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Sex differences in recollective experience for olfactory and verbal information

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Abstract

We examined recollective experience as a function of sex for olfactory and verbal information. In the first study, men and women studied a set of highly familiar odors with incidental or intentional encoding instructions. In the second study, participants were presented with a number of sentences. At recognition, participants indicated whether their positive response was based on conscious recollection (remembering), a feeling of familiarity (knowing), or guessing. The results indicated that recollection was higher among women than men, and that familiarity-based recognition was equally large across sex for both types of information. The finding that the sex-related experiential difference disappeared when controlling for verbal proficiency suggests that sex-related differences in activating verbal information play an important role for sex differences in recollective experience.

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A number of studies have reported that women perform better than men in episodic memory tasks. For example, women have a higher performance in word recall (Herlitz, Airaksinen, & Nordström, 1999), face recognition (Herlitz, Nilsson, & Bäckman, 1997), and name recognition (Larrabee & Crook, 1993). Likewise, research has indicated a female advantage in episodic odor memory (Lehrner, 1993; Öberg, Larsson, & Bäckman, in press).

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One factor that has been proposed to underlie the observed sex difference in episodic memory is the female advantage in verbal abilities (Hyde & Linn, 1988; MacCoby & Jacklin, 1974), suggesting that women process target information with a higher degree of elaboration. This view is supported by findings indicating that the influence of sex is pronounced in memory tasks where verbalization of the material is possible (Herlitz et al., 1999). In a related vein, Öberg et al. (in press) found that sex differences were reliable in episodic recognition for familiar odors (i.e., identifiable), whereas the difference was absent in memory for unfamiliar (i.e., unidentifiable) odors. Of interest to note was that statistical control of proficiency in odor identification (i.e., verbalization) resulted in that the female superiority in memory for familiar odors disappeared. This outcome suggests that women's higher memory performance was mediated by their superior verbal abilities.

Research suggests that recognition memory entails at least two distinct states of awareness (e.g., Gardiner & Java, 1993b; Rugg, Schloerscheidt, & Mark, 1998; Tulving, 1985). Specifically, recognition can occur when a stimulus evokes some specific experience or, alternatively, when a stimulus gives rise only to feelings of familiarity without any recollective experience. The former retrieval mode is based on associative and contextual information, whereas the latter relies on familiarity-based information (Gardiner & Java, 1993a; Rajaram, 1996). In laboratory conditions, the two states of awareness may be measured as "remember" and "know" responses (Tulving, 1985).

Remembering and knowing have been proven to be functionally independent in the sense that several variables affect remembering but not knowing, and vice versa. For example, remember responses are negatively affected by longer retention intervals (Gardiner & Java, 1991), divided attention during learning (Gardiner & Parkin, 1990), incidental as opposed to intentional learning (Gardiner & Java, 1993b), and are sensitive to level of processing (Gardiner, 1988). Know responses are unaffected by these variables, but are enhanced by masked repetition priming (Rajaram, 1993), modality match across study and test (Gregg & Gardiner, 1994), and suppression of focal attention (Mäntylä & Raudsepp, 1996); variables that exert little influence on remember responses. Taken together, these patterns of results support the view that remember and knowing reflect qualitatively different memory processes or systems.

To the best of our knowledge, no study has explicitly examined the influence of sex on recollective experience. The observation that women excel in episodic memory tasks and then particularly in tasks tapping verbal abilities, suggests that women have more contextual information available for the critical information. For example, verbal elaboration of target materials may result in a more distinct and contextually rich representation (e.g., Rajaram, 1993). To the extent that remembering reflects associative and contextual processing, it could be hypothesized that females should experience more recollection than males.

