements and communication in the gombe stream chimpanzees. In: Primates: studies in adaptation and variability. Jay, PC (Ed.) Holt, Rinehart, and Winston: New York

Goy, RW; and Resko, GA

1972. Gonadal hormones and behavior of normal pseudohermaphroditic nonhuman female primate. Rec. Progr. Horm. Res. 28: 707-733

Graybiel, A; and Knepton, J

1976. Sopite syndrome: a sometimes side effect of motion sickness. Aviation, Space, and Environmental Medicine. 47:873-882

Greco, M; and Baenninger, R

1991. Effects of yawning and related activities on skin conductance and heart rate. Physiology and Behavior Nov., 50(5):1067-1069

Greco, M; Baenninger, R; and Govern, J

1993. On the context of yawning: when, where, and why? Psych. Rec. 43:175-183

Hadidian, J

1980. Yawning in an old world monkey, *Macaca nigra*. Behaviour 75:133-147

Hall, KRL

1962. Behavior of monkeys towards mirror-images. Nature. 196, 1258-1261.

Hall, KRL

1967. Social interactions of the adult male and adult females of a patas monkey group. In S.A. Altmann (Ed.) Social Communication among primates (pp. 261-280). Chicago: University of Chicago Press.

Hall, KRL

1968. Behavior and ecology of the wild patas monkeys. In: Primates: Studies in Adaptation and Variability. PC Jay (Ed.) Holt, Rinehart, and Winston: New York

Hall, KRL; and DeVore, I

1965. Baboon social behavior. In I. Devore (Ed.), Primate behavior: Field Studies of monkeys and apes, pp.53-110. New York: Holt, Rinehart and Winston

Heusner, AP

1946. Yawning and associated phenomena. Physiol. Rev. 25:156-168

Hinde, RA (Ed.)

1972. Non-verbal communication. Cambridge University Press.

Hinde, RA; and Tinberger, N

1958. The comparative study of species specific behavior. In A. Roe & G.C. Simpson (Eds.), Behavior and evolution, pp.251-268. New Haven, Conn.: Yale University Press.

Hinde, RA; and Rowell, TE

1962. Communication by postures and facial expression in the rhesus monkey (*Macaca mulatta*). Proceedings of the Zoological Society of London 138:1-21

Holmgren, B; and Urba-Holmgren, R

1978. Cholinergic link in yawning. Nature 271:187-188

Huxley, J

1966. Introduction to “A discussion on ritualization of behaviour in animals and man.” Philosophical Transactions of the Royal Society of London. Series B. 251(772), 249-271

Izquierdo, I

1988. Now you’ll start yawning and you won’t know why. Trends in Pharmacological Science. Apr; 9(4):119

Jurko, MF; and Andy, OJ

1975. Post-lesion yawning and thalamotomy site. Applied Neurophysiology. 38:73-79

Kaplan, JR; Adams, MR; Clarkson, TB; Manuck, SB; and Shively, CA

1991. Social behavior and gender in biomedical investigations using monkeys: studies in atherogenesis. Lab. Anim. Sci. 41: 334-343.

Kataoka, J

1975. Free physical movements while standing and waiting. Journal of Human Ergology 4, 3-13

Kaufmanm, IC; and Rosenblum, LA

1966. A behavioral taxonomy for *Macaca nemestrina* and *Macaca radiata*, based on a longitudinal study of family groups in the laboratory. Primates 7:205-258

Kinzey, WG

1987. Evolution of Human Behavior: primate models. State University of New York Press: Albany, NY

Kishida, K

1973. Temporal change of subsidiary behavior in monotonous work. Journal of Human Ergology 2, 75-89

Lagarde, D; Laurent, J; Milhaud, C; Andre, E; Aubin, HJ; and Anton, G

1990. Behavioral effects induced by beta CCE in free or restrained rhesus monkeys, (*Macaca mulatta*). Pharmacol. Biochem. Behav. 35:713-719

Lambert, J

2001. Primatologist and Associate Professor of Anthropology, University of Oregon. Informal conversations on the relationships between yawning and various facial displays.

Louboungou, M; and Anderson, JR

1987. Yawning, scratching, and protruding lips: differential conditionability of natural acts in pigtail monkeys (*Macaca nemestrina*). Primates 28(3):37-375

Manson, JH; Perry, S; and Parish, AR

1997. Nonconceptive and sexual behavior in bonobos and capuchins. International Journal of Primatology. 18(5):767-786

Mastripieri, D; Schino, G; Aureli, F; Troisi, A

1992. A modest proposal: Displacement activities as an indicator of emotions in primates. Animal Behavior 44:967-979

McCutchean, F

1970. Stimulation, control, and phylogenetic projection of the telostean reflex. Comparative Biochemistry and Physiology 34:339-344

Michael, RP; Bonsall, RW; and Zumpe, D

1987. Testosterone and its metabolites in male cynomolgus monkeys (*Macaca fascicularis*): behavior and biochemistry. Physiology and Behavior 40:527-537

Miller, G

2000. The Mating Mind: how sexual choice shaped the nature of the human mind. Doubleday: New York

Mogilnicka, E; and Klimek, V

1977. Drugs affecting dopamine neurons and yawning behavior. Pharmocol. Biochem. Behav. 7:303-305

Moore, JE

1942. Some psychological aspects of yawning. J. General Psychol. 27:289-294.

Mori, U

1979. Inter-unit relationships. In M. Kawai (Ed.), Ecological and sociobiological studies of gelada baboons. Contributions to primatology. (Vol. 16), pp.83-92. Karger: Basel.

