supports the importance of preserving genetic variability as a way of increasing the viability of wild populations.

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Olfaction

The world smells different to each nostril

The flow of air is greater into one nostril than into the other because there is a slight turbinate swelling in one[1–3]. The nostril that takes in more air switches from the left to the right one and back again every few hours[4–6], but the effect of this switching on the sense of smell has been unclear[7,8]. Here we show that this difference in airflow between the nostrils causes each nostril to be optimally sensitized to different odorants, so that each nostril conveys a slightly different olfactory image to the brain.

The slight swelling that obstructs each nostril (Fig. 1a) causes odorants to be drawn into the nostrils at different rates. But for an odorant to act on the olfactory receptors, it must first cross the olfactory mucosa. Different odorants sorb to and cross the mucosa at different rates[9]. In the bullfrog, for example, a specific odorant's sorption rate interacts with the rate of airflow across the mucosa to produce varying amplitudes of response in the olfactory nerve[10]. A high-sorption odorant induces a smaller response when airflow is low and a larger one when it increases. In contrast, a low-sorption odorant induces a smaller response at a high airflow rate and a larger response when there is less airflow (Fig. 1b).

This occurs because, when a high-sorption odorant has a low airflow rate, the odorant molecules sorb to the mucosa before moving very far along it. Only a small portion of the epithelium is involved in the response, which is small. When the same odorant flows at a high airflow rate, it spreads across a larger mucosal area before sorbing, so the response is larger. When a low-sorption odorant flows quickly, it moves past the mucosa without sorbing so the epithelial response is small. When the same low-sorption-odorant flows slowly, it has time to sorb across the mucosa and the response is larger[10].

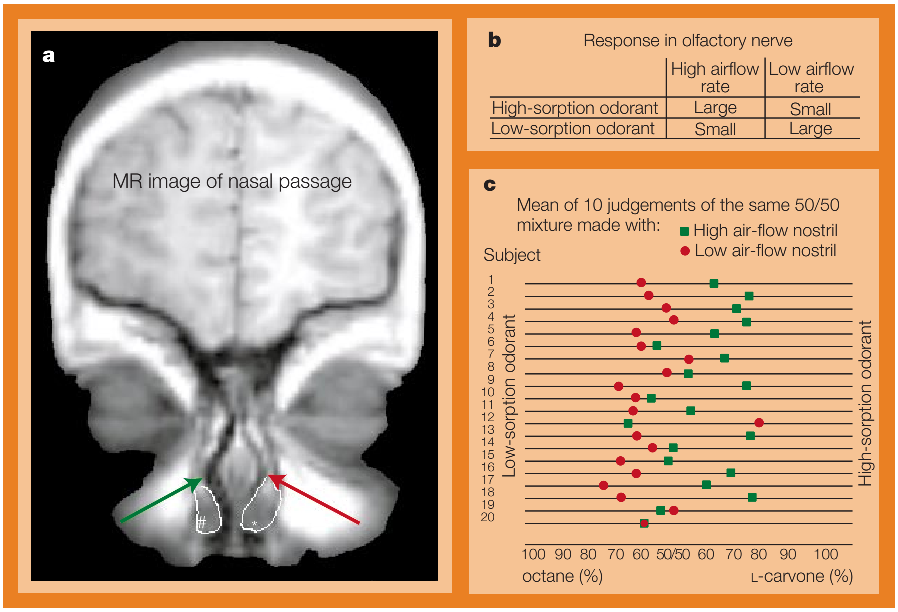

Figure 1 Different nostrils convey different olfactory information to the brain. **a,** Magnetic resonance image of the nasal passage, which appears dark. The swollen (*) and relaxed (#) turbinates, outlined in white, result in an occluded right nostril (red arrow) and a clearer left nostril (green arrow). **b,** The interaction between airflow rate and odorant sorption, which brings about a response in the olfactory nerve[10]. **c,** On each of ten trials, subjects were asked to smell an identical mixture of 50% octane and 50% L-carvone using either the left or right nostril. They were then given each individual odorant component to smell separately and judged the composition of the mixture by marking the line (experimental sequences were randomized and counterbalanced). Using the high-flow-rate nostril (green), the average judgement was that the mixture consisted of 55% L-carvone and 45% octane. Using the low-flow-rate nostril (red), the judgement was that it consisted of 61% octane and 39% L-carvone ($t(19) = 3.74$, $P = 0.001$). For the 20 subjects, there was no significant group difference in airflow rate between the left and right nostrils, but there was a significant group difference between the high-flow-rate nostril and the low-flow-rate nostril (high mean = 51 l min^{-1}, low mean = 31 l min^{-1}, $t(19) = 5.6$, $P < 0.0001$).

We therefore investigated whether the nostril with the higher airflow in humans is the more sensitive to high-sorption odorants and the nostril with lower airflow more sensitive to low-sorption odorants. We used an olfactometer to produce an equally proportioned mixture of the high-sorption odorant L-carvone and the low-sorption odorant octane. The mixture was always the same but subjects were told that it was slightly different for every trial.

Subjects sampled the mixture by sniffing with one nostril (the other nostril was occluded) and made a judgement about the relative proportion of the two components in the mixture (for example, 55% octane and 45% L-carvone). The task was repeated for the second nostril and the judgements compared. The rate of airflow for each sniff was measured by anterior rhinomenometry. We found that 17 of 20 subjects (binomial, $P = 0.001$) thought the mixture contained more octane when they used the low-airflow nostril, and more L-carvone when they used the high-airflow nostril (Fig. 1c).

The nostril with the higher airflow reverses periodically[4–6], so we tested eight subjects after the nostril with greater airflow had switched, and found that the perception of the same mixture reversed in seven of the eight subjects (binomial, $P = 0.035$). Odorant perception was therefore dependent on airflow rate, not on whether the odorant was smelled by the left or right nostril.

The different airflow between the nostrils results in a disparity of olfactory perception. Providing the olfactory system with two disparate images of the olfactory world with each sniff in this way may improve olfactory acuity by expanding the range of odorants that are within optimal sensitivity in a given sniff.

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