OLFACTORY ACUITY AS A FUNCTION OF AGE AND GENDER: A COMPARISON OF AFRICAN AND AMERICAN SAMPLES

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ABSTRACT
A frequently reported finding in age-related sensory impairment is that olfaction shows consistent and uniform decline with age. In most studies, discerning whether loss in olfaction is due to aging per se or to factors extrinsic to the aging process (e.g., smoking, chemical exposure, head injury) is difficult. Moreover, studies of olfaction have generally relied on data collected from samples drawn primarily from Western societies. As such, little is known regarding differences in olfaction involving non-Western cultures. Using international data from the 1986 National Geographic Smell Survey, responses of 19,219 American respondents and 3,204 respondents from Africa were analyzed. All respondents were screened for factors negatively affecting olfaction. Measures of olfactory acuity included odor detection, identification, intensity, and quality. The odor of interest was androstenone, a scent produced by bacteria on the human body and appearing in sweat. The results indicate that some measures of olfactory acuity tend to decline across age groups, but that this decline is less marked than reported in previous studies. The most important finding is that loss of olfaction is not consistent or uniform between geographic regions of America or Africa, between male vs. female respondents, or among the four measures of olfactory acuity. African respondents (both men and women) had significantly higher percentages of detection than did American respondents, women generally reported higher levels of olfactory functioning than did men, and some measures of olfaction were stable across age groups, or were higher among older respondents (e.g., odor identification).
Investigative zeal frequently needs to be tempered with the realization that certain research strategies and practices may—and often do—result in distorted views of aging. Most often, this distortion is in the form of emphasizing and exaggerating loss. Three examples can be cited in this regard. First, reliance on cross-sectional research designs for descriptions of age-changes involves a confounding of age and cohort effects, and can result in an overstatement of the amount of loss that occurs with age [1]. Second, inclusion of research subjects who have not been carefully screened for age-extrinsic risk factors may overstate the case for age-related loss due to difficulty in discerning whether reported findings are a product of normal aging or pathological factors such as disease and prejudicial environments [2]. Third, the paucity of cross-cultural studies restricts our view of the plasticity of human functioning and performance throughout the human life cycle [3].

Even when these issues are recognized and addressed, a significant problematic practice remains: the categorization of research populations into diseased versus normal. In studies where samples have been carefully screened for pathology, researchers often feel confident in inferring patterns of normal age-related loss from the comparatively lower average scores of older age groups. Closer examination of these data sets, however, reveals that there is also substantial heterogeneity among age groups. For example, in spite of the finding that average scores for older age groups are usually lower than those reported for younger age groups, there are older persons with minimal or no physiologic loss when contrasted with average performances of their younger counterparts.

One conclusion to be drawn from the phenomenon of heterogeneity within age groups is the importance of conceptually distinguishing between normal and successful aging [2]. Normal aging connotes differences in average performance and functioning across age groups, whereas successful aging describes those instances wherein performance and functioning of older subjects does not parallel “average” loss and decline, and may in some instances exceed that of younger subjects.

The distinction between usual and successful aging is an intriguing concept, the value of which is often hidden (or at least not fully appreciated) when research on age-related changes does not include cross-cultural comparisons. For example, when examined only within the context of Western industrialized societies, age-linked increases in blood pressure, body weight, and serum cholesterol levels appear to be usual or normal components of aging. Indeed, such changes may be—and often are—viewed as age-intrinsic. Only in the context of cross-cultural investigations is it apparent that change in these variables (e.g., increases in blood pressure) and the resulting age-linked increases in heart disease may be normal or usual in Western industrial countries, although this is true among pastoral and traditional agricultural societies [4]. In this instance, the concept of successful aging (operationalized in terms of heterogeneity in factors
affecting heart disease) is revealed only through cross-cultural comparisons involving both industrial and agricultural societies.

More directly relevant to the focus of this article is the work of Rosen et al. [3] who reported that measures of auditory performance were more adversely affected by age in an American sample than in a Mabaan sample, a nomadic African tribe [3]. Age-related differences in hearing were reported for both the African and American samples. However, these differences were significantly less in the African sample. Auditory performance scores for seventy to seventy-nine-year-old members of the Mabaan were similar to those of Americans in their thirties and forties. Even though these data were collected using a cross-sectional research design, the reported cross-cultural differences suggests that rate of hearing loss over the life course is not due solely to age-intrinsic factors, but may be influenced by modifiable environmental factors such as noise pollution.

