

## IMPLICIT AND EXPLICIT MEMORY FORMATION: INFLUENCE OF GENDER AND CULTURAL HABITS

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### INTRODUCTION

Memory of past experiences can be experimentally assessed by direct or explicit recollection tests and by indirect or implicit retrieval tests; the latter do not require conscious recollection, or awareness of the nature of the memory probe.

A widely used task to explore implicit memory is the word stem-completion test (WSCT). WSCT consists in presenting the subject with a list of words; after a time interval the initial three letters stem of each word of the list are given and the subject is required to complete the stem with the first appropriate word that comes to mind. The test is based on the fact that implicit memory for items can be only inferred from changes in the efficiency or probability that an item is reproduced or elicited by appropriate cues at test. Thus, the exposure to a list of words facilitates subsequent identification of the words when the corresponding stems are provided (e.g. stem *ele\_\_* for the word *elephant*). The facilitation is indicated by completion-responses corresponding to the target-words; it is referred to as priming effect and the rate of correct responses, that estimates the magnitude of the effect, represents the priming score (17).

It can be argued that priming score of WSCT may be inflated by false-positive responses, that is, correct stem-completions occurring by pure chance, as in the case of target-words with a high probability of coming to mind to complete the stem, independently of previous exposure. In order to hinder false-positive responses we selected the targets of WSCT according to probabilistic criteria fully described elsewhere (Lorenzi et al. submitted). In short, we collected potential completion-words of each experimental stem (22 stems, 25 different words per stem on average) and computed the frequency and order of occurrence of each word across the population. These measures provided an index of probability that estimates the likelihood of each word to be the said for completing the stem in absence of memory cues. The target of each experimental stem was chosen among the potential completions with a medium/low probability of occurrence, and corresponded to the word that most complied with the semantic and phonetic constraints suggested by literature of WSCT.

The primary goal of present work was to compare the implicit and explicit memory performance of control subjects with that of patients scheduled for surgical oper-

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ation the day after memory testing. The rationale of the study is that impending surgery, being a possible source of anxiety, may affect the formation of implicit memory; if so, this knowledge can help to interpret the reports that unconscious memories for events may be formed during general anaesthesia (7). We this aim we tested an homogeneous population of patients undergoing surgery for non severe thyroid diseases and non hospitalised individuals matched for age and sex with the patients. The patients were free from additional physical or mental disorders and were well aware that the disease they were suffering was far from life threatening.

Results revealed the lack of consistent differences between presurgery patients and controls on both memory tasks. This negative finding permitted to pool together the two groups and investigate in a large sample of subjects (82 in total) possible influences of gender, education and cultural habits on the implicit and explicit memory.

## METHODS

### *Subjects*

42 hospitalised individuals (21 males and 21 females aged between 18 and 75) suffering from thyroid mild pathologies that needed surgical operation under general anaesthesia; 40 non-hospitalised controls (20 males and 20 females) matched for age and sex with the patients. None of subjects presented psychiatric or neurological disorders or auditory defects.

### *Experimental material*

Two lists of words (list A and list B), each consisting of 11 nouns said by a female voice at the speed of one word every two seconds. The two lists were recorded on separate tapes; each list was repeated three times alternate with 25 seconds of neutral music (Japanese flute sound) for a total listening time of 3 minutes. The criteria underlying the choice of target words that ensure the equivalency of the two lists have been reported elsewhere (Lorenzi et al. submitted).

### *Procedure*

Subjects were randomly assigned to group A or group B and listened to the corresponding list by earphone. The subjects were not given instructions but to pay attention to the words for afterwards some questions may be asked. After a night interval each subject was presented with tree-letter stems written on a panel and spelled by the experimenter and was asked to complete each stem with the first noun that came to mind. Next, the subjects were required to recall without memory cues the words they remembered from the study session. Finally, each subject was interviewed about the years of schooling and thus assigned to low, middle or high class of education. The habits of reading books and doing crossword puzzles were investigated. The reading habit was assessed in terms of number of books read per year (< 5 or > 5); the crosswords habit was established as the long-standing practice to do crosswords at a regular base of once a week.

