THE OFFICIAL PUBLICATION OF THE OLFACTORY RESEARCH FUND VOL.VII, NO.2

THE AROMA-CHOLOGY REVIEW℠

FOCUSING ON OLFACTORY DEVELOPMENTS AROUND THE WORLD

SEXUAL FANTASY, WOMEN AND FRAGRANCE

Cynthia A. Graham, Ph.D.
Department of Psychology, Indiana University

Erick Janssen, Ph.D., Stephanie A. Sanders, Ph.D.
The Kinsey Institute for Research in Sex, Gender, and Reproduction

There is very little in the way of scientific research on the role of fragrance in sexual response in women. The aim of our study was to explore the effects of fragrance on sensuality and mood in women at different phases of the menstrual cycle.

The study consisted of a laboratory-based experiment in which women wore scented "necklaces" as they observed a sexually erotic film, a sexually neutral film, or fantasized about pleasant sexual experiences. There were three different fragrance conditions: female perfume (an aldehydic floral type), male cologne (a fresh fougere type), and a "blank" or control substance. Previous research had suggested that both sexual arousal and sense of smell might fluctuate over the menstrual cycle. We tested women at two different phases of their cycle: during the postmenstrual phase, and around the time of ovulation (mid-cycle). Both self-reported and physiological measures of sexual arousal and mood were used. Self-reported sexual arousal and mood were measured using brief

continued on page 6

FIGURE 1. The unsolvable maze.

THE SMELL OF FAILURE

Gisela Epple, Ph.D., Rachel S. Herz, Ph.D.
Monell Chemical Senses Center
Philadelphia PA

Imagine that the first time you walked past a hardware store and smelled the odor of paint you tripped over a pothole and hurt your ankle. From that moment on it would be very likely that the smell of paint would cause you to look where you were stepping. What has happened is that you have learned to

continued on page 2

ALSO IN THIS ISSUE

THE SMELL OF FAILURE

continued from page 1

associate the smell of paint with the danger of injury. It has been proposed that the way in which we acquire our subjective responses to smells is through associations with personal experience and the conditioning and modeling of cultural norms (Engen, 1982; 1988; Herz & Engen, 1996). This produces general agreement for the perceived pleasantness or unpleasantness of many odors within a culture, but also accounts for individual differences on the basis of idiosyncratic experiences.

Smells may influence a wide range of interactions with our social and physical environment through associative learning. Associative odor learning begins very early in life and can occur from the fetal period through adulthood (Van Toller & Kendall-Reed, 1995). Mothers and their new-borns quickly learn to recognize each others body odors, and these scents may play important roles in mother-infant bonding (Winberg & Porter, 1998). Infants who are exposed to artificial scents such as cherry or ginger oil while being gently stroked develop preferences for such scents (Winberg & Porter, 1998). Moreover, at early ages of development (before social modeling and learning has occurred) no differences in hedonic preferences are manifested to odors considered to be either very pleasant or very unpleasant by adults (Engen, 1988; Stein, 1958).

Among adults, odors acquire meaning most readily when they are associated with emotionally salient events (Herz & Engen, 1996). Adults who are exposed to odors while working on a stressful task experience anxiety when they encounter these odors again (Kirk-Smith et al., 1983; Newman et al., 1994). Additionally, memories evoked by odors are more emotional than memories evoked by other sensory stimuli (Herz & Cupchik, 1995; Herz, 1998). On the basis of such findings, we have proposed that scents which are experienced during an emotionally arousing event can acquire the meaning of that event and then later evoke emotions similar to those associated with the original event. These emotions, in turn, may modify behavior.

To test this hypothesis we recently conducted an experiment sponsored by the Olfactory Research Fund. In this experiment we exposed young children to one or two unfamiliar ambient odors while they performed a frustrating/failure task and then later during an unrelated intellectually challenging test. Another group of children was given this test without any odor present. We predicted that if the same ambient odor was present during both the failure task and the cognitive test then the emotions associated with the original odor (frustration/failure) would be experienced and that these emotions would influence test performance accordingly.

Experimental subjects were 24 boys and 24 girls between four and five years of age. Subjects were recruited from the local Philadelphia community, and were compensated for their participation. We chose young children as subjects because emotions in children can be easily manipulated in the laboratory. Moreover, we thought that children might be especially sensitive to associative learning of odors because of the novelty and significance of so many experiences early in life.

