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SHORT COMMUNICATION

Odor Discrimination and Task Duration in Young and Older Adults

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Abstract

The effect of task duration on odor discrimination in aging was studied. Twenty-seven young male adults and 24 young female adults between 18 and 30 years of age, and 17 older male adults between 45 and 65 years of age completed an odor discrimination task. The odor discrimination task consisted of two parts of 16 trials each in which, from three bottles consisting of two identical and one aberrant odor, the aberrant odor had to be identified. The two parts were identical except that the aberrant odor was interchanged with the identical odors in the second as compared with the first part. Results revealed a decrease in odor discrimination with age. Moreover, with increased task duration odor discrimination performance decreased considerably in older male adults while it remained unchanged in young male adults. In addition, in young adults a small advantage in females as compared with males was found in the first part of the odor discrimination task, but this effect disappeared with increased task duration. In conclusion, task duration should be taken into consideration as a factor influencing odor discrimination in aging.

Introduction

Several studies have revealed age-related changes in olfaction in humans. Increased odor detection threshold (Deems and Doty, 1987; Cain and Gent, 1991; Stevens and Spencer, 1994), decreased smell identification (Doty *et al.*, 1984; Murphy *et al.*, 1997), decreased odor memory (Murphy *et al.*, 1997) and decreased odor discrimination (Schiffman, 1979) have been shown in elderly as compared with young adults. Moreover, it has been suggested that elderly adults are more prone than young adults to olfactory adaptation and are slower to recover threshold sensitivity following a brief exposure to a suprathreshold level of the same odorant, even when individual odor detection threshold concentrations were controlled for. At suprathreshold levels elderly adults were also slower to track odor intensity (Stevens *et al.*, 1989).

Interestingly, in an odor detection threshold study the strong impact of age emerged only through repeated testing (Cain and Gent, 1991). Such an effect may be related to increased reliability of the measurement, due to improved separation of the stimulus from background noise, resulting in greater consistency and acuity in the process. However, task duration may also be implicated. It is not known if task duration influences odor discrimination differently in older adults than in young adults. Moreover, little is known about changes with age in odor discrimination ability. Therefore, we measured the effect of task duration on odor discrimination in young and older adults with intact odor detection ability. In addition, in young adults the interaction between odor discrimination task duration and sex was studied. The results were controlled for general attention level and working memory performance.

Materials and methods

Subjects

Eighty subjects participated in the study: thirty males and 30 females aged 18–30 years, and 20 males aged 45–65 years. Subjects were recruited by means of advertisements placed in newspapers and were paid for their participation. Exclusion criteria were a cold within 3 weeks of the experiment, current neurological and/or psychiatric disorder, alcohol or drug abuse, and pregnancy or menstruation. After subjects had given their written informed consent, they were assessed individually in the morning by an experienced examiner. Intact odor detection was used as the criterion for inclusion (see The odor detection task) (Hulshoff Pol *et al.*, 1998).

Nine participants did not attain the odor detection level, one participant showed a serious deficit in odor discrimination and two had a neurological disorder detected at the time of testing. Mean age ± SD was 23.6 ± 3.0 years in the 27 young males, 21.9 ± 2.6 in the 24 young females and 56.2 ± 6.2 in the 17 older males.

Olfactory tasks

The odor detection task

The odor detection task was adapted from a task developed by Doty and co-workers (Doty *et al.*, 1986; Doty, 1991), and consisted of 16 trials in which a subject had to decide which of two 250 ml glass vials presented in fixed random order had the strongest smell. One bottle contained 18 ml of the odorant phenylethyl alcohol (PEA), a flower-like non-trigeminal odor (Doty *et al.*, 1978; Cometto-Muñiz and Cain, 1990), diluted in dipropylene glycol (DPG), an almost odorless substance, and the other bottle contained 18 ml of DPG alone. On every other trial, the concentration of PEA in DPG was increased by 1 log step from –8.0 log v/v to –1.0 log v/v in young, and by 0.5 log stepa from –4.5 log v/v to –0.5 log v/v in older adults. The intertrial interval was kept at 20–30 s. A subject was considered to have intact odor detection ability when he or she first reached a score of four correct trials in a row (chance 6%). The highest concentration within these four trials was considered the detection level. If this criterion was not reached, the threshold could not be determined and the subject was not included in the study. For direct comparison of detection levels, levels reached at –7 and –6 log v/v were artificially set at –5 log v/v in young adults. In older adults, levels were rounded to integers (e.g. –2.5 was rounded to –2.0 log v/v).

