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SEX DIFFERENCES IN ODOR IDENTIFICATION ABILITY A CROSS-CULTURAL ANALYSIS

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Abstract—To ascertain the generality of a sex difference noted in odor identification ability, the University of Pennsylvania Smell Identification Test (UPSIT) was administered to four groups of subjects: Black Americans ($n=438$), White Americans ($n=1559$), Korean Americans ($n=106$), and Native Japanese ($n=308$). The women of all four groups outperformed the men to the same relative degree. The Korean American group performed better than the Black and White American groups, which, in turn, outperformed the Native Japanese. Analyses of the proportions of subjects correctly answering each of the test items revealed considerable similarity of relative item difficulty among the subject groups. Taken together, these data suggest that sex differences in odor identification ability are probably not due to ethnic or cultural factors, *per se*.

INTRODUCTION

RECENT studies of olfactory function have revealed that women surpass men in their ability to identify odors in both forced-choice and free recall test paradigms [3, 8, 14]. Furthermore, such sex differences have been found to occur across both prepubertal and postpubertal age ranges [8]. Since these studies have focussed mainly upon Caucasian subjects, however, the generality of their findings to other ethnic groups is not known. The demonstration of comparable sex differences in persons of different ethnic and cultural backgrounds would suggest a biologic, rather than an experiential, basis.

The present study sought to determine if the sex difference noted on a recently developed standardized odor identification test is present in each of four ethnic/cultural groups: (a) American Blacks; (b) American Whites; (c) American Koreans; and (d) Native Japanese. Although cross-cultural studies have been performed previously within the chemical senses [e.g. 1, 25], this work is the first to focus on sex differences in chemosensory function among such groups.

METHODS

Subjects

The study population consisted of 660 male and 899 female White Americans ($\bar{x}$ ages = 39.1 and 41.1 yr, respectively), 210 male and 228 female Black Americans ($\bar{x}$ ages = 29.7 and 36.0 yr), 53 male and 53 female Korean Americans ($\bar{x}$ ages = 14.1 and 14.3 yr), and 117 male and 191 female Native Japanese ($\bar{x}$ ages = 25.5 and 21.8 yr). The proportions of male and female cigarette smokers were similar within each of the samples, with the exception of the

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Japanese group, which had many more male than female smokers (% male and female current smokers, respectively: White Americans, 8.4, 9.8; Black Americans, 15.8, 16.2; Korean Americans, 0,0; Native Japanese, 20.5, 1.3).

The White American and Black American subject groups consisted mainly of (a) University of Pennsylvania employees, (b) residents of homes for the elderly, (c) persons attending regional health fairs, (d) university students, (e) primary and secondary grade school students, and (f) youngsters enrolled at summer camps and day care centers in the Philadelphia area. The data from 97%of the white subjects and 80% of the black subjects have been presented in previous publications [13, 14]. The Korean Americans were recruited from a Sunday school population at a local Korean church. The Japanese subjects were members of the staff and faculty of a hospital in a medium-sized Japanese metropolitan city (Kawasaki-shi).

Odor identification test

The University of Pennsylvania Smell Identification Test (UPSIT; commercially available as the Smell Identification Test™, Sensonics, Inc., Philadelphia) was administered in this study [14]. This test consists of four envelope-sized booklets containing 10 odorants apiece, one odorant per page. The "scratch 'n sniff" stimuli are embedded in 10–50-μm-diameter microencapsulated crystals located at the bottom of each page [5, 14]. A multiple-choice question with four alternative answers for each item is located immediately above each odorant. For example, one of the test items reads, "This odor smells most like: (a) chocolate; (b) banana; (c) onion; or (d) fruit punch". The subject is required to answer one of the four alternatives, even if no smell is perceived (i.e. the test is forced-choice). The stimuli and the criteria for their selection are presented elsewhere [14]. This test is internally consistent (odd-even r after Spearman–Brown correction = 0.94), highly reliable (short-term test–retest reliability coefficient $r = 0.95$; six-month test–retest reliability $r = 0.92$), and sensitive to a number of subtle aberrations of smell function, including those associated with Korsakoff's psychosis and multiple sclerosis [12, 14]. Indeed, scores on this test have been shown to correlate strongly with cerebral spinal fluid levels of a major metabolite of norepinephrine in Korsakoff's psychosis patients [21].