### *Data analysis*

In each subject we assessed the priming score, i.e. the rate of correct stem-completions that estimates implicit memory, and the rate of correct responses in the free-recall condition that estimates explicit memory. Percent values were transformed by arcsines function and submitted to analyses of variance (ANOVAs) that evaluated implicit and explicit memory performance in relation to the following between-subjects factors: Presurgery condition (yes vs no); Gender (male vs female); Age (< 50 vs. > 50 yr.); Education level (low, middle, high); Number of books read per year (< 5 vs. > 5) and Crosswords-doing habit (yes vs no). *Post hoc* comparisons were performed by two-tailed t-tests.



RESULTS

ANOVA (1 within x 3 between factors) shows that the main factor Type of memory is highly significant ( $F(1,74) = 7.2$   $p = 0.009$ ) for the free-recall scores outnumber the stem-completion scores. The variables Age ( $F(1,74) = 0.95$  ns) and Presurgery condition ( $F(1,74) = 0.82$  ns) are not significant while Gender represents a consistent source of variance ( $F(1,74) = 7.11$   $p = 0.0091$ ) due to females of either class of age that perform significantly better than males on both tasks. The gender difference tends to be larger in patients than in controls but interaction Gender x Presurgery does not reach significance ( $F(1,74) = 3.2$   $p = 0.07$ ). The findings are graphically represented in Figure 1.

Hence the lack of difference between patients and controls, the two groups were pooled together for further analyses taking into account the subjects education and cultural hobbies. Results are shown in Figure 2.

Education is a highly influential factor of explicit memory for higher education levels are consistently associated with higher scores on the free-recall task ( $F(1,70) = 5.33$   $p = 0.007$ ); the effect is present in males as in female of both classes of age. Education is not significant for implicit memory.

Subjects that habitually do Crosswords (38/82) and subjects without this habit (44/82) are close in number, but the former are mostly women (26 females vs 12

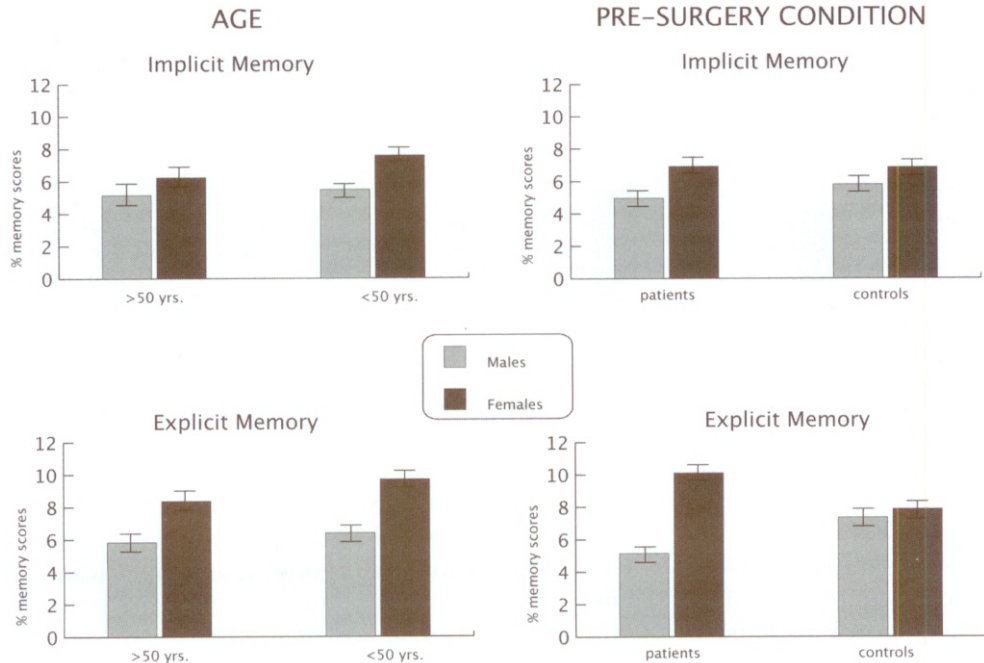


Fig. 1. - Memory scores (means and standard errors) of males and females as a function of subjects age (< 50 yr vs. > 50 yr) and clinical condition (patients vs. controls).