The main aim of the present work was to investigate the impact of sex on recollective experience accompanying recognition in two different episodic memory tasks. Based on earlier findings, we expected an overall female superiority over men in both tasks (e.g., Herlitz et al., 1999; Öberg et al., in press). In the first study, men and women were presented with a set of highly familiar odors with incidental or intentional

encoding instructions. Participants in the second study were presented with a list of nouns with instructions to memorize. For both tests, participants indicated whether their positive recognition response was based on conscious recollection (remembering), a feeling of familiarity (knowing), or guessing. We predicted that women would show more conscious recollection and equal amounts of familiarity-based recognition as compared with men across both tasks. Furthermore, in order to examine whether verbal abilities may drive the expected sex difference in recollective experience, we used two indices of verbal proficiency. Based on earlier research showing that odor naming taps into the same cognitive domain as verbal abilities (e.g., Larsson, Finkel, & Pedersen, 2000), we used naming proficiency as a verbal index in the first study. Verbal fluency performance served as the verbal marker in Study 2. By statistically controlling for these factors, we expected that sex differences in recollective experience (i.e., remember responses) would disappear or at least be attenuated across both tasks.

1. Study 1

1.1. Method

1.1.1. Participants

A total of 68 subjects (33 men and 35 women) ranging in age from 19 to 36 years of age participated. All subjects resided in the Stockholm area, had responded to newspaper advertisements for participation, and reported being in good health. Participants received no monetary reward, but were offered information about their own results after the study was completed. Background data concerning demographic (i.e., age, educational level) and health status (i.e., perceived state of health) variables were collected. Self-perceived health status was measured by using a five-graded scale ranging from very poor (1) to very good (5). Means and standard deviations for these variables are presented in Table 1.

One-way analyses of variance (ANOVAs) revealed no significant differences between men and women with respect to age, years of education, or perceived state

Table 1
Participant characteristics in Studies 1 and 2

	Age (years)		Years of education		Health rating	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<i>Study 1</i>						
Men	26.9	4.7	14.1	2.7	3.2 ^a	0.8
Women	28.6	4.6	14.8	2.3	3.1	0.8
<i>Study 2</i>						
Men	55.2	16.3	11.2	4.3	0.8 ^b	0.4
Women	54.2	16.4	11.7	4.1	0.7	0.5

^a 1 = very poor to 5 = very good.

^b Do you feel healthy? 1 = yes and 0 = no, proportion of yes responses.

of health ($p > 0.20$). In addition, to control for potential influences of smoking on olfactory performance, information concerning smoking habits was gathered (i.e., current smoker, past-smoker, non-smoker). Smoking habits were unrelated to olfactory sensitivity and odor memory performance as determined by a series of correlations ($p > 0.20$).

1.1.2. Materials

1.1.2.1. Odor recognition stimuli. The test set of familiar odors ($n = 24$) was based on real-world substances and has partly been used in earlier studies (Larsson & Bäckman, 1993, 1998). The following 24 familiar odors were included: tobacco, lemon, cleaning liquid, cinnamon, peppermint, white pepper, after shave (Brut), cocoa, peanut butter, bitter almond, garlic, strawberry, coffee, soap, mustard, snuff, cloves, petrol, apple, vanilla, whisky, licorice, tuna fish, and beer.

Odor substances were placed in 60-ml opaque bottles with narrow mouths and screw-on-lids that occluded any visual cues. Twelve odors served as targets and 12 served as distractors in each set. The presentation order of odor items was counter-balanced such that half of the participants within each sex group received odors 1–12 at encoding and the other half encoded odors 13–24. Also, two scrambled and different orders were used at testing.

Because some earlier findings indicate sex differences in olfactory perception favoring women (e.g., Doty, 1976), odor sensitivity was assessed in an olfactory threshold test. In this task distilled water and 1-butanol were mixed in a series of 11 dilutions presented in 200-ml opaque bottles (cf. Larsson & Bäckman, 1993; Murphy, Cain, Gilmore, & Skinner, 1991). The dilutions ranged from 8 ml (strongest) to 0.1 μ l (weakest) of 1-butanol/200 ml of distilled water. If a participant could detect the weakest concentration, a score of 10 was given; if the second weakest concentration was detected, a score of 9 was given; and so forth. For a more detailed procedure see Larsson and Bäckman (1993, 1998). A one-way ANOVA indicated that men ($M = 9.42$, $SD = 1.06$) and women ($M = 9.54$, $SD = 0.61$) did not differ in olfactory thresholds ($p > 0.50$). Importantly, perceived familiarity of test odors, as indexed by familiarity ratings on 100 mm Visual Analog Scales (see below), did not differ between men and women as indicated by a one-way ANOVA ($p > 0.10$).