Cross-cultural comparisons may represent one of the most effective means of identifying age-group heterogeneity and highlighting the parameters of successful aging [5]. For example, without benefit of findings such as those reported by Rosen et al. age-related differences in measures of auditory functioning in American samples appear to be normal, even accounting for heterogeneity of performance within age groups [3]. Only when cross-cultural differences between African and American samples are observed does it become apparent that the performance parameters defining successful aging (in auditory performance and functioning) in American culture needs to be altered.

What about other sensory modalities, particularly those that have received less empirical attention, such as taste or smell? Do cross-cultural comparisons similar to the one reported by Rosen and his colleagues [3] reveal that age-linked losses in sensory perception and functioning within American culture may be exaggerated?

This article focuses on the sensory modality of olfaction, or sense of smell. The key question guiding this analysis was to what extent age-related changes in olfaction normally attributed to age per se might also be a product of environmental factors that vary between Western and non-Western cultures.

Numerous studies have documented consistent and uniform age-related declines in olfaction [6]. For example, we know that older persons demonstrate higher detection thresholds for scents [7-10], and often have an impaired ability to correctly identify and discriminate odors [10-16].

Importantly, the majority of these studies have been conducted on samples primarily in the United States and other Western origins. What about olfaction in non-Western countries and regions? A literature search for studies conducted within the last ten years identified only two cross-cultural studies on olfaction involving non-Western cultures. One was a comparison of odor threshold values in Japan and the Netherlands [17]. The other reported a monumental attempt to collect olfactory data using an international survey distributed by the National
Geographic Society in 1986 [5]. Unfortunately, the bulk of published findings derived from this database have centered primarily on analyses of data collected from a large United States sample [16]. International comparisons involving non-Western cultures have been only minimally published.

Additionally, what many olfactory studies have failed to do—including the cross-cultural studies cited above—is to systematically separate the influence of aging per se from the deleterious effects of factors such as poor health habits, noxious environments, or disease and its treatment. There appear to be age-related losses in olfactory acuity. What remains unclear is the extent to which these losses are exaggerated by inclusion of smokers, people who suffer diseases that might adversely affect olfaction, and/or individuals who live or work in environments with chemical exposure.

The purpose of this study was to compare four measures of olfactory acuity in samples of healthy women and men residing in America and Africa. “Healthy” was defined as the reported absence of life styles and conditions that negatively affect olfaction (e.g., smoking, exposure to chemicals, head injury, allergies, etc.).

**METHODS**

**Data**

Data utilized in these analyses are cross-sectional in nature, and were collected as part of a project funded by the National Institutes of Health and conducted jointly by the Monell Chemical Senses Center and the National Geographic Society. The Monell researchers were asked to collaborate in the design of an olfactory questionnaire to be inserted within an article on the sense of smell. The resulting smell survey appeared in the September 1986 issue of the *National Geographic*, and was sent to 10.5 million subscribers worldwide. The 1.5 million responses to this survey were compiled by the National Geographic Society and made available on magnetic tapes. The data tapes contain information on four groups: 1) U.S. respondents (1.2 million); 2) Canadian respondents (98,998); 3) respondents from other countries and geographic regions worldwide (199,000); and 4) a 2 percent random subsample of United States respondents (26,200). This article compares the 2 percent U.S. subsample with 4,132 respondents residing in the geographic region of Africa; specifically Egypt, Kenya, Malawi, Nigeria, South Africa, Zambia, Zimbabwe, and Bahrain.

**The Survey Questionnaire and Measurement of Variables**

The first section of the survey solicited information on self-rated health and demographic variables. This section included questions such as: How would you describe your sense of smell? (5-point scale, poor to excellent). Have you ever
experienced a loss of smell due to the following? (exposure to chemicals, pregnancy, flu/common cold/sinus infection, head injury, allergy attack, unknown causes). Do you currently smoke tobacco? (yes, no). What is your age? Are you male or female? The remaining sections of the survey assessed respondents' olfactory acuity for six odor samples (androstenone—sweat; isoamyl acetate—banana; Galaxolide—musk; eugenol—cloves; mercaptans—natural gas; and rose). Androstenone (sweat) is the focus of this article.

Occurring in some plants and animals, androstenone is also produced by bacteria in human underarms and appears in sweat. Humans frequently display anosmia, or odor blindness, for androstenone [5]. Some suggest that this anosmia is genetically inherited [18, 19].

