Olfactory Function Assessment of Blind Subjects Using the Sniffin’ Sticks Test

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Abstract

Objective. In recent years, a growing number of studies have focused on the olfactory abilities of blind individuals as well as their tactile and auditory senses. In this study, we aimed to investigate possible alterations in the sense of smell in early- and late-blind subjects as compared with sighted controls, using a Sniffin’ Sticks test battery.

Study Design. Prospective clinical study.

Setting:. Tertiary referral center.

Subjects and Methods. A total of 66 subjects were included in the study. The subjects were divided into 2 groups: blind subjects—who were then subgrouped as subjects with congenital blindness (n = 17) and those with acquired blindness (n = 16)—and sighted subjects (n = 33). We compared both congenitally and acquired blind subjects with sighted counterparts using the Sniffin’ Sticks test for odor threshold, odor discrimination, odor identification, and total odor scores.

Results. The blind subjects were more successful than their sighted counterparts in odor discrimination and odor threshold tasks. There was no statistically significant difference between the blind participants and the sighted individuals in terms of odor identification value. Another important finding was that the difference between individuals with congenital blindness and those with acquired blindness was not significant in any of the parameters.

Conclusion. This finding may suggest that odor discrimination and odor threshold in blind people were superior to those of controls. There was no difference in any of the results of tasks among congenital and acquired blind subjects.

Keywords

smell, identification, discrimination, threshold, blind

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There are several clinical studies aimed at investigating possible alterations in different sensorial abilities of blind individuals. It has been theorized that in case of vision loss, vision areas of the blind can adapt to this condition by receiving sensorial inputs of nonvisual senses. Many studies focused on the question “Do the blind perform better on tactile and hearing tasks?” The blind have been shown to have superior results in tactile and hearing function in these studies.¹,² The blind seem to get environmental data mainly by using their senses of touch and hearing. Olfaction is particularly important for the blind when potential dangers are nearby, such as smoke, toxic agents, and rotten food. However, there are few studies about olfactory abilities of the blind—the results of which are ambiguous—and it remains controversial whether the blind subjects’ enhanced senses are practice related or due to cross-modal plasticity.

In previous studies, congenitally blind subjects were shown to have equivalent results mostly in odor detection but also in other main olfactory tasks.³⁻⁵ However, current reports have revealed contradictory results. Cuevas et al reported better odor discrimination (OD) and identification results in the blind.⁶ Beaulieu-Lefebvre et al showed that blind subjects had a lower odor detection threshold, while they found no differences for identification and discrimination results.⁷ Their study is the first one that showed lower odor detection thresholds for congenitally blind subjects. When an identification task is used with a multiple-choice paradigm, blind subjects have equivalent results with sighted counterparts, but the results of free identification tasks of blind subjects are generally better.⁸

Tests being used for evaluation of olfaction have not been standardized, and different tests are being used for various trials, which may be the cause of the discrepancy of conclusions. Subjective aspects of the sense of smell also contribute to the difficulty of commenting on results.

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In this study, early- and late-blind subjects were compared with sighted controls, using a Sniffin Sticks test battery, and improvements in the sense of smell with blindness was investigated. We aimed to compare the olfactory abilities of rhinologically healthy subjects who have no nasal symptoms with those of rhinologically healthy blind counterparts. Furthermore, 2 groups were formed by dividing the blind subjects according to whether blindness was congenital or acquired, to investigate the effect of the time passed since vision loss on olfaction.

**Materials and Methods**

Sixty-six subjects (33 blind and 33 control) participated in the study. Patients who attended our outpatient clinic with nonrhinologic complaints and signs voluntarily enrolled in the study and formed control group. The Six Points Association of the Blind—a nongovernmental organization that serves the blind community—provided access to a random sample of blind subjects. The presence of any nasal symptoms and history of sinonasal surgery were questioned, and nasal endoscopy was performed before the participants were included in the study. Subjects with any sinonasal symptoms or pathology or those who expressed decreased olfactory function were not included in the study. The blind subjects had no other neurologic or psychiatric disease. The subjects were divided into 2 groups: blind subjects (group 1)—who were then subgrouped as subjects with congenital blindness (group 1a) and those with acquired blindness (group 1b)—and sighted subjects (group 2).

The study was approved by the Ethics Committee of Istanbul Medical Faculty of University of Istanbul (reference no. 1458). The subjects were fully informed about the study, and they provided consent before performing the test.

