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Effect of Age and Food Novelty on Food Memory

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Abstract The influence of age of the consumer and food novelty on incidentally learned food memory was investigated by providing a meal containing novel and familiar target items under the pretense of a study on hunger feelings to 34 young and 36 older participants in France and to 24 young and 20 older participants in Denmark and testing them a day later on recognition of the targets among a set of distractors that were variations of the target made by adding or subtracting taste (sour or sweet) or aroma (orange or red berry flavor). Memory was also tested by asking participants to indicate whether the target and the distractors were equal to or less or more intense than the remembered target in sourness sweetness and aroma. The results showed that when novelty is defined as whether people know or not a given product, it has a strong influence on memory performance, but that age did not, the elderly performing just as well as the young. The change in the distractors was more readily detected with familiar than with novel targets where the participants were still confused by the target itself. Special attention is given to the influence of the incidental learning paradigm on the outcome and to the ways in which it differs from traditional recognition experiments.

Keywords Age · Consumer · Food Behavior · Food Memory · Incidental Learning · Novelty · Sensory Perception

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Introduction

Research on food memory is quite recent and scarce. In fact, only since the late 1970s, much research was carried out on odor or taste memory, but most of the authors used odorants or tastants in solutions (see for a review Schab and Crowder 1995; Algom et al. 1993; Herz and Engen 1996; Vanne et al. 1998; Baeyens et al. 2001; Stevenson and Boakes 2003) and in many cases they asked people explicitly to memorize them in view of a later memory test. Very few authors carried out research on food memory by actually using food as stimuli and even fewer did so under conditions that resembled normal everyday eating behavior. Among the authors that did, Köster and colleagues proposed a recognition paradigm to assess the memory for food sensory characteristics as it is formed when eating a meal (Mojet and Köster 2002, 2005; Köster et al. 2004). This paradigm consists of three distinct phases. During the acquisition phase, participants are exposed to the food to be remembered later (target food). This phase is characterized by incidental learning, i.e. while being exposed to the target food, the participants are not asked to memorize anything, but they just eat and drink as they always do. In order to create a rather normal eating situation, the participants are offered a meal under a false pretense (*e.g.*, measurement of hunger feelings). In a second session after a retention interval, the participants are unexpectedly asked to recognize the target food among a set of distractors with a flavor and/or a texture that is more or less different from the target (retrieval phase). For each sample, the participants are asked to indicate whether it is identical to or different from the one tasted during the previous session. This paradigm differs from that used in almost all other (implicit and explicit) memory experiments in the literature. It focuses on the recognition of slight changes of the aspects of a target, whereas the other experiments are directed at finding one or more distinct objects from an earlier encountered set of diverse objects amongst a new set of equally distinct other objects. In experiments on olfactory memory (Cain and Murphy 1987; Stevens et al. 1990; Murphy et al. 1991; Larsson and Bäckman 1993, 1997; Lehrner et al. 1999; see also the review of Larsson 1996), the interpretation is often further confused by introducing elements of verbal memory and verbal identification through the use of common well-known odors. Thus, many sources of possible differences between participants other than pure odor recognition alone are introduced.

The few experiments that assessed food memory by using this paradigm or a similar one have already revealed a number of interesting properties of food memory (Mojet and Köster 2002, 2005; Köster et al. 2004; Møller et al. 2004, 2007; for review see Morin-Audebrand et al. 2007). The present experiment was designed to go further in the characterization of food memory by using the same recognition paradigm as the one used by Köster and colleagues and exploring the impact on food memory of two factors: age and food novelty.

Many authors have reported a decline of odor recognition performance with age (Cain and Murphy 1987; Stevens et al. 1990; Murphy et al. 1991; Larsson and Bäckman 1993, 1997; Lehrner et al. 1999). This effect of age on odor memory was usually explained by a deterioration of the peripheral sensory functions which leads to a decrease of sensitivity and supra-threshold intensity perception for odors, and by a deterioration of central cognitive functions which leads to a decrease of the processing resources available for learning and retrieving information (see Larsson 1996 for a review). However, in a carefully controlled experiment with uncommon odors which carry no semantic information, it was found that elderly people remember incidentally learned odors as well as young people (Møller et al. 2004). Young participants only performed at a superior level when odors were learned intentionally, that is when participants were explicitly instructed to remember the odors in the exposure (learning) phase of the experiment. To the best of our knowledge, only one study has investigated the impact of age on flavor memory (Møller et al. 2007). This study found that flavors were remembered as well by elderly participants as by young under incidental learning and that young participants excelled when learning was intentional. Thus, a first question to be answered in the present experiment was whether age affects memory for food stimuli that are varied both in their olfactory and gustatory components and presented under quasi-natural conditions to invoke incidental learning. To answer this question, food recognition performance of young adults (below 30 years) was compared to that of elderly participants (over 60 years).

