Working Memory Across the Lifespan: Age and Gender Variations

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Abstract

Working memory decline with increasing age has been widely researched, yet there is minimal evidence from Pakistan. This gap highlights the need to examine working memory performance in a Pakistani context, focusing on the three domains: short-term storage, attention, and executive control. The present study compared these domains across young adulthood (19 to 40 years), older adulthood (41 to 64 years), and mature adulthood (65 years and above). A cross-sectional correlational design was used, and 277 individuals were approached, of whom 223 completed the questionnaire. The 30-item Working Memory Questionnaire, developed by Vallat-Azouv et al. (2012), rated on a 1–6 Likert scale, was administered to assess short-term storage, attention, and executive control. Results showed significant positive correlations among all three domains. ANOVA findings indicated that young adults scored lowest across all domains, followed by older adults. In contrast, mature adults scored highest, suggesting poorer working memory, as higher scores reflect greater cognitive difficulty, which means young adults possess significantly better working memory than older and mature adults. Women outperformed men across all domains, demonstrating better attention, short-term storage, and executive control. These findings confirm that age-related working memory decline is consistent within the Pakistani cohort and highlight meaningful gender differences. Limitations, cultural implications, and recommendations, including the need for future studies to ensure equal numbers of men and women, are provided.

Keywords: Working memory, short-term storage, attention, executive control, age Group, gender.

Introduction

Working memory is the cognitive system that holds and manipulates information during ongoing mental activities (Baddeley, 2020). The concept was first introduced by Miller, Galanter, and Pribram in the 1960s (Sepp et al., 2020). It plays an essential role in reasoning, decision-making, and purposeful behaviour (Aggarwal, 2024). Working memory consists of

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three components: attention, short-term storage, and executive control (Baddeley, 2020). Attention involves focusing on relevant stimuli (Mancas, 2016). Executive control refers to the regulation of impulses and organising the organisation of actions toward goals (Lara & Wills, 2014). Short-term storage involves temporarily retaining information supported by neural activity patterns (Colom et al., 2005).

Memory improves during adolescence but declines with age, especially working memory performance (Ferguson et al., 2021; Nettelbeck & Burns, 2010). Younger adults demonstrate better item–context binding (Fandakova et al., 2014), whereas older adults show reduced contextual integration, which affects short-term memory (Kessels et al., 2007; Peterson & Naveh-Benjamin, 2016). Age-related cognitive deterioration is also associated with reduced hippocampal and frontal lobe volumes (Bachmann et al., 2023). Deficits in working memory are prominent in mild cognitive impairment and Alzheimer-related conditions (Kirova et al., 2005; Mian et al., 2024). Younger adults generally perform better on working memory tasks than older adults (Humes et al., 2022; Wang et al., 2011). A recent study in Pakistan reported that young adults scored significantly higher on working memory domains, including attention, short-term storage, and executive control, compared to middle and mature adults, indicating that working memory declines with age (Shahid et al., 2025). However, the literature remains limited in the Pakistani context.

Gender differences in working memory remain inconsistent. Some studies show women perform slightly better on verbal tasks and free recall, while men perform better on specific spatial or span tasks (Voyer et al., 2021). Other research reports no meaningful gender differences in attention or memory performance (Gaillard et al., 2021; Solianik et al., 2016). Some studies report mixed age-related gender patterns, with women showing poorer performance at older ages, whereas in other populations, women outperform men in free recall and perceptual speed during young and middle adulthood (León et al., 2016; Maitland et al., 2020). Given the inconsistent findings and the lack of Pakistani studies on age- and gender-related differences in working memory, further investigation is needed.

Rationale

There is limited research in Pakistan examining age- and gender-related differences in working memory domains i.e. short-term storage, attention and executive control. Therefore, the current study aims to investigate differences across young adults aged 19 to 40 years, older adults aged 41 to 64 years, and mature adults aged 65 years and above. The study aims to contribute to Pakistani literature and provide culturally relevant implications for cognitive functioning across the lifespan.

Research Objectives

1. To assess the relationships among working memory domains, i.e., short-term storage, attention, and executive control.
2. To compare performance on working memory domains—short-term storage, attention, and executive control—across young, older, and mature adults.
3. To examine gender differences with respect to working memory domains, i.e., short-term storage, attention, and executive control.

Hypotheses

H1: There will be a positive and significant relationship among the working memory domains, i.e., short-term storage, attention, and executive control.

H2: Significant mean differences in short-term storage, attention, and executive control are expected across the age groups.

