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ON HUMAN OLFACTORY SENSITIVITY ACROSS ODORANTS AND SUBJECTS

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Abstract

We present concentration-detection (i.e., psychometric) odor functions for 28 odorants tested on subgroups from a pool of 132 normosmic, nonsmoker participants (64 female), most of them between 18 and 40 years old (n=123), a few between 41 and 59 years old (n=9, 2 female). Odorants included n-alcohols (n=4), acetate esters (n=4), 2-ketones (n=4), alkylbenzenes (n=5), aldehydes (n=6), and carboxylic acids (n=5). Vapors were presented by dynamic olfactometry. We used a three-alternative forced-choice procedure against carbon-filtered air blanks, and an ascending concentration approach. During subject testing, gas chromatography (flame ionization detector) served to quantify delivered concentrations. The results from 12 subjects (8 female) tested on 10 or more odorants showed strong across-subject agreement regarding the least potent (highest odor detection thresholds) and the most potent (lowest thresholds) odorants. Odor functions from 6 subjects (3 female) tested on a common set of 6 odorants, agreed fully on which were the least and the most potent odorants, and agreed partially on the odorants of intermediate potency. Across these 6 subjects, the odor threshold range between the least and the most potent odorant covered 2 to 3 orders of magnitude. For each of the 6 odorants in common, the ratio between the least and the most sensitive of the 6 subjects was at or below 1 order of magnitude. All odorants had thresholds below 1 part per million by volume (ppm). Notably, carboxylic acids with 4 or more carbons in the chain length, and the aldehydes were the most potent olfactory stimuli with thresholds often below the part per billion (ppb) level.

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Introduction

Over the last few years, we have measured individual and group odor concentration-detection functions for 28 odorants belonging to six chemical series: n-alcohols, acetate esters, 2-ketones, n-alkylbenzenes, aldehydes, and carboxylic acids. Across studies, we have employed a uniform olfactometric, chemico-analytical (gas chromatography), and psychophysical methodology, aimed to optimize precision and effectiveness in odorant vapor delivery, chemical quantification, and chemosensory responses. Here we present the combined results of these studies in terms of their outcome regarding human olfactory sensitivity across odorants and across individual subjects.

Results and Discussion

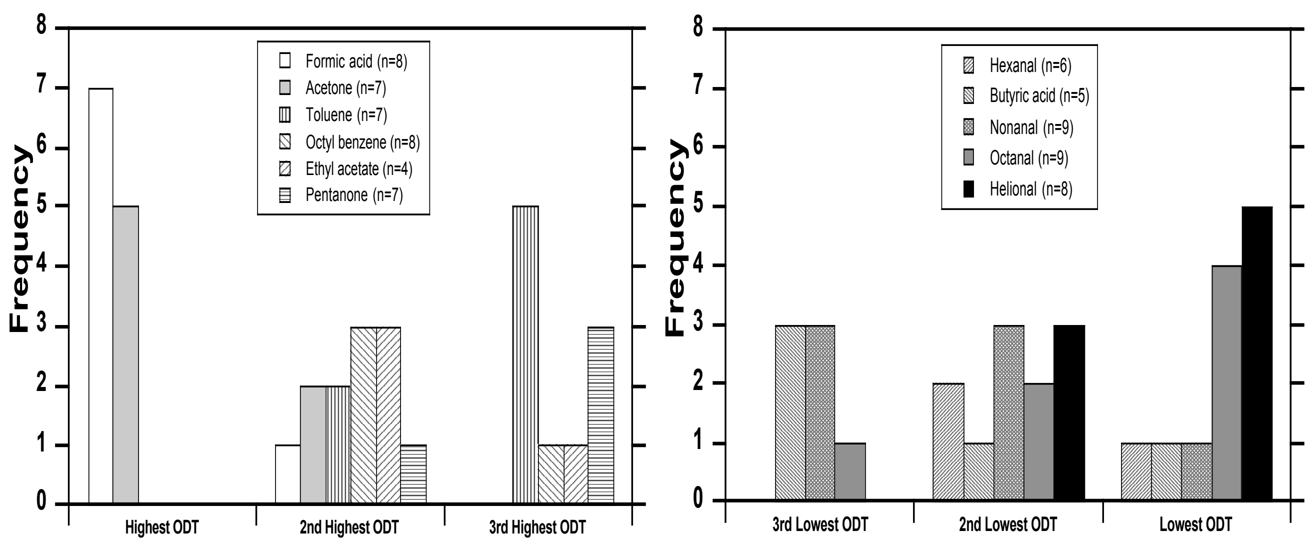

Figure 1. Left. Distribution of frequency (i.e., number of subjects out of the total indicated by "n") for which the odorants shown had the **highest**, **2nd highest**, and **3rd highest** odor detection threshold (ODT) among at least 10 and as many as 20 odorants, as shown in Figure 2. Right. Similar to left but for odorants having the **lowest**, **2nd lowest**, and **3rd lowest** odor detection threshold (ODT).