Four measures of olfactory acuity are reported: detection, identification, intensity, and quality (pleasantness). To measure each of these olfactory attributes, respondents were asked to “scratch” the odor sample, smell the sample, and then answer the following questions:

1. Detection: “Did you smell something?” (yes or no)
2. Identification: “Which word best describes this odor?” (Choices included: no odor, floral, musky, urine, foul, ink, spicy, woody, fruity, burnt, sweet, and other). Identification for androstenone was scored “correct” if the respondent indicated “musky,” “foul” or “urine.”
3. Intensity: “How intense is the odor?” (5-point scale: 1 = weak, 5 = strong)
4. Quality: “How would you rate the quality of this odor?” (5-point scale: 1 = unpleasant; 5 = pleasant).

Description of Samples

To control for factors other than age that might adversely affect olfactory acuity, samples from both America and Africa were screened to exclude respondents who reported that they smoked. Also excluded were respondents who indicated that they had experienced a loss of smell due to one or more of the following conditions: 1) exposure to chemicals, 2) pregnancy, 3) head injury, and 4) allergies. Exclusion of pregnant women, commonly thought to be smell-sensitive, was based on research indicating that they may actually experience a diminished sense of smell [20]. Also excluded from the analyses were individuals who failed to indicate both age and gender.

This screening process resulted in a sample of 19,219 Americans and 3,204 Africans who were deemed “healthy” in terms of olfactory acuity. Slightly more than one in every five respondents was excluded due to the screening criteria in both samples (American sample = 26.6%; African sample = 22.5%). Attrition rates did vary across age groups in both samples. The highest attrition rate was in the twenty to twenty-nine year age group (American sample = 30.4%; African sample = 24.6%). The lowest rates were for the age seventy-plus group (16.7% and 16.3% respectively).
The frequency distribution of respondents by sex across all age categories for each geographic region is depicted in Figure 1.

Men comprised 44.8 percent (8,607) of the American sample, and women 55.2 percent (10,612). These percentages were reversed in the African sample: 54 percent (1,731) were men and 46 percent (1,473) were women. In the African sample there were more men in every age group after age twenty-nine. Due to higher mortality rates among men, women were under-represented in the African sample, particularly at older ages. In the American sample, women were under-represented at ages seventy or above.

Figure 1. Percentage distribution of male vs. female respondents.
In the American sample, mean age was 40.2 (range = 10 to 93) years. Percentage distributions by age in decades are presented in Figure 1. In the African sample, mean age was 39.1 (range = 10 to 86) years. Percentage distributions by age in decades are also given in Figure 1.

LIMITATIONS, RESULTS AND DISCUSSION

Limitations

Given the focus on age changes in olfaction over the life cycle, the most prominent limitation of this study is the cross-sectional nature of the data. There is no way of knowing to what extent age-group differences in measures of olfactory acuity reflect patterns of change associated with the processes of aging, or are a product of cohort effects [1]. Most likely, the age group differences reported here reflect the influence of both age and cohort membership.¹

A second limitation is that respondents are not representative of the populations of the countries surveyed, or even of the population that subscribes to the National Geographic. There also is no guarantee that only subscribers completed and returned the survey. The population for this study includes anyone likely to pick up a copy of the National Geographic and complete an enclosed survey. In the United States, National Geographic subscribers tend to have higher mean income and more years of formal education than the general population (based on 1984 membership information provided by the National Geographic Society). Such may also have been the case for respondents from the African countries.

Self-Rating of Smell

As would be expected of samples “screened” for olfactory problems, the self-ratings of smell were high and, with few exceptions, were consistent for men and women across all age groups in both geographic regions. Women generally reported higher self-ratings than did men. In fact, with regard to same-age group comparisons, there was only one instance wherein women reported lower ratings than men: ten to nineteen-year-old African women versus ten to nineteen-year-old American men (Figure 2).

