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ORIGINAL PAPER

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Olfactory deficits in anorexia nervosa

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Abstract *Objective* Young patients admitted to the hospital due to anorexia nervosa report reduced pleasure and impaired perception of smell while eating. So far, two studies on odour identification ability in eating disorders did not suggest any significant deficits. Therefore a new and more detailed method of olfactory testing may be needed, in order to determine the subjective impairment of olfaction. *Method* By using all three subtests of the recently developed smell test called "Sniffin' Sticks", the olfactory deficits were assessed in more detail and the results of female anorectic patients (n = 17) were compared with those of healthy females (n = 15). *Results* By examining the anorectic patients no deficits in the subtest *odour identification* were found. On the contrary, in the subtests *odour discrimination* and *odour threshold* deficits of the anorectic patients were detected. *Conclusion* Reduced olfactory perception might be considered as a common deficit in anorexia nervosa with possible influences and consequences for therapy.

Key words eating disorders · olfaction · smell · taste

Introduction

Many patients suffering from anorexia nervosa report a reduced pleasure in eating [1] and may show a low hedonic responsiveness to flavour [2–4]. Further, reports of changed eating patterns of patients suddenly becoming anosmic are striking [5–9] and hyposmia may lead to a diminished enjoyment of eating [7, 10]. In view of this, the question arises whether the disturbed eating behaviour of anorectic females may be influenced by an impaired olfaction as well [11].

Two studies have been conducted on olfaction in anorexia nervosa so far, where the University of Pennsylvania Smell Identification Test (UPSIT) was performed using olfactory stimuli of clearly higher intensity than the detection threshold of the average population [12]. In the UPSIT 40 different odours are presented to the subject, who has to identify the smell stimulus by choosing among 4 possible answers for each of the odours. This procedure is regarded as an *odour identification* test.

In the first study – carried out by Kopala et al. [13] – the anorectic patients showed no significant deficits in the UPSIT. This result is consistent with the finding of normal serum zinc levels (a reduced concentration of zinc in plasma may cause hyposmia [14, 15] and zinc supplementation may enhance the rate of recovery in anorexia nervosa [16]).

Fedoroff et al. [17] used the UPSIT, too, to test the odour identification ability and performed an odour threshold test employing the rose-like stimulus phenylethyl-alcohol in different concentrations. Fifty-five patients suffering from food-restricting anorexia nervosa with and without bulimic features and from bulimia nervosa participated in this study, but a deficit was found only in severely disturbed anorectic patients, i. e. the more underweight the more impaired the olfactory function was. It was suggested that the olfactory deficits may have implications for the recovery process and therefore a vicious circle of orosensory deficits and reduced food intake may exist. To break this physiologically vicious circle, controlled weight gain seems to be the best basis for a successful course of further therapy. The importance of weight gain has been acknowledged mainly with respect to the relatively poor prognosis of anorexia nervosa [18], but biological factors, which may hinder the intake of food, have not been explained suffi-

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ciently so far [19–21]. It is suggested that orosensory deficits (even if developed by starvation only) may be of great importance in this respect [17].

The aim of this study was to verify this assumption by using the more detailed and standardised "Sniffin' Sticks" method [22] for the first time in anorexia nervosa. In addition to the commonly used subtest *odour identification*, the two subtests *odour discrimination* and *odour threshold* were performed here.

Method

Subjects

In the period of March 2001 to July 2002, 17 female anorectic patients who were admitted to the Department of Psychiatry and Psychotherapy, Friedrich-Alexander University of Erlangen-Nuremberg, Germany, in order to start a multimodal therapy, were asked to participate in this study. All patients gave informed consent. They all clearly fulfilled the criteria of ICD 10 for anorexia nervosa, restricting type (mean BMI 14.6; standard deviation 1.39). The diagnosis was made independently by two board-certified child and adolescent psychiatrists. No bulimic symptoms or other comorbidities like depression etc. could be found. Their mean age was 16.7 years (standard deviation 3.0 years).