Procedure

The UPSIT was self-administered by the majority of the subjects following detailed instructions by a trained test administrator. The tests were administered in English to all groups but the native Japanese, who received a Japanese version of the test.

RESULTS

The mean correct UPSIT scores, associated standard deviations, and age-adjusted means for the four groups are presented in Table 1. A sex by culture analysis of covariance (covariates = age and age^2) revealed significant sex and culture main effects [F_{sex} (1, 2402) = 39.80, $P < 0.001$, % variance accounted for using coefficient of partial determination = 0.46, and $F_{culture}$ (3, 2402) = 78.11, $P < 0.001$, % variance accounted for = 5.41], cf. [27]. No sex by culture interaction effect was present [F (3, 2402) = 0.13]. The two covariates were included because scores on the UPSIT are non-linearly related to age [13, 14]. As expected, both age and age^2 were statistically significant [F_{age} (1, 2402) = 393.46, $P < 0.001$ and F_{age^2} (1, 2402) = 750.88, $P < 0.001$].

Table University of Pennsylvania Smell Identification Test (UPSIT) raw score means, standard deviations, and means adjusted for age by analysis of covariance (see text for details)

	Males			Females			Combined		
	Raw mean	S.D.	Adjusted mean	Raw mean	S.D.	Adjusted mean	Raw mean	S.D.	Adjusted mean
Native Japanese	31.8	3.52	29.5	33.5	3.18	31.8	32.9	3.41	31.0
Black Americans	33.6	5.53	32.4	34.7	5.61	34.0	34.1	5.59	33.2
White Americans	33.2	5.53	33.6	34.9	6.32	35.8	34.2	6.85	34.9
Korean Americans	37.2	2.14	36.6	38.6	1.21	38.0	37.9	1.86	37.3

On the average, women outperformed men in all four groups, correctly answering between 3% and 5% more of the test items in each case (Table 1). A Tukey *B* multiple-comparison *post hoc* analysis revealed that the means for all of the cultural groups differed significantly from one another ($Ps < 0.01$), with the exception of those of the American Black and White groups, which did not differ. Overall, the Korean Americans outperformed the Black and White Americans who, in turn, outperformed the Native Japanese. Despite these significant differences, however, the means of three of the four groups were within four points of one another.

To ascertain whether the various test items were missed in similar relative degree among the four groups, Kendall Coefficients of Concordance [30] were calculated for the male and female groups across the test items ranked, within each culture, according to the proportion of the group correctly answering them. Considerable similarity existed among the relative rankings of the four ethnic groups [for males, $W(39) = 0.67$, $P < 0.001$; for females, $W(39) = 0.64$, $P < 0.001$], suggesting that the "hard" and "easy" items were similar among the groups. Spearman correlations computed between such ranks for the males and females of each culture revealed that males and females tended to miss the same items to the same relative degree (Native Japanese $r = 0.84$, $P < 0.001$; Black American $r = 0.82$, $P < 0.001$; Caucasian American $r = 0.90$, $P < 0.001$; Korean American $r = 0.52$, $P < 0.001$). The lower r value for the Korean Americans reflects, in part, the extremely large number of tied ranks in this highly performing group (over 50 ties were distributed among 12 values for the males and eight values for the females).

Although there was general agreement in the performance of the four groups across the 40 items of the test, a few of the items were disproportionately missed by the Japanese nationals, possibly reflecting cultural differences in familiarity. Those items which were incorrectly identified most often by the Japanese group were "cherry" (65.5% of the Japanese group missed this item, vs 10.5, 7.5, and 8.8% of the Caucasian American, Black American, and Korean American groups, respectively), "fruit punch" (54.6 vs 19.9, 18.3 and 24.6%), "wintergreen" (25.6 vs 10.5, 11.6 and 2.8%), and "dill pickle" (32.5 vs 19.8, 18.3 and 24.6%).