H3: Significant gender differences are expected in the working memory domains, i.e., short-term storage, attention, and executive control.

Methodology

A cross-sectional correlational design was employed to examine working memory performance across age and gender among Pakistani participants. A total of 277 individuals were approached, of whom 223 completed the questionnaire. The inclusion criteria were: age between 19 and 40 years for young adults, 41 and 64 years for older adults, and 65 years and above for mature adults; a minimum education level of Intermediate; and participation from both men and women. Working memory was assessed using the Working Memory Questionnaire (Vallat-Azouv et al., 2012), consisting of 30 items rated on a 1-6 Likert scale, measuring short-term storage, attention, and executive control. Higher scores reflect greater working memory difficulty. Participants completed the questionnaire after being informed of the study purpose and providing written consent. Data Collection took place in educational and community settings while ensuring confidentiality. Analyses were conducted in SPSS version 29 using Pearson correlations to examine relationships among the working memory domains, ANOVA to assess age-related differences, and independent samples t tests to evaluate gender differences.

Results

Table 1: Demographic characteristics of the sample (N = 223)

Characteristics	Frequency	Percentage	*M*	*SD*
Gender				
Men	98	44		
Women	125	56		
Age			50.42	18.87
Age Groups				
Young Adulthood (18-40)	83	37.2		
Older Adulthood (41-64)	61	27.4		
Mature adults (65+)	79	35.4		
Qualification				
Intermediate	11	5		
Bachelor	81	36		
Master	91	41		
PhD	40	18		

Note: M = Mean, *SD* = Standard Deviation

The study included 223 participants, comprising 98 men (44%) and 125 women (56%). The mean age of the sample was 50.42 years (*SD* = 18.87). Based on age categories, 83 participants (37.2%) were in young adulthood (18–40 years), 61 participants (27.4%) were in older adulthood (41–65 years), and 79 participants (35.4%) were classified as mature adults (65 years and above). In terms of educational qualifications, 11 participants (5%) had completed Intermediate education, 81 (36%) held a Bachelor's degree, 91 (41%) had a Master's degree, and 40 participants (18%) held a PhD.

Correlational Analysis

Table 2: Pearson product–moment correlations among the study variables (N = 223)

Variables	1	2	3
1.Short term storage	-	.60**	.58**
2.Attention			.60**
3.Executive control			-

*Note: **p<.01*

The results show that all three working memory components are significantly and positively correlated. Short-term storage was strongly and positively associated with attention (r = .60, p < .01) and executive control (r = .58, p < .01). Similarly, attention demonstrated a significant positive correlation with executive control (r = .60, p < .01). These correlations indicate that higher difficulties in one domain of working memory are consistently associated with higher difficulties in the other domains.

ANOVA

Table 3: Mean differences among the age groups of the participants (N = 223)

	Young Adults(n=83)		Old Adults(n=61)		Mature Adults(n=79)				
Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F (220)*	*P*	Cohen's d
STS	29.89	8.17	33.27	5.61	33.12**	5.90	6.19	.002	0.46
Attention	27.90	7.88	30.08	5.58	30.16*	5.65	3	.05	0.32
EC	29.85	8.04	32	4.33	33.35**	6.90	5.46	.005	0.46

*Note: *p ≤ .05, **p < .01,* STS= Short-Term Storage, EC= Executive Control

The findings indicate significant age-related differences in all three working memory domains among the 223 participants. For short-term storage, mature adults scored significantly higher (M = 33.12, SD = 5.90) than young adults (M = 29.89, SD = 8.17) and older adults (M = 33.27, SD = 5.61), indicating greater working memory difficulties, F (220) = *6.19*, p = *.002*, Cohen's *d = 0.46*. In the attention domain, mature adults again obtained higher scores (M = 30.16, SD = 5.65) compared to young adults (M = 27.90, SD = 7.88), reflecting poorer attention performance, F(147) = *3.00*, p = *.05*, Cohen's *d* = *0.32*. Similarly, for executive control, mature adults demonstrated more difficulties (M = 33.35, SD = 6.90) than both young adults (M = 29.85, SD = 8.04) and older adults (M = 32.00, SD = 4.33), F (147) = *5.46*, p = *.005*, Cohen's *d = 0.46*. Because higher scores represent poorer working memory functioning, the results indicate that mature adults reported the greatest difficulties, whereas young adults exhibited the strongest working memory abilities across domains.

