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# Incidental and Intentional Flavor Memory in Young and Older Subjects

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## Abstract

Incidental and intentional learning and memory for 2 novel flavors were compared in young and elderly subjects. Incidental and intentional learning groups rated 2 new soups on acceptability for different occasions and were tested for memory the next day. On the first day, only the intentional group was asked to memorize the stimuli. With incidental learning, elderly and young were equally good, but the young performed better with intentional than with incidental learning, whereas the elderly did not. There were no age-related differences in perceptual discrimination. When comparing perceived flavor with the memory of it, the elderly tend to overrate intensities of remembered flavor attributes, whereas the young tend to underrate them. Memory was not related to flavor pleasantness or neophobia. Like memory for taste and texture, flavor memory seems to be mainly tuned at detecting changes and based on “feelings of not knowing” rather than on precise identification and recognition of previously encountered stimuli.

**Key words:** absolute memory, age, liking, neophobia, relative memory

## Introduction

Expectations about food are based to a certain (and probably rather large) extent on earlier experiences with the same or similar food items. Although food expectations and more specifically their role in the acceptance and rejection of food products have been the object of many investigations (Cardello 1994, 1996; Meiselman 1996), little attention has been devoted to their content and to the nature of the memories on which they are based. What do people remember spontaneously of the things they eat? Over the last few years, a number of studies have investigated the memory for incidentally learned product properties such as textural aspects (Mojet and Köster 2002, 2005), taste (Köster et al. 2004), and flavor (Sulmont-Rossé et al. 2003). The paradigm used in all these experiments included the same key elements. The subjects were invited under a false pretence (to take part in a study on hunger feelings) and were offered a standard meal containing a number of target items “in order to standardize their intake.” They registered their hunger feelings before and after this meal and continued to do so at regular times during the rest of the day while noting any food they consumed in a diary. Memory was never mentioned, and when the subjects came back to hand in their data and were debriefed by asking them about the purpose of the experiment, none of them mentioned memory. The subjects then

took part in a recognition experiment, in which they had to recognize the earlier eaten target items amidst systematically varied versions of these items which served as distractors (absolute memory measurement). They also rated liking for both the targets and the distractors and indicated whether they considered them to be more, equally, or less pleasant (sweet, fatty, crispy, etc) than the one they had eaten during the meal (relative memory measurement). The results showed both forms of memory but indicated that relative memory was somewhat better than absolute memory for texture and taste and that memory varied strongly depending on the product properties varied. Subjects remembered crispness and bitterness extremely well, but memory for sweet and fattiness was poor. Memory for flavor showed good results in one case (Mojet and Köster 2002) and positive, but somewhat poorer, results in another (Sulmont-Rossé et al. 2003).

All these experiments were carried out with predominantly young subjects, and studies of age effects on incidental learning and memory for sensory aspects of foods and for smell and taste are very rare. Most authors who have studied age effects on odor memory (e.g., Murphy et al. 1991; Larsson and Bäckmann 1997; and review by Larsson 1997) used explicit learning instructions and directed their attention to the

role of odor identification in the memory process (see reviews by Herz and Eich 1995; Herz and Engen 1996). Only recently (Møller et al. 2004), incidental and intentional odor memory in young and elderly subjects were compared using very uncommon odors in order to avoid interference by verbal memory. The elderly remembered the odors at least as well and even slightly better than the young in the incidental learning condition, but in the intentional condition they showed no improvement and even some loss in performance, whereas the young did significantly better than in the incidental condition and than did the elderly. At the same time, it could be demonstrated that this improvement in the young over conditions was not due to verbal mediation or better feature analysis in working memory. This was shown by presenting the stimuli once more at the end of the experiment and asking the subjects to name these very uncommon odors. Although the young produced more odor names than the elderly, the spontaneously given names were not used in memory and remembering the odors. Four arguments supported this conclusion.

1. There were no more names given for the targets than for the distractors.
2. The recognition indices for odors with a name were not higher than for odors that could not be named (named [ $d' = 1.028$ ] and unnamed [ $d' = 1.023$ ]).
3. The correlations between the individual recognition indices of the subjects and the number of names they produced were low ( $R$  young = 0.05, elderly = 0.22, all = 0.15) and statistically not significant.
4. Learners (i.e., persons who, in the within-subject design used, improved their performance by intentional learning on the second test day compared with incidental learning on the first day of the experiment [intentional > incidental by  $d'$  of >0.5]) did not produce more odor names than nonlearners.

Because the 2 conditions were measured in the same groups of subjects, one drawback of this study was that in all groups the intentional condition had to follow the incidental one in order to make sure that the subjects did not suspect that memory was involved during incidental learning. Thus, it was possible that the difference between the age groups in the intentional condition was due to the fact that the elderly suffered more from proactive interference than the young. Another questionable aspect of the study was the external validity, which might have been reduced by the use of the highly uncommon odors. These odors proved instrumental in showing the absence of verbal mediation in the olfactory memory performance but at the same time might have obscured differences between the elderly and the young in the incidental condition that would have been found with everyday odors and foods.

The present experiment is designed to remedy these weaknesses. Separate groups of both young and elderly have been used in the incidental and the intentional learning conditions, and the stimuli were soups, which, although unknown to the Danish population, contained no extremely uncommon constituents in their base formulation. These soups were chosen to exclude the influence of preexperimental exposure on the memory performance. They were altered by addition of 1 of 2 flavors to create the distractors, one flavor that was quite common and one that was uncommon to the Danish population, to check whether this led to differences that could be attributed to neophobia. Finally, it was also decided to look for possible gender differences because in other research with food memory such differences play a role (Mojet and Köster 2002, 2005).