DISCUSSION

The present data demonstrate that women from four different ethnic/cultural groups outperform their male counterparts to the same degree in a forced-choice odor identification task. This finding suggests the sex difference in olfactory identification ability is a general trait.

Although some previous studies (limited to Caucasian subjects) have noted sex differences in olfactory function, others have not, leading to controversy on this point [8]. The present data suggest that the sex difference in odor identification ability, even though statistically significant, is subtle. As has been noted for sex differences in verbal and spatial abilities, cf. [6, 23], this difference accounts for only a small proportion of the total variance. The use of over 2000 subjects in the present work probably resulted in a clear detection of this difference—a difference not robust enough to be detected by small sample sizes and less reliable olfactory measures.

Since approximately equal proportions of males and females in the White American and Black American groups smoked, and none of the subjects in the Korean American group smoked, the sex difference noted in these three groups is unlikely to be due to cigarette smoking. In the relatively young Japanese group, significantly more men than women

REFERENCES

1. BERTINO, M., BEAUCHAMP, G. K. and JEN, K. C. Rated taste perception in two cultural groups. *Chem. Senses* **8,** 3–15, 1983.
2. BROWN, M. P. Menstrual rhythms in sensory processes: a review of fluctuations in vision, olfaction, audition, taste, and touch. *Psychol. Bull.* **93,** 539–548, 1983.
3. CAIN, W. S. Odor identification by males and females: predictions vs performance. *Chem. Senses* **7,** 129–142, 1982.
4. CORSO, J. F. Age and sex differences in pure-tone thresholds. *Archs Otolar.* **77,** 385–405, 1963.
5. DAVIS, R. G. The microencapsulation of odorants as a method of stimulus control and delivery in studies of odor quality perception, *Chem. Senses Flav.* **4,** 191–206, 1979.
6. DENNO, D. Sex differences in cognition: a review and critique of the longitudinal evidence. *Adolescence* **17,** 779–788, 1982.
7. DOTY, R. L. Gender and reproductive state correlates of taste perception in humans. In *Sex and Behavior: Status and Prospectus*, T. MCGILL, D. A. DEWSBURY and B. SACHS (Editors), pp. 337–362. Plenum Press, New York, 1978.
8. DOTY, R. L. Gender and endocrine-related influences upon olfactory sensitivity. In *Clinical Measurement of Taste and Smell*, H. L. MEISELMAN and R. S. RIVLIN (Editors). MacMillan, New York, 1985 (in press).
9. DOTY, R. L., FORD, M., PRETI, G. and HUGGINS, G. Human vaginal odors change in pleasantness and intensity during the human menstrual cycle. *Science* **190,** 1316–1318, 1975.
10. DOTY, R. L., GREEN, P. A., RAM, C. and YANKELL, S. L. Communication of gender from human breath odors: relation to perceived intensity and pleasantness. *Horm. Behav.* **16,** 13–22, 1982.
11. DOTY, R. L., KLIGMAN, A., LEYDEN, J. and ORNDORFF, M. M. Communication of gender from human axillary odors: relationship to perceived intensity and hedonicity. *Behav. Biol.* **23,** 373–380, 1978.
12. DOTY, R. L., NEWHOUSE, M. G., and AZZALINA, J. Internal consistency and short-term test–retest reliability of the University of Pennsylvania Smell Identification Test. *Chem. Senses*, in press
