UC San Diego

UC San Diego Previously Published Works

Title

Sensory Properties of Selected Terpenes: Thresholds for Odor, Nasal Pungency, Nasal Localization, and Eye Irritationa

Permalink

<https://escholarship.org/uc/item/6672v2dv>

Journal

Annals of the New York Academy of Sciences, 855(1 OLFACTION AND)

ISSN

0077-8923 1749-6632

Authors

COMETTO-MUNIZ, J. ENRIQUE
CAIN, WILLIAM S
ABRAHAM, MICHAEL H
[et al.](#)

Publication Date

1998-11-01

DOI

10.1111/j.1749-6632.1998.tb10640.x

Data Availability

The data associated with this publication are within the manuscript.

Peer reviewed

Sensory properties of selected terpenes: Thresholds for odor, nasal pungency, nasal localization, and eye irritation

J. Enrique Cometto-Muñiz¹, William S. Cain¹, Michael H. Abraham², and Rachel Kumarsingh²

¹Chemosensory Perception Laboratory, Dept. of Surgery (Otolaryngology), University of California, San Diego, La Jolla, CA 92093-0957, USA

²Department of Chemistry, University College London, London WC1H 0AJ, UK

Address for correspondence:

Dr. J. Enrique Cometto-Muñiz
Chemosensory Perception Laboratory,
Department of Surgery (Otolaryngology),
Mail Code 0957
University of California, San Diego
La Jolla, CA 92093-0957

Phone: (619) 622-5832
FAX: (619) 458-9417
e-mail: ecometto@ucsd.edu

Running head: Chemosensory thresholds for terpenes

Abstract

We tested four normosmics and four anosmics in detection thresholds for six terpenes commonly found indoors: cumene, p-cymene, delta-3-carene, linalool, 1-8 cineole, and geraniol. Normosmics provided odor thresholds and anosmics provided nasal pungency thresholds. All subjects provided nasal localization (i.e., right/left nostril) and eye irritation thresholds. Each type of threshold was measured eight times per subject-stimulus combination. Stimuli were presented from squeeze bottles in a two-alternative forced-choice procedure via an ascending method of limits. Odor thresholds ranged between 0.1 and 1.0 ppm. Nasal pungency thresholds lay about three orders of magnitude above odor thresholds. Nasal localization and eye irritation thresholds did not differ between normosmics and anosmics, and fell close to nasal pungency thresholds. Olfactory thresholds could be obtained for all stimuli in all repetitions using the criterion of five correct choices in a row. Trigeminal thresholds (i.e., pungency, localization, and eye irritation) could be obtained on all repetitions only for some terpenes using that same criterion. Carene and cineol produced nasal pungency and eye irritation on all repetitions. None of the terpenes could be localized on all repetitions, but cineol was localized a higher percentage of instances than were the other stimuli. At the other extreme, geraniol failed to evoke any of the three trigeminal responses in most instances. Overall, the results indicate that the three trigeminal thresholds produce a uniform view of the potency of these terpenes, with nasal pungency and eye irritation being slightly more sensitive than nasal localization. Furthermore, application of a previously-derived linear solvation energy relationship to the results reinforced the view that physicochemical properties can predict the chemesthetic impact of volatile organic compounds.

Previous studies have measured odor, nasal pungency, and eye irritation thresholds for a number of homologous series of chemicals (see review¹). Odor thresholds probed into the olfactory potency of substances whereas three threshold endpoints probed their trigeminal chemosensory potency: 1) nasal pungency, measured in anosmics (for whom odor sensations do not interfere), 2) eye irritation, and 3) nasal localization or lateralization whereby participants sought to detect, upon dirhnic presentation, which nostril received the stimulus and which blank air.² Eye irritation and nasal localization thresholds were measured in normosmics and anosmics.

Homologous series have provided a convenient physicochemical “unit” (i.e., carbon chain-length) against which to compare sensory responses in order to map different aspects of the molecular basis for olfactory and trigeminal stimulation by chemicals^{3–5}. In the present study we measured olfactory and trigeminal sensitivity to six terpene-related compounds: delta-3-carene ($C_{10}H_{16}$), cumene (C_9H_{12}), p-cymene ($C_{10}H_{14}$), linalool ($C_{10}H_{18}O$), 1,8-cineole ($C_{10}H_{18}O$), and geraniol ($C_{10}H_{18}O$). These compounds provided a broader chemical variety than that of homologues and permitted expansion of the range of structure-activity relationships. They were also selected based on their importance as odorants and on their frequent presence indoors where they could lead to unwanted sensory reactions. Mineral oil served as solvent for all substances. Starting from the undiluted chemical (100%v/v), threefold dilution steps (i.e., 33, 11, 3.7, etc. %v/v), made in duplicate, were prepared for each stimulus. Stimuli were presented from “squeeze bottles”. Quantification of the vapor-phase concentration was achieved via direct gas chromatography (FID detector) of the headspace, and using the saturated vapor concentration at room temperature ($\approx 23^\circ\text{C}$) of each compound as a reference.