## Materials and methods

This study investigates the effects of incidental and intentional learning on the recognition of 2 soups by groups of young and elderly men and women. In the first test, the absolute memory was tested, whereas in the second test the relative memory for a number of attributes was tested. Liking for the stimuli was also measured.

## Subjects

Sixty-four subjects (18 elderly women, mean age 65.1 years, standard deviation [SD] = 5.9 years; 13 elderly men, mean age 67.3 years, SD = 4.6 years; 17 young women, mean age 23.6 years, SD = 2.6 years; 16 young men, mean age 24.7 years, SD = 3.8 years) participated in the experiment.

All subjects were independently living and were naive as to the purpose of the experiment. They received a gift for their participation in the experiment.

The young and elderly subjects were divided into 2 groups, here referred to as, respectively, the “incidental learning group” and the “intentional learning group.” The incidental and intentional learning groups consisted of approximately the same number of men and women.

## Stimuli

Two kinds of powdered soups, Knorr Feinschmecker Alpenländer Käsecreme Suppe (Käsecreme soup) and Knorr Feinschmecker Fränkische Grünkerncreme Suppe (Grünkern soup), supplied by Unilever BESTFOODS (Heilbronn, Germany) were used as the stimuli to be remembered in the experiment. For the exposure sessions on the first day, samples of 125 ml of each soup were prepared according to the instructions on the packages. Serving temperature was 60 °C.

In the memory test sessions (second day), samples of these soups were presented among samples of the same soups, which had been changed by adding various amounts of flavor.

In a preexperiment, the appropriate amounts of bacon (well known) and lovage (uncommon in Denmark) flavors

(also provided by Unilever) to be used for the distractors in the memory measurement had been determined. Three distractors were prepared for each combination of soup and added flavor. Bacon flavor distractors for the Grünkernen soup were prepared by adding 2, 4, and 6 g/l. The 3 lovage distractors for Grünkernen soup contained, respectively, 1, 2, and 4 g/l. For the Käsecreme soup, respectively, 3, 5, and 7 g/l of bacon flavor and, respectively, 1, 2, and 4 g/l of lovage flavor were added to produce the distractors. The samples consisted of 25 ml of soup and were served in small plastic cups marked with 3-digit codes. Serving temperature was 60 °C, the same as the serving temperature of the target stimulus on day 1.

### Procedure

All subjects came to the laboratory on 2 consecutive days. Subjects in the incidental and intentional learning groups received the same stimuli and tests. The only difference in treatment between the 2 groups was in the instructions they received.

#### *Incidental groups, day1*

Subjects in the incidental learning groups came to the laboratory under the pretence that they participated in an olfactory experiment (lateralization of hedonicity, intensity, and familiarity for pleasant and unpleasant common and uncommon odors). After the olfactory experiment had been conducted, subjects were asked to spend a few moments to participate in a small consumer study of 2 different soups that were about to be introduced on the Danish market. Subjects were told they participated in a consumer survey, they were requested to drink whole of the 125 ml of each of the soups presented to them and were asked to fill out a questionnaire. They were to put a mark in 1 of 7 boxes anchored at positions 1 and 7 with the descriptors “not at all” and “very much,” as an answer to each of the following questions:

1. How well do you like the soup?
2. Is the soup appropriate in the following context or time of year?
3. a) On an everyday basis. b) For a party. c) As a between-meals dish. d) For lunch. e) For dinner. f) In summer. g) In winter.

#### *Intentional groups, day1*

Subjects in the intentional learning groups were exposed to exactly the same stimuli as subjects in the incidental learning groups. That is, the subjects first performed the olfactory lateralization experiment before they received the 2 portions of soup and were asked to fill out the same questionnaire as the subjects in the incidental learning groups. The only difference was that the subjects were explicitly asked to try to re-

member the flavor of the 2 soups because their memory of the soups would be tested the next day.

#### *Both groups, day 2*

*Absolute memory.* On day 2, the “absolute” memory was tested, that is, how well subjects could remember the soups they ate on day1 by recognizing them among the distractors.

Each subject was presented with a series of 10 samples of each soup. Each of the 6 distractors was presented once and the target (the soup without any added flavor) was presented 4 times. First, the 10 Grünkernen soup stimuli were presented. The male and female subjects in all 4 condition groups (young incidental learning, young intentional learning, elderly incidental learning, and elderly intentional learning) were divided into 5 subgroups consisting of respectively subjects 1 and 6, subjects 2 and 7, etc. Each of these subgroups received a random sequence of the 10 stimuli, which was different from the sequence that was presented to the other subgroups. The sequences used were the same for all 4 condition groups. Subjects were instructed to spit out the sample after tasting, cleanse their mouth with water, and eat a piece of cracker before tasting the next sample. For each sample, subjects put a mark in a box indicating whether or not the soup they just tasted was the same as one of the 2 soups they tasted the day before. For each sample, the subjects also indicated how well they liked the sample on a 7-point scale (very little to very much).

After completion of the Grünkernen soup measurements, the same procedure was repeated for the stimuli based on Käsecreme soup. Five new sequences of distractors and targets were used for the Käsecreme soup stimuli and balanced over the subjects in the same way as above.