13. DOTY, R. L., SHAMAN, P., APPLEBAUM, S. L., GIBERSON, R., SIKSORSKI, L, and ROSENBERG, L. Smell identification ability: changes with age. *Science* **226,** 1441–1443, 1984.
14. DOTY, R. L., SHAMAN, P., DANN, M. Development of the University of Pennsylvania Smell Identification Test: a standardized microencapsulated test of olfactory function. *Physiol. Behav.* **32,** 489–502, 1984.
15. DRUZ, L. L. and BALDWIN, R. E. Taste thresholds and hedonic responses of panels representing three nationalities, *J. Food Sci.* **47,** 561–569, 1982.
16. GORSKI, R. A., HARLAN, R. F., JACOBSON, C. D., SHRYNE, J. E. and SOUTHAM, A. M. Evidence for the existence of a sexually dimorphic nucleus in the preoptic area of the rat. *J. comp. Neurol.* **193,** 529–539, 1980.
17. GREENOUGH, W. T., CARTER, C. S., STEERMAN, C. and DEVOOGD, T. J. Sex differences in the dendritic patterns in hamster preoptic area. *Brain Res.* **126,** 63–72, 1977.
18. JERGER, J. and HALL, J. Effects of age and sex on auditory brainstem response. *Archs Otolar.* **106,** 387–391, 1980.
19. KOELEGA, H. S. and KÖSTER, E. P. Some experiments on sex differences in odor perception. *Ann. N.Y. Acad. Sci.* **34,** 51–66, 1970.
20. LE MAGNEN, J. Les phenomenes olfacto-sexuels chez l'homme. *Archs Sci. Physiol.* **6,** 125–160, 1952.
21. MAIR, R. B., MCENTEE, W. J. and DOTY, R. L. Olfactory perception in Korsakoff's psychosis: correlation with brain noradrenergic activity. *Neurology* **33,** (Suppl. 2), 64–65, 1983.
22. MATSUMOTO, A. and ARAI, Y. Sexual dimorphism in 'wiring pattern' in the hypothalamic arcuate nucleus and its modification by neonatal hormonal environment. *Brain Res.* **190,** 238–242, 1980.
23. MCGEE, M. G. Human spatial abilities: psychometric studies and environmental, genetic, hormonal and neurological influences. *Psychol. Bull.* **86,** 889–919, 1979.
24. MCGUINNESS, D. Sex differences in the organization of perception and cognition. In *Exploring Sex Differences*, B. LLOYD and J. ARCHER (Editors), pp. 123–156. Academic Press, New York, 1976.
25. MOSKOWITZ, H. W., KAMURIAH, V., SHARMA, K. N., JACOBS, H. L. and SHARMA, S. D. Cross-cultural differences in simple taste preferences. *Science* **90,** 1217–1218, 1975.
26. NEI, M. and ROYCHOUDHURY, A. K. Gene differences between Caucasian, Negro and Japanese populations. *Science* **177,** 434–435, 1972.
27. NETTER, J. and WASSERMAN, W. *Applied Linear Statistical Models.* Richard D. Irwin, Homewood, Illinois, 1974.
28. REED, T. E. Caucasian genes in American Negroes. *Science* **165,** 762–768, 1969.
29. SCHNEIDER, R. A. and WOLF, S. Olfactory perception thresholds for citral utilizing a new type olfactorium. *J. appl. Physiol.* **8,** 337–342, 1955.
30. SIEGEL, S. *Nonparametric Statistics for the Behavioral Sciences.* McGraw-Hill, New York, 1956.
31. TOULOUSE, E. and VASCHIDE, N. Mesure de l'odorat chez l'homme et chez la femme. *C.r. Acad. Sci. Biol., Paris* **51,** 381–383, 1899.
32. VENSTROM, D. and AMOORE, J. E. Olfactory threshold in relation to age, sex or smoking. *J. Food Sci.* **33,** 264–265, 1968.
33. WYANT, K. W. and MEISELMAN, H. L. Sex and race differences in food preferences of military personnel. *J. Am. diet. Ass.* **84,** 169–175, 1984.

32. VENSTROM, D. and AMOORE, J. E. Olfactory threshold in relation to age, sex or smoking. *J. Food Sci.* **33,** 264–265, 1968.
33. WYANT, K. W. and MEISELMAN, H. L. Sex and race differences in food preferences of military personnel. *J. Am. diet. Ass.* **84,** 169–175, 1984.