As healthy controls 15 girls from different classes of an Erlangen high school and female students from the University of Erlangen-Nuremberg were recruited (mean BMI 19.6; standard deviation 1.40). Their mean age was 16.2 years (standard deviation 3.1 years). They had reported that they had not been showing any dieting behaviour during the last 3 months or had visited a psychiatrist.

Exclusion criteria for both groups were smoking, medication, drug use (particularly in view of inhalational drug abuse) and any oropharyngeal problems.

A re-testing after weight gain could be performed in six patients only.

Procedure and instruments

The patients and the controls were all examined after lunch between 13:30 and 14:30 by the same observer (V. R.) using the identical method, in quiet, well-ventilated rooms. Both groups, patients and controls, were asked before the testing about their subjective rating of olfaction and a possible feeling of impairment. Testing was performed by the "Sniffin' Sticks" method consisting of first the subtest *odour threshold*, second the subtest *odour discrimination* and third the subtest *odour identification*. The test had shown good test-retest reliability (r24 = 0.73) [22] similar to data reported by Doty [23]. It was also demonstrated that the "Sniffin' Sticks" test discriminates the well-known age-related changes in olfactory performance and clearly differentiates between olfactory performance in males and females [24]. In addition, it could be shown that the "Sniffin' Sticks" test provides the possibility to clearly distinguish between anosmics and normosmics, whereby the results proved to be highly reproducible. Furthermore, this method permits a semi-quantitative assessment of partial olfactory disorders [25].

The detailed test conditions and background information on their development are described by Hummel et al. [22]. In our study, we strictly followed the testing method described by Hummel [22]. Information about this method is summarised comprehensively to facilitate understanding of the process of development and the performance guidelines of the commercially available "Sniffin' Sticks" test:

Odourants were presented in felt-tip pens. Instead of liquid dye, the reservoir of the 112 pens was filled with 4 ml of liquid odourant or odourants dissolved in propylene glycol. For odour presentation, the cap was removed and the tip of the pen was placed approximately 2 cm in front of both nostrils for about 3 s, although separate testing for each nostril is also possible in principle. For the two subtests *odour threshold* and *odour discrimination* the test persons were blindfolded with a sleeping mask to prevent visual identification of the target sticks.

The *odour threshold* test was performed with n-butanol using a single staircase, triple-forced choice procedure. Sixteen solutions were prepared in a geometric row starting with a 4 % n-butanol solution (dilution ratio 1:2 in deionized aqua conservata as the diluent). At each stage, three pens were presented in a randomised order, two containing the solvent only and the third the odourant at a certain dilution. The subjects had the task to identify the odour-containing pen. First, triplets with increasing concentrations were presented at intervals of 20 s. Reversal of the staircase was performed when the odour was correctly identified in two successive trials. The staircase was then again reversed after two wrong answers. The threshold was defined as the mean of the last four out of seven staircase reversal points. The scores ranged between 0 and 16, whereby results with two counting digits after the comma (e. g. 5.75) could be obtained. In this subtest higher scores indicate an impairment of olfaction.

The *odour discrimination* test was performed by means of triplets of odourants, two pens containing the same odourant and the third a different odourant. Criteria for the selection of odourants were as follows [22]:

- Odourants comprising a triplet should be similar with regard to intensity (clearly higher intensity than the detection threshold of the average population [25]) and hedonic tone.
- Correct discrimination of individual odourants should be above 75 % in healthy subjects.

The subjects' task was to identify, which of the three odour-containing pens smelled different. The interval between the presentation of individual pens of a triplet was approximately 3 s. The presentation of triplets was separated again by at least 30 s. With a total of 16 triplets tested, the scores ranged again from 0 to 16. The higher the score the better is the ability of odour discrimination.