Self-ratings in these “healthy” samples are higher than those reported in other studies wherein respondents were not screened for factors adversely affecting

¹ Given the cross-sectional data used in this study, changes in olfaction over the life cycle were not directly assessed. However, some of the language used in presenting findings may imply age-related change (i.e., increase, decrease, decline). Remember that patterns of olfactory performance scores from age ten to seventy-plus actually represent comparisons of different age groups at one point in time.
Figure 2. Self-rating for smell. Rating Scale: 1 = Poor, 5 = Excellent.

smell. Using the entire sample of 1.2 million United States respondents to the National Geographic Smell Survey, Wysocki and Gilbert [16] reported that women's self-ratings increase through the fifth decade and then decrease, with an accelerated decline in the seventh decade. Further, they reported that self-ratings for men decrease in a linear fashion across the life span. Such was not the case for African men whose self-ratings remained fairly constant across age groups.
Detection

In terms of cross-cultural comparisons, what is striking about self-ratings for smell is that American women generally reported higher ratings than did African women, and that American men reported higher ratings than did African men. Assuming that self-ratings would be predictive of actual performance on olfactory measures, one might expect that a comparatively higher percentage of American respondents would report detecting androstenone, but such was not the case. The shape of the age-response curve in the olfactory measure of detection varied significantly between the American and African samples, with a higher percentage of the African sample reporting detection of androstenone. This was true for every age group (Figure 3).

Within geographic regions, there was also a significant gender difference, with women more often reporting detection of the odor than men. Importantly, African men had higher detection rates than did American women, and this was true for all age groups.

The age-response curve for detection represented a linear decline beginning in the first decade, and continuing through the seventh decade. Generally speaking, the rate of decline across all age groups was similar for both males and females and for both geographic regions. The only exception to this trend was for African women wherein a slight increase in detection was reported between that third and fifth decade.

Identification

It is important to note that detection and identification are related measures of olfactory acuity, but they are not necessarily mutually exclusive. Whereas detection reflects principally a sensory process, identification reflects both sensory and cognitive processes [21]. In samples where subjects are cognitively healthy (e.g., the absence of dementia), measures of detection and identification correlate strongly. Because of the cognitive component of identification, however, age effects on olfactory identification may also be a product of the strategy used to assess identification. In this study, “cued” identification was used. That is, subjects were given a list of twelve adjectives that could be used to describe the odor of androstenone (no odor, floral, musky, urine, foul, ink, spicy, woody, fruity, burnt, sweet, and other) and asked to indicate which adjective best described the odor. Previous studies have indicated that although cued identification of odors might counteract problems of retrieval from memory (where no cues are given) in both young and old individuals, it seems to work better for younger subjects [22]. As a result, it is possible that cued identification of odors exaggerates differences from middle age to old age.

In addition to age-bias in odor identification, there is also the possibility of culture bias. Odor learning—assigning appropriate descriptors to scents—is life-long and depends largely on familiarity and exposure, which may vary from
culture to culture, and even among birth cohorts within a given culture. The descriptive adjectives used in this survey were generated from previous studies and from pilot tests conducted by the Monell Chemical Senses Center in Philadelphia, Pennsylvania, and by International Flavors and Fragrances in Union Beach, New Jersey [16]. For each odor in the survey, the most frequently chosen adjective from these pilot studies was included among the twelve adjectives from which respondents had to choose, and from which a "correct" identification was determined. As was previously mentioned, "correct" identification
of the odor of androstenone was predicated on selecting one of three adjectives: musky, foul, or urine. It should be noted that the adjective, floral, technically could have been counted as correct since androstenone is an odor of some plants.

The pilot tests and preliminary studies used to generate these adjectives attempted to collect data from diverse audiences. Nevertheless, the final slate of adjectives, as well as the adjectives used to determine "correct" identification, were largely normed in a manner that did not include non-Western cultures. When combined with problems that often arise in translation, there is the possibility that the measure of odor identification was not equivalent across all cultures included in the survey, particularly for non-Western cultures such as Africa.

The percent of respondents identifying androstenone within each age group is given in Figure 4. Generally, correct identification of androstenone was quite low. In no instance did more than 35 percent of a group (defined in terms of gender, age, and/or geographic region) correctly identify the odor.

For the American sample (both men and women), the age-response curve for identification was generally linear, with a steady increase from the first through the seventh decade. Such was not the case for African respondents. For both African women and men, identification decreased from the first through the third decade, increased from the third through the fourth decade, and steadily decreased thereafter. Among African respondents, the reasons for the cohort differences in identification (i.e., the drop in identification scores in the first three decades, and the significant increase in fourth decade) are not clear. What can be noted, however, is that the factor(s) that influenced these trends appear to have a similar impact on both women and men.

**Intensity**

Odor intensity was a measure of how strong the respondent perceived the odor sample to be (rated on a 5-point scale: 1 = weak, 5 = strong). Ratings of odor intensity (as well as odor quality) were based only on odor samples that a respondent was able to detect. Depicted in Figure 5 are the mean intensity ratings for androstenone for all age groups.