1.1.3. Procedure

All participants were tested individually and the first task was to fill in a questionnaire concerning health status, olfactory aptitude, and educational background. Also, they were interviewed regarding potential sources that may affect chemosensory functioning (e.g., smoking). Next, the olfactory threshold test was presented, which took about 10 min to complete. Following completion of this test, participants were presented with the odor recognition test. Participants assigned to the incidental encoding condition were told that the aim of the study was to collect information on subjective experiences of various odors. The participant was instructed to rate the presented odors according to a number of different dimensions (e.g., familiarity).

Participants in the intentional encoding condition were also presented with the rating protocol, but they were also asked to try to memorize the odorants for purposes of a later memory test. After encoding, a set of distractor tasks were distributed (i.e., odor intensity discrimination and the Trail-Making Test; Reitan & Davidson, 1974) which took about 10 min to complete.

This was followed by a recognition test. In this test, participants were presented with the 12 target odors along with 12 distractor odors that were randomly intermixed. For each of the 24 odors, participants were asked to indicate whether they recognized (yes-response) or did not recognize (no-response) the presented odor from the earlier presentation. For each odor recognized, the participant was instructed to classify their response into one of three categories—“remember” (R), “know” (K), or “guess” (G). To clarify the distinction between the three different response modes, participants were instructed to make R responses for odors that evoked some specific contextual recollection from the learning phase (e.g., an association, image, or some other more personal experience). K responses were to be given when the target was associated with feelings of familiarity, but in the absence of any specific contextual recollection of that item’s previous presentation. When participants had difficulties to decide whether their target recognition was based on conscious recollection or feelings of familiarity, they were asked to make a G response, to indicate that their judgment was based on guessing. The purpose of including a guess option was to reduce the effects of guessing on R and K responses (i.e., that participants would be biased to indicate “know” when they were unsure as to their response). In conjunction with each recognition response, participants were also instructed to name each odor presented.

1.2. Results and discussion

The data analyses consisted of three main parts. First, overall recognition memory was examined followed by an analysis on odor identification ability. We then turned to a closer examination regarding recollective and familiarity-based operations in odor recognition. These analyses were based on absolute proportions and the alpha-level was set at 0.05 in all analyses. There were no order effects in any analyses; therefore the data were collapsed across order.

1.2.1. Recognition memory

1.2.1.1. Hit rates. Mean proportions of hits, false alarms, and A' as a function of sex are displayed in Table 2. A 2 (sex : male, female) \times 2 (encoding condition: incidental, intentional) factorial ANOVA on proportions of hit rates indicated that women recognized more odors than men, $F(1, 64) = 4.77$, $MSE = 0.01$, $p < 0.05$, $\eta^2 = 0.07$. Encoding condition and the sex \times encoding interaction did not affect hit rates ($F_s < 1$).

Table 2
Recognition performance as a function of sex (hits, false alarms, and A')

	Males		Females	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<i>Study 1</i>				
Hit rates	0.84	0.15	0.90	0.08
False alarm rates	0.28	0.19	0.18	0.16
A'	0.83	0.12	0.89	0.16
<i>Study 2^a</i>				
Hit rates	0.68	0.25	0.76	0.23
False alarm rates	0.15	0.17	0.12	0.16
A'	0.82	0.11	0.85	0.11

^a Estimated marginal means adjusted for list-type.