Köster and colleagues observed that learning took place both for food texture (Mojet and Köster 2002) and food taste (Köster et al. 2004), but not to the same degree for the different texture or taste qualities in a given food, and not to the same degree for the same texture or taste quality in different foods. For instance, in Mojet and Köster (2002), a grainy pâté was recognized more often than an elastic one. In Köster et al. (2004), recognition performance was better for bitterness than for sweetness in orange juice, and was better in yoghurt than in cream cheese for sourness. In other words, the degree to which a sensory property is memorized and remembered depends on the sensory context (on the food) in which it is presented. In line with these first conclusions, one might wonder whether memory performance also varies over different foods, and in particular differs between novel and familiar foods. In fact, it is well-known from research with more traditional methods on verbal and visual stimuli that recognition memory is better for unfamiliar stimuli than for familiar ones (Kishiyama and Yonelinas 2003). Thus, Guttentag and Carroll (1994) observed superior memory for low frequency than for high frequency words. Obviously, the influence of novelty in memory for food is of special interest since humans, like all omnivores, are supposed to have a peculiar and cautious attitude towards novel food (Rozin 1984; Pliner and Hobden 1992).

Materials and Methods

Participants

Thirty-four young participants (11 men and 23 women of mean age 20 years and range 18–28 years) and 36 elderly participants (18 men and 18 women of mean age 70 years and range 60–84 years) were recruited in France, and 24 young participants (seven men and 17 women of mean age 25 years and range 21–34 years) and 20 elderly participants

(11 men and seven women of mean age 66 years and range 55–75 years) were recruited in Denmark. To participate in the study, candidates should consume at least sometimes orange juice and dairy products, and should not already have taken part in a memory study or in a descriptive sensory study. In order to leave the participants unaware of the real purpose of the experiment (i.e., study food memory), they were told that the aim of the experiment was to measure hunger feelings after a meal of known caloric composition ("cover story"). The participants were paid for their participation.

Products

An orange juice made with concentrate served as familiar food in both countries, a red berry-strawberry Yosa® (oat fermented "yoghurt" mixed with 100 g/kg of red berry-strawberry jam) served as the novel food in France and a Yayla yoghurt® (natural 10% fat, mixed with 138 g/kg of strawberry juice and of 4.4 g/kg of red fruit color) served as the novel food in Denmark. At the time of the experiment, Yosa® was not available in France and Yayla Yoghurt® has an insignificant market share in Denmark. Unfortunately, it was not possible to have the same novel product in France and in Denmark (some products were novel in both countries, but they were not easily modifiable). For each food, the concentration of a tastant and the concentration of an aroma were varied in order to obtain one target stimulus and six distractors (Table 1). The tastants and the aromas used to modify the sensory aspects of the food were the same as the ones used for the production of the regular market product. A preliminary experiment was carried out with a separate group of 18 young participants and 18 elderly participants to estimate the concentrations of the tastants and aromas that had to be added to the foods to obtain just noticeable differences (JNDs) To this purpose, the procedure described in Köster et al. (2004—preliminary experiment) was followed. After calculation of the JNDs, one target and three distractors per varied sensory quality were made for each food. It should be noted that for the orange juice, the target stimulus deviated somewhat from the regular market product in order to be able to separate the effect of experimental learning from everyday familiarity. The distractors were respectively one JND lower, and one and two JND higher in concentration than the target stimulus. All distractors contained the same concentration of the non-varied sensory quality as the target. The composition of the stimuli is given in Table 1.

Procedure

Participants were invited to take part in three breakfast sessions (either at 8:00 am or at 9:00 am) on consecutive days. They were asked not to eat or drink anything prior to arrival at the laboratory.

Session 1: Learning Phase

At arrival, informed consent was obtained and participants were informed that the experiment was on the development of their hunger feelings after a breakfast. They were asked to answer questions related to hunger. Subsequently, they were served a breakfast, consisting of a piece of bread (about 50 g), the familiar target food (orange juice) and the novel target food (Yosa® in France or Yayla yoghurt® in Denmark). Both Yosa® and Yayla yoghurt® were presented to the participants as a "fruit dessert". They were asked to eat all of it on the pretence that its caloric value had been carefully composed for the study of hunger feelings. At the end of the meal, participants were asked to answer more questions on hunger and were given another questionnaire to fill out each hour until lunchtime. In fact, everything was

Table 1 Characteristics of the products

		Familiar food		Novel food			
		Orange juice		Yosa®		Yayla yoghurt®	
	Code	Orange aroma (ml/l)	Citric acid (ml/l)	Red berry aroma (ml/kg)	Sucrose (g/kg)	Red berry aroma (ml/kg)	Sucrose (g/kg)
Target	T	1.2	2.5	0.4	10	0.4	10
Taste −1 JND	S^{-1}	1.2	0.0	0.4	0	0.4	0
Taste +1 JND	S^{+1}	1.2	5.0	0.4	20	0.4	20
Taste +2 JND	S^{+2}	1.2	7.5	0.4	30	0.4	30
Aroma −1 JND	A^{-1}	0.0	2.5	0.2	10	0.2	10
Aroma +1 JND	A^{+1}	2.4	2.5	0.6	10	0.6	10
Aroma +2 JND	A^{+2}	3.6	2.5	0.8	10	0.8	10

JND Just noticeable difference

done to guarantee incidental learning and to make the participants believe that the experiment was about hunger. Memory was never mentioned.

