SHORT COMMUNICATION

Effect of Nasal Dilators on Perceived Odor Intensity

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Abstract

Subjects wearing nasal dilators rated olfactory stimuli as being more intense compared with ratings done without nasal expansion. The results support a perceptual constancy model in olfaction. **Chem. Senses 22: 177–180, 1997.**

Nasal dilators are widely used by high school, college and professional athletes. The nasal dilator is an adhesive device consisting of two tabs at the ends of a connecting plastic spring. The tabs of the dilator are placed on the nares such that the spring, by its elasticity, continuously dilates the nasal valve. Nasal dilators have been shown to reduce the sound intensity and number of snores per minute, especially during slow wave sleep (Hoijer *et al.*, 1992; Hoffstein *et al.*, 1993). In addition, dilators have been shown to reduce the frequency and severity of obstructed breathing during somnolence (Hoijer *et al.*, 1992).

Using rhinomanometry in awake, sitting subjects, Hoijer and co-workers (1992) observed that nasal dilators decreased nasal resistance by an average of 18% compared with undilated controls. However, the effect, if any, this decreased resistance has on olfactory ability has yet to be studied. Certainly, one possibility is that the decreased resistance could affect sniff vigor. This change in sniff vigor could in turn, as proposed by Teghtsoonian *et al.* (1978) and Youngentob *et al.* (1986), influence the size of the perceptual response.

Methods, results and discussion

In experiment 1, 10 subjects (six females and four males, 22–40 years old) were recruited from the SUNY Health Science Center. Most had previous experience with psychophysical testing, but none had previously used nasal dilators. After signing an informed consent, subjects were randomly placed into one of two groups. After subjects in group 1 first rated the intensity of a series of odorants, a nasal dilator (Breathrite Nasal Strips, Med/Lg, CNS Inc., Chanhassen, MN) was applied to the area around the nasal valve and the intensities of the same odors were rated again. For group 2, the order of the testing was reversed, such that the first series of ratings were done with nasal dilators, followed by ratings done after the dilator had been removed. After a wait of at least 1 h, the order of testing was reversed. That is, subjects in group 1 now followed the original testing order for group 2, and vice versa.

The stimuli consisted of 20 odorants presented in random order. Half of the test battery was composed of 10 odorants at concentrations similar to those in the Odorant Confusion Matrix (OCM) designed by Wright (1987). To extend the range of perceived odor intensities, the second half of the odorant set consisted of the same chemicals at either 10 times or 1/10 times the base concentration (see Table 1; the concentrations for phenethyl alcohol and 2-propanol were increased only 8-fold because of the limits of their solubility).

Subjects evaluated perceived odor intensity with the aid of a Labeled Magnitude Scale (Green *et al.*, 1996). Each evaluation was made on a separate paper ballot. Results were analyzed with a 3-factor mixed model ANOVA: main effects of condition (with versus without nasal dilator), stimulus (20 odorants) and subject. Condition and stimulus were considered fixed effects, and subject a random effect.

Experiment 2 was undertaken to determine the reproducibility and specificity of the results in experiment 1. With the exception of the following changes, experiment 2 was conducted in much the same way as in experiment 1. The odorant series was expanded by two, with the addition of two blanks: distilled water, and the solvent, 1,2-propanediol. Eleven subjects (five females and six males, 26–65 years old) who had not participated in the first experiment were recruited. The subjects were placed in two groups. Group 1 ($n = 6$) wore nasal dilators as they rated the intensity of the 22 odorants. The dilator was then removed and the intensity of each odorant rated again. Group 2 ($n = 5$) wore a butterfly strip (Johnson & Johnson, Band-aid brand, Medium Butterfly Closures, New Brunswick, NJ) when they first rated the odorant series. The strip was removed and the intensity of the odorants rated again. The butterfly controlled for the possibility that the presence of adhesive on the nose produced changes in perceived odor intensity.

In experiment 1 (Table 2) the nasal dilator increased odor intensity by an average of 4.44 units or 16.7% (main effect of condition, $P = 0.008$). As expected, since the odorants had different intensities, there was a significant effect of stimulus (main effect of stimulus, $P < 0.001$). Although the effect of nasal dilator was somewhat different for the various stimuli, this difference was not significant (condition × odor interaction, P = n.s.). While people tended to use different portions of the labeled magnitude scale (main effect of subject, $P < 0.001$) and the effect of dilator differed between people (subject × condition interaction, $P = 0.013$), the nasal dilator was associated with larger ratings of odor intensity in 9/10 subjects. In other words, the presence of the nasal dilator produced intensity ratings that were increased compared with intensity ratings without dilation. Since the subjects had no prior experience with nasal dilators, it is unlikely that they brought to the study the 'expectation' that odor intensity would increase. At the end of testing, most subjects expressed surprise at how much more intense the odorants were when the dilators were used.

Table 1 Stimuli and concentrations

Odorant name	Chemical	Concentration (% v/v)
Ammonia (OCM)	ammonia	0.22
Ammonia (high)	ammonia	2.18
Cinnamon (OCM)	*trans*-cinnamaldehyde	1.60
Cinnamon (high)	*trans*-cinnamaldehyde	16.0
Licorice (OCM)	*trans*-anethole	0.19
Licorice (high)	*trans*-anethole	1.93
Mint (OCM)	R-carvone	6.27
Mint (high)	R-carvone	62.7
Mothballs (OCM)	naphthalene	0.63
Mothballs (high)	naphthalene	6.32
Orange (OCM)	D-limonene	0.19
Orange (high)	D-limonene	1.93
Rose (OCM)	phenethyl alcohol	12.5
Rose (high)	phenethyl alcohol	100
Rubbing alcohol (OCM)	2-propanol	12.5
Rubbing alcohol (high)	2-propanol	100
Vanilla (OCM)	vanillin	0.42
Vanilla (high)	vanillin	4.22
Vinegar (OCM)	acetic acid	25.0
Vinegar (low)	acetic acid	2.50

The results of experiment 2 were similar to those of experiment 1. For all six subjects who wore the nasal dilator, average intensity ratings with the dilator were higher than without the dilator (with = 32.51, without = 26.67, $P < 0.02$, paired t-test). The average intensity rating of the distilled water was 6.17 with the dilator and 4.00 without. For the OCM solvent, the ratings were 4.50 with the dilator and 1.87 without.