The odor discrimination task

The odor discrimination task was developed to measure the ability to qualitatively distinguish odorants without verbal labeling and consisted of two parts, I and II. The odor discrimination task I consisted of 16 trials in which from three bottles, consisting of two identical and one aberrant odor, the aberrant odor (target odor) had to be identified. The odorants were offered in 30 ml glass vials, with screw-on lids, on ethylvinyl acetate pellets to enable a constant and comparable suprathreshold concentration of the odors in the bottles. A 30 g cotton wrap was placed on top. The number of pellets in the bottles varied between odorants and was based on subjective intensity ratings of six subjects. The bottles were painted white on the side and bottom to prevent participants from getting visual cues concerning the number of pellets. Eight odorants (see Table 1) were used in 16 different combinations divided in fixed random order over trials 1–16, with the restriction that odors always differed between two consecutive trials. The odor discrimination task II was identical to I, with the subjects smelling exactly the same total amount and quality of odorants. However, in the odor discrimination task part II the target odor was interchanged in all trials 17–32 and trials were presented in a different fixed random order. The intertrial interval was kept at 60 s.

Table 1 Odor discrimination task

Odor[a]	Pellets	Odor	Pellets
Spanish rosemary	1	California orange oil	6
Grapefruit oil	11	distilled Italian bergamot	3
Fixateur 404	8	distilled Mexican lime	2
Terpineol	18	spearmint	1

The eight odors used in the odor discrimination tasks I and II, with the number of 10% w/w odor-saturated ethylvinyl acetate pellets added to the vials.

[a]Odors were kindly provided by International Flavors and Fragrances.

Working memory task

The non-olfactory level of functioning of attention and working memory was assessed by the digit span test from the Dutch adaptation of the Wechsler Adult Intelligence Scale (Stinissen, 1970). The digit span test comprises two different tests, digit span forward and digit span backward. In both tasks increasing numbers of orally presented digits at a rate of one per second have to be repeated—in digit span forward in the same order and in digit span backward in reversed order. Digit span forward starts with three digits and digit span backward with two digits. Every other trial the number of digits is increased by one. When errors in two consecutive trials are made, the test is ended. The number of correctly recalled trials is counted for forward and backward span. Digit span forward is considered to be related to efficiency of attention, while digit span backward is related to working memory functioning.

Procedure

Assessment took place in a room in which the humidity was kept constant at 70%, the temperature was 22°C and the air was cleaned continuously by a table-model charcoal filter. No odor bottle was opened more than once during the test session. The bottles were renewed every 2 weeks. Between test sessions the bottles were kept at 5°C. The test session started with the odor detection task. Following the digit span task and other, non-odor-related tasks, parts I and II of the odor discrimination were completed immediately after each other.

Statistical analysis

Multivariate analyses of variance (MANOVA) were calculated on the total score in odor discrimination tasks I and II and in digit span tasks forward and backward, with age (young, older) in male adults and sex (male, female) in young adults as the between-subjects factor, and task duration (odor discrimination task I, II) or order (digit span forward, backward) as the within-subjects factor. For significant interaction effects, post-hoc two-tailed Student's *t*-tests with Bonferroni correction (α/2) were calculated to determine which part of the tasks contributed (most) to the effects. The effects of age and sex on odor detection level were measured by two-tailed Student's *t*-tests. Correlation coefficients (*r*) between digit span forward and/or backward and the odor discrimination task I and II were made for each group separately. In case of a significant correlation, a multivariate analysis of covariance (MANCOVA) was calculated on the total scores in the odor discrimination tasks I and II, with age in male adults and sex in young adults as the between-subjects factor, task duration (odor discrimination task I, II) as the within-subjects factor and digit span forward and/or backward as covariate(s).

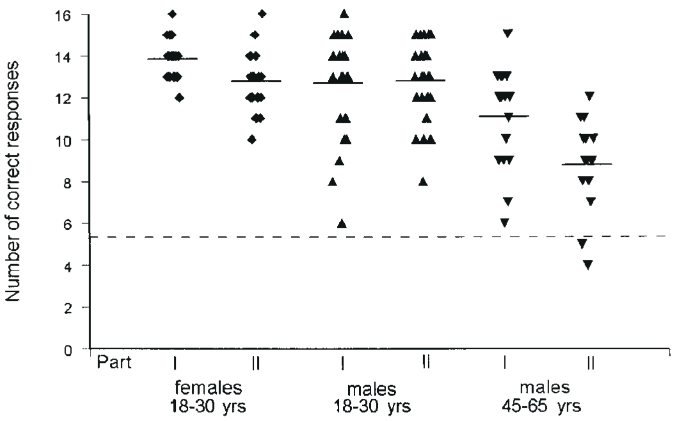

Figure 1 Effects of task duration on odor discrimination. Individual performance on the first (I) and second (II) 16 trials of the odor discrimination task in young male (n = 27) and female (n = 24) and older male (n = 17) adults.

Results and discussion

Odor detection

The mean log v/v PEA/DPG odor detection level did not differ between young (–2.5, SD = 1.2) and older (–2.3, SD = 0.9) male adults [$t(42) = 0.86$, P = n.s.]. The mean odor detection level was higher in male (–2.5, SD = 1.2) than in female (–3.5, SD = 1.1) young adults [$t(49) = 3.01$, $P < 0.01$].

Odor discrimination

Data are shown in Figure 1.