1.2.1.2. False alarm rates. New odors incorrectly recognized as old were classified as false alarms. The ANOVA on proportions of false alarms indicated that men generated more false alarms than women, $F(1, 64) = 5.18$, $MSE = 0.03$, $p < 0.05$, $\eta^2 = 0.07$. The main effect of encoding format and the sex \times encoding condition interaction were not significant ($F_s < 1$).

1.2.1.3. A' . The proportions of hit and false alarm rates were transformed into A' scores (Snodgrass & Corwin, 1988). The ANOVA on A' scores indicated higher discrimination ability among women than men, $F(1, 64) = 8.44$, $MSE = 0.01$, $p < 0.005$, $\eta^2 = 0.12$. Encoding condition and the sex \times encoding format interaction did not influence A' scores ($F_s < 1$).

1.2.1.4. B'' . To determine whether there were any sex differences in response bias we employed the measure B'' devised by Snodgrass and Corwin (1988). An ANOVA on the B'' scores showed no main effects of sex or encoding condition and the sex \times encoding condition interaction proved not significant ($F_s < 1$).

1.2.2. Odor naming

For the analysis of participants odor identification ability, we used a strict scoring criterion. Only responses identical to the corresponding target names were scored as correct. The number of correctly named odors were submitted to a 2 (sex: male, female) \times 2 (encoding condition: incidental, intentional) ANOVA, indicating that women ($M = 13.17$, $SD = 3.88$) identified more odorants than the men ($M = 9.12$, $SD = 4.00$), $F(1, 64) = 17.48$, $MSE = 15.67$, $p < 0.01$, $\eta^2 = 0.21$. No other effects were reliable ($F_s < 1$).

1.2.3. Recollective experience

A one-way ANOVA with repeated measures and post-hoc tests indicated that for hits the R ($M = 0.64$, $SD = 0.20$) responses were more frequent than K ($M = 0.13$, $SD = 0.11$) and G ($M = 0.10$, $SD = 0.10$) responses ($ps < 0.05$). The amount of the two latter response types did not differ, $F(2, 67) = 2.16$, $MSE = 0.05$, $p < 0.0001$.

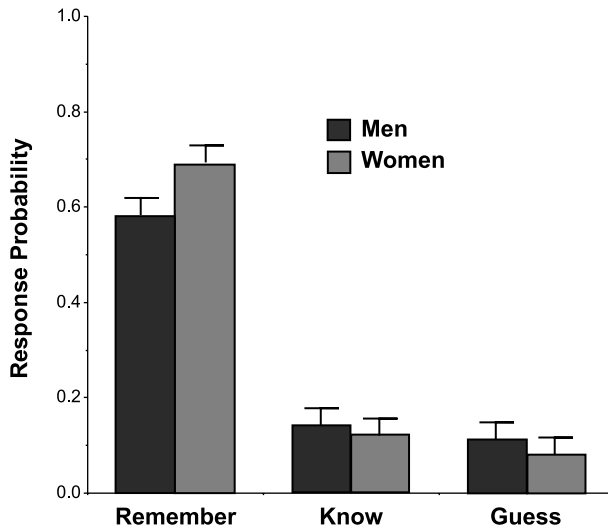


Fig. 1. Recollective experience in odor memory as a function of sex (means; SEMs).

The proportions of remembering and knowing as function of sex in odor recognition is depicted in Fig. 1. A multivariate analysis of variance (MANOVA) was conducted on the remember/know/guess responses, with sex and encoding condition as the independent variables. The MANOVA showed that the overall effect of sex was marginally significant (Wilks's $\lambda = 0.91$, $F(3, 62) = 2.10$, $p < 0.10$, $\eta^2 = 0.09$). In order to evaluate the effects of sex on each specific response type, the information from the univariate F tests in the MANOVA was used. There was a main effect of sex in remember responses ($F(1, 64) = 5.48$, $p < 0.02$, $\eta^2 = 0.08$) indicating that women showed more recollection than men. There were no reliable effects of sex in the number of generated know and guess responses, respectively ($F_s < 1$). Encoding condition showed no effect on overall memory performance and did not interact significantly with sex ($p_s > 0.15$).