Morris, D

1954. The reproductive behavior of the river bullhead *Cottus gobio* with special reference to the fanning activity. Behaviour 7:1-32

Moynihan, M

1970. Control, suppression, decay, disappearance, and replacement of displays. Journal of Theoretical Biology 29:85-112

Myrberg, AA

1972. Ethology of the bicolor damselfish, *Eupomacentrus partitus* (Pisces: Pomacentridae). A comparative analysis of laboratory and field behaviour. Animal Behaviour Monogr. 5:199-283.

Napier, JR and Napier PH

1967. A handbook of living primates. Academic Press: London.

Napier, JR and Napier PH

1985. The Natural History of the Primates. British Museum, London England

Nishida, T

1970. Social behavior and relationships among wild chimpanzees of the Mahali Mountains. Primates 11:47-84

Nolman, B

2000. Why Yawn: the Nolman Valve Theory
http://www.members.home.com/hilaryking/Oldbrain1.htm. original publication in PARADIGM, April 1998 (put out by Consumer Development Project of the C.M.H.A.)

Parker, GA

1974. Assessment strategy and the evolution of fighting behaviour. Journal of Theoretical Biology. 47:223-243

Pellatt, A; Wright, PG; and Levine, LS

1981. Yawning and the thyroid gland. South African Journal of Science. September, 77:391-394

Petrie, M; Halliday, T; and Sanders, C

1991. Peahens prefer peacocks with elaborate trains. Animal Behavior. 41:323-31

Petrikovsky, B; Kaplan, G; and Holsten, N

1999. Fetal yawning activity in normal and high-risk fetuses: a preliminary observation. Ultrasound Obstet. Gynecology Feb., 13(2):127-130

Phoenix, CH; and Chambers KC

1984. Sexual behavior and serum hormone levels in aging rhesus males: Effects of environmental change. Hormones and Behavior 18:206-215

Phoenix, CH; and Chambers KC

1986. Minireview: Aging and primate male sexual behavior. Proceedings from the Society for Experimental Biology and Medicine. 183:151-162

Plavcan, JM

1999. Mating systems, intrasexual competition and sexual dimorphism in primates. in Comparative Primate Socioecology. pp. 241-260 Lee, PC (Ed.) Cambridge University Press: Cambridge

Poirier, FE

1970. The communicative matrix of the nilgiri langur (*Presbytis johnii*) of South India. Folia Primatologica 13:92-136

Provine, RR

1986. Yawning as a stereotyped action pattern and releasing stimulus. Ethology. 72: 109-122

Provine, RR; and Hamernik, HB

1986. Effects of stimulus interest. Bulletin of the Psychonomic Society, 24:437-438

Provine, RR; Hamernik, HB; and Curchack, BB

1987. Yawning: relation to sleeping and stretching in humans. Ethology. 76:152-160

Provine, RR; Tate, BC; and Geldmacher, LL

1987. Yawning: No Effect of 3-5% CO2, 100% 02, and Exercise. Behavioral and Neural Biology. 48: 382-393

Provine, RR

1989(a). Contagious yawning and infant imitation. Bulletin of the Psychonomic Society. 27:125-126

Provine, RR

1989(b). Faces as releasers of contagious yawning: an approach to face detection using normal human subjects. Bulletin of the Pyschonomic Society. 27:211-214

Provine, RR

1997. Yawns, laughs, smiles, tickles, and talking: Naturalistic and laboratory studies of facial action and social communication. In Russell and Fernandez-Dols (Eds.) *The psychology of facial expression*. Cambridge Univ. Press: Cambridge.

Provine, RR

2001. Electronic mail correspondence on "Why is yawing contagious?" study (Schniter, 2001), discussing the merits of yawning as a social signal.

Rahaman, H; and Parthasarathy, MD

1968. The expressive movements of the bonnet macaque. Primates 9:259-272

Rasa, O; and Anne E

1971. The causal factors and function of yawning in *microspathodon chrysurus* (Pisces: Pomacentridae). Behaviour 39:39-57

Redican, WK

1975. Facial expressions in nonhuman primates. In: Primate Behavior: Developments in Field and Labaratory Research, Vol. 4. pp. 103-194 (Roseblum, L. A., Ed.) Academic Press, New York.

Redican, WK

1982. An evolutionary perspective on human facial displays. In P. Ekman (Ed.) *Emotion in the human face* (2nd ed.). Cambridge Univ. Press: Cambridge.