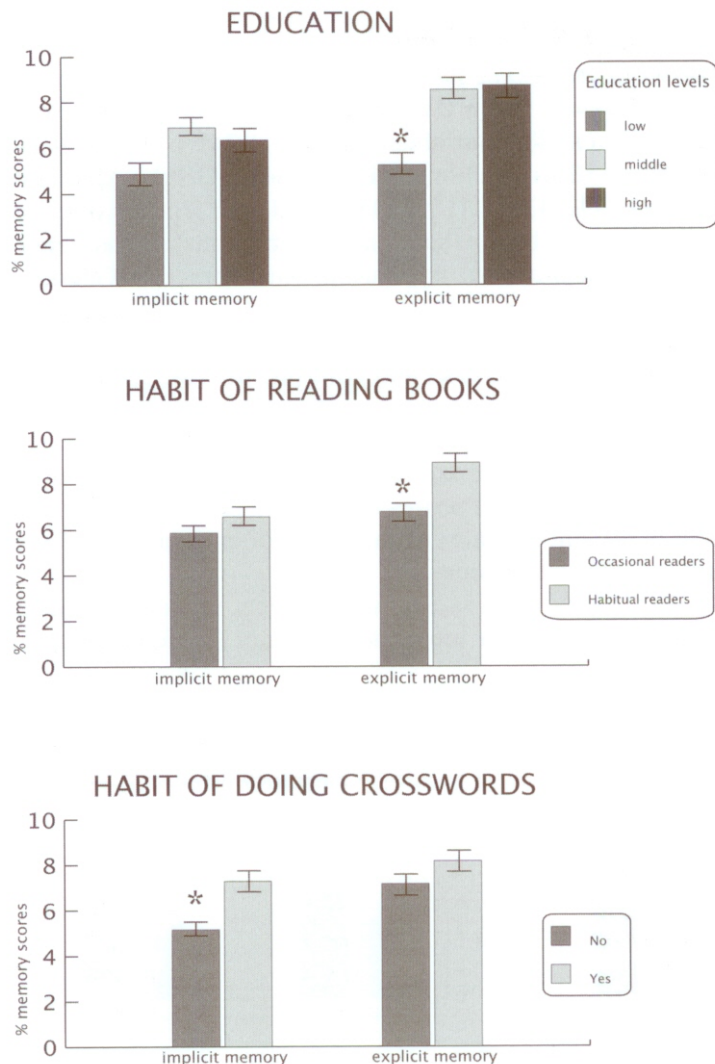


Fig. 2. - Memory scores (means and standard errors) computed on the whole population (patients and controls) as a function of education levels, crosswords-doing and books-reading habits.

males) and the latter mostly men (29 males vs 15 females); the habit, however, is near equally represented between younger (< 50 yr 19/38) and older subjects (> 50 yr 19/38). ANOVA, having Crosswords and Age as between-subjects factors, shows that the habit of doing crosswords is associated with highest scores on the stem-completion test ( $F(1,78) = 7.3$   $p = 0.008$ ), the difference being greatest in the group of subjects > 50 yr ( $t = 4.5$   $p = 0.01$ ). The factor Crosswords is not significant for explicit memory ( $F(1,78) = 0.4$  ns).

The majority of subjects (50/82) claimed to read less than 5 books per year and may be considered occasional book-readers. They are near equally distributed between the two classes of age (younger 24/50; older 26/50) yet, overall, males outnumber females (28 males vs 22 females). Compared to habitual book-readers (i.e.

subjects reading 5 or more books per year), the occasional book-readers of either class of age present worse memory performance on both tasks. ANOVA indicates that the difference is significant on the free-recall task only ( $F(1,78) = 4.5$   $p = 0.03$ ).