There was an interaction effect between age and odor discrimination task duration [$F(1,42) = 13{,}91$, $P < 0.01$]. Moreover, there was a main effect for age on odor discrimination ability [$F(1,42) = 22.65$, $P < 0.001$]. In the odor discrimination task I average performance was somewhat lower in older (11.06, SD = 2.38) than in young (12.67, SD = 2.42) male adults, but the difference was not significant after Bonferroni correction [$t(42) = 2.16$, P = n.s.]. However, in odor discrimination task II the differences in average performance between older (8.76, SD = 2.05) and young (12.78, SD = 1.83) male adults had increased considerably [$t(42) = 6.77$, $P < 0.001$]. These findings are in concordance with earlier findings suggesting an increased impact of age effects after repeated testing (Cain and Gent, 1991). A post-hoc analysis correlating odor detection threshold levels with odor discrimination did not reveal a significant correlation with overall odor discrimination (I plus II) or with part I, but it did with part II (0.51, $P < 0.05$) in older male adults. No significant correlations were revealed for young male adults. Thus, the decrease in odor discrimination performance in the second part of the task could to some extent be related to odor detection ability. Note that different dilution steps were used for the two age groups, reducing comparability.

There was an interaction effect between sex and odor discrimination task duration in the younger group, due to higher mean peformance in females as compared with males in the odor discrimination task I but not II [$F(1,49) = 4.32$, $P < 0.05$]. There was no main effect for sex on odor discrimination ability [$F(1,49) = 2.10$, P = n.s.]. Variance was not equal across cells for the odor discrimination task I [Levene's test for equality of variances: $F(1,48) = 14.80$, $P < 0.001$], thereby violating a prerequisite for MANOVA. However, because the larger variance was associated with the larger (male) group, the F statistic may be considered as relatively conservative (Stevens, 1996). Moreover, post-hoc *t*-values with equal variances not assumed revealed a higher mean performance in female (13.83, SD = 0.87) than in male (12.67, SD = 2.42) young adults in odor discrimination task I [$t(33.3) = 2.34$, $P = 0.025$], but no difference in performance in II [12.78, SD = 1.83; 12.79, SD = 1.41; $t(49) = 1.45$, P = n.s.]. In several earlier studies females outperformed males on tests of odor detection (Koelega and Koster 1974; Koelega, 1994) and identification (Doty *et al.*, 1984) at all ages, whereas others revealed no differences between the sexes (Cain and Gent, 1991). One of the factors influencing these conflicting results may thus be related to task duration.

Working memory

There was no interaction effect between age and digit span order [$F(1,42) = 0.39$, P = n.s.]. However, there was a main effect for age on digit span ability [$F(1,42) = 6.99$, $P = 0.01$]. Both digit span forward and backward were lower in older (6.29, SD = 2.08; 6.53, SD = 2.07) as compared with younger (8.00, SD = 1.96; 7.89, SD = 2.19) male adults. In older male adults there was a significant correlation between digit span backward ($r = 0.69$, $P < 0.01$) and odor discrimination task I. There were no other significant correlations in older or in young male adults. MANCOVA revealed that both the interaction effect between age and odor discrimination task duration [$F(1,41) = 13.81$, $P < 0.01$] and the main effect for age on odor discrimination ability [$F(1,41) = 16.75$, $P < 0.001$] remained significant after correction for digit span backward in male adults. Earlier findings also suggested that with advancing age (particularly backward) digit span shrinks (Craik *et al.*, 1990; Fastenau *et al.*, 1996). However, while some influence of working memory on odor discrimination performance may have occurred, the relation was not obvious and did not explain the findings with increased task duration. It can only be speculated what other mechanism(s) are responsible for the decreased odor discrimination in older adults with increased task duration. Possibly, a change in recovery from olfactory adaptation influenced performance. Under continual exposure to a suprathreshold odorant elderly persons appeared to lose sensitivity more rapidly and recovered it more slowly than did young persons (Stevens *et al.*, 1989). When one takes into account that recovery from olfactory adaptation is thought to take 15–20 min (Köster, 1971), the effects may have lasted for the duration of the odor discrimination task. Moreover, the intensity of a suprathreshold offered odor smelled 25 min earlier has been found to unintentionally influence subsequent odor intensity judgement (Hulshoff Pol *et al.*, 1998). Thus, adaptation, cross-adaptation and context effects may have influenced performance at the peripheral and possibly central level, resulting in poor discrimination at longer task duration in older adults.

Mean ± SD digit span forward and backward performance was comparable in male (8.00 ± 1.96, 7.89 ± 2.19) and in female (7.58 ± 1.89; 7.33 ± 1.52) young adults; moreover, there were no significant correlations between digit span and the odor discrimination task.

There are a number of qualifications to add to these conclusions. We did not measure odor discrimination in adults over 65 years of age, and therefore we cannot make inferences regarding odor discrimination in old age. Neither did we measure odor discrimination in older female adults. However, evidence was found for an effect of task duration on odor discrimination in older male adults. Task duration should therefore be taken into consideration as a factor influencing odor discrimination in older adults.

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