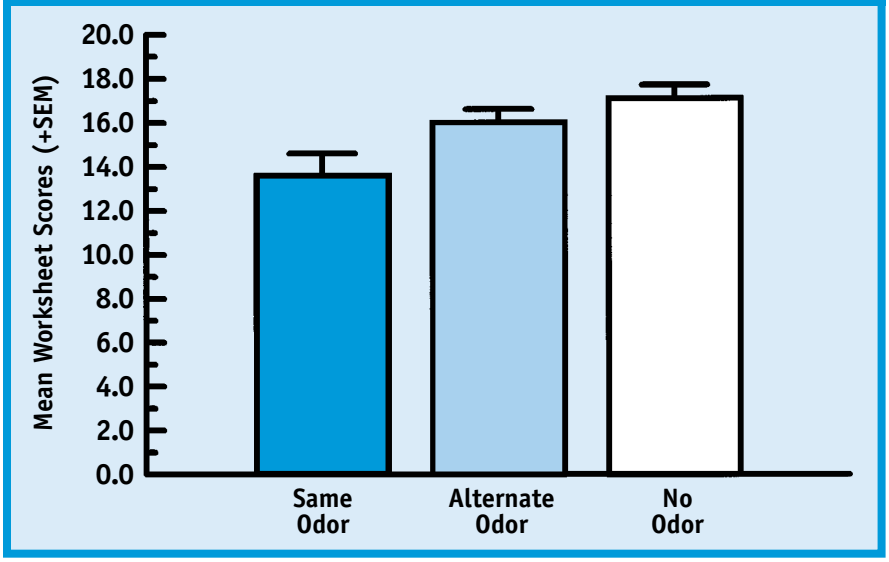
Children were tested one at a time in two sessions, a frustration/failure task, followed by a cognitive test, with a 20 minute break between them. The frustration/failure task was an unsolvable maze (see Figure 1). Children sat in front of a three-dimensional maze and were instructed to move a toy figure from two possible start-points to the center of the maze without crossing a line. A desirable toy was shown and the children were told that if they could solve the maze successfully they would win it as a reward. However, there was no possible way in which the maze could be mastered. Children worked on the maze for five minutes before the 20 minute break. The maze room (8.5 x 7.5 x 9 feet) was scented with either "Northern Rainforest" or "Key West." These two odors were considered equally pleasant. Odors were delivered into the room using a hidden environmental-odor delivery system. Odors and delivery apparatus used in this research were donated by AromaSys Inc.

After the break, during which subjects were read a short story, the child was taken to a different room (8 x 8 x 9 feet) that was either scented with the same odor, the alternate odor, or no odor. The cognitive test was then administered. A worksheet with 120 animal pictures was put before the child. Among the pictures were 40 identical puppies, 20 of which were missing their tails. The child was told to find and circle all tail-less puppies by the time a voice on audio tape counted to 10 (90 seconds). At the end of the test, each child was praised for their performance and presented with the toy that they were unable to win earlier. For each subject, the number of correctly circled puppies minus the number of incorrectly marked pictures was calculated as the measure of performance. Higher scores indicated better performance.

Figure 2 shows the mean performance of children in the three odor groups at test. Analysis of Variance conducted on the scores with odor-test group and gender as variables revealed that children who performed the cognitive test in the presence of the same odor as the failure maze did worse than subjects in any other group $F(2,42) = 3.57$, $p < 0.05$. Fisher's LSD post-hoc comparisons confirmed that subjects in the same odor group did worse than subjects in the alternate odor and no odor groups.

continued on page 6

FIGURE 2. Mean (+SEM) worksheet performance scores as a function of ambient odor during the test.



HUMAN AND INSECT OLFACTION MAKE NEWS AT ACHEMS

Craig B. Warren, Ph.D.
Consultant

The 20th annual AChemS meeting was held in Sarasota Florida, April 22-26, 1998. Over 500 specialists in taste and smell from over 19 countries attended. Approximately 95% of the attendees were from Universities, Research Centers and Medical Centers with the rest from industry. During the four day meeting researchers presented 311 papers and posters detailing their findings in areas ranging from the sensory science to the neuroscience of taste and smell to taste and smell disorders.

As an industrial scientist with 30 years of experience in new product development, I have always found the AChemS meeting loaded with hidden treasure. The diversity of scientific disciplines represented at this meeting coupled with the small fraction of research results sponsored by industry makes for a wealth of potential new product ideas.