When the false alarm data were broken down by response type, the results showed that most of the non-studied items were categorized as as G ($M = 0.10$, $SD = 0.10$) rather than R ($M = 0.07$, $SD = 0.09$) or K ($M = 0.06$, $SD = 0.09$). A MANOVA on the distributed remember, know and guess responses for the false positives, with sex and encoding condition as independent variables was performed. This analysis showed that the overall effect of sex was significant, (Wilks's $\lambda = 0.86$, $F(3, 62) = 3.26$, $p < 0.05$, $\eta^2 = 0.14$). The univariate F tests showed no reliable effects of sex on remember and know responses ($F_s < 1$), whereas men attributed more guess responses than women for false positives ($F(1, 64) = 8.05$, $p < 0.01$, $\eta^2 = 0.11$).

As noted, odor identification proficiency was used as an index of available contextual information. To determine whether womens' higher generation of R responses was related to the female superiority in identifying the odors, an analysis of covariance, with number of correct identified odors as covariate was conducted. Interest-

ingly, this analysis yielded no sex effect in R responses ($p > 0.80$), whereas odor identification proficiency proved to be a strong predictor of recollective experience, $F(1, 65) = 24.51$, $MSE = 0.03$, $p < 0.001$, $\eta^2 = 0.27$.

2. Study 2

Earlier studies have suggested that sex differences in cognitive functions may appear as a function of interest and/or familiarity of different materials (e.g., McKelvie, Standing, St Jean, & Law, 1993; West, Crook, & Barron, 1991). Therefore, we wanted to examine whether the observed sex difference in olfactory recollective experience would generalize also to verbal information.

The data in Study 2 are derived from a sub-sample of the Betula study, which is a larger-scale population-based longitudinal study focusing on aging, memory, and health (Nilsson, 1999; Nilsson et al., 1997). Two recognition memory tasks assessing recollective experience were included in the project: one verbal in which participants were presented with simple sentences (e.g., roll the ball) and one subject performed task, in which participants enacted these sentences. Because the latter task suffered from severe ceiling effects in performance, only the verbal task was considered in the present analyses.

2.1. Method

2.1.1. Participants

The sample considered in the present study consisted originally of 600 individuals from 12 different age cohorts (35, 40, 45, . . . , 90 years). The participating group was an independent sub-sample of the Betula study tested for the first time at the third wave of data collection. These participants were randomly drawn from the population registry in Umeå, a city of about 100,000 inhabitants. The participants were all screened for dementia, severe sensory handicaps, and mental retardation. Within this sample, 338 individuals were assessed with the Remember/Know procedure. Of these, 15 were excluded due to failures of understanding the test instructions. Thus, 323 participants remained for the present study. Means and standard deviations for relevant background characteristics are presented in Table 1. One-way ANOVAs revealed no sex differences in age, years in formal education, and health status ($F_s < 1$).

2.1.2. Materials

A total of 32 nouns, belonging to eight different semantic categories served as the materials to-be-remembered. The nouns were divided into two lists of 16 items with four semantic categories in each (animals, kitchen utensils, reading materials, and articles of clothing in one list, and parts of the body, musical instruments, carpentry tools and fruits, in the other). Importantly, the degree of typicality of the nouns did not vary across lists (Nilsson, 1973). For the study phase, each noun was paired with a verb to form unique sentences presented in an imperative form (e.g., lift the

book). For each list, eight random orders of items were prepared. About half the participants received list one during study, the other participants received list two.

Two test lists, each containing 32 nouns were constructed. The lists were composed of eight nouns from each of the two lists described above. These 16 nouns were intermixed with 16 distractors (two nouns from each of the categories described above). The distractors were assigned to each type of encoding according to their category belongings and according to which type of encoding this category derived from. The lists were counterbalanced across participants and encoding conditions (i.e., verbal and subject-performed format).

