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Updating the Positivity Bias in Older Adults: How do Subjective Memory Complaints Influence Emotional Distraction in a Working Memory Task?

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Abstract

Introduction: Subjective memory complaints (SMCs), commonly reported by older adults, refer to self-perceived difficulties with memory. While the link between SMCs and objective cognitive decline remains unclear, SMCs may reflect subtle cognitive changes, particularly in working memory, which is known to be influenced by emotional context. Older adults typically display a positivity bias, which is a tendency to focus more on and better remember positive over negative information. However, the positivity bias has yet to be explored in individuals with SMCs. This study aims to address this gap by examining how emotional distractors affect working memory performance in older adults with varying levels of SMCs. **Method**: Forty-seven older adults (ages 55-79) were categorized into low and high SMCs groups based on self-reported memory complaints. Participants completed an emotional n-back task with three levels of cognitive load (0-back, 1-back, 2-back) and emotional distractors (positive, negative, neutral). Task performance was measured using accuracy, response bias, and reaction times. Mixed-design ANOVAs were conducted, with cognitive load, emotional condition, and complaint group as factors. **Results**: Results revealed significant main effects of cognitive load on performance, with performance declining as task demands increased. A three-way interaction between cognitive load, emotional condition, and complaint group showed that participants with high SMCs were more distracted by positive stimuli under high cognitive load, leading to decreased accuracy. In contrast, participants with low SMCs showed reduced accuracy with positive distractors under low cognitive load. **Conclusions**: These findings suggest that emotional distractors, particularly positive ones, affect working memory performance differently in older adults depending on their level of SMCs. Future research should aim to uncover the mechanisms underlying theses effects.

Keywords

Subjective memory complaints, positivity bias, emotional working memory, n-back task, aging

Introduction

As populations age, understanding how cognitive functions evolve has become a central issue for both researchers and clinicians.

Subjective memory complaints and cognitive aging

Cognitive aging is a natural process characterized by progressive changes across multiple cognitive domains, including memory, language, and executive functions (Dumas, 2015; Luo & Craik, 2008; Murman, 2015). These changes are often observed through objective cognitive tests, but they are also subjectively experienced by older adults, who frequently report that their cognitive abilities are no longer as sharp as they once were. Such self-perceived difficulties, known as subjective cognitive complaints, vary greatly from one individual to another and occur even in the absence of measurable deficits (Langlois & Belleville, 2014). Among these complaints, subjective memory complaints (SMCs) are the most frequently reported, referring specifically to concerns about everyday memory functioning (Reid & MacLullich, 2006). SMCs are typically assessed via self-reported tools, such as questionnaires measuring the perceived frequency and impact of memory difficulties in daily life (e.g., Langlois & Belleville, 2014). While SMCs are highly prevalent in older adults, they may become particularly problematic when they interfere with daily functioning or cause significant anxiety, especially as they are often interpreted as early signs of dementia (Norman et al., 2020).

Research consistently suggests that SMCs are more strongly associated with emotional distress than with objective cognitive performance (Burmester et al., 2016; Gass & Patten, 2020; Hurt et al., 2011; Pawlaczyk et al., 2021; Pearman et al., 2014; Yates et al., 2017). Older adults who report greater concern about their memory tend to exhibit higher levels of anxiety and depressive symptoms, which may in turn intensify their perception of cognitive difficulties (e.g., Balash et al., 2013; Brigola et al., 2015; Yates et al., 2017). This relationship underscores the crucial role of emotional factors in how individuals perceive and report their memory abilities (Dux et al., 2008; Rowell et al., 2016).

Although SMCs are strongly associated with emotional distress, a growing body of evidence indicates that they may also signal increased vulnerability to future cognitive decline. While cross-sectional studies have shown inconsistent links between SMCs and current cognitive abilities, longitudinal data revealed that individuals with SMCs are at higher risk of experiencing cognitive decline over time (Brigola et al., 2015; Reid & MacLullich, 2006). This supports the idea that SMCs may serve as an early indicator, identifying individuals who are more susceptible to future cognitive deterioration and even dementia (Jonker et al., 2000; Viviano et al., 2019; Waldorff et al., 2012). For instance, some studies have found that older adults with SMCs are more likely to develop mild cognitive impairment, a recognized precursor to Alzheimer's disease and related dementias (Mitchell et al., 2014), emphasizing the importance of monitoring these complaints carefully.