*Relative memory.* In the relative memory session, right after the absolute memory measurements had been completed, subjects were again exposed to 7 different and newly coded stimuli (1 target and all 6 distractors) of each of the 2 soups. Each subgroup of 2 or 3 subjects received a random sequence of stimuli that was different from the random sequences received by the other subgroups. The 7 Grünkernen soup stimuli were presented first. Subjects were instructed to spit out the soup after tasting and rinse with water and eat cracker bread between samples. For each sample, subjects were asked to indicate whether the sample was weaker, equal, or more intense on the 6 attributes (tastes or flavors) than the soup they tasted on day 1 (the target soup). The 6 attributes to be rated were salty taste, smoked flavor, spinach flavor, bouillon flavor, cheese flavor, and cereal flavor. Three of them (salty, smoky, and bouillon like) related directly to the added flavors that had actually been varied in the distractors. Of the other 3 flavors, cheese was present, but not varied, in Käsecreme soup; cereal was present, but not varied, in Grünkernen soup; and spinach was used as the nearest attribute to describe the unknown taste of lovage.

After completion of the Grünkernen soup relative memory measurements, the same procedure (serving temperature, sample size, rinsing between samples, rated attributes) was repeated for the stimuli based on Käsecreme soup. Finally, after the absolute and relative memory measurements, all subjects completed a Danish translation of the Food Neophobia Scale questionnaire of Pliner and Hobden (1992).

### Statistical analysis

Absolute memory was tested by means of the signal detection method, which makes it possible to obtain a measure of recognition  $d'$ , independent of the response bias caused by the subjects' tendency to say yes or no. This tendency is expressed in the decision criterion  $k$ .

For each soup, the percentages of hits (saying yes to a target), misses (saying no to a target), false alarms (saying yes to a distractor), and correct rejections (saying no to a distractor) are determined. These percentages are then transformed into  $z$  scores under the normal probability curve, and the recognition index ( $d'$ ) and the decision criterion ( $k$ ) are calculated per subject.

$$d' = z(\text{hits}) - z(\text{false alarms}) \text{ and}$$

$$k = - [z(\text{hits}) + z(\text{false alarms})] / 2$$

To avoid infinite values, proportions of 0 and 1 were converted to  $1/(2N)$  and  $1 - 1/(2N)$ , respectively (Macmillan and Creelman 1991).

To verify that the individual recognition indices ( $d'$ ), obtained by each of the 2 age groups under each of the 2 learning conditions but averaged over the 3 different levels of both added flavors, were better than chance guessing,  $t$ -tests were used to verify that the  $d'$ 's differed from 0.

To determine whether or not the memory for the soups differed depending on the learning condition, an analysis of variance (ANOVA) (PROC GLM) was carried out with learning condition (2), age (2), gender (2), soup base (2), and the interactions between learning condition and age, between condition and gender, between condition and soup base, and between condition, age, and soup base as independent factors and  $d'$  and  $k$  as dependent variables in the model. A similar model was applied with hits, misses, correct rejections, and false alarm as dependent variables.

To investigate whether the concentration differences could be noticed, the recognition indices for the different concentrations of each of the 2 added flavors in each of the 2 soups obtained by the young and the elderly in the incidental and the intentional conditions were calculated.

To test the relative memory for sensory aspects, the responses "less," "equal," or "more" than the remembered target were transformed respectively into  $-1$ ,  $0$ , and  $+1$ . The  $t$ -tests were used to determine whether the deviations differed from 0. A repeated measures ANOVA (PROC GLM) was used to investigate the between-subject effects of learning condition, age, and gender and the within-subject effects

of soup base, flavor, and concentration on the relative memory for the sensory attributes and liking. In addition, liking was analyzed per type of response (yes or no) in the absolute memory test by means of an ANOVA with response (yes/no), age group (elderly/young), gender (male/female), condition (incidental/intentional), and neophobia (high/low) as independent variables and liking as dependent variable.

The  $t$ -tests and ANOVA were conducted by means of SAS and SAS/STAT.

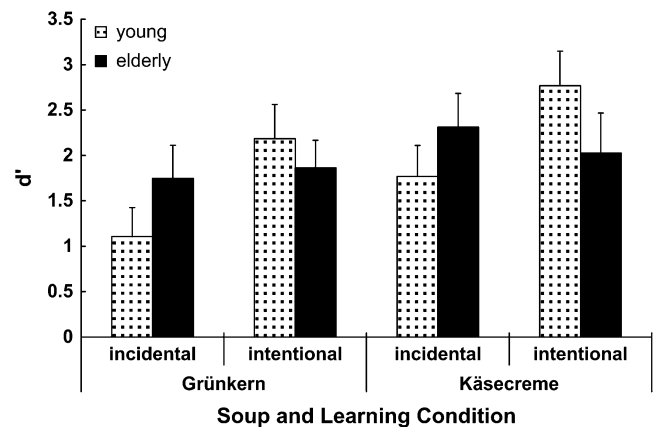
## Results

### Absolute memory

#### Recognition

The recognition indices ( $d'$ ) obtained by each of the 2 age groups under each of the 2 learning conditions, but averaged over the 3 different levels of both added flavors, are given in Figure 1. All recognition indices were significantly different from zero ( $t > 3.45$ ;  $P < 0.004$  in all cases). PROC GLM showed significant main effects for condition ( $F(1, 118) = 3.93$ ;  $P < 0.05$ ) and for product ( $F(1, 118) = 4.61$ ;  $P < 0.04$ ), indicating that Käsecreme soup is better remembered than Grünkernen soup. There was no significant main effect for age group or gender, but there was a significant interaction effect between condition and age group ( $F(1, 118) = 4.71$ ;  $P < 0.04$ ). A 3-way interaction between condition, age, and soup base was not significant.

A comparison of the means shows that the young remember the soups better under the intentional learning condition than under the incidental learning condition ( $t(1, 58) = 2.97$ ;  $P < 0.005$ ), whereas the elderly remember the soups about equally well under both conditions. Furthermore, it is remarkable that, under the incidental learning condition, the performance of the elderly is at least as good and perhaps



**Figure 1** Means and standard error of means (SEMs) of the recognition indices ( $d'$ ) for the difference between the target and the 6 distractors of each of the 2 soups obtained by the young and the elderly under the 2 learning conditions.

marginally better than that of the young for both soups ( $t(1, 54) = 1.73$ ;  $P < 0.09$ ], whereas with intentional learning the young are somewhat, but not significantly, better than the elderly.

