

COMPARISON OF ODOR THRESHOLDS OBTAINED BY A THREE ALTERNATIVE CHOICE PROCEDURE AND BY THE METHOD OF LIMITS

Friedrich Müller and Matthias Metz
*Institute for Experimental Industrial Psychology
Leuphana University Lüneburg*

Abstract

50 healthy normosmic students obtained odor thresholds for butanol using the Sniffin`Sticks test (SnS), as well as the method of limits (ML) in ascending and descending order. The procedures were repeated about 2 weeks later. For each session and method the performance time was taken and subjects rated the pleasantness of the odor and the strain required by the task using a category anchored Visual Analogue Scale. For all subjects plausible thresholds could be obtained by the SnS procedure and by the ascending ML. For 22 out of 50 subjects, however, thresholds could not be obtained by the descending ML. Further analysis of the data revealed worse performance and significantly lower retest-reliabilities for those subjects in the ascending ML and the SnS-procedure as well.

Compared to other sensory modalities like loudness or visual acuity, thresholds for odorous stimuli are difficult to obtain. It's not only the sometimes confusing distinction between detection and recognition thresholds. Difficulties also result from adaptation and re-adaptation (Engen, 1973) and the location of olfactory receptors in the nasal cavity in their interaction with the timecourse and volume of sniffs (Hornung, 2006). Furthermore there is a high volatility within subjects; the sensibility for odors may differ within hours or even minutes (Stevens et al., 1988) and it is not rarely that anosmia for single specific scents in otherwise sensitive subjects are observed (Hummel et al., 2007). These influences of procedural factors on threshold values are still poorly understood (Pierce et al., 1996).

Regardless of all the difficulties there is considerable need for efficient and valid diagnostics of olfactory function in clinical practice especially in the diagnosis of Alzheimer's and Parkinson disease. In Germany the "Sniffin`Sticks" tests (Hummel et al. 1997) is the most widely used psychophysical tool for a differentiated assessment of olfactory function. It consists of 3 subtests, one for the determination of olfactory threshold and others for identification and discrimination between different odors. The Sniffin`Sticks test is scientifically well researched and proven in clinical use. Disadvantageous, however, is the test duration. Threshold determination alone requires about 20 minutes which may overstrain attention span and the power of concentration especially of elderly patients.

Aim of this study was to compare procedures and results of threshold determination using the Sniffin`Sticks test (SnS) and the method of limits (ML) in ascending and descending order. Dependent variables are the time needed for each method, the effort required from the subjects, the magnitudes of thresholds obtained and retest reliabilities for each procedure.

Using a cross over design 50 healthy normosmic students (32 women and 18 men, mean age 23,9 years, sd = 3.4) took part in the experiments. Separated by a 15-minutes-break they produced odor thresholds with both methods. All subjects appeared again about 2 weeks later (mean 13,2 days; sd = 2,4) to repeat the experiments.

Method

Sniffin` Sticks test

The Sniffin`Sticks test battery consists of 48 pen marker-like odor dispensing devices. The pens are about 14 cm long with an inner diameter of 1,3 cm. The tampons inside of 16 sticks contain 4 ml butanol in different dilutions with the highest concentration at 4%. Further concentrations were produced by consecutive dilution at a ratio of 1:2. Solvent for butanol is water. The remaining 32 sticks are blanks. Odor thresholds are obtained in a single-staircase, 3-alternative forced-choise procedure. After the cap is removed, the sticks tip is presented for 3 sec. about 2 cm in front of both nostrils of the blindfolded subject. Three sticks of a set, one containing butanol and two blacks, are randomly presented within a 20 s interval. The task of the subjects is to identify the butanol-containing stick. Concentrations were scaled down when the odor was correctly identified in 2 successive trials. Higher concentrations were presented when the odor was not correctly identified in one trial. Threshold is defined as the arithmetic mean of the last 4 out of 7 staircase reversals.