Effects of cultural habits on memory performance are independent of education. Indeed, the prevalence of subjects with Crosswords-doing habit on the implicit memory task is found at each education level, as well as the prevalence of habitual book-readers on the explicit task. Interaction between the factors Crosswords and Books is fully significant for implicit memory ( $F(1,78) 4.3$   $p = 0.041$ ) and marginally significant for explicit memory ( $F(1,78) 3.8$   $p = 0.055$ ). This reflects the fact that the habitual book-readers with Crosswords-doing habit score on both memory tasks significantly higher than the habitual readers without Crosswords habit (impl  $t = 9.5$   $p = 0.002$ ; expl  $t = 4.2$   $p = 0.040$ ); the difference is not significant in the group of occasional books-readers.

## DISCUSSION

Surgical operation under general anaesthesia may be regarded as a stressful life event and the individuals may experience worries and strain for impending surgery even when the treatment is needed for a mild pathology to cure. In this light the emotional state of presurgery patients might be expected to interfere with memory formation, either facilitating or attenuating the priming effect, like other stress (2) and anxiety conditions do (13, 5). Present results, however, do not support the hypothesis. The negative finding may simply indicate that presurgery condition does not correspond to an acute stress or anxiety condition and this is why implicit and explicit memory are both unaffected. An alternative explanation is that effects of anxiety on implicit memory may be revealed by target-words with an emotional negative meaning (11) and our memory test, because the targets are emotionally neutral words, is not apt to measure differences between patients and controls.

On the whole sample of subjects, patients and controls together, we investigated possible effects of gender, age, education and cultural habits on memory formation.

Gender difference for implicit memory has been little studied (3). Our results show that priming effect is higher in females than males, thus suggesting that the prevalence of females, widely assessed for verbal explicit memory (16, 9), occurs also for the verbal implicit memory. In male as in female group, the memory performance is not determined by the subjects age. Non significant difference between 'younger' (< 50 yr) and 'older' (> 50 yr) subjects on the stem-completion task agrees with the findings that priming score does not change with age (14). This may be accounted for by the cognitive abilities engaged by implicit memory tests, such as the conceptual processing that is impaired by Alzheimer disease but unaffected by old age (8, 10). The lack of significant age-effect on the free-recall task is rather surprising for the explicit memory is known to decline with age. The finding may depend on the fact that in our sample the elders (65-75 yr) are under-represented relative to the total number of old (> 50 yr) subjects. It is worth noting, however, that



equivalent performance of elderly and young individuals on the free-recall test is reported also in a recent study that compares demented patients and controls of different classes of age (12).

The influence of education on memory capabilities has been mostly studied in elderly population to assess whether higher levels of schooling might attenuate the general cognitive decline of old age (4, 1). With respect to explicit memory, it has been found that the least educated elders show the greatest memory impairment (15), old males being consistently more impaired than old females of the same education level (6). Present results confirm that higher education yields better performance on explicit memory and suggest that the effect is age independent since it occurs in younger as in older subjects.

Finally, there is a consistent influence of books-reading habit on explicit memory; habitual books-readers, whatever their education level, perform better than occasional readers. In contrast, the habit of doing crosswords improves mostly the implicit memory, and the effect is greatest in older subjects. The latter finding may support folk suggestion that crosswords-doing habit is a sort of cued memory exercise with beneficial effects on memory, especially in older people.

#### SUMMARY

The study was aimed to investigate whether impending surgery, considered as a stressful life event, might interfere with memory formation like other stress and anxiety conditions do. Results do not support the hypothesis. Implicit and explicit memory performance are both unaffected by presurgery condition and seem influenced, rather, by subjects gender, education and cultural habits. Females perform generally better than males and, regardless of age and sex, higher educated individuals score higher on the explicit memory task. The habits of reading books and doing crosswords are associated to best performance on explicit and implicit memory task respectively.

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