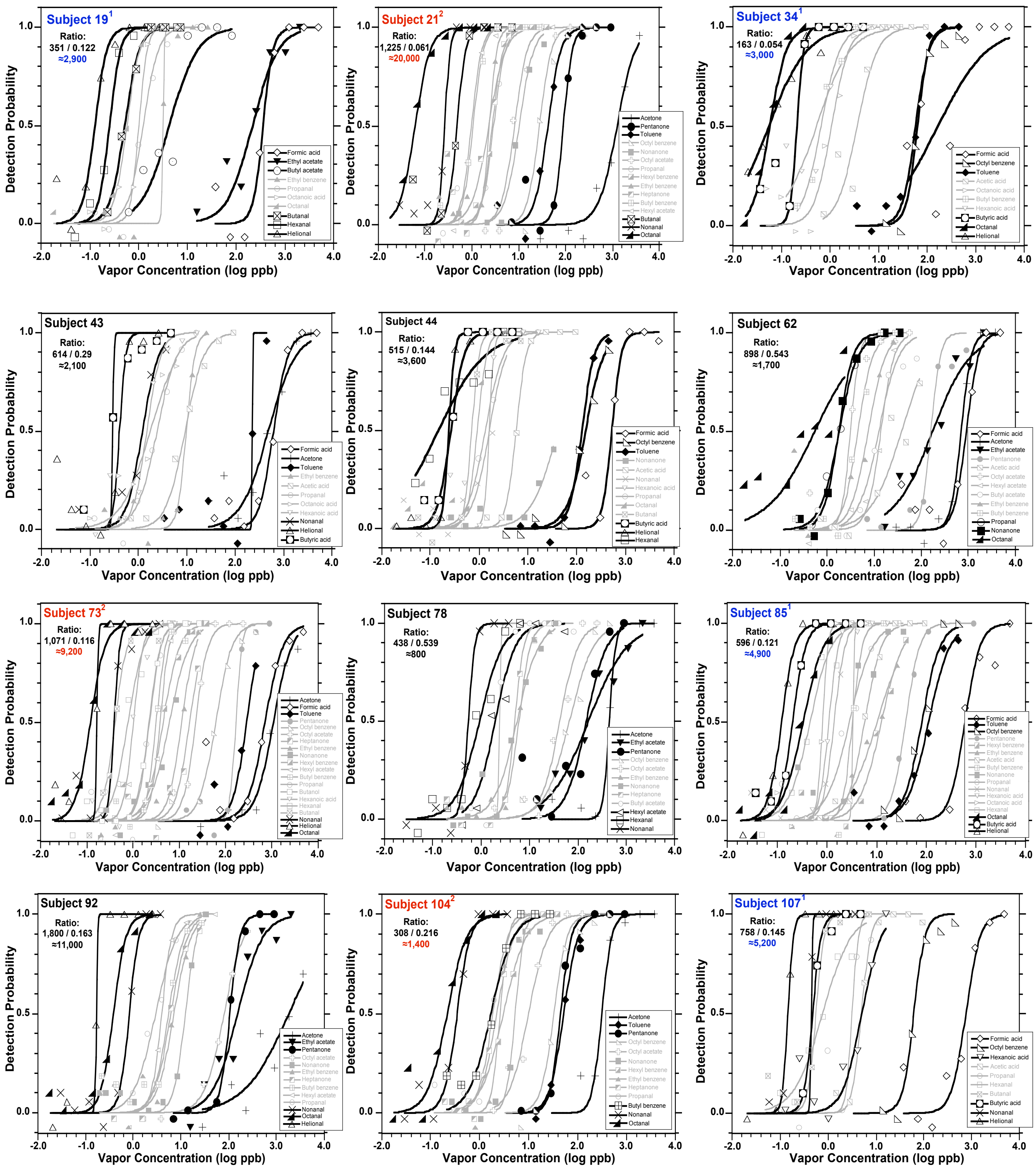

Figure 2. Individual odor concentration-detection (i.e., psychometric) functions for 12 healthy, young (average age ±SD: 25±5 years, range: 19–37 years),

normosmic, and nonsmoker subjects (8 female) tested on 10 or more odorants. **In each graph, the odor functions for the three most potent odorants (i.e., lowest odor thresholds, functions towards the left) and the three least potent odorants (i.e., highest odor thresholds, functions towards the right) are highlighted in dark traces.** Odorants within each plot's legend are ordered from highest to lowest odor threshold. Subjects sharing a font color and superscript number also shared their outcome in terms of the most and least potent odorants. We also show, for each subject, the ratio between the odor threshold for the least potent odorant and that for the most potent odorant (both concentrations expressed in ppb units). Odor functions were fitted by a sigmoid (logistic) equation: $P = P_{max}/(1 + e^{(-(x-C)/D)})$ where P = detection probability ($0 \leq P \leq 1$), P_{max}= 1.0, x = vapor concentration (in log ppb by volume), and C and D are constants. Note that C is the value of x when P = 0.5, i.e., when detection probability is half way between chance (P = 0.0) and perfect (P = 1.0) detection, i.e., the odor detection threshold (ODT) in units of log ppb, whereas D defines the steepness of the function.