For the *odour identification* test 16 common odourants [26] like peppermint, vanilla etc. were chosen. The criteria for the selection of odourants were similar as described above for the *odour discrimination* test [22]:

- The test subjects should be familiar with odour-describing items.
- At least 75 % of the control group should be able to correctly identify the smell stimulus out of the 4 possibile answers presented.
- Odourants included in the test should be similar with regard to both intensity (clearly higher intensity than the detection threshold of the average population [25]) and hedonic tone.

Subjects were free to sample the odours as often as necessary to take a decision. The interval between presenting different odour identification tasks was at least 30 s to prevent olfactory desensitization [28]. The scores ranged from 0 to 16 (1 point for each successful answer), higher scores indicate a better ability of odour identification.

An influence on single scores mediated by the hedonic tone of some odours might be seen in anorexia nervosa in regard of the existing general aversion against all food-related stimuli. As only in the *odour identification* test food-related odours are applied, this might have led to changes of the intensity perceived [27].

Both the *odour discrimination* and the *odour identification* tests were performed using the forced multiple choice procedure. This means the subject had to tick one answer in each case, it was possible to give right answers by chance. The stimuli in the *odour discrimination* and the *odour identification* test were clearly of suprathreshold intensity [25].

Statistical analysis was performed using the T-test (group differences), the Pearson-test (correlation) and the Mann-Whitney U-test (to compare results of food- vs. non-food related odours in the *odour identification* test; n = 3 for non-food related odours permits using a T-test).

Results

Most individuals rated their olfaction as being normal (normal/decreased/increased n = 13/2/2 in anorexia nervosa vs. n = 13/1/3 in controls). The two different groups showed no significant differences in age, but as expected the BMI differed between the two groups (14.87 for patients, standard deviation 1.69 vs. 19.62 for controls, standard deviation 1.40; $p < 0.001$).

The *odour identification* test revealed no significant difference (13.82 for patients, standard deviation 1.29 vs. 13.33 for controls, standard deviation 1.18; $p = 0.272$). No differences between food related (n = 13; rank sum 218.5 for patients vs. rank sum 277.5 for controls; $U = 98.5$; $Z = -0.881$; $p = 0.378$) and non-food related odours (n = 3; rank sum 236.0 for patients vs. rank sum 260.0 for controls; $U = 116.0$; $Z = 0.183$; $p = 0.855$) were found.

For the *odour discrimination* test slight deficits in anorectic patients were found (12.18 for patients, standard deviation 1.84 vs. 13.93 for controls, standard deviation 0.88; $p = 0.002$). In the *odour threshold* test the patients showed a significantly higher olfactory threshold (6.25 for patients, standard deviation 2.12 vs. 11.57 for controls, standard deviation 2.39; $p < 0.001$) than the controls. This finding indicates that anorectic patients showed a reduction of the peripheral olfactory perceptual ability compared to healthy controls.

A correlation between olfactory performance and the BMI could be found in the total sample for the *odour identification* test ($r = -0.331$, $p = 0.032$), for the *odour discrimination* test ($r = 0.395$; $p = 0.013$) and for the *odour threshold* test ($r = 0.65$; $p < 0.001$). The intercorrelations did not reach significance (*odour threshold* and *odour discrimination* $r = 0.27$; $p = 0.65$; *odour threshold* and *odour identification* $r = 0.12$; $p = 0.26$; *odour discrimination* and *odour identification* $r = -0.01$; $p = 0.47$).

After weight gain (mean BMI 15.03 standard deviation 1.31 before vs. 18.33 standard deviation 1.12 after weight gain; $p < 0.001$) we were able to re-test 6 of the 17 anorectic patients. We observed a trend towards improvement in *odour threshold* (mean 6.92 standard deviation 1.91 before vs. 9.00 standard deviation 1.81 after weight gain; $p = 0.81$) and *odour discrimination* (mean 10.83 standard deviation 1.47 before vs. 13 standard deviation 2.10 after weight gain; $p = 0.65$), whereas *odour identification* ability did not change (mean 13.67 standard deviation 1.37 before vs. 13.83 standard deviation 1.94 after weight gain; $p = 0.867$).