2.1.3. Procedure

As noted, the present study is a part of a larger battery of cognitive tasks (see Nilsson et al., 1997; Nilsson, 1999 for a full description). The study phase was carried out 5 min into the test session. Each participant was presented with the TBR imperatives at a rate of 8 s/item. At both study and test, the materials were presented visually printed on cards and also read out aloud by the experimenter. Participants were specifically instructed to remember the whole sentence.

During the study-test interval, participants were presented with a series of cognitive tests (e.g., verbal fluency). Recognition memory was assessed after approximately 25 min. For each of the nouns, participants were instructed to indicate whether they recognized (yes-response) or did not recognize (no-response) the presented noun from the previous presentation. With similar instructions as applied in Study 1, the participant was instructed to classify each positive recognition into one of the categories—“R”, “K”, or “G”.

In the verbal fluency task, participants were asked to (a) say aloud as many words as possible with the initial letter A, (b) generate as many professions as possible with an initial letter B, and to (c) produce as many five-letter words as possible with the initial letter M. Generation time for each test was 1 min. Performance in the three word-finding trials proved to be moderately correlated ($df = 321$) A/B ($r = 0.44$), A/M ($r = 0.60$), B/M ($r = 0.36$); all $ps < 0.01$, and were therefore aggregated and transformed to z-scores to form one composite verbal fluency variable. A one-way ANOVA showed that women ($M = 0.15$, $SD = 0.79$) generated significantly more words than men ($M = -0.15$, $SD = 0.79$); $F(1, 322) = 12.13$, $MSE = 0.62$, $p < 0.001$, $\eta^2 = 0.037$.

2.2. Results and discussion

Preliminary analyses of potential effects of list-type on recognition performance (A'), with a 12 (age cohort) \times 2 (sex) \times 2 (list type) ANOVA, indicated a main effect of list-type (i.e., an effect of different semantic materials), $F(1, 277) = 5.93$, $MSE = 0.01$, $p < 0.02$, $\eta^2 = 0.021$. List-type did not interact with sex ($F < 1$). Because list-type was not completely counterbalanced across sex, it was included as a covariate in all of the analyses reported below. Furthermore, since preliminary ana-

lyses failed to establish any reliable interactions between age and sex in any of the dependent measures (all $ps > 0.40$), the age factor was collapsed.

2.2.1. Recognition memory

Mean proportions of hits, false alarms, and A' scores as a function of sex are summarized in Table 2.

2.2.1.1. Hit rates. A one-way ANCOVA on proportions of hit rates and with list type as covariate was conducted. This analysis yielded a significant effect of sex, $F(1, 320) = 6.97$, $MSE = 0.06$, $p < 0.01$, $\eta^2 = 0.021$, indicating that women recognized more target nouns than men.

2.2.1.2. False alarms. New nouns incorrectly recognized as old were classified as false alarms. An ANCOVA on the proportions of false alarms revealed no effect of sex, $F(1, 320) = 1.54$, $MSE = 0.03$, $p > 0.20$.

A' The ANCOVA on the A' scores revealed a higher discriminatory ability for women, as compared with men, $F(1, 320) = 5.96$, $MSE = 0.01$, $p < 0.02$, $\eta^2 = 0.018$.

B'' The ANCOVA on the B'' scores revealed no sex effects in response bias for verbal information ($F < 1$).

2.2.2. Recollective experience

A repeated measures ANOVA comparing the frequency of remember, know and guess responses revealed an overall effect of recollective experience, $F(2, 644) =$