Ridley, M

1993. The Red Queen: sex and the evolution of human nature. Penguin Books: New York, NY.

Roe, A; and Simpson GC (Eds.)

1958. Behavior and evolution. New Haven, Yale University Press: Conn.

Rowe, N

1996. The Pictorial Guide to the Living Primates. Pogonia Press: East Hampton, NY

Rowell, T; and Hinde, RA

1963. Responses of rhesus monkeys to mildly stressful situations. Animals Behaviour. 11:235-243

Sadalla, EK; Kenrick, DT; and Vershure, B

1987. Dominance and Heterosexual Attraction. Journal of Personality and Social Psychology. 52:730-738

Sapolsky, RM

1994. Why zebras don't get ulcers: a guide to stress, stress-related diseases, and coping. W.H. Freeman and Company: New York

Sauer, EGF; and Sauer, EM

1967. Yawning and other maintenance activities in the South African ostrich (*Struthio camelus australis*). The AUK 84: 571-587.

Schaller, GB

1963. The Mountain Gorilla: ecology and behavior. University of Chicago Press. Chicago, Illinois.

Schaller, GB

1972. The Serengeti lion: a study of predator-prey relations. University of Chicago Press. Chicago, Illinois.

Schino, G; and Aureli, F

1989. Do men yawn more than women? Ethol. Sociobiol. 10:375-378.

Schino, G; Scucchi, S; Maestripieri, D; and Turillazzi, PG

1988. Allogrooming as a tension-reduction mechanism: a behavioral approach. American Journal of Primatology 16:43-50

Schino, G; Perretta, G; Tagliano, AM; Monaco, V; and Troisi, A

1996. Primate displacement activities as an ethopharmacological model of anxiety. Anxiety 2:186-191

Scuchi, S; Maestripieri, D; and Schino, G

1991. Conflict, displacement activities, and menstrual cycle in long-tailed macaques (*Macaca fascicularis*). Primates 32(1):115-118

te Boekhorst, IJA; de Weerth, C; and van Hooff; JA

1991. Does scratching signal stress in chimpanzees.? In: Social structure of three great ape species. (Ed. IJA te Boekhorst) pp.157-175. University of Utrecht Press: Utrecht.

Thierry, B

1985. Patterns of agonistic interactions in three species of macaques (*M. mulatta, M. fascicularis, M. tonkeana*). Aggress. Behav., 11: 223-233.

Tinbergen, N

1952. "Derived" activities; Their causation, biological significance, origin, and emancipation during evolution. Quarterly Review of Biology, 27, 1-32.

Tooby, J; and Devore, I

In Kinzey, WG 1987. The Reconstruction of Hominid Behavioral Evolution.

Troisi, A; Aureli, F; Schino, G; Rinaldi, F; and DeAngeli, N

1990. The influence of age, sex, and rank on yawning behavior in two species of macaques (*M. fascicularis* and *M. fuscata*). Ethology. 86:303-310

Tugendhat, B

1960. Feeding in conflict situations and following thwarting. Science. 132:896-897

Uno, H; Tarara, R; Else, JG; Suleman, MA; and Sapolsky RM

1989. Hippocampal damage associated with prolonged and fatal stress in primates. Journal of Neuroscience 9:1705-1711

Urba-Holmgren, R; Gonzalez, RM; Holmgren, B

1977. Is yawning a cholinergic response? Nature. 267:261-262

Van Hooff, JA

1976. The comparison of facial expressions in man and higher primates. In M. von Cranach (Ed.) Methods of inference from animal to human behaviour. pp. 165-196.

Vine, I

1970. Communication by facial-visual signals. In: Social behavioir in birds and mammals. Crook, JH (Ed.). Academic Press: London

von Cranach, M. (Ed.)

1976. Methods of inference from animal to human behaviour. Aldine: Chicago.

von den Steinen, K

1894. New edition 1917. In: Ethology, the Biology of Behavior. 2nd edition Eibl-Eibesfledt, I. author, 1975.

Weller, MP

1988. Yawning. Lancet. Apr. 23: 1 (8591): 950

Wimalaratna, HS, Capildeo, R

1988. Is yawning a brainstem phenomenon? Lancet. Feb. 6; 1 (8580): 300

Wolfheim, JH; and Rowell, TH

1972. Communication among captive talapoin monkeys (*Miopithecus talpoin*). Folia Primatologica 18:224-255

Yamada, K; and Furukawa, T

1980. Direct evidence for involvement of dopaminergic inhibition and cholinergic activation in yawning. Pyschopharmacology 67: 39-43.

Zahavi, A; and Zahavi, A

1997. The Handicap Principle. Oxford University Press.

Zucker, EL; Gerald, MS; and Kaplan, JR

1998. Frequencies and contexts of gape yawn displays of free-ranging patas monkeys (Erytrocybus patas.) American Journal of Primatology 45(2):215. (Abstract) UI:984278