Beyond their potential predictive value, SMCs have also been examined in relation to specific cognitive domains. Although findings remain mixed, some studies have reported subtle impairments in episodic memory, attention, executive functioning, and working memory (Bassel et al., 2002; Cespón et al., 2018; Esmail et al., 2022; Matotek et al., 2001; Montejo Carrasco et al., 2017; Saunders & Summers, 2010; Wolfsgruber et al., 2020). Among these, working memory is particularly relevant given its fundamental role in the temporary storage, updating and manipulation of information. Difficulties in this domain may account for the types of challenges commonly reported by older adults with SMCs. For example, difficulties with working memory may hinder one's ability to follow conversations or retain recent instructions, with may in turn exacerbate concern about memory loss.

Working memory and the n-back task

To explore the relationship between SMCs and working memory more precisely, experimental tasks with high specificity are required. One such task is the n-back task (Kirchner, 1958), which assesses working memory by presenting participants with a series of stimuli, typically letters, and requiring them to identify whether the current stimulus matches the one presented *n* trials earlier. The task is parametric: the cognitive load increases as the value of *n* increases (e.g., 0-back, 1-back, 2-back), with higher levels requiring participants to store, update and manipulate more information (Gajewski et al., 2018; Miller et al., 2009). Its design is particularly useful for identifying subtle deficits in older adults with SMCs who may perform normally on traditional neuropsychological assessments (Van Der Linden et al., 1989). Although often used as a measure of working memory updating, the validity of the n-back task as a measure of working memory has been debated (Kane et al., 2007; Miller et al., 2009). For example, the 0-back condition largely involves perceptual and attentional processes, which is why it serves as a baseline condition. In contrast, higher n-back conditions require a broader range of cognitive processes, including updating, interference inhibition, and attentional control (Gajewski et al., 2018). The 2-back condition in particular demands switching focus and updating information held outside the immediate attention field, which may pose greater challenges for older adults (Bopp & Verhaeghen, 2018; Gajewski et al., 2018; Verhaeghen et al., 2005). Supporting this, a meta-analysis showed that while older adults perform comparably to younger adults in the 1-back condition, they show significantly lower performance in the 2-back condition (Bopp & Verhaeghen, 2018).

Emotional distraction and the positivity bias

In addition to internal cognitive demands, external contextual factors – such as the emotional salience of stimuli – can also modulate working memory performance, including in paradigms like the n-back. For example, a meta-analysis found that task-relevant emotional content enhances performance, with participants responding more quickly and accurately than under neutral conditions (Schweizer et al., 2019). Similarly, in emotional variants of the n-back task, both positive and negative task-relevant stimuli were associated with improved accuracy and faster reaction times (Lindström & Bohlin, 2011). However, when emotional stimuli serve as distractors, they tend to impair performance, as attentional resources are redirected toward inhibiting the emotional interference (Dolcos et al., 2013; Dolcos & McCarthy, 2006). Indeed, studies using emotional distractors in n-back paradigms have reported increased error rates or slower responses (Berger et al., 2015; Ladouceur et al., 2005; Lim & Birney, 2021).

These effects may be further modulated by age, as emotional processing evolves throughout the lifespan, modifying how older adults respond to emotional content during working memory tasks (Berger, 2017; Gerhardsson et al., 2019; Mammarella et al., 2013; Mikels et al., 2005). A well-established phenomenon in aging is the positivity bias, in which older adults preferentially attend to or better remember positive over negative or neutral information (Carstensen & DeLiema, 2018). This bias has been observed across several cognitive domains, including autobiographical memory, attention, and decision-making (Kim & Barber, 2022), and suggests a general shift in the way emotional information is processed with age. According to Socioemotional Selectivity Theory (SST), this shift reflects a motivational change whereby individuals prioritize emotionally meaningful and positive experiences as their perception of future time becomes limited (Carstensen, 2006). SST posits a cognitive shift in information processing, leading to greater attention to positive information in older age (Reed et al., 2014). This phenomenon appears to be supported by emotion regulation mechanisms, including cognitive control strategies that enhance positive and suppress negative content (Mather & Carstensen, 2005; Reed & Carstensen, 2012).