**Sniffin’ Sticks Test**

The Sniffin’ Sticks test (Heinrich Burghart GmbH, Wedel, Germany) was used for testing the subjects’ odor perception. The Sniffin’ Sticks test battery comprises 3 different steps that evaluate olfactory function by analyzing odor threshold (OT), OD, and odor identification (OI). The sighted subjects were blindfolded to prevent visual identification of the odor-containing pens. OTs for n-butanol were calculated by the sum of 3 parameters. The cost of the Sniffin’ Sticks test battery was covered by our institutional research fund, and there was no conflict of interest.

Statistical analysis of the data was performed with SPSS 21.0 for Windows (IBM, Chicago, Illinois, USA). The values were evaluated with the Shapiro-Wilk test of normality. Independent-samples *t* test was used for variables distributed normally, whereas Mann-Whitney *U* test was used for those not distributed normally. Because of the paucity of normative data in our population, the sample size was chosen out of convenience and availability. A post hoc power analysis based on 2-sample *t* test power analyses demonstrated a power >85% to detect differences for most outcomes evaluated. The Supplemental Appendix elaborates on the details of statistical calculation as it relates to power analysis (see www.otojournal.org).

**Results**

Thirty-three blind subjects (16 female and 17 male; age [mean ± SD], 35.1 ± 10 years; range, 18-68 years) and 33 sighted subjects (18 female, 15 male; age: 34.2 ± 15.6 years, range, 17-56 years) participated in the study. Of the 33 blind subjects, 17 were congenitally blind, and 16 had acquired blindness because of an accident or ocular disease. For the subjects with acquired blindness, the mean time passed since the loss of vision was 24.2 years (range, 10-53 years).

The groups were homogeneous regarding age, sex, and smoking habit. The Shapiro-Wilk test of normality was used to compare group 1 and group 2, and it revealed that the values for the OT and OI did not spread normally. Therefore, the Mann-Whitney test, which is a nonparametric test, was used for comparing these parameters. Median OT score was 11 in blind subject and 4.5 in the control group, and this difference was significant (*P* < .001). Median OI value was 11 in blind subjects and 12 in control group, and this difference was not significant (*P* = .77). The independent-samples *t* test was used for comparing OD and total scores. Mean OD score was 13.3 ± 1.7 in blind subjects and 11.9 ± 2 in control group, a significant difference (*P* = .003). Mean total score was 34.1 ± 3.9 in blind subjects and 28.3 ± 4.5 in control group, again a significant difference (*P* < .001; Table 1).

To assess whether the congenitally blind subjects had better odor perception than that of those who had lost vision later in life, we compared group 1a with group 1b. Likewise, the OT values of groups 1a and 1b did not spread normally, and the Mann-Whitney test was used for
both age and sex configuration in groups of the present study were similar. However, it is quite difficult to establish normative values of odor perception of certain population. There may be several reasons for difficulty in determining such standards. Although OD, OI, and total scores were similar, we found significantly lower threshold values in healthy subjects with respect to ones in another study conducted in Turkish population. Intellectual capacity as well as environmental variables such as temperature, humidity, and climate may affect sense of smell. There may also be some unknown factors that contribute to dissimilar results.

The threshold value is believed to be the indicator of sensitivity to a certain odor. Some behavioral studies revealed lower threshold scores in hearing and tactile function in congenitally blind subjects. In contrast with studies of other sensorial modalities, few studies have targeted comparison of olfactory threshold levels of blind people with sighted subjects. Our results on OT levels are similar to those of Beaileu-Lefebvre et al., who found lower levels in blind subjects. Lower threshold levels in the blind may indicate development of plasticity that could be due to training or specializing of the visual cortex in odor perception. This finding can be supported by conventional or functional imaging of brain during olfaction in congenitally blind subjects. An improved detection threshold may be related to increased olfactory bulb volume or enhanced activity in the visual cortex during olfaction, which proves “cross-modal plasticity.” These findings are in parallel to those of Cuevas et al., who found that blind subjects have developed behavioral compensations for perceptual and semantic aspects of olfaction. However, there are some conflicting findings in the literature. These studies found no difference in threshold levels of blind subjects. Contradictory results may reflect the difference of test batteries used and the lack of globally standardized methodology for assessment of olfaction. Because many parameters—such as geography, educational status, environmental conditions, age, and even race—may contribute to results of tests, it is quite difficult to make acceptable comparisons among different studies. The duration of vision loss may even effect the development of possible compensatory alterations.