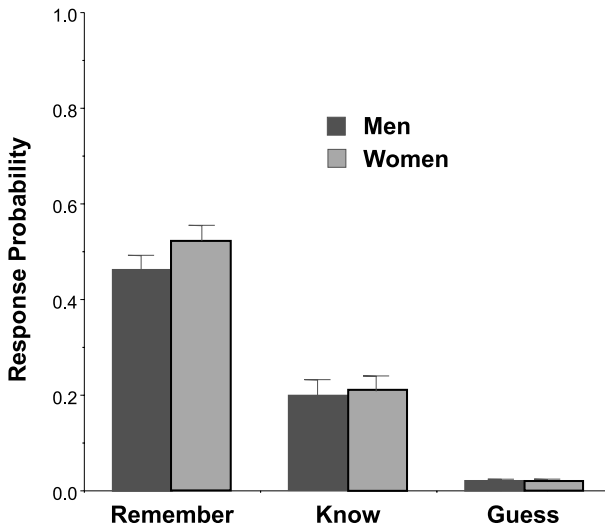


Fig. 2. Recollective experience in verbal memory as a function of sex (adjusted means; SEMs).

406.10, $MSE = 0.05$, $p < 0.0001$, $\eta^2 = 0.558$. Simple effect ANOVAs, with Bonferroni adjustment for multiple comparisons, indicated that R responses ($M = 0.49$, $SD = 0.27$) were more frequent than K ($M = 0.20$, $SD = 0.18$) or G responses ($M = 0.02$, $SD = 0.06$), and that participants generated more know than guess responses ($ps < 0.001$).

The proportions of remember, know, and guess responses as a function of sex is displayed in Fig. 2. A MANCOVA with list type as covariate was conducted on the absolute proportions of correct remember, know and guess responses, with sex as the independent variable. The results showed that the overall effect of sex was marginally significant, (Wilks's $\lambda = 0.98$, $F(2, 318) = 2.48$, $p < 0.07$, $\eta^2 = 0.023$). In order to evaluate the effects of sex on each specific response type, the information from the univariate F tests in the MANCOVA was used. There was a main effect of sex in remember responses ($F(1, 320) = 4.62$, $MSE = 0.07$, $p < 0.04$, $\eta^2 = 0.014$) indicating that women generated more remember responses than men. There were no reliable effects of sex in the number of emitted know and guess responses ($Fs < 1$).

When the false alarm data were broken down by response type, the repeated measure ANOVA revealed a main effect of response type, $F(2, 644) = 50.15$, $MSE = 0.01$, $p < 0.0001$, $\eta^2 = 0.135$. Most of the falsely recognized non-studied items were categorized as K ($M = 0.09$, $SD = 0.13$) rather than R ($M = 0.03$, $SD = 0.08$) or G responses ($M = 0.02$, $SD = 0.05$). R responses were more frequent than G responses ($ps < 0.04$). A MANCOVA was conducted on the false remember, know and guess responses, with sex as the independent variable. The overall effect of sex was not reliable, (Wilks's $\lambda = 0.99$, $F < 1$) and the univariate F tests showed no reliable effects of sex on remember, know, and guess responses ($Fs < 1$).

As noted above, performance in the fluency tasks was used as an index of verbal ability. To examine whether the female superiority in recollective experience was related to proficiency in verbal fluency, an ANCOVA with fluency performance as covariate was conducted. This analysis showed that the obtained sex difference in recollective experience disappeared when fluency proficiency was statistically controlled for ($p > 0.35$), whereas verbal fluency proved to be a reliable predictor of recollective experience, $F(1, 319) = 27.84$, $MSE = 0.06$, $p < 0.001$, $\eta^2 = 0.135$.

3. General discussion

This research replicates earlier findings in demonstrating a female superiority in episodic recognition for olfactory and verbal information (e.g., Lewin, Wolgers, & Herlitz, 2001; Öberg et al., in press). More interesting, however, was the finding of a sex-related experiential difference in recognition memory. Across both tasks, results indicated that recollection, as indexed by proportion of remember responses, was lower among men than among women, and that familiarity-based recognition, as indexed by know responses, was equally large across both sexes. Thus, the current data suggest that females have more contextual information available at recognition as compared with men.