I divided the 311 meeting papers and posters into three categories: human olfaction, molecular mechanisms of olfaction and mosquito olfaction and selected a small sample of research papers in each category on the basis of their potential interest to the readership of the Aroma-Chology Review. For those who want to see more, the AChemS web site gives the complete 20th annual AChemS program listing and the AChemS membership directory. Their site can be accessed by searching on "AChemS" or by inputting "http://neuro.fsu.edu/AChemS//home-page.htm". As a search aid I have provided the program number (#xx) for each paper so that it can referenced to the program listing on the web site.

HUMAN OLFACTION

This area comprised 42 papers covering an array of interesting topics such as human pheromones (#53, #113), cognitive development and odor categorization (#56), effects of odor on task performance (#59), theoretical computations of odorant uptake in the human nose (#60), semantic-free sorting of odor qualities (#108), effect of nasal dilators on olfactory function (#109, #110), adaptation to odors (#115, #123), and, recall and recognition memory for odors (#55, #58, #120).

The topic of human pheromones has been controversial since the moment it hit the press in the mid-seventies when the boar pheromone, androstenone, was found in human underarm sweat. While much has been written about the subject, the existence of a human pheromone that is substantiated by solid data remains at large. We were fortunate to have two presentations on this subject at the meeting.

Louis Monti-Bloch and coworkers at University of Utah and Pherin Pharmaceuticals presented a poster (#113) suggesting that the steroid found on human skin, androsta-4,16-dien-3-one, is a female, human pheromone. They report that this steroid significantly reduced negative affect, while increasing relaxation, well being and contentment. Concomitant with the psychological changes there was significant reduction in respiratory and cardiac frequency, decreased skin conductance, increased body temperature, and increased alpha brain waves. In the control group, which received propylene glycol, there were no statistically significant psychological or autonomic nervous system changes. Monti-Bloch, *et. al.* concluded that local androstadienone stimulation of the female human VNO without subjective olfactory sensation, induced behavioral and autonomic nervous system changes that persisted for 30 minutes. Thus, the authors conclude: "that there would appear to be no criteria by which to exclude androstadienone from being accepted as a human pheromone."

Suma Jacob and Martha McClintock at the University of Chicago presented a slide talk (#53) describing the results of their study with androsta-4,16-dien-3-one and 1,3,5(10)16-estratetraen-3-ol. Both had been suggested by Monti-Bloch, *et. al.* to have pheromonal activity. Jacob and McClintock found that the two skin steroids did not function as human pheromones in their studies. That is, they found none of the psychological changes reported by Monti-Bloch and coworkers.

While it remains for the two labs to reconcile their differences the controversy is where it belongs which is in the laboratory.

Christine Jehl and Claire Murphy of San Diego State University (#56) tested children in the age groups of 5-7, 8-11, and 12-16 for their ability to identify 33 common odors. While the children's abilities improved with increased age, the unexpected finding was that the children were much better at identifying odors belonging to the inanimate category than to the animate one. Jehl and Murphy postulate that this may reflect children's increased experience with odors associated with edible items.

Successfully aging is arriving at 77 to 87 with good mental and physical health. Your nose knows if you have taken care of yourself.

Jehl and Murphy's study focused on cognitive development in children. This study may achieve added value, however, by providing product developers with knowledge of the types of odors children remember.

Keyvan Keyhani, Peter Scherer and Max Mozell of Georgia Tech, University of Pennsylvania, and SUNY, Syracuse, respectively, (# 60) built an anatomically correct, finite element model of the human nose. This allowed them to relate the transport of odor molecules through the nose to their physiochemical properties such as water solubility. They presented data to show that the model's predictions are in agreement with various psychophysical and electrophysiological studies of olfaction.

This research may have the potential for identifying the fragrance ingredients that are diffusive.

On the same note, Pamela Dalton of Monell and Peter Scherer of University of

continued on page 4

Over the past 10 years, huge advances have been made in our understanding of the events that start with the detection of an odor molecule by an olfactory receptor and end with a perceived odor sensation.

HUMAN AND INSECT OLFACTION MAKE NEWS AT ACHEMS

continued from page 3

Pennsylvania presented a poster describing a mass transport model of human olfactory adaptation. (#123). In their poster they describe the use of Keyvan Keyhani's finite element model of the human nose to study odorant uptake, accumulation and clearance. Dalton and Scherer report that they have used the model to explain findings from recent studies on long term adaptation, thus, validating the model.