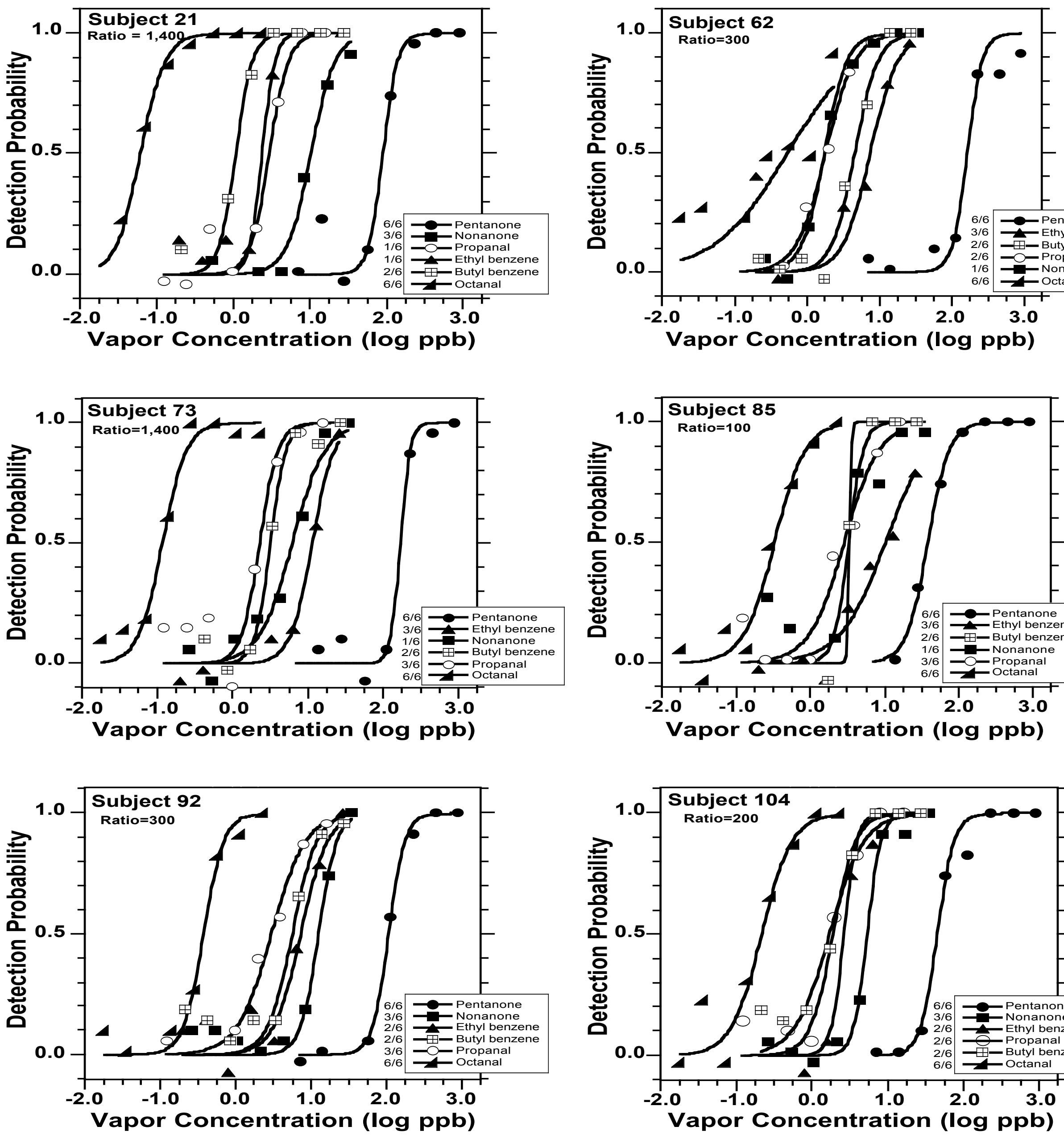

Figure 3. Spread of odor psychometric **functions across the same 6 odorants for each of 6 subjects**. The list of odorants shown under each subject's graph is ordered from highest to lowest odor threshold. For each subject we show the ratio of odor thresholds between the least and the most potent odorant. Note that, for every subject, 2-pentanone had the highest odor threshold, and octanal had the lowest odor threshold.