Session 2: Absolute and Relative Memory Tasks

For each food, participants were presented with a series of 12 samples, which consisted of six samples of the target stimulus and one sample of each of the six distractors. They were asked to taste each sample and to indicate whether this sample was certainly identical, probably identical, probably different, or certainly different from the sample tasted during the previous breakfast (absolute memory task). After completion of this series, the participants were briefly informed that food flavor is in fact a combination of taste (sweet, salty, sour or bitter) and aroma. They were given some examples (*e.g.*, coffee has a bitter taste and a roasted aroma). Then, they were presented with two new series of seven samples, in which the target and the six distractors for each food were represented once only. They were asked to taste each sample and to answer the following questions (relative memory task): “Is this sample less, equally, or more sour than the one tasted on yesterday morning?” (sourness item); “Is this sample less, equally, or more sweet than the one tasted on yesterday morning?” (sweetness item); “Is the aroma intensity of this sample weaker, equal, or stronger than the one tasted on yesterday morning?” (aroma intensity item).

Session 3: Perception Task

For each food, the participants were presented with one reference (the target variant sampled in the learning session) and a series of seven samples (one sample of the target and one sample of each distractor). They were asked to taste the reference, then to taste a sample, and to answer the following questions: “Is this sample less, equally, or more sour than the reference?” (sourness item); “Is this sample less, equally, or more sweet than the reference?” (sweetness item); “Is the aroma intensity of this sample weaker, equal, or stronger than the reference?” (aroma intensity item). The participants were allowed to re-taste the reference as many times as they wanted. We labeled this task ‘perception task’ to make a distinction between a situation in which participants compared the samples to a physically presented target and a situation in which participants compared the samples to a remembered target (relative memory task). At the end of the session, participants were asked to indicate for each product whether they knew the name or the origin of the product (if yes, they provided this name), whether the product was similar to products that they were used to consume, and how on the whole they liked the product. For the last two items, participants answered on 7-point scales.

Experimental Conditions

All test sessions were conducted in a sensory room equipped according to the AFNOR standard (AFNOR 1987) and participants were seated in separate booths. The order in which the foods were presented to the participants was systematically balanced and varied over participants, but for a given participant, this order was the same over the three tasks (absolute memory task, relative memory task, perception task). For each food, the order in which samples were presented within a series was systematically varied over participants and over the tasks. The samples were coded with three digit numbers that varied over the three tasks. In the relative memory task and the perception task, the order of the questions was systematically balanced and varied over the participants, but for a given participant, this order was the same over the two tasks.

In the learning session, participants were served 100 ml of orange juice in a 250-ml plastic glass and 100 g of Yosa® or Yayla yoghurt® in a 100-g plastic cup. In the absolute memory task, the relative memory task and the perception task, participants received samples consisting of 20 ml of orange juice in a 80-ml plastic glass or 10 g of Yosa® or Yayla yoghurt® in a 10-g plastic cup, except for the references in the perception task which were served in the same way as in the learning session. The samples of orange juice were served at room temperature. The samples of Yosa® or Yayla yoghurt® were served at +8 °C. During the memory and the perception session, the participants were asked to rinse their mouth with water and to eat some bread after each sample.

Data Analysis

All statistical analyses were conducted using SAS/STAT® (1990). Concerning the absolute memory task, scores that assessed memory strength and response bias were computed. To facilitate reading, the computation of these scores is extensively presented in the result section. Binomial tests (AFNOR 2004) were used to evaluate deviations from chance guessing both in the relative and perception tasks. Since the number of participants per between-participants factor was not perfectly balanced, all analyses of variance (ANOVA) were performed with the GLM procedure of SAS (type III SS). Least-squares means (LS-means) and standard error of the LS-means were computed for each factor. LS-means are predicted population margins; that is, they estimate the marginal means over a balanced population. Originally, we included gender as a factor in the analysis, but since this factor was never significant, we removed it to facilitate reading.

Results

Characterization of the Products

A two-way ANOVA carried out on the two ratings obtained at the end of the last session reveals a significant country × food type interaction both on the degree of similarity between the tasted products and products that participants are used to consume ($F_{(1,112)}$=17.42, MSe=3.35, p=0.001) and on the liking ratings for the tested products ($F_{(1,112)}$= 7.13, MSe=3.63, p=0.01). Table 2 presents the mean scores obtained for these ratings. In France, the Yosa® was rated actually as less similar to known products and tended to be less liked than the orange juice (p=0.09). Unexpectedly, in Denmark, the Yayla yoghurt® was rated as more similar to known products and was more liked than the orange juice. However, in both countries, none but one of the participants knew the name or the origin of the supposed novel product. The data from the Danish participant who knew the name of the Yayla yoghurt® were removed from the data analysis.