This is an exciting finding because Dalton and Scherer's model may allow for the correlation of the molecular structure of fragrance ingredients with their rate of adaptation.

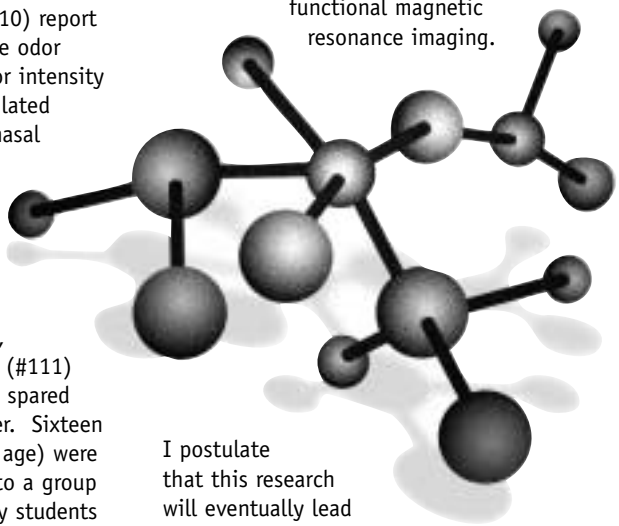
Some of us may have used a "Breathe-rite" nasal dilator on the tennis court or at night. Has anyone considered using one to enjoy the aroma of a meal or a fragrance. Two groups, D.J. Smith and coworkers at SUNY Syracuse (#109) and Bryan Raudenbush and Robert Frank at University of Cincinnati (#110) report that nasal dilators decrease the odor threshold and increase the odor intensity of odorants relative to an undilated control. They postulate that nasal dilators increase the number of odorant molecules available to olfactory receptors.

Steven Nordin, Umea University, Sweden, Ove Almkvist, Karolinska Institute, Sweden, and Birgitta Berglund, Stockholm University, Sweden, (#111) tell us that there is hope for a spared sense of smell as we grow older. Sixteen elderly people (77-87 years of age) were compared for odor sensitivity to a group of 16 young, healthy university students (20-25 years of age). The results showed almost identical odor sensitivity in the successfully aged as in the young adults. Successfully aging is arriving at 77 to 87 with good mental and physical health. Your nose knows if you have taken care of yourself.

Unfortunately, Mario Dulay and Claire Murphy, San Diego State (#120) tell us that odor recall and recognition ability begins to decline as early as the 50s. Dulay and Murphy found significant differences between 20s/30s age groups and 50s age group for short and long delay odor recall and odor recognition. The flip side of this research is to understand what middle-aged people like me still remember. Are some fragrances more memorable than others are?

MOLECULAR MECHANISMS OF OLFACTION

With more than 100 papers this was the largest body of research presented at the meeting. Over the past 10 years, huge advances have been made in our understanding of the events that start with the detection of an odor molecule by an olfactory receptor and end with a perceived odor sensation. The advances in this field are riding on the advances in the fields of molecular biology, particularly gene cloning and analysis; and analytical chemistry, high-resolution calcium imaging and functional magnetic resonance imaging.



I postulate that this research will eventually lead to the rational design of both molecules that have a particular odor character and molecules that modulate the sensation of odor.

The papers fell into four areas: 1) functional aspects of olfactory receptor cells, 2) cloning olfactory receptor genes, 3) physiology and structure of central olfactory pathways and 4) coding in the olfactory system. Here is a sampling of papers. It is impossible to cover this area in any comprehensive way.

Xiaojin Yang and coworkers at Yale University and the University of Groningen (#62) used functional magnetic resonance (fMRI) imaging to map the odor-evoked olfactory response in the olfactory bulb of the rat. Their results support other evidences that odor-evoked activity occurs in very specific areas of the olfactory bulb at the level of individual glomeruli or groups of glomeruli. The researchers postulate that with further improvement, fMRI should be ideal for systematic studies of the correlation between the structures of odor molecules and the response specificity of individual glomeruli. In other words, this research may lead to development of the relationship between the odor of a molecule and the spatial pattern of the glomeruli that it activates.