Finally, there is also a significant interaction between product and gender ( $F(1, 118) = 5.44$ ;  $P < 0.03$ ). Women remember the 2 soups about equally well, whereas the men remember the Käsecreme soup much better ( $t(1, 50) = 3.12$ ;  $P < 0.003$ ) than the Grünkernen soup and remember the Käsecreme soup also better than the women do ( $t(1, 62) = 2.63$ ;  $P < 0.02$ ).

The group indices indicating the recognition of the difference between target and distractor for the different concentrations (1, 2, or 3) of the different flavors (bacon = b, lovage = l) in the 2 soups (Grünkernen = g, Käsecreme = k) obtained by the young (Y) and the elderly (E) in the incidental and the intentional conditions are given in Figure 2. As can be seen from the figure, with a few exceptions, the recognition increased with increasing flavor concentration in the distractors for all 4 groups, indicating that the concentrations used could be discriminated reasonably well. At the same time, it is clear that discrimination between the distractors and the target seemed somewhat better for the bacon than for the lovage flavor, which in its lowest concentration (gl1) was hardly recognized as different from the Grünkernen target by all 4 groups. For almost all flavor combinations, the young intentional group showed the highest recognition, and overall this remained true even if the one soup flavor combination (kb2) with an exceptionally high group recognition index was left out.

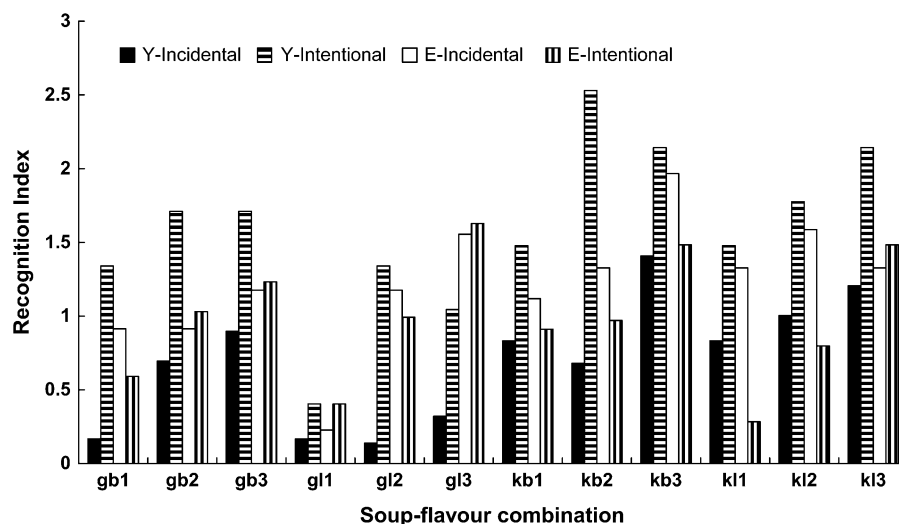
#### Response bias

With regard to the criterion ( $k$ ), there is a main effect of condition ( $F(1, 118) = 4.72$ ;  $P < 0.04$ ), indicating that in

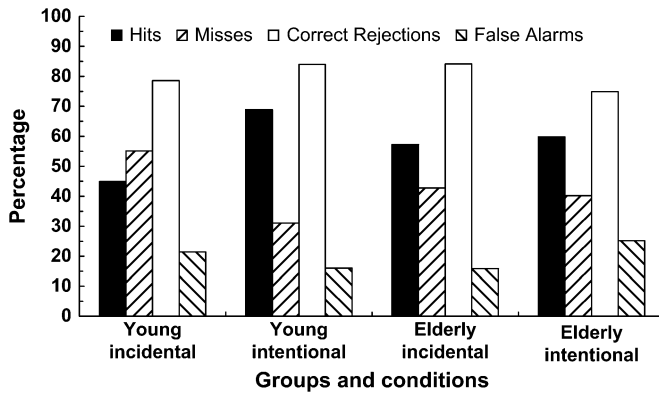
the incidental condition the subjects are more cautious in making hits and false alarms (i.e., indicating positive recognition) than in the intentional condition, and a main effect of product ( $F(1, 118) = 4.44$ ;  $P < 0.04$ ), indicating that the subjects say more easily that they recognize the Käsecreme than the Grünkernen soup. There are no main effects of age group and gender, and there are no interactions involving age group, gender, or condition, indicating that overall the different age and gender groups did not differ in their response bias.

A more detailed account of the responses in terms of hits, misses, correct rejections, and false alarms for each of the age groups in the different learning conditions is given in Figure 3.

Measured over both age groups, the percentage of hits is higher (all  $F$ 's here and below (1, 118)) in the intentional than in the incidental condition ( $F = 7.82$ ;  $P < 0.006$ ), whereas the difference in percentage of hits between the conditions is not significant for the 2 age groups (interaction condition  $\times$  age group  $F = 2.47$ ;  $P < 0.12$ ). The young produce more hits under the intentional than under the incidental condition and this holds both for Grünkernen ( $t(1, 29) = 2.50$ ;  $P < 0.02$ ) and for Käsecreme soups ( $t(1, 29) = 2.15$ ;  $P < 0.04$ ], whereas the difference between the conditions is in the same direction but never becomes significant for the elderly. This may indicate that the young are able to remember some specific properties of the targets if they make an effort to do so, whereas the elderly do not do well in this respect. It should be realized however that under the incidental condition the percentage of hits of the young remains under 50%, indicating that spontaneously they do not recognize the target better than chance and that their memory performance is therefore based on their low false alarm rate and consequently on their high correct rejection rate (% correct rejection =  $100 - \%$  false alarm). Even under the intentional condition, the percentage of correct rejection contributes more to the recognition



**Figure 2** Group recognition indices for the different Grünkernen (g)-or Käsecreme (k) soup and bacon (b) or lovage (l) flavor combinations of different flavor concentration (1, 2, 3) for the young (Y) and the elderly (E) in the 2 learning conditions.