Discussion

Most anorectic patients and controls appraised their olfaction as normal. Interestingly, no individual reported a feeling of impairment independent of the self-rating of olfaction.

Since reduced orosensory stimulation may be related to eating behaviour and body weight [30], perception and cognition measures of odours were compared between anorectic patients and healthy controls, using the newly developed "Sniffin' Sticks" method [22]. In agreement with previous results obtained by UPSIT (*odour identification* test) in anorectic patients [13, 17], no significant olfactory deficits in the subtest *odour identification* were found in this study, while the subtests *odour threshold* and *odour discrimination* did indicate olfactory deficits in anorectic patients.

However, results of *odour discrimination* tests in general and of this subtest in the "Sniffin' Sticks" method in particular should be regarded with caution. Particularly this subtest is influenced by both peripheral olfactory ability and higher cortical olfactory skills:

On the one hand the observed reduction of *odour discrimination* performance might be based on deficits in *odour threshold*, an indicator of peripheral olfactory deficits [31]. On the other hand, especially the subtest *odour discrimination* might be influenced by central factors, e. g. attention [32].

Hence two main conclusions may be drawn:

- The peripheral ability of olfactory receptors in anorectic patients seems to be impaired only to such a degree that the suprathreshold olfactory stimuli of constant intensity presented in the *odour identification* and partly in the *odour discrimination* test could be perceived to a sufficient extent.
- These results seem to be divergent from data in patients suffering from other psychiatric diseases, e. g. schizophrenia, major depression, who have shown deficits in the UPSIT (*odour identification* test) [15, 33]. It has been mentioned that the UPSIT primarily indicates deficits reflecting impairment in frontolimbic brain systems [34] and therefore, central factors such as attention, memory etc. may have an essential influence on both 'higher-cortical' odour tests (*odour identification* and (to some extent) *odour discrimination* test) [35].

  It may be suggested that 'higher-cortical' functions needed for these odour identification performances are hardly impaired in anorexia nervosa, in contrast to patients suffering from depression or schizophrenia.

However, deficits in the *odour threshold* and in the *odour discrimination* test indicated hyposmia as a common deficit in the anorectic subjects. It might be possible that restrained nutrition may be related to reduced olfaction. But so far no valid empirical findings are available to explain the patho-physiological background [15, 36], which also holds true for the assumption of a reduced cellular proliferation during starvation [37, 38].

Regarding the controversy about a possible recovery of the olfaction after weight gain [2, 17], a tendency for improvement could be observed only in peripheral olfactory perception (*odour threshold* and *odour discrimination* test). This might be consistent with the hypothesis that food reduction in anorexia nervosa leads to an impaired peripheral olfactory ability. Because of these

limited data, further studies with a larger sample size should be performed to elucidate this issue.

The topic is of practical relevance, since several studies have revealed that the use of flavour enhancers in the elderly increases appetite, food intake and body weight [39, 40]. Bromley [15] has further suggested to use flavour enhancers irrespectively of the age of the patient suffering from hyposmia. At first sight, it seems unlikely that the concept of using flavour enhancers in the elderly can be transferred to the therapy of anorectic patients. Nevertheless, it may be possible that flavour enhancers could help to facilitate refeeding in anorexia nervosa, after the first successful initiative steps of therapy have been completed.

Conclusion

Because of the orosensory deficits found in anorectic patients in the subtest *odour threshold* and in the subtest *odour discrimination*, reduced olfactory detection should be considered as a common deficit in anorexia nervosa. Therefore, orosensory deficits should be investigated routinely for patients suffering from eating disorders. Concerning treatment of anorexia nervosa the probably positive effects of the use of flavour enhancers on eating behaviour should be tested.

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