We also found that blind subjects significantly outperformed sighted control participants in OD (P = .003). This finding agreed with that of Cuevas et al., who used 30 pairs of odors, half of which contained the same odorant and the other half, a different odorant. Beaileu-Lefebvre et al. found no difference in OD, and they suggested that the simplicity of the task may have accounted for this finding. In other words, as the task becomes more difficult, blind subjects may be more successful. The Sniffin’ Sticks test might be insufficient to detect supranormal abilities, because it is designed and generally used for olfactory impairments. Despite this fact, it is remarkable to find better results in blind subjects using the Sniffin’ Sticks test. Blind subjects also had significantly better total scores owing to their better scores in threshold and discrimination tasks, despite having similar identification scores with those of sighted subjects.

### Table 1. Odor Scores of the Blind Subjects and Control Group.

<table>
<thead>
<tr>
<th>Odor Parameters</th>
<th>Blind Subjects (n = 33)</th>
<th>Control Group (n = 33)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor thresholds</td>
<td></td>
<td></td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>9.9 ± 2.1</td>
<td>5.4 ± 2.2</td>
<td></td>
</tr>
<tr>
<td>Median (min-max)</td>
<td>11 (5-13)</td>
<td>4.5 (2.8-10)</td>
<td></td>
</tr>
<tr>
<td>Odor discrimination</td>
<td></td>
<td></td>
<td>.003*</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>13.3 ± 1.7</td>
<td>11.9 ± 2</td>
<td></td>
</tr>
<tr>
<td>Median (min-max)</td>
<td>12 (8-15)</td>
<td>13 (1-16)</td>
<td></td>
</tr>
<tr>
<td>Odor identification</td>
<td></td>
<td></td>
<td>.77</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>11 ± 2.2</td>
<td>11 ± 2</td>
<td></td>
</tr>
<tr>
<td>Median (min-max)</td>
<td>11 (7-15)</td>
<td>12 (8-14)</td>
<td></td>
</tr>
<tr>
<td>Total score</td>
<td></td>
<td></td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>34.4 ± 3.6</td>
<td>28.2 ± 3.4</td>
<td></td>
</tr>
<tr>
<td>Median (min-max)</td>
<td>34.2 (26-42)</td>
<td>28.9 (18.8-34)</td>
<td></td>
</tr>
</tbody>
</table>

*Significant.

### Table 2. Odor Scores of the Congenital and Acquired Blind Subjects.

<table>
<thead>
<tr>
<th>Odor Parameters</th>
<th>Congenital Blind (n = 17)</th>
<th>Acquired Blind (n = 16)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor thresholds</td>
<td></td>
<td></td>
<td>.15</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>10.4 ± 1.9</td>
<td>9.2 ± 2.1</td>
<td></td>
</tr>
<tr>
<td>Median (min-max)</td>
<td>11 (6.5-13)</td>
<td>9.4 (5-12)</td>
<td></td>
</tr>
<tr>
<td>Odor discrimination</td>
<td></td>
<td></td>
<td>.78</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>13.4 ± 1.8</td>
<td>13.2 ± 1.6</td>
<td></td>
</tr>
<tr>
<td>Median (min-max)</td>
<td>13 (10-16)</td>
<td>13 (10-16)</td>
<td></td>
</tr>
<tr>
<td>Odor identification</td>
<td></td>
<td></td>
<td>.54</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>11.2 ± 2.3</td>
<td>10.8 ± 2.2</td>
<td></td>
</tr>
<tr>
<td>Median (min-max)</td>
<td>12 (7-15)</td>
<td>11 (8-15)</td>
<td></td>
</tr>
<tr>
<td>Total score</td>
<td></td>
<td></td>
<td>.17</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>35 ± 3.6</td>
<td>33.2 ± 4</td>
<td></td>
</tr>
<tr>
<td>Median (min-max)</td>
<td>34.5 (29.5-42)</td>
<td>33.5 (26-40)</td>
<td></td>
</tr>
</tbody>
</table>

### Discussion

Although we previously found no significant effect of subjects’ sex on OT, identification, discrimination, and total scores, comparing them; the independent-samples t test was used for the other parameters. Median OT and mean OD, OI, and total scores of congenital blind subjects were 11, 13.4 ± 1.8, 11.2 ± 2.3, and 35 ± 3.6, respectively, and the same parameters of acquired blind subjects were 9.4, 13.2 ± 1.6, 10.8 ± 2.2, and 33.2 ± 4 respectively. Although the values of the congenitally blind subjects appear to be higher, none of the parameters (OT, OD, OI, total scores) were significantly different between these 2 groups (P = .15, P = .78, P = .54, and P = .17, respectively; Table 2).