Absolute Memory Task

Memory performance was quantified using signal detection method which allows calculation of a measure of recognition d' independent of the response bias caused by the participants' tendency to answer identical or different. This tendency is expressed in the decision criterion c. For each food (familiar *vs.* novel) and for each participant, the proportion of hits (saying "identical" to a target) and the proportion of false alarms (saying "identical" to a distractor) were determined. To avoid infinite values, proportions of 0 and 1 were converted to respectively $1/(2N)$ and $1-1/(2N)$ (MacMillan and Creelman 1991). These proportions were then transformed into z scores under the normal probability curve and the recognition index ($d'=z$ (hits)$-z$ (false alarms)) and the decision criterion ($c=-0.5$ [z (hits)+z (false alarms)]) were calculated. T-tests were used to assess whether d' and c differed from 0 or not. A positive d' indicates that recognition was better than chance guessing. A positive c indicates a bias to respond "different" and a negative c indicates a bias to respond "identical". An ANOVA was carried out with age (young *vs.* elderly), country (France *vs.* Denmark), food type (familiar *vs.* novel), their two-way interactions and participant within age and country as factors, and d', c, the proportion of hits and the proportion of false alarms as dependent variables in the model. The factors age and country and their interactions were tested against the factor participant.

Table 3 presents the mean of the proportion of hits, the proportion of false alarms, the index d' and the index c computed for each level of factors of interest (age, country, food type). On the whole, this table shows that the indices d' and c are always significantly higher than 0, indicating that recognition was better than chance guessing and that participants had a bias to answer "different". It should also be noted that the frequencies of hits are quite low (just below 0.50) indicating that the memory effect was due to the correct rejection of the distractors rather than to the correct recognition of the targets. None of the indices were associated with a significant effect of age (p>0.05). However, the ANOVA revealed a significant effect of country on c ($F_{(1,109)}$=5.91, MSe=0.22, p=0.01) and on the proportion of false alarms ($F_{(1,109)}$=4.30, MSe=0.04, p= 0.05). The tendency to answer "different" was higher in Denmark than in France and the frequency of false alarms was lower in Denmark than in France. However, this result is difficult to interpret as one cannot decide whether it is related to a cultural specificity of one of the countries or to the fact that on average, Danish participants liked more the products than French participants. The ANOVA also revealed a significant effect of food type on d' ($F_{(1,110)}$= 5.87, MSe=0.27, p=0.05), on c ($F_{(1,110)}$=23.75, MSe= 0.15, p=0.001), on the proportion of hits ($F_{(1,110)}$=4.24, MSe=0.04, p=0.05) and on the proportion of false alarms ($F_{(1,111)}$=25.13, MSe=0.03, p=0.001). Recognition was better for familiar food than for novel food, and the tendency to answer "different" was higher for familiar food than for novel food. Congruently, the proportions of hits and false alarms were lower for familiar food than for novel food. None of the interaction were significant (p>0.05). In particular, the interaction country × food type was not

Table 2 Characterization of the products

Country food type	Similarity to known products	Overall liking
France familiar	3.01 (0.22)[b]	3.00 (0.23)[bc]
France novel	1.91 (0.22)[c]	2.46 (0.23)[c]
Denmark familiar	3.02 (0.28)[b]	3.34 (0.29)[b]
Denmark novel	4.00 (0.28)[a]	4.18 (0.29)[a]

Least-squares means (standard error) for the two ratings obtained at the end of the last session. For each rating, means that are significantly different are indicated by different letters (p< 0.05)

Table 3 Results of the absolute memory task

	Hits	False alarms	*D*′	*C*
Age factor				
Young	0.47 (0.02)	0.31 (0.02)	0.46 (0.08)***	0.31 (0.04)***
Elderly	0.46 (0.02)	0.35 (0.02)	0.32 (0.08)***	0.27 (0.05)***
Country factor				
France	0.49 (0.03)	0.36 (0.02)[b]	0.38 (0.07)***	0.21 (0.04)[a] ***
Denmark	0.44 (0.02)	0.30 (0.02)[a]	0.40 (0.09)***	0.37 (0.05)[b] ***
Food type factor				
Familiar	0.44 (0.02)[a]	0.26 (0.02)[a]	0.49 (0.07)[b] ***	0.41 (0.04)[b] ***
Novel	0.50 (0.02)[b]	0.39 (0.02)[b]	0.29 (0.07)[a] ***	0.16 (0.04)[a] ***
Country × food type				
France × familiar	0.48 (0.03)	0.31 (0.02)	0.47 (0.10)***	0.31 (0.06)***
France × novel	0.51 (0.03)	0.41 (0.02)	0.28 (0.10)**	0.11 (0.06)*
Denmark × familiar	0.40 (0.04)	0.22 (0.03)	0.50 (0.13)***	0.52 (0.07)***
Denmark × novel	0.48 (0.04)	0.37 (0.03)	0.31 (0.13)**	0.21 (0.07)**

Least-squares means (standard error) of the proportion of *hits*; the proportion of *false alarms*, the index *d*′, and the index *c* were computed for each factor. For each factor, means that are significantly different are indicated by different letters ($p < 0.05$). *T*-tests were used to assess whether *d'* and *c* differed from 0 or not

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

significant despite different novel foods were tested in France and in Denmark (*d*′, $p = 0.99$; *c*, $p = 0.36$).