Independent Sample T test

Table 4: Mean differences between genders (men and women) of the participants with respect to the study variables (N = 223)

	Men (n=98)		Women (n=125)				
Variables	*M*	*SD*	*M*	*SD*	*t (221)*	*P*	Cohen's d
Short-Term Storage	34.30	5.41	30.12	7.44	4.85	<.001	0.63
Attention	31.17	5.57	27.83	7	3.96	<.001	0.52
Executive Control	34.22	5.79	29.68	7.11	5.24	<.001	0.69

*Note: *** p <.001*

An independent samples *t*-test was conducted to examine gender differences across the three working memory domains. Men scored significantly higher than women on short-term storage (M = 34.30, SD = 5.41 vs. M = 30.12, SD = 7.44), t (221) = 4.85, p < .001, with a medium effect size (Cohen's d = 0.63). A similar pattern was found for attention, where men again obtained higher scores (M = 31.17, SD = 5.57) compared to women (M = 27.83, SD = 7.00), t(221) = 3.96, p < .001, reflecting a medium effect size (Cohen's d = 0.52). For executive control, men scored significantly higher (M = 34.22, SD = 5.79) than women (M = 29.68, SD = 7.11), t (221) = 5.24, p < .001, demonstrating a medium to large effect (Cohen's d = 0.69). Because higher scores represent greater working memory difficulties, these results indicate that men reported more difficulties than women across short-term storage, attention, and executive control.

Discussion

There is substantial literature regarding working memory, age-related decline, and gender differences in working memory. However, such studies are rare in the cultural context of Pakistan. Therefore, the aim of this study is to evaluate age group differences (i.e., young adults, middle-aged adults, and mature adults) and gender differences (i.e., men and women) with respect to the working memory domains, namely short-term storage, attention, and executive control. This study seeks to fill the gap in research within the Pakistani cultural context and provide useful implications related to age and gender differences.

The first hypothesis was supported, as significant correlations were found among short-term storage, attention, and executive control. These components work together to support cognitive functioning and are neurologically interconnected (Hester & Garavan, 2005; Baddeley, 2020; Sullivan et al., 2024; Salmi et al., 2020; Fond et al., 2018).

The second hypothesis was confirmed. Mature adults demonstrated weaker working memory across all domains than older and young adults, while young adults performed best. This finding is consistent with previous research showing that working memory declines with age due to reductions in attention, short-term storage, and executive control (Klencklen et al., 2017; Kirova et al., 2015; Cansino et al., 2020). Age-related changes in neurotransmitters such as dopamine, serotonin, acetylcholine, norepinephrine, and GABA also contribute to this decline (Li et al., 2022; Bayram et al., 2021; Furman et al., 2021; Jiménez-Balado & Eich, 2021).

Women outperformed men across all domains. Neuroimaging research indicates that women rely on limbic and prefrontal brain regions that enhance emotional regulation and strategic processing (Hill et al., 2014). Hormonal influences, particularly estrogen, may strengthen hippocampal functioning and cognitive control (Li et al., 2022; Meneses, 2014). Women's multitasking roles in Pakistani cultural settings may also reinforce these strengths (Jurado & Rosselli, 2007; Hayes et al., 2013).

Conclusion

The present study highlights significant age- and gender-related differences in working memory among Pakistani adults. Findings indicate that working memory declines with age, with mature adults showing the most significant difficulty in short-term storage, attention, and executive control. Young adults demonstrated the strongest performance, reflecting better cognitive efficiency. Women consistently outperformed men across all domains, suggesting gender-specific advantages in short-term storage, attention and executive control. The positive and significant correlations among the three domains underscore their interdependence in cognitive processing. These results align with global research on age-related cognitive decline while providing culturally relevant insights. Neurobiological, hormonal, and social factors may underlie the observed gender differences. Overall, the study underscores the importance of considering both age and gender in assessments of working memory in Pakistan.

Implications

The findings highlight the importance of age- and gender-sensitive cognitive interventions. Women's strengths in working memory can be leveraged in academic and workplace contexts, while men may benefit from targeted cognitive training to enhance attention and executive functioning. Lifestyle strategies, including healthy nutrition, physical exercise, social engagement, and mindfulness practices, can help preserve cognitive health. A recent study on physical activity and cognitive deficits found that those with higher levels of physical activity tend to have significantly better cognitive abilities than those with lower levels (Shahid et al., 2025). Community-based programs and workshops in educational institutions, workplaces, and public settings can raise awareness and equip participants with practical strategies to enhance working memory performance across the Pakistani population.

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