The effect of the nasal dilation is in contrast to results

Table 2 Intensity responses by odorant with and without nasal dilators

Odorant	Without dilator	With dilator	Difference
At OCM concentrations			
1. Ammonia	37.70	40.00	2.30
2. Cinnamon	18.55	20.55	2.00
3. Licorice	12.05	19.65	7.60
4. Mint	20.50	29.50	9.00
5. Moth balls	29.80	31.65	1.85
6. Orange	10.35	15.90	5.55
7. Rose	16.20	20.65	4.45
8. Rubbing alcohol	17.50	24.50	7.00
9. Vanilla	15.05	21.10	6.05
10. Vinegar	62.20	65.85	3.65
At 10× OCM concentrations			
1. Ammonia	65.70	69.35	3.65
2. Cinnamon	26.10	29.95	3.85
3. Licorice	23.60	31.15	7.55
4. Mint	26.30	36.05	9.75
5. Moth balls	37.30	43.50	6.20
6. Orange	24.35	25.10	0.75
7. Rose	28.90	31.95	3.05
8. Rubbing alcohol	30.25	32.25	2.00
9. Vanilla	19.60	20.10	0.50
At 1/10× OCM concentration			
10. Vinegar	8.35	10.55	2.20
Average =	26.52	30.96	4.44

seen with the butterfly strip. The butterfly strip did not alter intensity ratings (average = 22.88 with and 25.46 without, P = n.s., paired t-test).

As mentioned above, nasal dilators produce an 18% reduction in nasal resistance. Since nasal resistance is related at least in some manner to nasal airflow, it is possible that odorant delivery would also be altered. Electrophysiological recordings from the tortoise and the hare (Beidler, 1957; Tucker, 1963) have shown a positive relationship between nasal airflow and the size of the olfactory nerve discharge. In a study not using nasal dilators, Rehn (1978) also found a positive relationship between perceived odor intensity and inhalation flow rate. This was true under a variety of sniffing conditions, including constant duration sniffing, constant volume sniffing and three successive short sniffs. However, in a similar study, Teghtsoonian *et al.* (1978) taught subjects to sniff at two flow rates, one twice as great as the other. Subjects then made magnitude estimates of odor strength for a variety of suprathreshold olfactory stimuli. Unlike the observations of Rehn, these investigators found that subject-controlled flow rate had no effect on the perceived odor strength. To explain the lack of relationship between flow rate and psychological intensity, Teghtsoonian *et al.* (1978) invoked a size constancy model in which judgements of odor intensity are made in relation to perceived sniff vigor. 'It may be argued...that, even if flow rate is an important parameter of the proximal stimulus for odor strength (discharge rate in the olfactory nerve), information about sniff vigor may control its effect on the perceptual response' (Teghtsoonian *et al.*, 1978).

Youngentob *et al.* (1986) asked subjects to rate the intensity of odorants as they sniffed against increasing resistances. As resistance increased, the odor strength decreased. These investigators also found that increases in resistance did not result in changes in sniffing behavior. That is, any change in resistance was counterbalanced by an equal change in sniff vigor and flow rate remained unchanged. Youngentob *et al.* (1986) went on to interpret the reduction in odor strength with no alteration in sniffing behavior as further support for the Teghtsoonian *et al.* (1978) size constancy model. That is, an increase in sniff vigor fails to produce a concordant change in flow rate, and perceived odor intensity decreases.

Although Youngentob *et al.* (1986) were able to add to the normal resistive load (and so increase nasal resistance for any given subject), they had no mechanism by which to decrease resistance below a subject's baseline level. In the present study, the use of nasal dilators provided a mechanism by which to test the applicability of the perceptual constancy model in olfaction at resistances below baseline.

The results of both current experiments are consistent with the concept of a perceptual constancy model in olfaction. That is, a decrease in nasal resistance would be expected to decrease perceived sniff vigor and produce an increase in perceived odor intensity. However, it is also possible that the reduction in nasal resistance produced by the dilator might result in an increase in odorant flow rate and an increase in the delivery of odorant molecules to the olfactory receptors as described by Beidler (1957) and Tucker (1963). To determine if nasal airflow was effected by the nasal dilator, two subjects (one who had participated in the study and one who had not) rated the intensity of four odorants (rubbing alcohol and vanilla at both high and low concentrations) with and without a nasal dilator. Nasal airflow was measured with a No. 2 Fleisch pneumotachograph as described by Youngentob *et al.* (1986).

Although these data must be considered preliminary, flow rate, sniff volume and duration were not altered by the nasal dilator. The nasal dilator produced no obvious change in the sniff characteristics despite the fact that these subjects also reported an increase in odor intensity when wearing the dilator.

The observation in experiment 2 that the intensity ratings of the distilled water and the OCM solvent were increased when wearing the dilator again seems to argue in favor of a size constancy model. That is, increased intensity ratings of odorless (or nearly odorless) stimuli could likely only happen if the intensity ratings themselves included some component of sniff vigor.

In summary, the data from these two experiments seems to provide additional support for the existence of perceptual size constancy in olfaction. The relationship between nasal resistance, size constancy, and performance on odor threshold and odor recognition tasks require further study.

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