For all groups (male and females, American and African respondents), odor intensity dropped sharply between the first and second decade. Thereafter, intensity remained relatively stable for female respondents, but gradually declined in a linear fashion through the seventh decade for male respondents. Within each geographic region, female respondents reported higher intensity ratings than did male respondents.

**Quality (Pleasantness)**

The fourth and final measure of olfactory acuity addressed in this article is odor quality; that is, the perceived "pleasantness" of an odor. Higher scores were indicative of a more pleasant odor (1 = unpleasant; 5 = pleasant).
As previously noted, odor detection reflects principally a sensory process. The same is true for odor intensity. The measures of odor identification and quality, however, are more complex. Odor identification also includes cognitive processes, and the rating of odor quality involves evaluative process that may vary across cultures. In previous reports of the National Geographic Smell Survey [16], investigators have reported that quality or pleasantness ratings varied in idiosyncratic, odorant-specific fashion with advancing age, indicating perhaps
the fact that an assessment of odor quality is the most complex measure of olfactory acuity.

As can be seen from Figure 6, ratings of odor quality over the life span increased through the first two decades, remained relatively stable through the fifth decade, and then increased thereafter. Men tended to rate androsteneone as more pleasant than did women, and this was true for both geographic regions.
CONCLUSION

This article began with several key premises; one was that age-related changes reported in gerontological research have overstated the case for loss due to a variety of questionable research practices. Among these has been the inclusion of individuals afflicted with diseases and conditions extrinsic to the aging process. Results reported here indicate that some measures of olfactory acuity
such as detection tend to decline with age even in a “healthy” sample screened for factors that would negatively affect smell, but that this decline is less marked than that reported for Smell Survey samples not screened for factors negatively affecting olfaction [16]. The implication of this observation is that at least some of the age-related loss in olfaction initially reported from analyses of National Geographic Smell Survey data may be a function of variables other than age.

Another premise was that heterogeneity is a critical dimension of the aging process often overlooked when investigators emphasize only comparative average performance scores among age groups. Very few individuals are actually represented by average values. This is particularly important among older age groups since differences between individuals (usually represented statistically by the standard deviation from the mean) increases with age [23]. By almost any standard and across a variety of parameters, humans age at different rates and these differences increase with advancing calendar age.

With regard to variability in olfactory acuity, Wysocki and Gilbert observe that older persons often participate with gusto in gourmet societies, and that perfumers and wine tasters improve with age [16]. Conversely, many prescription medications are known to affect taste and smell, and contribute to variability in olfactory performance and functioning. To focus exclusively on average loss—and to ignore variability—in olfaction leads to a view of sensory loss as inevitable and irreversible.

The concepts of plasticity [24] and successful aging [2] build on the observation of variability or heterogeneity. Plasticity and successful aging are concepts connoting that the capability for a given attribute such as a measure of olfaction is not fixed, but may be modified. The case for modification is strengthened by cross-cultural studies wherein variability in performance and functioning hints that reasons for differences may be linked to culture [3, 4].

With this in mind, perhaps the most important finding in this study is that loss of olfaction (with regard to the odor of androstenone) is not consistent or uniform between the geographic regions of America or Africa, between male vs. female respondents, or among the four measures of olfactory acuity. African respondents (both women and men) had significantly higher percentages of detection than did American respondents, women generally reported higher levels of olfactory functioning than did men on many measures, and some measures of olfaction revealed stability or even an increase with age (e.g., odor identification).

What do these differences mean? Since this was a descriptive study, explanatory answers are difficult. So many variables are involved. The relatively lower rates of detection among American respondents may have been a product sampling bias. Perhaps American respondents who could not detect the odor were simply more prone to complete and return the survey than were African respondents who could not detect the odor. The geographic differences may also
indicate that there were environmental factors affecting olfaction. For example, research indicates that repeated exposure to androstenone can improve the ability to detect it [16]. Perhaps the African respondents had higher detection levels because the cultures in which they live involved more frequent exposure to androstenone.

Whatever the explanations for differences in olfactory measures, the finding that differences exist—especially cross-cultural differences—emphasizes that chronological age itself is not always a reliable marker for olfactory aging, even for sensory processes linked to genetic inheritance such as the detection of androstenone. The fact that there are differences in olfaction and that some individuals display comparatively higher levels of performance, functioning and well-being in later life than others suggests that there are reasons for these differences. If these reasons can be identified, then perhaps clues can be gleaned with regard to optimizing olfaction in human aging.

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