Relative Memory Task and Perception Task

For these tasks, participants were presented with series of seven samples including the target and the six distractors for each food. For each sample, they were asked to judge its sourness, its sweetness, and its aroma intensity relative to the remembered target sample tasted during the previous breakfast (relative memory task) or to a presented target sample reference (perception task). To examine the variation of performance across variants, the proportions of possible answers ("less", "equal", "more") made by the whole panel were determined for each food (familiar or novel), for each task (relative memory or perception), for each item of interest (sourness for familiar food, sweetness for novel food, aroma intensity for both foods) and for each variant (Fig. 1). The proportion expected by chance (1/3), and the significance thresholds (the minimum and maximum proportion that is respectively significantly higher or lower than the chance level, $(n/3 + z\sqrt{(2n/9)}$, where n=panel size and $z = 1.64$ for $p = 0.05$), are respectively represented by a dashed line and solid lines on this figure. Results obtained in the relative memory task were systematically compared to results obtained in the perception task.

Whatever the food, the proportion of "equal" for the target (T) is always above the significance threshold, except in one case (in the perception task, the proportion of "equal" for the familiar food and the item sourness is below the significant threshold but above the chance level). In other words, both the familiar and the novel target were predominantly perceived as equally sour, sweet, and intense in aroma as the remembered target from the learning session.

Familiar Food, Sourness Item As expected, the results of the perception task show that perception of sourness was affected by changes in citric acid concentration: S^{-1} is associated with a significant proportion of "less sour" while S^{+1} and S^{+2} are associated with a significant proportion of "more sour". Results of the relative memory task show that only the increase in sourness was accurately remembered: S^{+1} and S^{+2} are associated with a significant proportion of "more sour". However, S^{-1} is associated with a significant proportion of "equally sour". Despite the fact that this distractor was perceived as less sour than the target in the perception task, it was not perceived as less sour than the remembered target in the relative memory task.

Familiar Food, Aroma Intensity Item As expected, the results of the perception task show that perception of aroma intensity was affected by changes in aroma concentration: A^{-1} and A^{+2} are respectively associated with a significant proportion of "less intense in aroma" and "more intense in aroma" and for A^{+1}, the proportion of "more intense in aroma" is below the significant threshold but above the chance level. Nevertheless, results of the relative memory task show that A^{+1} and A^{+2} but also A^{-1} are associated with a significant proportion of "more intense in aroma". It seems that participants tended to systematically judge the presented distractor as "more intense in aroma" than the remembered target, whatever the nature of the distractor. This may indicate that the aroma intensity of the remem-

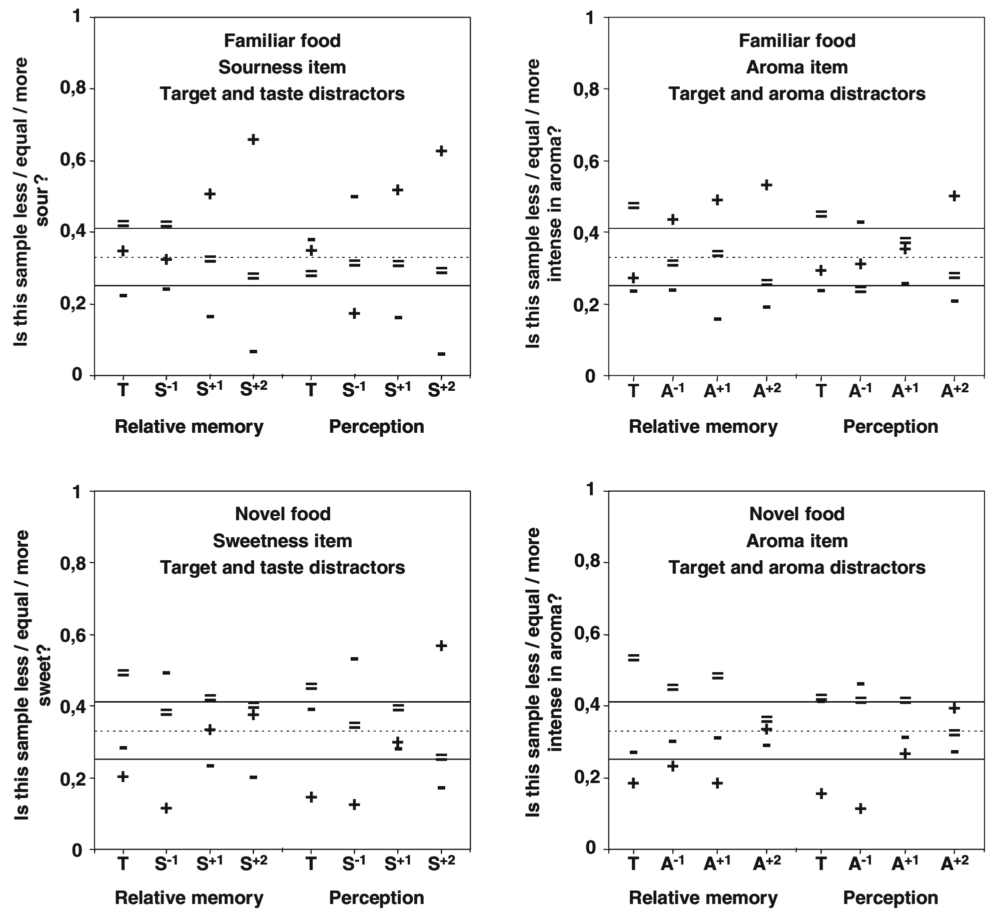

Fig. 1 Relative memory and perception task. For each food, task and item, a graph plots the proportion of each possible answer (− for "less", = for "equal" and "+" for more) associated with each variant. The proportion expected by chance (1/3) and the significant thresholds are respectively represented by a *dashed line* and *solid lines*. See Table 1 for the meaning of the product codes

bered target has shifted in memory to a lower level and that as a result the aroma intensity of all distractors appears to be stronger than the remembered target.