Method of limits

Using the method of limits (ML) each session started in ascending order, beginning with the stick containing the lowest concentration (0.00012% butanol). Then followed by the 3rd, 5th concentration ... and so on, until subjects reported having a smell. At this point the next lower concentration was presented, followed by a blank. If the blank was correctly identified the target with the last correctly identified concentration was repeated and after presentation of a blank the stick with the next higher concentration. If the answers of the subject were consistent the presentation in descending order was started with a concentration 3 steps above the threshold obtained in ascending order. The descending procedure went stepwise, occasional interrupted by blanks, until subjects reported no smell. The interstimulus-intervall was always between 20 and 25 sec. Threshold was defined as the arithmetic mean of the threshold obtained in ascending and descending order.

Scaling psychological tension as an indicator for strain and pleasantness of the target

As a measure for the effort subjects reported the magnitude of strain as perceived as activation or psychological tension required by the tasks using a category anchored visual analogue scale. The measures were given by moving a slider onto the appropriate position of the scale (Fig 1, lower part). Invisible to the subject the experimenter got a corresponding scale value in a range between 1.0 = "very low strain" and 18.5 "very high strain" (Fig 1 upper part). A similar scale was used for the quantification of the pleasantness of the butanol stimuli with the categories "very unpleasant" "unpleasant", "neutral", pleasant" and "very pleasant". The measures for pleasantness and strain were taken after each of the threshold determinations was completed.

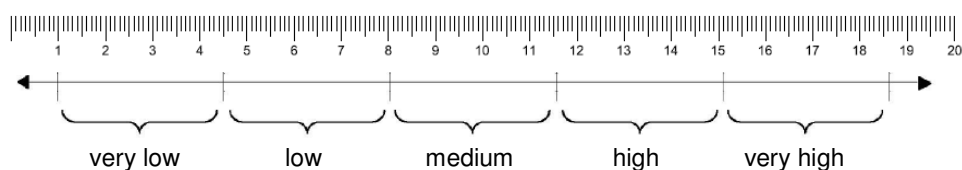


Fig 1. Category anchored VAS for the assessment of strain. The upper scale is only visible for the experimenter

Results

The most surprising result is that for 22 subjects thresholds in the descending ML could not be ascertained (10 in the first test session, 9 in the retest and 3 in both sessions). Regardless of whether a target or a blank was presented, these subjects reported smelling the target odor throughout the experiment.

This observation led to evaluate the collected data separately for those 28 subjects who ascertained plausible threshold in all experimental conditions and for the remaining 22 subjects who failed in the descending ML.

The overall data are presented in Fig. 2. On the left the averaged threshold obtained are shown for the first test sessions (T) and retest (R) and separately for the Sniffin` Sticks-procedure (SnS) and the Method of limits (ML) in ascending (up) and descending (down) order. The presented numbers represent the label names of the used sticks with no. 16 for the stick containing the lowest butanol concentration and no. 1 for the stick containing the highest concentration.

The middle part of fig.1 shows the averaged time needed (minutes) for each of the tasks. On the right the scaled strain indicator and hedonic value of the target are given. If not obvious as in the durations of SnS vs. ML, statistical significant differences are denoted.

