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BETTER IDENTIFICATION OF GAS LEAKAGE BY LEARNING THE SMELL OF ODORANTS

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Abstract

Within the scope of this study, olfactory examinations of different domestic odors compared to odourizers were carried out at the DVGW research center at the Engler-Bunte-Institut of KIT. The main question was to answer whether "learning" specific smell of the sulfur-free odorant Gasodor® S-Free leads to a better recognition of the odorant Gasodor® S-Free and to less confusion with other typical house odors. For this purpose, odor evaluations were carried out using a questionnaire with a total of 123 subjects in three measuring technology runs on the olfactometer. In addition to the sulfur-free odorant Gasodor® S-Free and the sulfur-containing odorant THT, domestic odors such as, for example, onion, garlic and glue were evaluated to assess the odor intensity and odor characteristics. A group of people had "learned" the specific odor of the Gasodor® S-Free by means of corresponding odor labels. The results show that learning or an adaptation to the odor of the odorant can lead to an increase in safety. Learning the odorant odor Gasodor® S-Free improves the identification (reduces the risk of confusion) and the intensity of the perception.

1. Introduction

The odorization of distributed gases from the public gas supply is proving to be a big safety concern for the population (Graf, 2016). The safety concept of odourization is based on the intensity and characteristic odor of odorants in the distributed gas. The safety requirements for odorization in the public gas supply in Germany are described in the DVGW worksheet G 280-1 "*Gasodorierung*" (G280-1, 2016). According to this, the gas supply company responsible for the distribution must ensure that the distributed gas has a sufficient warning odor at all times throughout the distribution network. Furthermore, the worksheet describes requirements for odorants for use in the public gas supply, technical framework conditions of the odorization and the determination of the K value. This enables the calculation of the minimum odorant concentration used in the natural gas supply network (G280-1, 2016). Essential requirements for ensuring the "warning odor" are (G280-1, 2016):

- The odor must not be confused with other frequently occurring odors
- It must be unpleasant but not too repulsive
- Smell must not show variation in different concentrations in air

Table 1: Odourizing agents developed after "long-term practical experience" according to G 280-1 (2012) (G280-1, 2016)

Odorant	Minimum-Odoriermittelkonzentration in mg/m³
THT	10
Sulphur free odorant	8
Ethylacrylate-/THT-mix	6
Mercaptane	3 (natural gas); 8 (LPG)

The warning odor of an odourizer must be perceived in very low concentrations in the air and can lead to the gas technician being warned and given sufficient time to avert danger to himself and the environment. Table 1 lists the odorants currently approved in Germany according to G 280-1 with their minimum odorant concentration (G280-1, 2016). The minimum odorant concentration is inversely proportional to the intensity of odor perception. In order to achieve this safety, leaking natural gas must be reliably perceived as natural gas in air within 20% of the lower

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explosive limit. For odorized natural gas (lower ignition limit of approx. 4% by volume in air), this warning odor stage must be reached at a natural gas concentration of 0.8% by volume in air. The odorant-dependent K-value indicates the odorant concentration in air, which is necessary to safely reach the level of odorants and to calculate the minimum odorant concentration (G280-1, 2016). The warning odor level corresponds to the average odor intensity, in which each person with average smell ability and with an average physiological condition can certainly perceive the smell (G280-1, 2016).

2. Principles and the applied olfactometer

The perception of an odor occurs when inhaling certain volatile substances through the olfactory organ and is an organoleptic attribute (arousing to a sense organ). The sense of smell is then the consciousness due to a sensory perception which follows a corresponding stimulus of the smell system (DIN EN 13725, 2016). The sense of smell in people is thus a subjective impression, which is influenced by many factors such as age, sex and experiences (Puschmann, 2013). The same odorous impressions are therefore perceived differently by different persons and also subsequently are evaluated differently. In addition, the individual assessment of odors is dependent, inter alia, on the respective "daily form" and the previously perceived odors and tastes of the person. In order to be able to adequately assess an odorant (odorizing agent) with regard to its odor properties, the intensity and the characteristic (hedonics) of the substance must be determined in addition to the odor threshold (DIN EN 13725, 2016). The evaluation of an odor generating substance with the human nose is called olfactometry and is carried out with the aid of subjects. The subjects assess the intensity of the presented odorant with the aid of the intensity scale from 0: no odor to 6: extremely strong (Table 2). The assessment of the odor characteristic of an odor sample is referred to as hedonics and is also carried out on the olfactometer. The hedonic examination serves to estimate the harassment effect of an odor sample.