Novel Food, Sweetness Item As expected, the results of the perception task show that perception of sweetness was affected by changes in sucrose concentration: S^{-1} is associated with a significant proportion of "less sweet" while S^{+2} is associated with a significant proportion of "more sweet". Results of the relative memory task show that S^{-1} was actually remembered as less sweet than the target and that S^{+2} tended to be remembered as more sweet than the target (the proportion of "more sweet" is just below the significant threshold).

Novel Food, Intensity Aroma Item As expected, the results of the perception task show that A^{-1} was perceived as less intense and that A^{+2} tended to be perceived as more intense in aroma than the target. Indeed, both proportions of "less" and "equally intense in aroma" are significant for A^{-1} and the proportion of "more intense in aroma" just failed to be significant for A^{+2}. However, results of the relative memory task show that participants almost systematically judged the presented distractor as "equally

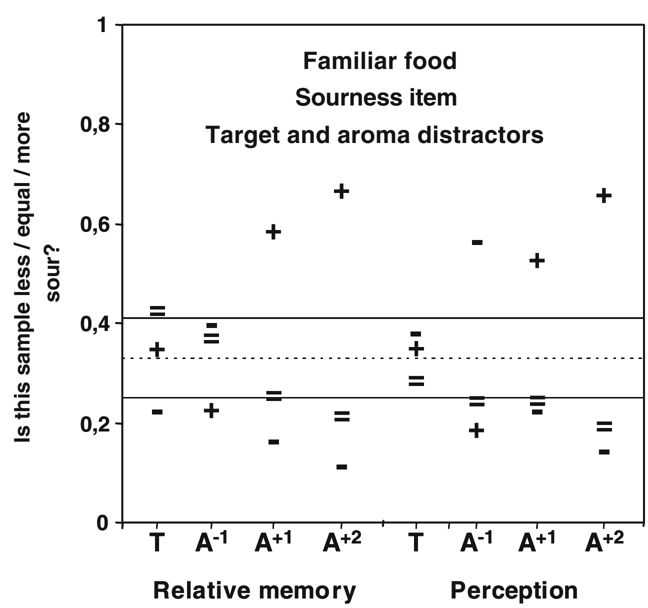

Fig. 2 Odor–taste interactions. The graph plots the proportion of each possible answer (− for "less", = for "equal" and "+" for more) obtained for the sourness item for each aroma distractor in the familiar food. The proportion expected by chance (1/3) and the significant thresholds are respectively represented by a *dashed line* and *solid lines*

intense in aroma" as the remembered target, whatever the nature of the distractor.

Odor–taste Interaction An interesting interaction was also found (Fig. 2). Changing the aroma concentration in the familiar food also affected the perception of sourness. A^{-1} is associated with a significant proportion of "less sour" while A^{+1} and A^{+2} are associated with a significant proportion of "more sour". Accordingly, A^{+1} and A^{+2} are associated also with a significant proportion of "more sour" in the relative memory task. This result can not be attributed to a physico-chemical effect of the aroma solution since it was checked that changes in aroma concentration did not modify the pH of the orange juice. Actually, this result is probably due to an aroma–taste interaction: the more a juice was flavored, the more it was perceived and remembered as sour, and reciprocally.

Comparison of General Memory Performance Between Groups, Between Stimuli Varying in Novelty and Between the Perceptual Dimensions Used in the Experiment In order to compare the memory for the exact physical intensities of the stimuli, the judgments "less", "equal", and "more" were transformed into responses "expected", "unexpected", and "opposite to what was expected" in accordance to the relationship between the physical intensities of the compared stimuli (a remembered and a perceived one). Thus, when in the memory session a target stimulus was presented, both the responses "less" and "more" were transformed into "unexpected", whereas the response "equal" was transformed into "expected". In the case of a distractor that was less strong than the original target a "less" response was coded as "expected", an "equal" response as "unexpected", and a "more" response as "opposite" whereas in the case of a distractor that was stronger than the original target "more" was coded as "expected", "equal" as "unexpected", and "less" as "opposite". A multicategorical logit model (Fahrmeir and Rutz 1994) was fitted to the data by the method of maximum likelihood, taking "expected" as the reference category and with the explanatory variables age, country, food, modality (taste vs. aroma) and their interactions (LOGISTIC procedure of SAS). Results revealed no significant effect of age but a significant effect of country ($\chi^2_{(2)}=17.03$, $p<0.001$), food ($\chi^2_{(2)}=35.19$, $p<0.001$), and modality ($\chi^2_{(2)}=10.43$, $p<0.01$). None of the interactions were significant ($p>0.05$). Figure 3 depicts the estimated probability and its confidence interval (95%) for each category of response for each food (Fig. 3a) for each modality (Fig. 3b), and for each country (Fig. 3c). Examination of this figure shows that the intensities of novel stimuli were more often incorrectly remembered than those of familiar stimuli, that the intensity of taste was more often correctly identified than that of aroma, and