Four anosmics (two males, two females, age range: 23 to 53 years) and four normosmics (two males, two females, age range: 37 to 58 years) participated. Anosmics provided nasal pungency thresholds and normosmics provided odor thresholds. All subjects provided nasal localization and eye irritation thresholds. Each type of threshold was measured eight times (half with each nostril or eye) per subject-stimulus combination. Typically, each subject participated in a total of 10 to 14 sessions held on different days. Each session lasted between 1 and 3 hours. Stimuli were presented via a two-alternative forced-choice procedure (against the blank: mineral oil) with ascending concentrations over trials. Five correct choices in a row constituted the criterion for threshold.

Figure 1 shows that odor thresholds ranged from 0.1 ppm for geraniol to 1.7 ppm for 3-carene whereas nasal pungency thresholds lay about three orders of magnitude above odor thresholds, ranging from 235 ppm for cineole to 1,636 ppm for 3-carene. Only 3-carene and cineole produced a nasal pungency threshold in virtually all repetitions across anosmics, whereas geraniol failed to produce a pungency threshold in 88% of instances across anosmics. Between these extremes, cumene, linalool, and p-cymene failed to produce a pungency threshold in 22, 31, and 56 % of instances, respectively.

None of the terpenes could be localized on all repetitions but, again, cineole produced the lowest percentage of unresponsiveness (3% in normosmics, 28% in anosmics), and geraniol and p-cymene produced the highest (100% in both groups). In increasing degree of unresponsiveness, the order for the rest was cumene (19% in normosmics, 59% in anosmics), 3-carene (59% in normosmics, 56% in anosmics), and linalool (81% in normosmics, 100% in anosmics). When

obtained, nasal localization thresholds were similar in both groups and close to, or slightly above, nasal pungency thresholds.

Figure 2 shows that eye irritation thresholds did not differ significantly between normosmics and anosmics, and fell well into register with nasal pungency thresholds. Similarly to nasal pungency, only 3-carene and cineole produced an eye irritation threshold in virtually all repetitions for all anosmics. Again, geraniol was the least efficient trigeminal stimulus, failing to produce an eye irritation threshold in about 80% of instances for both groups. In increasing percentage of failure to produce an eye irritation threshold, the order for the rest was cumene, linalool, and p-cymene, which failed in 16, 38, and 62 % of instances, respectively, across normosmics and anosmics. Note that this is the exact same order, and similar percentage of failure, as that obtained for nasal pungency.

In conclusion, nasal pungency, eye irritation, and nasal localization thresholds gave a similar picture of trigeminal stimulatory efficiency across the terpenes, though nasal localization seemed slightly less sensitive than the other two sensory endpoints. As observed before for homologous alcohols,² normosmics and anosmics did not differ greatly in their trigeminal chemosensitivity for the terpenes, as measured by eye irritation and nasal localization thresholds. A previously developed equation⁶ predicted the nasal pungency thresholds for the terpenes reasonably well, except for linalool.

Supported by NIH (NIDCD) grant number R29 DC 02741, and by the Center for Indoor Air Research. Thanks are due to Mr. René Loya for excellent technical assistance.

References

1. Cometto-Muñiz, J.E. & W.S. Cain. 1996. Physicochemical determinants and functional properties of the senses of irritation and smell. In Indoor Air and Human Health, 2nd Edition. R.B. Gammage & B.A. Berven, Ed.: 53-65. CRC Lewis Publishers. Boca Raton.
2. Cometto-Muñiz, J.E. & W.S. Cain. 1997. Trigeminal and olfactory sensitivity: Comparison of modalities and methods of measurement. Int. Arch. Occup. Environ. Health (in press).
3. Mori, K. & G. Shepherd. 1994. Emerging principles of molecular signal processing by mitral/tufted cells in the olfactory bulb. Sem. Cell Biol. **5**: 65-74.
4. Scott, J.W., L.M. Davis, D. Shannon & C. Kaplan. 1996. Relation of chemical structure to spatial distribution of sensory responses in rat olfactory epithelium. J. Neurophysiol. **75**: 2036-2049.
5. Cometto-Muñiz, J.E., W.S. Cain & M.H. Abraham. 1997. Nasal pungency and odor of homologous aldehydes and carboxylic acids. Exp. Brain Res. (in press).
6. Abraham, M. H., J. Andonian-Haftvan, J. E. Cometto-Muñiz & W. S. Cain. 1996. An analysis of nasal irritation thresholds using a new solvation equation. Fundam. Appl. Toxicol. **31**: 71-76.

Figure Legends

Figure 1. Odor and nasal pungency thresholds ($\pm$ SD) for terpenes. The percentage of instances across sessions in which some terpenes failed to yield a nasal pungency threshold (unresponsiveness) is shown.

Figure 2. Eye irritation thresholds ($\pm$ SD) in normosmics and anosmics for the terpenes. The percentage of instances in which some terpenes failed to evoke an eye irritation threshold is shown. Nasal pungency thresholds are shown for comparison.

FIGURE 1

FIGURE 2

This is a pre-copyedited, author-produced version of an article accepted for publication in Annals of the New York Academy of Sciences following peer review. The version of record Annals of the New York Academy of Sciences **855**:648-651, 1998 is available online at: <http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.1998.tb10640.x/abstract> – DOI: 10.1111/j.1749-6632.1998.tb10640.x