Table 2: Classification of the odor intensity according to G 280-1 (2012)

Odour level	Definition	Comment
0	Not detectable	---
1	Very weak	Limits of perceptibility (Odor threshold)
2	Weak	---
3	Distinct	Average level of intensity
4	Strong	---
5	Very strong	---
6	Strongest	Highest intensity possible

In the course of this study, the olfactory examinations were carried out by means of an olfactometer, which was constructed according to the requirements of DIN EN 13725 (DIN EN 13725, 2016). The odorant analysed was in diluted with air which corresponded to 0.8% by volume to 1% by volume of natural gas in air. This was to ensure that the warning at the lower explosion limit (at the minimum odorant concentration) was clear. The olfactometer used allowed the performance of six different odorant samples to be evaluated in a direct comparison by a large number of people.

Figure 1: Olfactometry setup

The assessment of the subjective responses was carried out using a questionnaire, using the odor levels from "0 - no smell" to "6 - extreme smell". The assessment of the odor characteristics was carried out verbally (questionnaire) by the persons. The olfactometer is shown in Fig 1.

3. Analysis

The aim of this study was to verify the thesis that the "learning" of a certain odor - in this case, the odorant Gasodor® S-Free - can alleviate confusion in comparison to familiar domestic odors. For this purpose, the odors mentioned in Table 3 were presented in three trials to two different groups of subjects on the olfactometer. Group I learned the odor of the sulfur-free odorant by means of olfactory labels before the olfactory examination in trial 1, which was to determine the short-term re-detection of the odorant. People of this group learned the smell before trial 2 (about 6 months later). As a control group, a group of persons (group II) was subjected to the same odors in the trial 3 without prior adaptation to the odor. Group I consisted of 65 subjects and in the group 2 had 51 persons. The Group II, "untrained" persons, consisted of 58 people. The odors were assessed according to intensity and odor characteristics using the questionnaire.

Table 3: Odour samples for evaluation on the olfactometer

No.	**Smell sample**	**Concentration in mg/m³**	**Groups**	**No.**	**Smell sample**
			Group 1 Trial 1 (Nov. 15)	Group 1 Trial 2 (May 16)	Group 1 Trial 3 (May 16)
15059-G1	Gasodor® S-Free	11,1	2	2	2
15059-G2	Kitchen frying smell	-	6	-	-
15059-G3	Faecal smell	-	3	3	3
15059-G4	Garlic	-	4	6	6
15059-G5	Onion	-	5	1	1
15059-G6	Ethyl acetate (Glue)	-	1	5	5
THT	THT	10,8	-	4	4

4. Results

The results of the intensity determinations of the three trials are shown in figures. 2 to 4. The odor intensity of the sulfur-free odourizer was assessed "distinctly" and more strongly after "learning" the smell by 95.4% (Figure 2) and 84.3% (Figure 3) of the participants. Gasodor® S-Free (15059-G1) was somewhat weaker in the second run, but stronger than the sulfur-containing odorant tetra hydro thiophene (THT).