Frank Zufall and coworkers at Yale University and University of Maryland (#88) used laser scanning, confocal microscopy to visualize calcium signals in single cilia from olfactory receptor neurons (ORN). This allowed them to resolve the odor-evoked signal in ORN both spatially and temporally at the cilia level. Olfactory neurons of the salamander were exposed to acetophenone, n-amyl acetate, cineole, and citralava and ethyl butyrate. Different odorants activated different olfactory neurons. No variation was observed, however, between the cilia on a specific neuron. That is, all cilia of a given ORN are functionally uniform in their capacity to detect odor molecules. This means that they all contain the same odor receptor or receptor subset.

George Gomez and coworkers at Monell Chemical Senses Center, Allegheny University of the Health Sciences, and Thomas Jefferson University (#92) used olfactory neurons to gain insight into bipolar (manic-depressive) disorder. Studies on the nature of bipolar (or "manic depressive") disorder have implicated the role of inositol trisphosphate in calcium regulation of nerve cells. Olfactory neurons use the same calcium regulation process and are accessible for study via a biopsy procedure. Using high-resolution calcium imaging techniques, the researchers were able to differentiate between normal people, medicated bipolar patients and unmedicated bipolar patients by measuring the calcium content of their olfactory neurons. With this approach the

continued on page 7

FOCUS ON THE FUND

NEWS AND EVENTS AT THE OLFACTORY RESEARCH FUND

5TH ANNUAL NIGHT OF HONORS GALA TO RECOGNIZE CORPORATE LEADERS

The Fund's annual **Night of Honors** fund raising gala is scheduled for **Tuesday, October 20, 1998** at the United Nations in the Delegates' Dining Room. This celebration of the senses will begin with a reception at 6 p.m. followed by a sumptuous sensory dinner.

Olfactory Research Fund awards will be presented during the course of the evening. The highlight of the gala will be the presentation of the **Trophée Lalique Corporate Vision Award**. The evening's Honorary Chairman, **Steven T. Florio, President & CEO of Condé Nast Publications Inc.**, will present the award to **Shiseido Cosmetics (America), Ltd.** in recognition of its successful application of the science of aroma-chology to the product development and marketing of Shiseido's "Relaxing Fragrance." **Takashi Yamaguchi, President & CEO**, will accept the award on Shiseido's behalf.

The **Retail Sense of Smell Award** will be presented to **Federated Merchandising** in recognition of its outstanding efforts to educate fragrance sales specialists and consumers about the beneficial effects of fragrance on well being and quality of life. **Rita Mangan, Sr. Vice President, Cosmetics** will accept the award on behalf of Federated Merchandising.

The **Scientific Sense of Smell Award** will be presented to **Dr. Gary Beauchamp, President & Director** of the **Monell Chemical Senses Center**. The award recognizes Dr. Beauchamp's outstanding achievements in olfactory research and his support of the study of aroma-chology through research conducted at Monell.

The **Richard B. Salomon Award** will be presented to the **Howard Hughes Medical Institute** in recognition of its educational publication and companion web site entitled, "Hearing, Seeing & Smelling the World," which provides the public with information about how the sense of smell functions and its key role in our overall well being. **Maya Pines**, author of the publication, will accept the award on behalf of the institute.

In addition, **Medal of Honor Commendations** will be presented to those Corporate Sponsors who have made contributions to support the work of the Olfactory Research Fund. ■

AROMA-CHOLOGY MASTER CLASS – The first in a series of Aroma-Chology Master Classes has been scheduled for **Monday, November 16, 1998** at the Kitano Hotel in New York. The four-hour Master Class, focusing on **Mood & Emotion**, will provide a seminar-like environment to explore the topic in depth with the interactive leadership of recognized experts in the field. The class will be conducted by Dr. Avery Gilbert, Scientific Affairs Director of the Fund and President of Synesthetics, Inc. and Dr. Mark Greenberg, a clinical psychologist with a practice in clinical neuropscyhology and clinical psychology. All participants will receive a Compendium of Olfactory Research, copies of key scientific papers and an annotated bibliography.

Invitations for the November 16th Master Class will be mailed in September. Class size will be limited. ■

EXCLUSIVE AROMA-CHOLOGY MASTER CLASSES are offered to employees of corporations who have made Leadership Level ($100,000) Medal of Honor contributions to the Olfactory Research Fund. To date, classes have been conducted for Avon Products, Chesebrough-Pond's US Co. and S.C. Johnson Wax. A class for Coty, Inc. will be scheduled for later this year. ■

THE TOVA FELLOWSHIP PROGRAM was developed to encourage students on the graduate level to pursue a course of study which will deepen the understanding of human odor perception and the positive effects of odor on human behavior. The program is supported by a grant from **The Tova Corporation**.

