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## Brain activation during episodic memory retrieval: Sex differences

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### Abstract

Behavioral studies have shown a tendency for women to outperform men on episodic memory tasks. Here, data from a series of positron emission tomography (PET) studies were analyzed to examine sex differences in brain activity associated with episodic memory retrieval (yes/no recognition). A total of 17 women and 17 men were included in the analyses. The strongest effect of the design was a retrieval-related increase in activity, involving right prefrontal and anterior cingulate regions, that was common to women and men. In addition, a significant task-by-sex interaction effect was observed which involved a distributed set of brain regions, including several frontal areas. These results suggest that while the neural correlate of episodic memory retrieval is largely the same for men and women, some differences do exist. Possible explanations for the observed differences are discussed, and it is concluded that biological and experiential factors jointly contribute to sex differences in brain activity. © 2000 Elsevier Science B.V. All rights reserved.

*Keywords:* Brain activity; PET; Sex differences; Episodic memory

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## 1. Introduction

Functional neuroimaging studies have identified several brain regions, including prefrontal, medial parietal, medial temporal, and cerebellar regions, whose activity is associated with components of episodic memory retrieval (Cabeza & Nyberg, 2000). Many of the studies that contributed to establish this association included both female and male subjects, suggesting that the activation pattern for episodic retrieval generalizes across gender groups. However, to the best of our knowledge, formal analyses of gender differences in the functional neuroanatomy of episodic memory have not been presented, likely due to limited statistical power to detect gender differences in individual studies. The purpose of the research to be reported here was to use data from a series of positron emission tomography (PET) experiments to explore gender differences in the neural correlates of episodic memory retrieval. We start by presenting a brief review of cognitive studies of gender differences in episodic memory, followed by an overview of functional neuroimaging studies of gender differences in various cognitive domains.

In addition to the well-known differences between men and women in visuospatial (men > women; Voyer, Voyer, & Bryden, 1995) and verbal abilities (women > men; Hyde & Linn, 1988), a number of studies have reported that women outperform men in episodic memory tasks (see Herlitz, Nilsson, & Bäckman, 1997). Performance differences have been found from age 5 (Kramer et al., 1997) to age 75 (Herlitz et al., 1997), and are typically smaller in recognition tasks (i.e., effect size  $d \approx 16$ ) than in recall tasks (i.e., effect size  $d \approx 27$ ; Herlitz, Airaksinen, & Nordström, 1999). The advantage women have over men in episodic memory is evident when the material to be remembered is words (e.g., Kramer, Delis, & Daniel, 1988), stories (e.g., Hulstsch, Masson, & Small, 1991), concrete pictures (e.g., Herlitz et al., 1999), faces (e.g., Wahlin et al., 1993), locations (Eals & Silverman, 1994), and odors (Lehrner, 1993). No sex differences have been found in recognition of abstract pictures (Herlitz et al., 1999; Lewin, Wolgers, & Herlitz, 2000) and of unfamiliar odors (Öberg, Larsson, & Bäckman, 2000). This pattern of findings has been taken to indicate that women will outperform men in episodic memory tasks in which verbal processing is required or can be used, whereas no differences between men and women will be found when verbalization of the material is inhibited (Lewin et al., 2000). Given that women excel in episodic memory tasks in which verbalization is possible, it is possible that this advantage is linked to women's higher verbal ability. However, women do not show higher performance in all verbal tasks, but rather in verbal fluency or verbal production tasks (Hyde & Linn, 1988). The common cognitive operation in episodic memory tasks and verbal production tasks may be that they require rapid access to and use of information in memory (Halpern, 1997).

Guided by sex differences in behavioral performance, several imaging techniques have been used to study sex differences in the brain's structural and functional organization. This includes analyses of differences in brain anatomy (e.g., Gur et al., 1999), analyses of differences in temporal responses (e.g., Reite, Cullum, Stocker, Teale, & Kozora, 1993; Skrandies, Reik, & Kunze, 1999), and analyses of differences in regional cerebral glucose metabolism during rest (e.g., Gur et al., 1995). Of main

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