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When we test, do we stress? Impact of the testing environment on cortisol secretion and memory performance in older adults

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Abstract
Context: The majority of studies find that older adults have worse memory performance than young adults. However, contextual features in the testing environment may be perceived as stressful by older adults, increasing their stress hormone levels. Given the evidence that older adults are highly sensitive to the effects of stress hormones (cortisol) on memory performance, it is postulated that a stressful testing environment in older adults can lead to an acute stress response and to memory impairments.
Objective: The current study compared salivary cortisol levels and memory performance in young and older adults tested in environments manipulated to be stressful (unfavourable condition) or not stressful (favourable condition) for each age group.
Methods: 28 young adults and 32 older adults were tested in two testing conditions: (1) a condition favouring young adults (constructed to be less stressful for young adults), and (2) a condition favouring older adults (constructed to be less stressful for older adults). The main outcome measure was salivary cortisol levels. Additionally, immediate and delayed memory performances were assessed during each condition.
Results: In older adults only, we found significantly high cortisol levels and low memory performance in the condition favouring young adults. In contrast, cortisol levels were lower and memory performance was better when older adults were tested in conditions favouring them. There was no effect of testing condition in young adults.

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Conclusions: The results demonstrate that older adults' memory performance is highly sensitive to the testing environment. These findings have important implications for both research and clinical settings in which older adults are tested for memory performance.

1. Introduction

Research suggests that older adults perform worse than young adults on declarative memory tasks (Zacks et al., 1999; Balota et al., 2000). While these deficits are presumed to be due to age-related cognitive decline, contextual features of certain testing environments might be inherently stressful for older adults and artificially result in observed cognitive impairments. In particular, the testing environment, or procedures used therein, may induce an acute stress response in older individuals, leading to acute memory impairments.

The stress hormone cortisol has an important impact on cognition as it crosses the blood—brain barrier and binds to receptors in the hippocampus, amygdala and frontal lobes, each of which are involved in cognitive processes. These regions also regulate cortisol levels by contextualizing relevant environmental stimuli in acutely stressful situations that can impair memory for both young (de Quervain et al., 2000; Lupien et al., 2002a) and older adults (Lupien et al., 1998; Lee et al., 2007). However, older adults' memory performance is particularly vulnerable to the impact of cortisol when compared to young adults (Seeman et al., 1997; Lee et al., 2007). Indeed, stress-induction paradigms that manipulate cortisol levels (pharmacologically or psychologically) increase forgetting in older adults compared to young adults (Lupien et al., 1997, 2002b).

Psychosocial researchers have identified four situational determinants that elicit a physiological stress response, namely; novelty, unpredictability, low sense of control and threat to one's ego (Mason, 1968; Dickerson and Kemeny, 2004). In laboratory stress-induction paradigms, such as in the Trier social stress test (TSST) (Kirschbaum et al., 1993), these situational determinants are implemented in order to trigger activity of the hypothalamic—pituitary—adrenal (HPA) axis and consequent surges in cortisol.

In some studies on cognitive ageing that compare memory performance of young and older adults, these situational determinants of the physiological stress response can be imbalanced and unfavourably be more distressing for older adults compared to young (Lupien et al., 2007). Various study design factors dissociate the level to which these situational determinants may be differentially experienced by young and older adults: (1) testing location, (2) age of the research assistant, (3) time of testing, (4) type of memory task and (5) task instructions.

First, many studies on memory performance in young and older adults take place on a university campus, which is familiar to young adults who are often attending as students at the time of the study. However, older adults are faced with the challenge of navigating to this unfamiliar destination. This involves greater novelty and unpredictability for older adults, leading to a more unfavourable (or stressful) testing condition upon arrival. This increased novelty in older adults could trigger a greater stress response in this population. Second, research assistants conducting the studies on ageing and memory are generally young graduate students. Consequently, young participants are tested by their peers, whereas much younger individuals test older adults. This can modify the quality of the relationship between participant and research assistant and/or lead to greater threat to the ego in the older adults and consequently to an increase in cortisol levels.

Third, it is reported that studies on memory performance tend to schedule participants' appointments in the afternoon (May et al., 1993). Yet, young adults perform significantly better when tested in the afternoon (between 1300 h and 1700 h), while older adults perform significantly better when tested in the morning (between 0800 h and 1100 h) (May et al., 1993; Intons-Peterson et al., 1998, 1999; May and Hasher, 1998; Winocur and Hasher, 2004). Studies generally report that when older adults are tested in the afternoon, their performance is significantly worse than young adults, whereas when they are tested in the morning, their performance does not differ (Borella et al., 2011). When the aforementioned studies report that they test participants in the morning, the time at which cognitive testing starts and ends tends to vary across studies; starting time may be anywhere between 0800 h and 0900 h and may end between 1000 h and 1200 h. Therefore, the exact time window of optimal testing time is presently difficult to determine, yet the advantage of morning testing time is found when cognitive testing ends as late as noon (Borella et al., 2011). Episodic memory, working memory and in particular tasks requiring inhibitory processes are influenced by the time of testing (May and Hasher, 1998; West et al., 2002; Yang et al., 2007). By contrast, tasks assessing semantic knowledge including verbal fluency and vocabulary are less sensitive and remain consistent throughout the day (May and Hasher, 1998; Brown et al., 1999; Martin et al., 2008). Taken together, the evidence suggests that older adults are at a disadvantage compared to young adults when tested during their non-optimal testing time.

Fourth, participants are typically instructed to memorize items (word lists; Chantome et al., 1999 or paragraphs; Foster et al., 1999) for memory tasks. Learning and memorizing are routine tasks for university students, but not for older adults. Memorizing may thus be perceived as novel and unpredictable for older adults, resulting in a greater physiological stress response in this population. Finally, it has been demonstrated that task instructions may also impact older adults' memory performance. Instructions tend to include several reminders that the task at hand aims to measure memory capacities, where participants are expected to memorize in order to be tested later (Rahhal et al., 2001). Studies have demonstrated that when instructions for memory tasks are modified to decrease the emphasis on the memory component of the task, previously observed differences between older and young adults are abolished (Hasher et al., 1999; Rahhal et al., 2001).