The **1998 Tova Fellowship** has been awarded to **Denise Chen**, a Ph.D. candidate in the Social/Developmental Psychology Program at **Rutgers University**. The $10,000 award will support Ms. Chen's study of human olfactory communication.

Suma Jacob, recipient of the first Tova Fellowship in 1997, spent the last year working with Dr. Martha McClintock on researching the behavioral role of odors and pheromones at the **University of Chicago**. An article about Ms. Jacob's research will appear in the next issue of The Aroma-Chology Review. ■

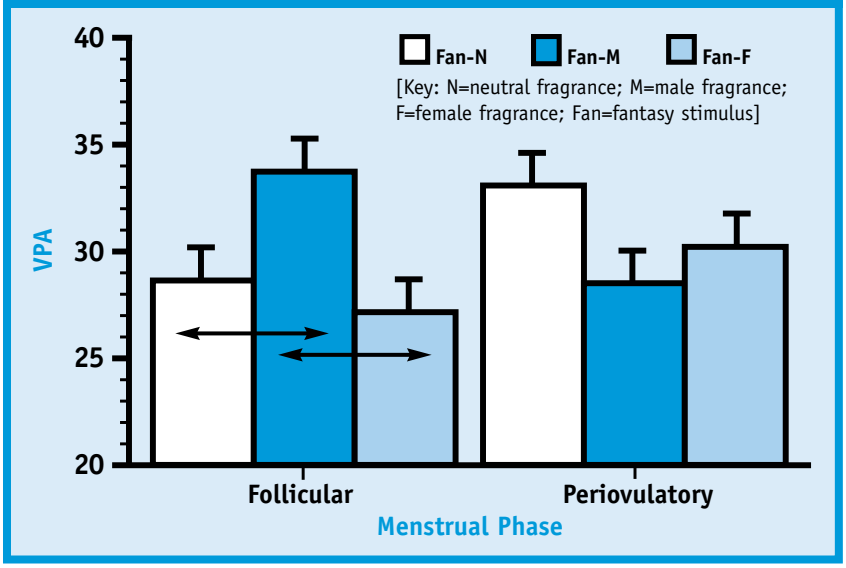
THE MEDAL OF HONORS CORPORATE SUPPORT PROGRAM is key to the success and continued growth of the Olfactory Research Fund's research, educational and public outreach programs. The Fund is pleased to announce the following Medal of Honor Pledges:

- **Coty, Inc.** – Leadership Level ($100,000)
- **Johnson & Johnson, Inc.** – Benefactor Level ($50,000)
- **Aromasys, Inc.** – Patron Level ($25,000)

All 1998 Medal of Honor contributions will be acknowledged at the "Night of Honors" on October 20, 1998.

The Fund offers many benefits to its corporate supporters. For additional information about the Medals of Honor program please contact Terry Molnar at (212) 725-2755. ■

VPA Difference Scores with Initial Baseline (Covariate Preceding Baseline) with Sexual Fantasy Stimulus



FRAGRANCE AND FEMALE SEXUALITY

continued from page 1

questionnaires. Physiological sexual arousal was measured using a small devise that assesses changes in vaginal blood flow (an index of genital arousal). Mood or emotional state was measured using an eyeblink startle response.

Forty women were recruited for the study, 28 completed both test sessions. The women were on average 26.9 years (age range 19-45 years).

Women's arousal was enhanced specifically by a male scent, not merely by an appealing smell.

Even with this relatively small number of women in the study, we found a statistically significant positive effect of the *male* fragrance on sexual arousal in women but only during erotic *fantasy*. This effect was most marked for the physiological sexual response. Since a female fragrance did not produce an effect, it seems likely that women's arousal was enhanced specifically by a male scent, not merely by an appealing smell. We also found that the physiological sexual response to male fragrance was evident only during the *postmenstrual* phase of the women's cycle, not during the peri-ovulatory phase. This was the case despite the fact that during the peri-ovulatory phase women reported overall greater sexual arousal. Exposure to male fragrance thus had the greatest impact on a women's sexual feelings when she had a lower "baseline" level of sexual arousal.

We found no significant effects of either fragrance on self-reported mood. However, the physiological index of mood (the startle response) did indicate a more positive emotional state in the presence of either a male or a female fragrance, compared to the "blank" control condition. This is consistent with studies by other investigators.

