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Occupational screening of olfactory function

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ABSTRACT

To assess the feasibility of mass screening of olfactory function in a corporate setting, we asked workers frequenting the cafeteria of the corporate offices of a major chemical manufacturing company to voluntarily self-administer the University of Pennsylvania Smell Identification Test. Although the majority agreed to participate in the project, only about half returned completed tests to the examiners, possibly reflecting the informal atmosphere in which the tests were distributed. On average, the corporate subjects performed slightly better than previously-tested controls matched on the basis of gender, age, smoking habits, and ethnic background. As in previous studies, women significantly outperformed men, and age was significantly related to the test scores. Approximately 1% of the group evidenced major olfactory dysfunction relative to published percentile norms. Thus, in addition to demonstrating that self-administered olfactory testing is practical and feasible within the corporate setting, these data suggest that the incidence of olfactory dysfunction is quite low in corporate groups not exposed to airborne chemicals used in manufacturing processes, providing a meaningful baseline for the assessment of test scores from chemically exposed occupational groups.
INTRODUCTION

Until recently, routine evaluation of olfactory nerve (CN I) function was rarely performed in occupational settings in spite of evidence that (a) employees who are unable to detect low concentrations of poisonous or explosive vapors are at risk in a number of occupational classifications and (b) losses or distortions in smell ability can occur as a result of job-related exposure to some chemicals (for reviews see Amoore, 1986; Doty, 1979; Schiffman, 1983). Aside from aiding in the detection of a variety of medical disorders, including major dementias, routine olfactory testing can alert the employer to problematic conditions within a plant, as well as minimize the impact of litigation claims from persons with olfactory problems unrelated to the work environment.

In the present chapter we briefly describe the application of a recently developed self-administered test of olfactory function to the workers of the corporate offices of a major chemical manufacturing company (for a complete description of the study, see Doty, Gregor & Monroe, 1986). This reliable and well-validated microencapsulated smell test, which was developed at our Center, is now used routinely in hundreds of otolaryngologic and neurologic clinics in North America and has been shown to be sensitive to numerous subject variables, including age, gender, and smoking habits. The fact that this test detects both gross and subtle alterations in olfactory perception (including decrements associated with Alzheimer's disease (Doty, Reyes & Gregor, 1986), cystic fibrosis (Weiffenbach & McCarthy, 1984), Korsakoff's psychosis (Mair et al., 1986) and Parkinson's disease (Doty, Stellar & Gregory, 1986)) suggests it is likely sensitive to neurotoxic olfactory problems caused by chronic or acute exposure to some environmental chemicals.

The primary goals of this pilot project were to (a) establish the level of acceptance of a voluntary olfactory testing program within a corporate setting, (b) determine the proportion of the sample that reported or evidenced marked olfactory impairment, (c) develop guidelines for using the test instrument as a medical surveillance tool for future testing of persons occupationally exposed to potentially toxic volatiles, and (d) compare the results of such testing to scores obtained from control subjects from other non-exposed populations matched on the basis of age, gender, and general occupational level.

DESCRIPTION OF MEASURING INSTRUMENT

The University of Pennsylvania Smell Identification Test (UPSIT; commercially termed The Smell Identification Test™, Sensonics, Inc., Haddonfield, NJ) consists of 4 booklets containing a total of 40 "scratch and sniff" odorants, one odorant per page (Figure 1). The odorants are embedded in 10-50 µm diameter microencapsulated crystals located on brown strips at the bottom of each
Above each strip is a multiple choice question with four response alternatives. For example, one of the 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 alternatives, even if no smell is perceived (i.e., the test is forced-choice). The reasons for the specific choice of odorants, response alternatives, and other elements of the test's format are described elsewhere (Doty, 1983; Doty, Shaman & Dann, 1984). The internal consistency and the test-retest reliability have been shown to be very high (e.g., test-retest r = 0.95, Doty, Newhouse & Azzalina, 1985). In general, scores on this test correlate strongly with those of traditional olfactory detection threshold tests (Doty, Shaman & Dann, 1984). Furthermore, as can be seen in Figure 2, administration of this test to large numbers of individuals reveals, on the average, (a) greater female than male performance (particularly in the later years) and (b) marked age-related alterations in the ability to smell.

![Graph showing smell identification test scores by age group](image)

**Fig. 1.** Picture of the microencapsulated forced-choice University of Pennsylvania Smell Identification Test (UPSIT). Reprinted with permission from Doty et al., Physiol. Behav., 1984, 32, 489–502.

**STUDY POPULATION AND GENERAL PROCEDURES**

The UPSITs were initially distributed to 640 volunteers frequenting the cafeteria of the corporate offices of a major chemical manufacturing company. The total workforce of the building was estimated to be approximately 1,000. Although we encouraged the participants to complete the test during the coffee break or lunch period in which they volunteered, we also allowed them to take the tests back to their offices with the instructions to
complete and return them at their convenience. Unfortunately, only 381 of the 640 volunteers returned the tests to us. Of those which were returned, 47 had been given to family members and 11 were incomplete, resulting in a final subject sample size of 323 or 50% of the initial sample. Only 10 of these individuals were in occupations where at least some contact with chemicals might be expected (8 chemists and 2 chemical engineers), and all were reportedly in good health. Details of the administration procedure and demographics of the study population are presented elsewhere (Doty, Gregor & Monroe, 1986).