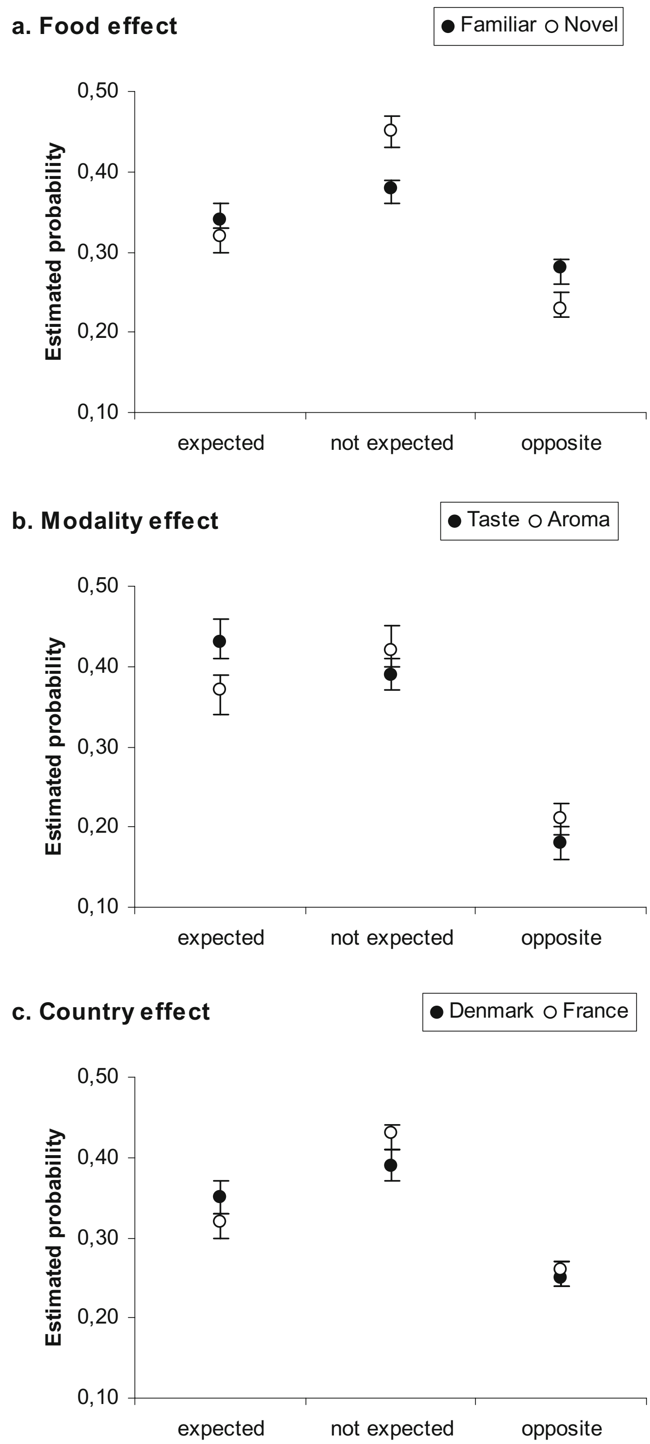

Fig. 3 Relative memory task: presentation of the estimated probabilities and their confidence interval ($p=0.05$) of "expected", "not expected" and "opposite" response obtained for each food (**a**), for each modality (**b**) or for each country (**c**)

that the Danish were more precise in their memory of the exact intensity than the French. This last result is difficult to interpret as the difference in memory performance between the two countries can either be due to a true country (culture) effect or to the fact that on average, Danish participants liked more the products than French participants.

Discussion

No Effect of Age was Observed on Food Memory

With aging, neurological changes in the nervous system (e.g., volumetric reductions, neurochemical alterations…) lead to a slowing down of speed of processing and to a decrease of processing resources to learn and retrieve information (Anderson and Craik 2000). For instance it is well known that difficulties with name finding and other semantic problems become more pronounced in the elderly and this might be especially the case in an area like olfaction where naming and identification are notoriously difficult even in young people. In the present experiment such semantic problems play less of a role, since it is the change of the target that people must detect and not the target itself. They do not even have to identify the nature of the change except when at the end of the experiment, they are explicitly asked to look for changes in specific attributes in the relative memory test. Like in most instances in normal life, the absolute memory test is all about detecting differences without the necessity to identify.