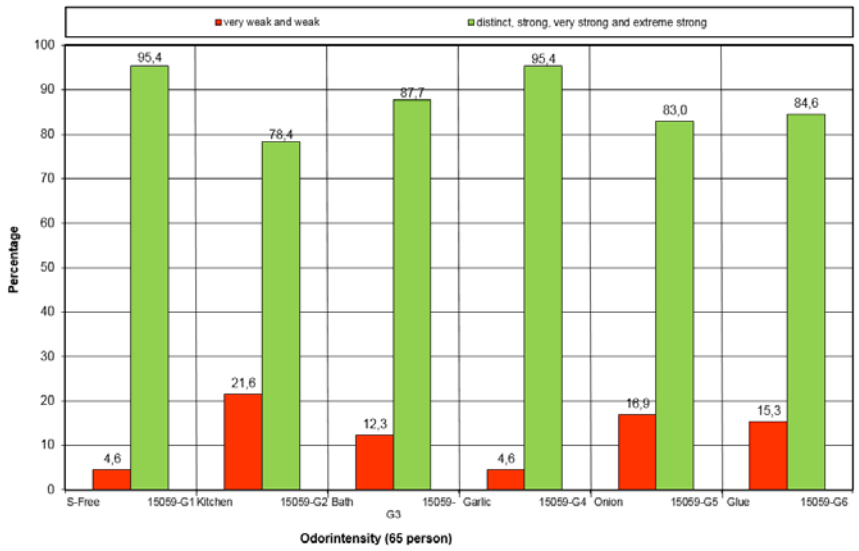

Fig. 2: Results of the odor intensity determinations (1st trial, Nov. 2015)

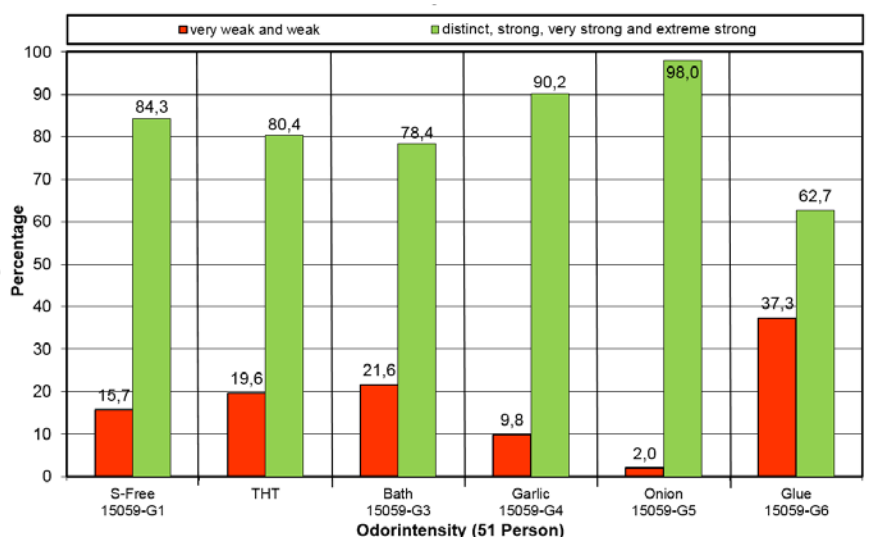

Fig. 3: Results of the odour intensity determinations (2nd trial, May 2016)

The greatest difference between the two trials are observed in differential recognition of onion odor (15059-G5) and ethyl acetate (15059-G6). The odor that was first presented was generally disproportionately high by the participants. In trial 1 this was the glue (ethyl acetate) and in the trial 2 and 3, it was the onion odor. In particular, the onion odor was judged to be significantly weaker in the first trial. In the comparative group "unstrained" (trial 3), Gasodor® S-Free was assessed by 75.9% of persons with an odor intensity of "distinct" and stronger. THT was judged to be the strongest in trial 3 with 91.4% similar to the gas 15059-G5 (onion which topped the list and was judged disproportionately strong). This means that learning has a positive effect on odor intensity detection.

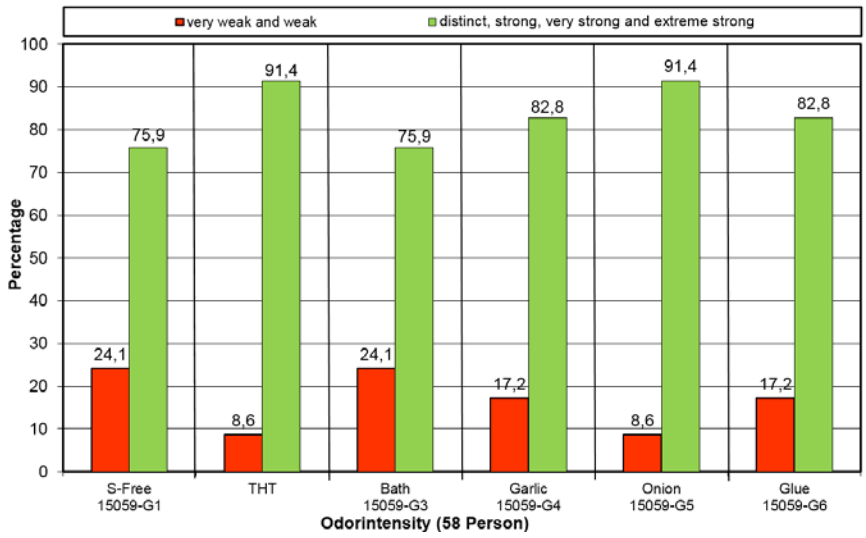

Fig. 4: Results of the odor intensity determinations (3rd trial, June 2016)