**Figure 3** Percentages of hits, misses, correct rejections, and false alarms of young and elderly subjects under each of the 2 learning conditions.

performance of the young than the percentage of hits. For the elderly, this is the case under both conditions. There is a main effect of gender on the false alarms, the women produced a higher percentage of false alarms than the men, whereas the men made more correct rejections than the women did ( $F = 4.17$ ;  $P < 0.05$ ).

### Relative memory

Relative memory was tested by asking the subjects to indicate for each of the stimuli (targets and distractors) whether or not the sample presented in the second session differed from the remembered target on a number of attributes and if so, in what direction (more or less). Negative deviations mentioned in this section mean that the test stimulus presented is judged to be weaker than the remembered target; positive deviations indicate that the stimulus presented seems stronger than the remembered target.

A repeated measures ANOVA (PROC GLM) over all products and added flavors shows strong effects for age on the deviations from memory of smoky ( $F(1, 55) = 12.35$ ;  $P < 0.001$ ), spinach ( $F(1, 54) = 6.46$ ;  $P < 0.01$ ), cheese ( $F(1, 54) = 16.25$ ;  $P < 0.001$ ), and cereal ( $F(1, 55) = 5.23$ ;  $P < 0.03$ ) and for concentration of the added flavor on the deviations of the attributes salty ( $F(3, 159) = 8.27$ ;  $P < 0.0001$ ), smoky ( $F(3, 165) = 49.20$ ;  $P < 0.0001$ ), and bouillon ( $F(3, 165) = 10.89$ ;  $P < 0.0001$ ). In all cases mentioned, the young judged the attributes in the test session to be more strongly present in comparison to the remembered target than did the elderly, who showed a rather strong tendency to judge attributes to be less strong than they remembered them. This indicates that the elderly distorted their memory of the strength of the earlier experiences. Nevertheless, where present, the influence of concentration of the added flavor was the same for both age groups (no interaction age by concentration), indicating that although the elderly are less precise in remembering the absolute intensity of the attribute, they discriminate differences in strength of the attributes equally well as the young.

Most interestingly, there are no overall condition effects, indicating that, compared with what is spontaneously acquired in the incidental learning condition, intentional efforts to remember the flavors do not seem to systematically improve the memory for specific features of the soups. Moreover, there is only 1 significant age by condition interaction effect. For the attribute smoky ( $F(1, 55) = 4.09$ ;  $P < 0.05$ ), the young give higher deviation judgments in the intentional learning condition than in the incidental learning condition, whereas the elderly do not show such systematic effects with learning intention. This age by condition interaction and the interesting absence of an age by concentration interaction, notwithstanding the presence of strong age and concentration effects, are illustrated in the Figure 4a,b. They also illustrate the clear tendency of the elderly to rate the presented stimuli as less strong than the remembered target on the nonvaried attributes.