Although this was a pilot study, we found the results intriguing. The findings suggest many new avenues for investigation: what is the mechanism for the effect of a male fragrance on sexual arousal? What fragrance types are most effective? Would a male fragrance have a greater or lesser effect during other phases of the menstrual cycle? Are there complimentary effects of women's perfumes on male arousal? We hope to be able to carry out further research on the relationship between fragrance and sexuality to answer some of these questions. If further research were to replicate our findings, one possible application might be in the area of sexual dysfunction, where women might try using fragrance during erotic fantasy to increase their sexual arousal. ■

THE SMELL OF FAILURE

continued from page 2

Performance of subjects in the alternate odor and no odor groups, however, did not differ. There were no differences between boys and girls (mean for boys = 15.50, mean for girls =16.04). Additional analyses showed that "Northern Rainforest" and "Key West" odors as the same odors produced no differences in performance.

The results of this study support the hypothesis that emotions can become conditioned to odors and in turn influence behavior. This finding substantiates the view that associative learning is a powerful mechanism by which odors acquire personal significance, especially when learning takes place under emotionally salient conditions (Kirk-Smith & Booth, 1987).

In adults, odor associations are very resistant to being un-learned or re-learned (Lawless & Engen, 1977), and are especially long-lasting (Engen & Ross, 1973). Thus, odors that have acquired specific meanings early in life may set-up long-lasting cognitive, emotional, and behavioral responses. Our results suggest that scents that have acquired specific, emotional associations can alter behavior and performance. There are important implications for this finding in any setting where ambient odor scenting can be achieved. For example, our present results suggest that odors associated with success and achievement may facilitate persistence and performance on intellectual tasks in children, both at school and at home. On the basis of previous work, scents associated with security also might help alleviate anxiety induced by unfamiliar environments in nonverbal, mentally-handicapped children (Epple et al., 1995). Further implementations include the possibility of improving behavioral responses in a variety of circumstances (from physical health to inter-personal relationships) by using odors that have become associated with positive and situationally-appropriate emotions. ■

Acknowledgments

The support by the Olfactory Research Fund of the study is gratefully acknowledged. We also thank AromaSys Inc. for donating the ambient odors and the odor delivery system.

References

Engen, T. (1982). The Perception of odors. Toronto: Academic Press.

Engen, T. (1988). The acquisition of odor hedonics. In S. Van Toller & G.H. Dodd (Eds.), Perfumery: The psychology and biology of fragrance, pp.79-90. New York: Chapman & Hall.

Engen, T., & Ross, B.M. (1973). Long-term memory odors with and without verbal descriptions. Journal of Experimental Psychology, 100, 221-227.

Epple, G., Antonucci, D., & Hawley-Moore, J. (1995). Do odor memories influence behavior in children? In A.N. Gilbert (Ed.), Compendium of Olfactory Research, pp. 55-56. Olfactory Research Fund, Ltd., Kendall/Hunt Publishing Company, Dubuque, Iowa.

Herz, R.S. (1998, in press). Are odors the best cues to memory? A cross-modal comparison of associative memory stimuli. Annals of the New York Academy of Sciences.

Herz, R.S., & Cupchik, G.C. (1995). The emotional distinctiveness of odor-evoked memories. Chemical Senses, 20, 517-528.

Herz, R.S., & Engen, T. (1996). Odor memory: Review and analysis. Psychonomic Bulletin and Review, 3, 300-313.

Kirk-Smith M.D., & Booth, D.A. (1987). Chemoreception in human behaviour: experimental analysis of the social effect of fragrances. Chemical Senses, 12, 159-166.

Kirk-Smith M.D., Van Toller, S., & Dodd, G.H. (1983). Unconscious odour conditioning in human subjects. Biological Psychology, 17, 221-231.

Lawless, H., & Engen, T. (1977). Associations to Odors: Interference, mnemonics, and verbal labelling. Journal of Experimental Psychology, 3, 52-59.

Newman, P.D., Hastings, L., & Frank, R.A. (1994). The conditioning of anxiety to an odor: A possible mechanism of sympton maintenance in "sick building syndrome." Abstract, 16th Annual Meeting of ACHEMS.

Stein, M., Ottenberg, M.D., & Roulet, N. (1958). A study of the development of olfactory preferences. Archives of Neurological Psychiatry, 80, 264-266.

Van Toller, S., & Kendal-Reed, M. (1995). A possible protocognitive role for odor in human infant development. Brain and Cognition, 29, 275-293.