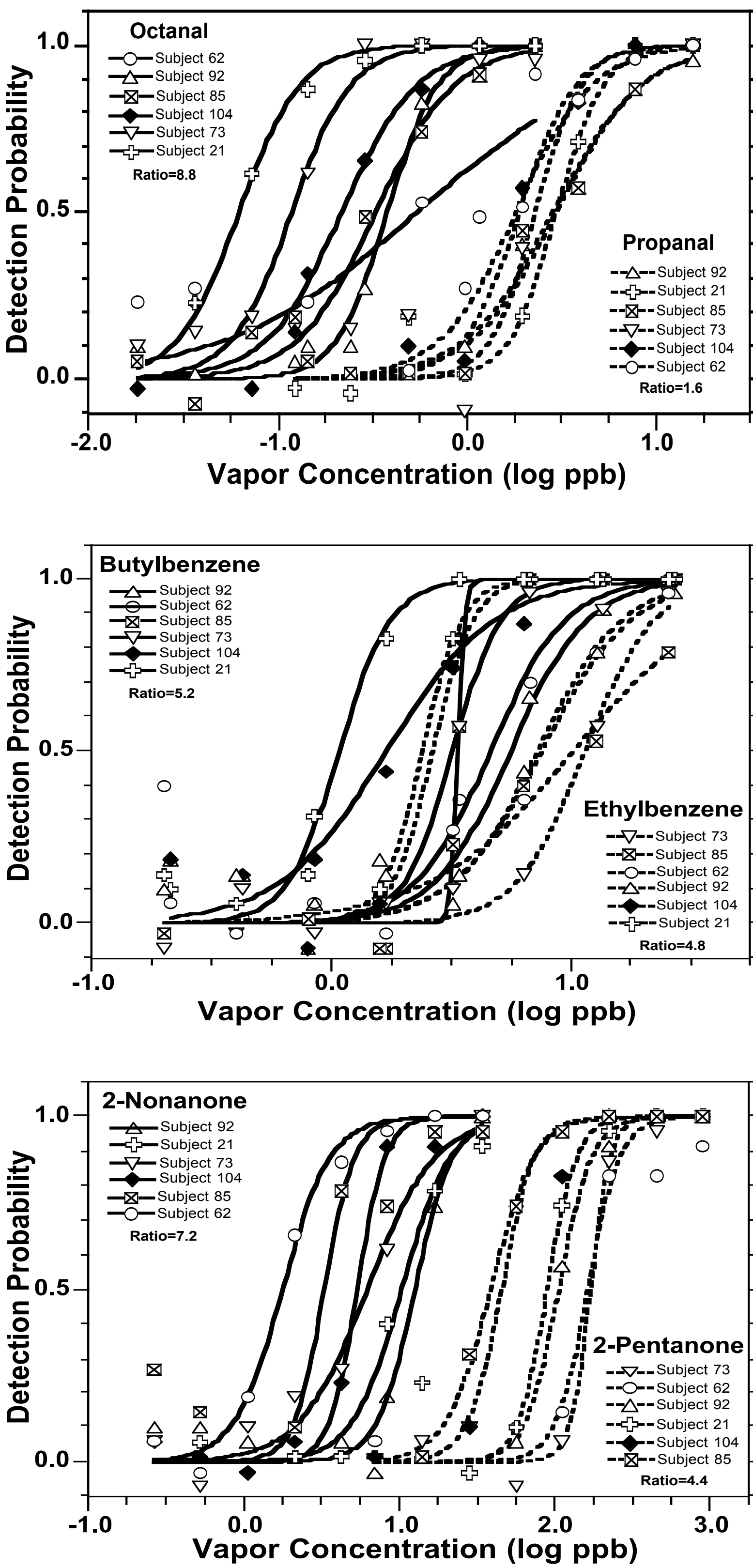

Figure 4. Spread of individual odor psychometric **functions across the same 6 subjects for each of 6 odorants**. The odorants comprised a shorter and a longer homolog from each of three chemical series: aliphatic aldehydes (upper plot), n-alkylbenzenes (middle plot), and 2-ketones (lower plot). The list of subjects under each odorant is ordered from least to most sensitive subject. For each odorant we calculated the ratio of odor thresholds between the least and the most sensitive subject.

Conclusions

Smell sensitivity assessed via odor psychometric functions among healthy, mostly young, normosmic, and nonsmoker individuals from both genders showed a high degree of similarity and comparability. For participants tested on sets of 10 or more odorants, olfactory potency across the sets, measured as the ratio between the least potent (i.e., highest threshold) and the most potent (i.e., lowest threshold) odorant, ranged between 3 and 4 orders of magnitude. For 6 subjects tested with a common set of 6 odorants, interindividual variability was at or below one order of magnitude.