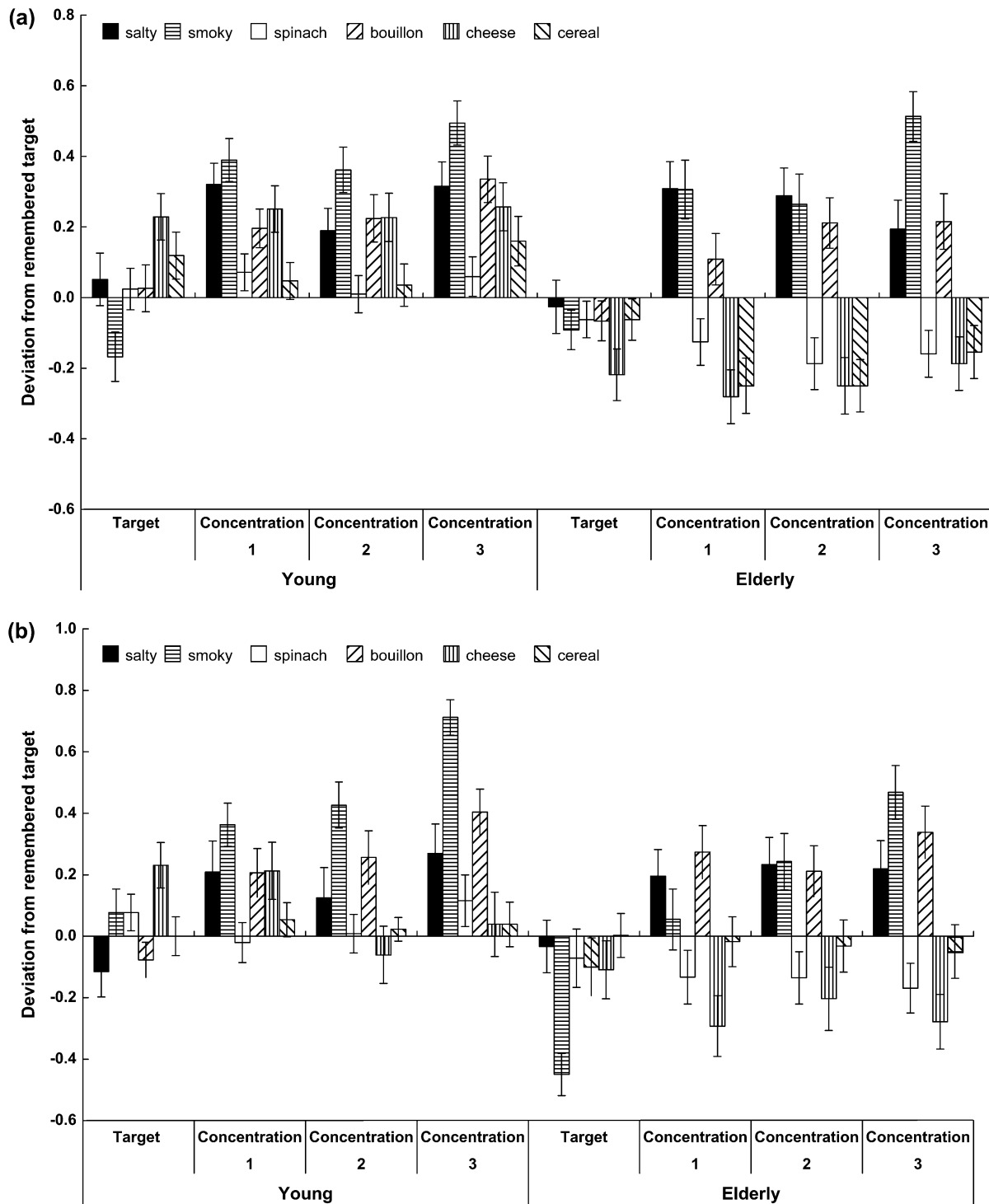
### Liking

Liking for the targets was measured at both the exposure (day 1) and the test session (day 2) of the experiment, liking for the distractors of course only at the latter session. Because in the appreciation of the target no significant differences between the 2 sessions were found, only the results of the test session are described here.

As regards the liking of the targets and distractors in the test session, the repeated measures analysis showed no main between-subject effects for learning condition and age group. Nevertheless, a significant interaction between condition and age ( $F(1, 51) = 6.68$ ;  $P < 0.02$ ) is found, showing that the elderly in the intentional condition like the soups better than the elderly in the incidental condition, whereas no such difference is found for the young.

A significant main effect for gender ( $F(1, 51) = 5.30$ ;  $P < 0.03$ ) was found, showing that men appreciated the soups better than women, specifically in the intentional learning condition and not in the incidental condition as was shown by a significant interaction between condition and gender ( $F(1, 51) = 5.88$ ;  $P < 0.02$ ).

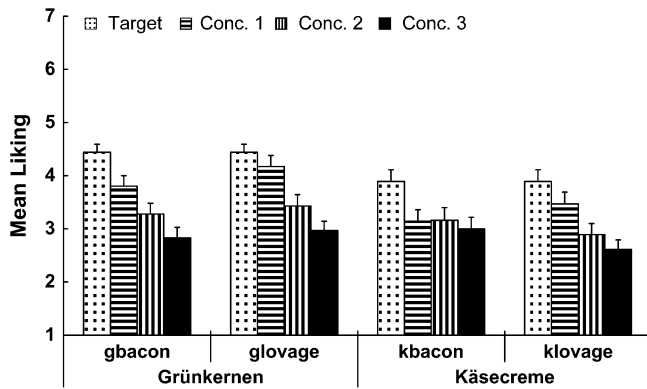
Furthermore, within-subject effects were found for soup base ( $F(1, 51) = 5.04$ ;  $P < 0.03$ ), where Grünkernen soup was preferred, and an interaction effect between soup and gender ( $F(1, 51) = 12.41$ ;  $P < 0.001$ ), showing that women clearly prefer Grünkernen over Käsecreme soup whereas men like the latter somewhat more than the former. Finally, there is a main effect of flavor concentration ( $F(3, 49) = 17.47$ ;  $P < 0.0001$ ), showing that addition of flavor reduced the liking for the soups, and an interaction effect between soup base and concentration, indicating that the liking did not decrease at the same rate for both soup bases. The fact that there were no significant interactions between flavor concentration and condition, age group, or gender once more indicates that the flavor concentrations had the same effect on all groups.



**Figure 4** Means and SEMs of the deviations from the remembered target on the 6 attributes of the presented target and the distractors with different added flavor concentrations (pooled over soups and flavors) by the young and the elderly in the incidental (a) and the intentional condition (b).

Figure 5 illustrates the liking of the targets and the distractors pooled over the 2 learning conditions and over the age and gender groups for, respectively, Grünkernen and Käsecreme soups.

As can be seen from this figure, none of the distractors are more liked than the target and all the stimuli with the highest and of the second highest concentration of added flavor were significantly (all  $P$ 's < 0.01) less liked than the target,



**Figure 5** Means and SEMs of the liking ratings for the target and the 3 different concentrations (1, 2, 3) of the flavors in the 2 soups.

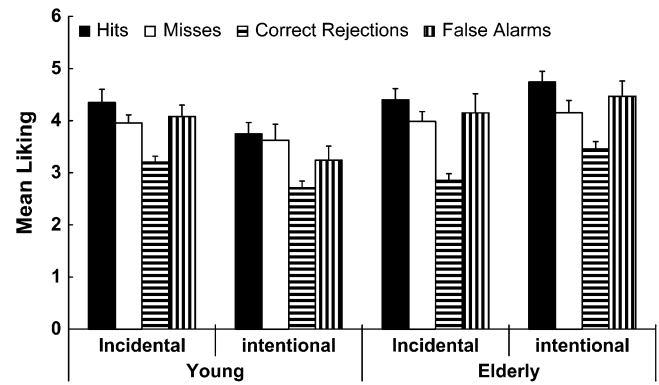
indicating that the concentration steps chosen were sufficiently large to allow for discrimination. Furthermore, it is clear that the unaltered Grünkernen soup target is somewhat more liked than the Käsecreme soup target.