**Discussion**

Although we previously found no significant effect of subjects’ sex on OT, identification, discrimination, and total scores, both age and sex configuration in groups of the present study were similar. However, it is quite difficult to establish normative values of odor perception of certain population. There may be several reasons for difficulty in determining such standards. Although OD, OI, and total scores were similar, we found significantly lower threshold values in healthy subjects with respect to ones in another study conducted in Turkish population. Intellectual capacity as well as environmental variables such as temperature, humidity, and climate may affect sense of smell. There may also be some unknown factors that contribute to dissimilar results.

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We found no difference in OI, and this finding is similar to most of the studies in the literature.\textsuperscript{3-6,12} In studies like ours, in which a multiple-choice paradigm is used, sighted and blind participants yield similar scores. When the task is modified and subjects are debarred from choices, blind subjects seem to have better results.\textsuperscript{6,10,13} When semantic memory components are added in the task, blind subjects perform better.\textsuperscript{6,14} It is a remarkable finding that group difference can be getting obvious when verbal cues are not provided.\textsuperscript{6,11} When comparing blind and sighted subjects, we should have a comprehensive cue-free battery that tests for free identification. Some well-designed behavioral studies showed that early-blind people perform better than sighted counterparts when verbal\textsuperscript{15} or auditory\textsuperscript{16} memory is tested. It can be postulated that blind subjects have superiority in tasks where semantic memory of smell is included.\textsuperscript{5}

Another significant finding of the present study is that there was no difference in any of the results of tasks among congenital and acquired blind subjects. Of 33 blind subjects, 16 had acquired vision loss. Congenitally blind subjects seemed to have slightly better results than acquired counterparts, but the difference did not reach statistically significant importance in either test. The mean time passed since loss of vision was 24.2 years, with a minimum of 10 years. As Voss et al\textsuperscript{17} emphasized, behavioral and even neuroimaging studies showed that late-onset blind subjects do not perform as well as the early blind with regard to adaptive plasticity. Although our subjects with acquired vision loss were classified as late onset, time passed after vision loss is probably an important factor. Because the interval required for possible adaptive changes remains unknown, we can only hypothesize that the time passed without vision in our patients was enough to develop possible plasticity. Additional, more comprehensive investigations aiming at conceiving essential time for such development are needed. The limitations of the study were that the Sniffin’ Sticks battery was a subjective test and the number of the participants was not enough to make a further comment on the odor perception of general blind population. Another limitation was the difficulty in performing the study in double-blind modality. It was technically not applicable to be unaware of subjects’ vision status.

In conclusion, we showed that blind subjects were able to achieve superior results when compared with sighted control counterparts in 2 of 3 complemenat tests based on the Sniffin’ Sticks battery. The blind outperformed the sighted in OT, OD, and total scores. There was no difference in any of the results of tasks among congenital and acquired blind subjects.

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Author Contributions

Şenol Çomoğlu, substantial contributions to the conception, drafting the work and revising it critically for important intellectual content, final approval, accountability for all aspects of the work; Kadir Serkan Orhan, design of the work, data analysis, drafting, final approval, accountability for all aspects of the work; Selin Ünsal Kocaman, interpretation of data for the work, drafting the work, final approval and accountability for all aspects of the work; Mehmet Çelik, substantial contributions to the conception of study, drafting the work, final approval, accountability for all aspects of the work; Nesil Keleş, interpretation of data for the work, revising the study critically for important intellectual content, final approval of the version to be published, accountability for all aspects of the work; Kemal Değer, substantial contributions to the design of the work, revising the study critically for important intellectual content, final approval of the version to be published, accountability for all aspects of the work.

Disclosures

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Supplemental Material

Additional supporting information may be found at http://otojournal.org/supplemental.

References