The control subjects consisted of 323 persons selected from a computerized subject pool maintained by the Smell and Taste Center. These subjects were matched to each employee on the basis of gender, age, smoking behavior, and general occupational category, and had previously been tested at health fairs and other public events. In cases where more than one control subject met the criteria of a needed match, a random process was used to select the matched control.

RESULTS

Seven of the corporate subjects reported, at the time of the collection of informed consent, histories of allergies or sinus problems. However, the test scores of these individuals were within the normal range for persons of their sex and age, as
indicated by published test norms (Doty, 1983). Three other subjects (aged 20, 24, and 61) scored considerably below the normal range (UPSIT scores of 28, 15, and 18, respectively), with only the 24 year old being aware of a smell problem.

To establish whether the corporate subjects differed from their matched controls, as well as whether subject age, gender, or smoking behavior influenced the test scores, an analysis of covariance was performed using age as a covariate and sex, current smoking behavior (yes, no), and subject group (corporate, control) as factors. The data from the three subjects with olfactory dysfunction were excluded from analysis. Significant effects of age \( (F = 5.72, \ df = 1/315, \ p < 0.017) \), sex \( (F = 4.32, \ df = 1/315, \ p = 0.038) \), and subject group \( (F = 8.61, \ df = 1/316, \ p < 0.004) \) were observed, with -- on the average -- younger persons performing better than older ones, women performing better than men, and the corporate group performing better than the matched controls. However, the study group did not contain many persons under 21 years or over 55 years of age, so the relationship to age was not marked, with the slope of the regression line relating UPSIT scores to age being very slight \((-0.02)\). Likewise, the effects of sex and subject group were quite small, being less than one UPSIT score value and accounting individually for no more than 2% of the total variance (Table 1). In this study, no statistically significant influence of smoking behavior was apparent \( (F = 1.66, \ df = 1/315, \ p = 0.20) \).

<table>
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<tr>
<th>Table 1: University of Pennsylvania Smell Identification Test Scores (+SD) of men and women from the study population and age-, gender-, race-, and smoking habit-matched controls.</th>
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<tbody>
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<td>Men</td>
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<td>Corporate Subjects</td>
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<td>Matched Controls</td>
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**DISCUSSION**

This pilot study taught us several important lessons regarding voluntary self-administered olfactory testing within a corporate population. First, while volunteering behavior for testing can be expected to be quite high, actual compliance in completing and returning tests may be rather low. Greater compliance might occur if such testing is performed either on a non-voluntary basis or on a voluntary basis within a more formal context, such as that of a medical examination. Second, UPSIT scores of corp-
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Orate subjects with no exposure to industrial chemicals will be close, if not identical, to those obtained from samples of other populations of non-exposed persons, such as those frequenting health fairs and numerous public events (see Doty et al., 1984). Third, only a small percentage of working-age persons appear to have marked smell dysfunction (in accord with threshold studies indicating a value of approximately 2%; cf. Amoore, 1986). Such low incidence provides a sound baseline for assessing the likelihood of olfactory alterations within a given occupational environment. Finally, this study indicates that self-administered olfactory testing is practical and feasible within the corporate setting, making rapid, inexpensive, and widespread screening of the olfactory function of industrial workers possible.

Because the receptors of the olfactory system are rather directly exposed to the outside environment, they are susceptible to adverse effects of viruses and environmental toxins (Doty & Kimmelman, 1986). For example, many viruses enter into the central nervous system via the olfactory primary receptor cells (Monath, Croop & Harrison, 1983; Stroop, Rock & Fraser, 1984; Tomlinson & Esiri, 1983) and damage, in some cases, the olfactory pathways (Goto et al., 1977; Reinacher et al., 1983). Because, in part, of the highly active transport mechanisms within the olfactory nerve cells (see Shipley, 1985), environmental toxins can similarly alter or damage olfactory structures (Buckley et al., 1985; Jiang, Buckley & Morgan, 1983; Rehn et al., 1981). Such alterations are presumably the basis of smell dysfunction following acute or chronic exposure to a number of solvents, heavy metals, and dusts (cf. Doty, 1979; Emmett, 1976). Unfortunately, there have been few sound quantitative studies of such problems to date, despite the large anecdotal literature on this topic.

The present study demonstrates the feasibility of mass olfactory screening in the industrial environment, and provides an initial baseline from which to interpret dysfunction in occupationally-exposed groups. Since the UPSIT (a) readily detects olfactory dysfunction associated with numerous diseases and medical problems and (b) correlates strongly with olfactory detection thresholds, it provides a convenient and quantitative means of quantitatively determining the consequences of exposure to air-borne chemicals in the workplace.

REFERENCES