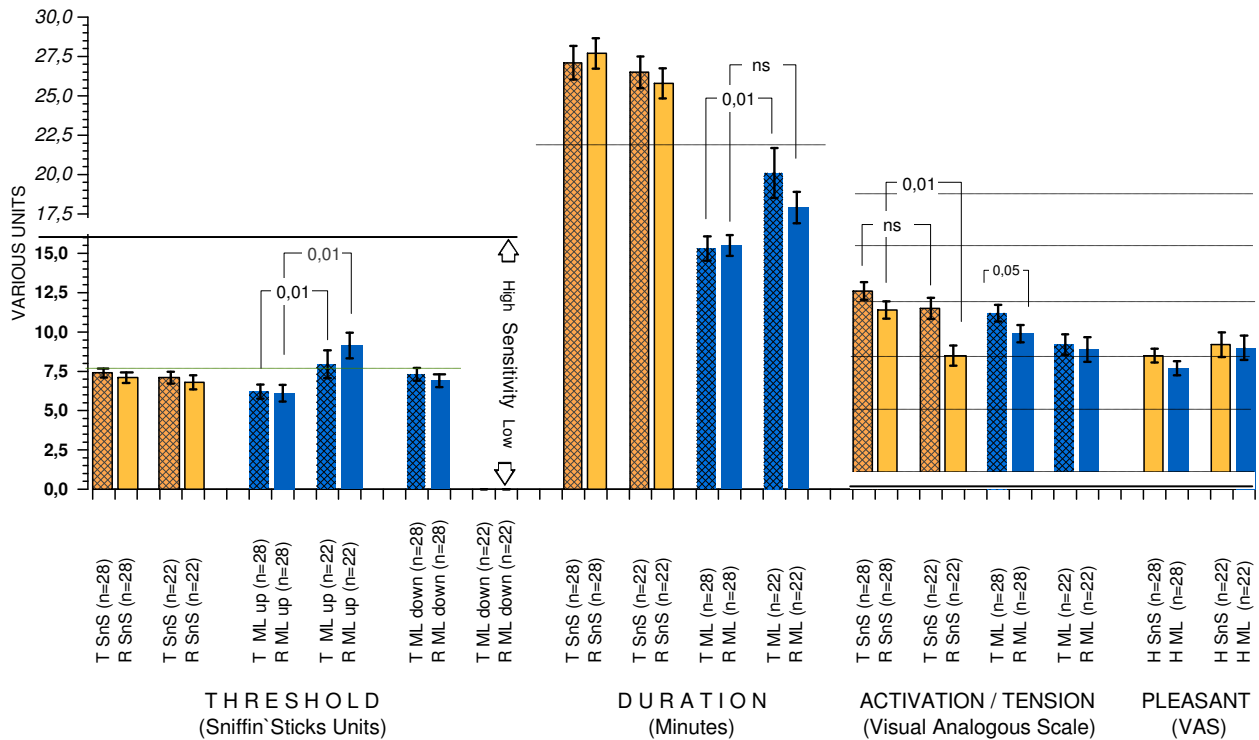


Fig 2. Averaged magnitude of thresholds, duration, scaled activation/tension as indicator of strain, and pleasantness of the target odor

In the first session, using the SnS-procedure the subjects who determined plausible thresholds in all experimental conditions seemed to be more sensitive with quicker performance. The correlation between threshold and duration in T SnS is $r_{\text{threshold/duration T SnS}} = -0,489$; $p < 0,01$; $n = 28$. The corresponding correlation for the group of 22 subjects is not significant ($r = -0,337$; ns). In the retest but not in the first test session the sensitivity for butanol is increased if activation increases ($r_{\text{threshold/activation R SnS}} = 0,507$; $p < 0,01$; $n = 28$ and $r_{\text{threshold/activation R SnS}} = 0,303$; n.s.; $n = 22$)

Table 1. Correlations and retest-reliabilities between tests (T) and retests (R) for odor thresholds obtained by the Sniffin´Sticks test (SnS) and the ascending (up) and descending (down) Method of Limits (ML) for a group of 28 subjects (upper right) who performed well in all experiments and for 22 subjects who failed in the descending ML (lower left)

		n = 28 subjects							
		T SnS	R SnS	T MLu	R MLu	T MLd	R MLd	T ML	R ML
n = 22 subjects	T SnS	—	0,651 p<0.001	0,408 p<0.05	-	0,524 p<0,01	-	0,527 p<0,001	-
	R SnS	-0,105 n.s.	—	-	0,316 P<0,05	-	0,418 p<0,05	-	0,382 p<0,05
	T MLu	0,267 ns	-	—	0,579 p<0,01	0,550 p<0,01	-	-	-
	R MLu	-	0,225 ns	0,439 p<0,05	—	-	0,762 p<0,001	-	-
	T MLd	-	-	-	-	—	0,647 p<0,001	-	-
	T MLd	-	-	-	-	-	—	-	-
	T ML	-	-	-	-	-	-	—	0,643 p<0,001
	R ML	-	-	-	-	-	-	-	—

Retest-reliabilities are reasonable in the group of 28 subjects. In the smaller group (n = 22) the retest-reliability is lower not only in the ML. Even a negative correlation is seen if the thresholds of test and retest obtained in the SnS are compared, whereas magnitude and variation of the determined thresholds (Fig 1) look similar. We may conclude that the 22 subjects identified by the descending ML are, for whatever reason, generally less qualified for the determination of odor thresholds. This difficulty, which may cause invalid thresholds, remains undiscovered by the Sniffin´Stick procedure but may be disclosed by a variation of the ML, a procedure which is for good reasons not used in clinical practice.

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