#### Liking and memory

The question whether liking plays a role in absolute memory can be answered either by correlating individual recognition indices with the individually perceived distances in liking between target and distractors or by verifying whether or not liking is possibly related to the response criterion (the tendency to answer yes or to answer no to the recognition question). To check the latter, one simply calculates whether liking is equal or not for the cases in which the subjects answer yes (hits plus false alarms) and the cases in which the subjects answer no (misses plus correct rejections). In the present experiment, no such equality is found. The liking for the stimuli that elicited a yes response (mean liking 4.25) was much higher ( $F(1, 104) = 16.99; P < 0.0001$ ) than for the ones that elicited a no response (mean liking 3.30). An analysis specified to the hits, misses, correct rejections, and false alarms of the relation between liking and response type is shown in Figure 6.

In all 4 groups shown in this figure, the hits and the false alarms are indeed more liked than respectively the misses and the correct rejections. It can therefore be concluded that the response bias is not independent of the hedonic evaluation of the stimulus and/or vice versa.

In order to verify whether or not the memory performance as expressed in the recognition index  $d'$  was also related to the hedonic appreciation of the stimuli, the distance between the average liking of the target and the average of the liking for its distractors has been calculated for each individual subject and then correlated with the individual  $d'$  value for the recognition of these stimuli. Table 1 gives an overview of the results of these correlations for the overall results and for differently selected subsets of the data.



**Figure 6** Means and SEMs of the liking ratings for the 4 types of responses (hits, misses, correct rejections, and false alarms) given by the young and the elderly in the 2 learning conditions.

**Table 1** Correlations between the individual differences in liking for targets and distractors (delta liking) and the individual recognition indices ( $d'$ ) or criteria ( $k$ ) in the absolute memory measurements calculated over all subjects (overall) and different subgroups

	$d'$ and delta liking		$k$ and delta liking	
	$R$	$P <$	$R$	$P <$
Overall	0.22	0.02	-0.12	0.19
Grünkernen soup	0.20	0.11	-0.12	0.34
Käsecreme soup	0.26	0.04	-0.14	0.28
Incidental learning	0.30	0.01	-0.16	0.19
Intentional learning	0.14	0.32	-0.08	0.56
Elderly subjects	0.22	0.09	-0.09	0.47
Young subjects	0.21	0.08	-0.13	0.31
Female subjects	0.35	0.01	-0.11	0.37
Male subjects	0.11	0.40	-0.12	0.39

First of all, this table shows that there is a positive overall correlation between liking and recognition performance but that this correlation is rather low and cannot even explain 5% of the variance ( $R^2 = 0.0484$ ). Furthermore, it seems that it is equally divided over the elderly and the young and that it is mainly based on the data for Käsecreme soup by the women. The correlation is significant but still low explaining not more than 9% of the variance, when calculated over all subjects in the incidental learning condition. Furthermore, all correlations between delta liking and the criterion are negative but small and statistically not significant. This indicates that, although there is overall a relationship between saying yes and liking of the stimulus (see above), diversity in the perceived distance in liking between target and distractors among the individual subjects is not related to changes in their response pattern.



Thus, the relationships between liking and responses in the recognition experiment show that people have a strong tendency to say yes when asked whether or not they recognize pleasant stimuli but that this tendency is unrelated to their actual memory and recognition performance.

### Neophobia

Neophobia was assessed at the end of the second session. On average, the elderly (mean = 31.25) showed higher ( $t(60) = 3.09$ ,  $P < 0.004$ ) neophobia scores than the young (mean = 24.97).

Neophobia and liking for the soups that were uncommon to the subjects were not related to each other. In fact, the elderly liked the soups more than the young, and even within each age group, there were no significant differences in the liking for the soups between a neophobic (above median) group and a nonneophobic (below median) group. Correlations between individual neophobicity scores and liking or absolute memory performance were also low and were not significant (all  $P$ 's  $> 0.05$ ) when calculated either over all subjects or within age groups or learning condition (incidental or intentional) groups.

### Discussion

A day later people spontaneously remember enough about the flavors of soups to recognize them significantly better than at chance level among variations of the same soups. Elderly subjects do this at least as well and perhaps even marginally better than young subjects, although this slight superiority may be due to another difference (e.g., motivation level) between the 2 groups. These results are in agreement with those obtained by Møller et al. (2004) with very uncommon odor stimuli. This agreement also holds for the fact that the young show better absolute memory in the intentional than in the incidental learning condition, whereas intentional learning does not seem to improve the absolute memory performance of the elderly.

It can therefore be concluded that the findings of Møller et al. (2004) on age differences were not due to possible artifacts arising from the use of highly uncommon pure odor stimuli or from the proactive interference effects caused by the use of the same group of subjects in the 2 learning conditions. The fact that incidental learning and the resulting odor or flavor memory do not deteriorate with age is in good agreement with findings in other areas where incidental learning and memory have been investigated (see reviews by Graf 1990; Parkin 1993; Hoyer and Lincourt 1998). On the other hand, the age effects, reflecting the superior performance of the young in the intentional learning condition, are in agreement with the findings of authors (e.g., Murphy et al. 1991) who used intentional learning and explicit memory tasks to compare groups of young and elderly. The good performance of the elderly in the ecologically much more

valid incidental learning condition used in the present experiment might warn us for drawing conclusions about real life consequences of memory deterioration with age found in explicit memory experiments. Intentional odor memory is simply not functional in normal life and the fact that young people are better at it may be an artifact because they are usually students, who still often practice a form of learning that is very rarely used later in life. On the other hand, it might also indicate that the elderly have more difficulty in separating out distinctive features of the stimuli when they try to encode them. They show hardly more hits in the intentional than in the incidental condition and produce significantly more false alarms (i.e., confusions of distractor and target) when they try to remember the soups intentionally. This suggests that the elderly have difficulty memorizing the specific features or may indeed have problems in separating out the distinctive features of the soups—in analogy to elderly suffering from the well-known auditory cocktail party syndrome, that is, the difficulty listening to one voice, when many speak—as Mojet (2004) and Mojet et al. (2005) proposed for taste perception.