Winberg, J., & Porter, R.H. (1998). Olfaction and human neonatal behaviour: clinical applications. Acta Paediatrica, 87, 6-10.

HUMAN AND INSECT OLFACTION MAKE NEWS AT ACHEMS

continued from page 4

researchers postulate that it may be possible to design a diagnostic procedure to identify individual differences in the disorder and focus treatments for the specific disorder based on their peculiar nerve cell functions. Right now the effect of the treatment is determined by trial and error.

MOSQUITO OLFACTION SYMPOSIUM

Only the female mosquito bites because she needs a blood meal to acquire the protein necessary to lay her eggs. Mosquitoes find their hosts by detecting the carbon dioxide from the animals breath as well as lactic acid and other less studied byproducts of metabolism. While regarded as a nuisance in the developed world mosquitoes are responsible for more than 200 million cases of malaria and more than one million deaths per year in Africa.

Ingredients that repel mosquitoes do so by repelling them from the host (negative hedonics), by disrupting their ability to find the host or by disrupting their ability to feed. All are mosquito olfaction issues and understanding how the mosquito finds its host should help in the development of mosquito repellents.

Willem Takken and Teun Dekker of Wageningern Agriculture University report that malaria mosquitoes (*Anopheles gambiae s.l.*) show a wide variation in host preference, some species preferring humans others preferring cows. The human seeking mosquito and the one most responsible for spreading malaria, is attracted to human body odors but not to human breath or cow body odor. The cow-seeking mosquito is attracted to cow body odor as well as to carbon dioxide, but not human body odor. Thus, the malaria mosquito can distinguish blood donors by smelling differences in the chemical composition of the volatiles emanating from the host.

Alan Grant, and coworkers at the Worcester foundation, and American Biophysics Corp have identified the sensory cells that respond to carbon dioxide and other attractants. The sensory cells are found in the hair-like structures, called sensilla, found on the surface of the mosquito's mouth. By recording electrical signals from these cells the researchers have identified that 1-octen-3-ol is a good attractant.

Martin Geier, University of California at Riverside and Jurgen Boeckh, University of Regensberg, Germany used an Y-tube olfactometer to find that the attractive effect of human skin odor for the yellow fever mosquito (*Aedes aegypti*) is based on the synergism between lactic acid and several other components. Lactic acid appears to play a key role in attracting mosquitoes because the skin odors lose their attractiveness without this component.

END NOTE

This was the 20th annual AChemS meeting. I have had the pleasure of attending most of these meetings and observing the growth in the magnitude and complexity of the chemoreception sciences. Wearing my other hat, I have also been fortunate to observe the growth in magnitude and complexity of the technology that underlies the flavor and fragrance industry. While it is easy to dismiss this meeting as being "too far up stream," experience has taught me that this year's science leads to next year's new product. ■

Mosquitoes find their hosts by detecting the carbon dioxide from the animals breath as well as lactic acid and other less studied byproducts of metabolism.

1998 OLFACTORY RESEARCH FUND GOLF INVITATIONAL RESCHEDULED FOR THURSDAY, OCTOBER 22, 1998

Fiddler's Elbow Country Club, Bedminster Twp., New Jersey

The Olfactory Research Fund has changed the date of its 1998 Golf Invitational due to a conflict in the original date with the American Cancer Society's Dream Ball. We hope this change helps accommodate the schedules of industry members who wish to attend both events.

Proceeds from the 1998 Olfactory Research Fund Golf Invitational will support the Fund's *Sports Rehab: Sensory Solutions Program*.

NEED TO REACH THE FUND? TRY OUR NEW E-MAIL ADDRESSES!

General information - info@olfactory.org
Annette Green – agreen@olfactory.org
Terry Molnar - tmolnar@olfactory.org
Stephanie Bruno - sbruno@olfactory.org

THE AROMA-CHOLOGY REVIEW

Managing Editor: Annette Green
Associate Editor: Theresa Molnar
Editorial Assistant: Stephanie Bruno
Design: Julia Ptasznik

THE AROMA-CHOLOGY REVIEW is published quarterly by the Olfactory Research Fund, Ltd., 145 East 32nd Street, New York, NY 10016, Tel: (212) 725-2755. Subscriptions: Contributors to the Olfactory Research Fund receive a complimentary subscription. Annual subscription: $40.00; Single copies: $20.00; Foreign subscriptions: $10.00 additional per subscription. **ISSN#1098-044X**