Overall, the present results are consistent with the assumption that the sex-related experiential difference in episodic recognition memory is mediated by the female advantage in verbal processing (Hyde & Linn, 1988). Statistical control of two indices of elaborative processing resulted in that the observed sex difference in recollective experience for both olfactory and verbal information disappeared. First, to the extent that odor naming proficiency indices activations of semantic and contextual factors, the current data suggest that sex-related differences in activating odor-specific knowledge underlie women's higher amount of remember responses (cf. Larsson, 1997). Second, although proficiency in the fluency tasks used in Study 2 tap more general verbal abilities, this factor alone eliminated the observed sex difference in recollective experience for verbal information. Taken together, these results are indicative of the crucial role played by verbal abilities for sex differences in recollective experience.

Furthermore, familiarity-based recognition refers to recognition devoid of contextual content and is not associated with awareness of any aspect of a specific study episode (Gardiner & Java, 1991; Rajaram, 1993). The present results showed that men and women based their recognition on feelings of familiarity to the same extent which suggests that the amount of data driven and perceptual processing is similar across sex (Gardiner & Java, 1993b). It is of interest to note that the finding of pronounced sex differences in conscious recollection, and the absent effects of sex in familiarity-based processing is congruent with previous research using other experimental paradigms. For example, reliable sex effects are typically obtained in tasks requiring conscious retrieval (i.e., episodic recall and recognition), whereas no differences are observed in non-conscious retrieval tasks tapping perceptual abilities (i.e., perceptual priming; Herlitz et al., 1997; Hultsch, Masson, & Small, 1991).

Although no study has examined the influence of intention to remember on episodic odor memory, research suggests that episodic memory for verbal and visual information may be enhanced following intentional as compared with incidental learning conditions (e.g., Kausler, 1994; Larsson, Nyberg, Bäckman, & Nilsson, in press). In contrast to these findings, the present results indicated that intention to learn has no reliable impact on subsequent recognition performance or on recollective experience. Explanations for this outcome remain unclear and need further exploration in future research. However, the fact that encoding condition did not interact with sex suggests that intention to learn is not a crucial factor underlying sex differences in odor memory.

It is also worth noting that the obtained sex differences in odor memory and recollective experience were not related to a peripheral sensory sex difference. Olfactory sensitivity, as tapped by the olfactory threshold test, proved equally high for both sexes which corroborates earlier findings (e.g., Brand & Millot, 2001; Cain & Gent, 1991; Venstrom & Amoore, 1968).

It has been argued that remember and know judgments simply reflect different degrees of confidence, such that remembering reflects high confidence and knowing low confidence. However, research suggests that confidence plays a minor role in the assessment of recollective experience which refutes the idea that recognition in the absence of remembering merely reflects a weak memory representation (Mäntylä, 1993;

Rajaram, 1993). In these studies, we sought to reduce potential effects from confidence judgments by using test instructions that discouraged guessing, and by incorporating guess as a third response alternative. Importantly, across both studies no sex differences were observed in the number of generated guess responses suggesting that men and women used this option to a similar extent.

Although evidence suggests that the functional neuroanatomy of episodic memory retrieval is highly similar for men and women, differences have been observed. From a series of PET studies, Nyberg, Habib, and Herlitz (2000) reported that females showed a greater activation in two regions of the anterior cingulum. This region has been pointed out as a center for executive attention (Posner, 1995), and shows increased activity during tasks tapping semantic generation and episodic memory (see Cabeza & Nyberg, 2000 for a review). Although highly speculative, it is possible that women's selectively higher activation level in this region may underlie the female performance superiority in tasks posing verbal generation demands, which ultimately may yield a richer and a more elaborate processing of target information.

To summarize, the present work extends previous findings in showing that sex influences the phenomenal experience that accompanies recognition for both olfactory and verbal information. Specifically, although both men and women produced more remember than know responses, there was a sex-related increment favoring women in remember responses in both studies. The finding that the observed female superiority in remember responses disappeared when verbal proficiency was controlled for suggests that sex-related differences in activating verbal information play an important role for sex differences in recollective experience.

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