The fact that in the present experiment the young show a higher hit rate in the intentional condition than in the incidental condition and produce about equal amounts of false alarms (and correct rejections) under both conditions suggests that the soups allow the young to analyze them and to memorize some, perhaps even verbally identifiable, features which help the subjects later to recognize the targets in the intentional condition. In this respect, the present experiment differs from the experiment of Møller et al. (2004), who found only a reduction of false alarms but no increase of hits when the young passed from the incidental to the intentional condition and who concluded on this and several other grounds that the increase in memory performance of the young in the intentional condition was not due to the memorizing of features or verbal labels of the uncommon monomolecular odors they used.

The results of the relative memory experiment demonstrate that the lesser performance of the elderly compared with the young in the intentional condition is not due to a loss of perceptual discrimination. Although there is a clear difference between the elderly and the young in the deviations of all stimuli from the remembered target, there is no interaction between age and concentration of the flavor in the distractors, indicating that the elderly and the young perceive the differences between the stimuli equally well. This result is in accordance with the findings of Mojet et al. (2003) who demonstrated that, although the elderly have a lower absolute taste sensitivity, their relative intensity perception is at least as good as that of the young. It furthermore may throw some light on the discussion about the influence of age-related loss of sensory sensitivity on food perception and appreciation and about the desirability of flavor enhancement in food for the elderly. In this connection, it might well explain the often cited finding that elderly whose sensitivity is

diminished often do not complain about loss of pleasure in eating (Stevens 1989) and in many cases do not even notice their loss (Nordin et al. 1995) or do not change their food intake (Mattes 2002). Unpleasant as it may seem to many research workers in the area of the chemical senses, this might mean that olfaction and taste are less important in eating pleasure than hitherto assumed. Perhaps, as recently proposed by Mojet (2004) and Mojet et al. (2005), the real satisfaction of eating is in intestinal somatosensory feelings provoked by the ingested food to which the preceding chemosensory signals are just linked by simple Pavlovian conditioning (see also Engen 1988 on odor hedonics). In that case, the precise quality (olfactory, gustatory, and tactile) and intensity would be immaterial to the provoked pleasure as long as one of them was detected because each of these stimuli might activate the “mental image” of the food and the pleasant expectations accompanying it. Especially in the elderly, in whom the pattern of the deteriorating sensory inputs has been changing very slowly over considerable time, such changes would probably remain unnoticed and leave eating pleasure intact.

The question arises as to what people remember and how they distinguish between the presented distractors and the remembered targets in respectively the incidental and the intentional learning conditions. Two possible variables that might have influenced memory or could even have been instrumental in remembering, liking for the stimuli and uneasy feelings as a result of neophobic tendencies in the subjects, have been practically ruled out in the analysis of the results. The difference in neophobia between elderly and young is in agreement with the findings of Tuorila et al. (2001), who also used Grünkernen as a novel product in some of her experiments (Puumalainen et al. 2002). However—in contrast to their results—no negative relationship between neophobia and liking was found in the present experiment, and the more neophobic elderly liked the novel soups even better than the young. The only indication of a weak relationship between liking for the stimuli and memory performance seems to occur for women in the incidental condition, and this is possibly related to their dislike for käsecreme soup, which they may interpret as being fattening. Otherwise, the results of the present experiment once more stress the fact that, at least in the incidental condition, the subjects do not seem to remember the specific features of the target but are very acute in knowing what they have not experienced before. As was pointed out above, the memory performance is mainly based on the ratio of the correct rejections and the false alarms, whereas the percentages of hits and misses are about equal. Thus, it must be concluded that incidental memory for flavors has the same characteristics as memory for tastes (Köster et al. 2004), memory for texture (Mojet et al. 2005), and memory for uncommon odors (Møller et al. 2004) and that the results of this experiment support the theoretical notions laid down in the discussion of these papers and in recent reviews (Köster 2004, 2005). It is argued that, at

least in the lower senses (olfaction, taste, touch), memory is mainly tuned at detecting deviations from what we already have experienced before (and hence from our expectations), rather than at recognizing or identifying previous stimuli with precision. Furthermore, it is suggested that this priority of change detection over identification might be of special importance in these lower and “near” senses because in case of danger, we have only 1 reaction possibility (fleeing in the case of smelling because we cannot stop breathing, spitting out in the case of tasting, and withdrawing in the case of touch or pain), whereas in vision early identification at a distance is important because it leaves time for choosing among varied reactions (ducking, hitting, smiling, etc.).

This view of olfactory (and probably other near sense) memory as being different from visual memory is in good agreement with the results of a series of experiments on olfactory meta-cognition by Jönsson et al. (2005), who showed that feelings of knowing (and not knowing) are much more prominent in olfactory memory for well-known odors than in memory for well-known faces and that these feelings seem mainly to be due to a lack of precise determination of the nature of the odor itself and not so much to a lack of finding the right name as it is often in failures to identify faces.

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