Under such conditions, the present experiment showed no significant effect of age on recognition performance, neither in the absolute memory task nor in the relative memory task. In other words, it seems that incidentally learned food memory is unaffected by age. This result is in good agreement with the results of earlier research on memory after incidental learning. Investigating both incidentally and intentionally learned memory, Møller et al. (2004), using uncommon odors as stimuli and Møller et al. (2007) using uncommon soups varied in flavor, demonstrated that with incidental learning the elderly were at least as good and even a bit better than young participants. In the intentional learning condition the young performed better than in the incidental condition and also better than the elderly who did not improve their performance under this condition. The absence of age effects with incidental learning in these and the present study are also in line with the many results obtained in implicit priming studies with verbal or visual stimuli (Graf and Schacter 1985; Schacter 1987; Fleischman and Gabrieli 1998; Fleischman et al. 2004). Nevertheless, the two paradigms are quite different. In the implicit priming experiments the learning phase can be quite explicit (e.g. reading lists of words aloud, reaction time measurement in picture naming) although often no intentional learning or memorizing is demanded on the part of the participant. In fact, in these experiments the implicitness of the memory is not based on the form of the acquisition at all, but on the fact that the participant uses the acquired information in responding to a seemingly unrelated situation and without awareness of the origin of his knowledge (the study phase) at the moment of response. In contrast, the present study takes great care not to attract explicit and special attention to the target in the acquisition phase, but refers explicitly to this earlier experience in the memory test phase. Studies that combine incidental learning with implicit memory testing are very rare. Some have been carried out in the area of olfaction (Degel and Köster 1999; Degel et al. 2001), but only with young participants.

The fact that difference detection is essential in this experiment may also explain why the elderly are as good as the young. There are clear indications that, although on average the absolute sensitivity for taste and olfaction diminishes in the elderly, their relative sensitivity does not become less acute than that of young people (Mojet et al. 2003). Thus, it need not surprise that, as long as the elderly have not become really anosmic—and notwithstanding ample evidence of olfactory sensitivity losses—their difference detection remains perfectly adequate compared to that of younger people. Needless to say this is a great comfort for both the elderly and the young (as prospective elderly) because differential sensitivity is probably much more important in normal functioning in everyday life than absolute sensitivity.

The Influence of Novelty on the Incidental Memory for Foods

The degree of familiarity/novelty of food was checked at the end of the last session through two items: a first one related to whether participants knew the products assessed in the present experiment and a second one related to the degree to which these products resemble products that participants are used to consume. These two items did not always give the same results. In both countries, none of the participants but one (his data were removed) knew the name or the origin of the novel product. In France, the Yosa® actually was rated as less similar to known products than the orange juice. However, in Denmark, the Yayla yoghurt® was rated as more similar to known products than the orange juice. Despite this limitation, a difference was found between familiar and novel food in both countries with regard to memory performance and no country × food type interaction was observed on memory performance. One could argue that difference in memory performance between familiar and novel food may be due to difference in liking. Actually, several experiments showed that novel stimuli are less liked than familiar ones (Jellinek and Köster 1979, 1983; Pliner 1982; Issanchou et al. 1987; Ayabe-Kanamura et al. 1998; Sulmont et al.

2002). In parallel, some experiments revealed a relationship between memory and liking (Møller et al. 2007; Laureati et al. 2008). However, while such an explanation may be plausible for France where novel food tends to be more liked than familiar food, this could hardly explain Danish results. Indeed, Danish participants preferred the novel food to the familiar one.

In the absolute memory measurements novel food lead to a higher proportion of false alarms and an only slightly higher proportion of hits (that nevertheless does not become larger than would be obtained by chance guessing). It results in a clearly lower recognition index d' and a much lower response bias index c for novel than for familiar food. Obviously novelty invokes a tendency to say less often "No, I did not have this last time" than in the case of familiar food. In other words, the participants seem more hesitant to reject the novelty in the distractor caused by the added taste or aroma, when they are still confused by the overall novelty of the target. This once more illustrates the difference between the present paradigm and traditional recognition experiments in the literature. As explained in the introduction, the present paradigm differs from almost all other in that it focuses on the recognition of slight changes of the aspects of a target, whereas the other experiments are directed at finding one or more distinct objects from an earlier encountered set of diverse objects amongst a new set of equally distinct other objects. In these traditional experiments novel stimuli were better remembered because they "stand out" among the other items in the set used in the learning phase (Guttentag and Carroll 1994; Tulving and Kroll 1995; Kishiyama and Yonelinas 2003). In the present experiment no such "distinctiveness" can play a role because it is not the target that has to be remembered as different from other stimuli, but the novelty of the distractor that has to be detected. In that case, the novelty of the target, that after only one encounter leads to uncertainty and specific exploratory behavior, hampers the detection of the distractor novelty (Berlyne 1965, 1967; Lévy et al. 2006; Sulmont-Rossé et al. 2008). This explains why, contrary to expectation along traditional lines, novelty does not lead to better memory. The negative results of the relative memory and perceptual measurements for the novel foods confirm this view of confusion about what has been changed. In the perceptual test the most clear effect is found for the effects of sweetness but on the whole the relative memory judgments are much more confused than in the case of the familiar food, where clear relationships between the additions (or omissions) and both the perception and the memory relative to the target are found.

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