In Figure 5, the odor attributes "unpleasant", "gas odor" and "alarming" of the three trials are summarized. In the evaluation of the odor characteristic, the attribute "gas odor" was used in the first trial of 3.1% of the persons for Gasodor® S-Free, although 72.3% of the persons recognized the smell as "learned".

In the second round, 33.3% of the subjects labeled the smell as "gas odor" and 68.6% had recollected it. In the trial 3 "untrained group", Gasodor® S-Free was attributed to as "gas odor" by 12.1%.

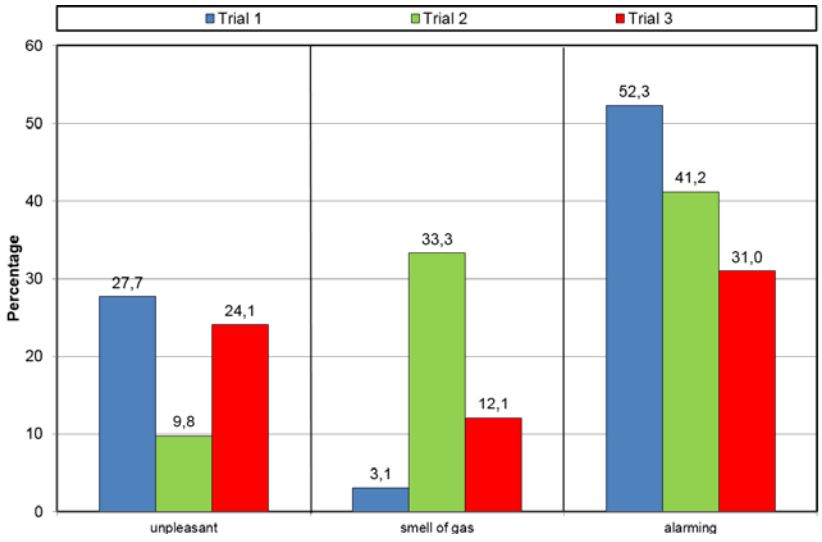

Fig. 5: Summary of the odour characteristic (selected attributes

Thus, the difference between these two groups is 21.2% points in favor of group I, which had "learned" the smell. From this it can be concluded that if the "learning" is repeated, then a significant improvement of the recognition is also to be expected in the long term. 52.3% of persons in group I (learned) have described Gasodor® S-Free as "alarming" in the first run. In the second round, the figure was 41.2%. Both values are clearly above those of the third round (untrained) with 31.0%. Compared to the domestic odors presented, Gasodor® S-Free was more likely to be perceived as alarming and more frequent than gas. However, there is a risk of confusion in the case of ethyl acetate (glue), which smells similar and is often classified as "alarming". The sulfur-containing odorant THT, which was also presented in the second and third trials, was rated higher than Gasodor® S-Free for all three attributes mentioned. At THT there was also a danger of confusion in the direction of gasoline.

4.1. Summary and Conclusion

Within the framework of the study, odor evaluations of the sulfur-free odorant Gasodor S-Free were carried out with the help of 123 voluntary persons and the smells were compared to various domestic odors and THT. The persons who evaluated the odors were presented to the olfactometer and the odor intensity and the odor characteristics were analysed on the basis of a questionnaire given to a set of test subjects who volunteered for the experiment. Overall, a "learning effect" can be seen. A high percentage (second trial: 33.3%) of persons who knew the odor of the sulfur-free odorant and were warned that it is a gas warning odor and successfully re-described the smell as gas odor. Learning the odorant odor Gasodor® S-Free improves the identification (reduces the risk of confusion), the "warning" function and the intensity of the perception. The results obtained in this study show that a learning or adaptation to the odor of the odorant is an important part of increase in safety of the gas supply system.

5. References

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