Although often considered adaptative, the positivity bias presents a more complex picture when emotional stimuli are irrelevant to the task. In such contexts, empirical findings are mixed. Some studies indicate that older adults are less distracted by negative stimuli compared to younger adults, suggesting a positivity-driven reduction in the negativity bias (Goeleven et al., 2010; Kennedy & Mather, 2024). Similar effects have been observed in an emotional n-back paradigms (Ding et al., 2022). Conversely, other research shows that positive distractors may disrupt performance more significantly in older adults, implying that the positivity bias could increase susceptibility to interference from positive stimuli (Kennedy et al., 2020; Ziaei et al., 2018). Still, additional findings suggest that negative distractors have a more detrimental effect on accuracy and/or reaction times (Truong & Yang, 2014), a pattern also found in emotional n-back task involving older participants (Berger et al., 2015). This inconsistency in the literature and the limited number of studies make it difficult to draw definitive conclusions about how positivity bias modulates working memory performance in emotionally distracting environments.

The present study

Notably, the potential influence of the positivity bias has not yet been explored in individuals with subjective memory complaints. The present study aims to address this gap by examining how emotional distractors influence working memory performance in older adults with lower versus higher levels of subjective memory complaints. Specifically, we sought to explore how the positivity bias manifests in older adults with SMCs during an emotional n-back task. We hypothesized that older adults reporting more SMCs would show an altered pattern of performance in the presence of positive emotional distractors compared to those with fewer SMCs. This research could provide valuable insights into the relationship between cognitive complaints, emotional processing, and working memory performance in aging.

Methods

Participants and procedure

A cross-sectional design was employed to investigate the effect of emotional distractors on performance in an n-back task among individuals with varying levels of subjective memory complaints (low vs. high). Participants were recruited via social media platforms and associations for older adults.

Initial screening was conducted over the phone, ensuring that all participants met inclusion criteria: having normal or corrected-to-normal vision and hearing, being French-speaking, and having no self-reported current psychiatric or cognitive disorders. Exclusion criteria included depression and anxiety symptoms exceeding clinical thresholds, assessed using the Beck Depression Inventory-II (Beck et al., 1996) and the Beck Anxiety Inventory (Beck et al., 1988), respectively, as well as clinically significant cognitive impairment, defined by a score below 23 on the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005).

A total of 48 older adults (aged 55-79, 44 women) participated in the study. However, data from one participant were excluded from analysis due to technical issues during data collection, resulting in a final sample of 47 participants. Based on the scores from the abbreviated version of the Self-Evaluation Questionnaire (in French, *Questionnaire d'auto-évaluation de la mémoire*, QAM; Van Der Linden et al., 1989), participants were categorized into two groups. Using a median score of 20 derived from the sample distribution, the sample was categorized into a "low complaint" group (22 participants with scores between 12 and 19, inclusively) and a "high complaint" group (25 participants with scores above 19). Demographic and clinical characteristics are presented in Table 1.

Prior to the experimental session, all participants completed the self-report questionnaires remotely via the LimeSurvey platform. Participants were then scheduled for the experimental session. Due to the ongoing pandemic, 33 participants completed the n-back task remotely via the videoconference platform Zoom, while 15 attended an in-person session in a laboratory setting. The task was administered online through Pavlovia (https://pavlovia.org/), an online platform for hosting and running behavioral experiments. Remote participants performed the task on their personal computer, while in-person participants used a laboratory computer. Regardless of testing format, a member of the research team was present throughout the entire session to answer any questions and ensure that the task proceeded smoothly. Apart from the differences intrinsic to the various computers used by the remote participants and their home environments, all conditions were the same between the two formats. Performance comparisons between remote and in-person participants revealed no significant differences across the n-back outcome measures, supporting the comparability of data across formats and justifying the grouping of all participants, regardless of their mode of testing (see Supplementary Materials). Following the n-back task, participants completed the MoCA, with remote assessments conducted in accordance with the official audiovisual administration guidelines.

Informed consent was obtained from all participants, and this research received approval from the Research Ethics Committee of Psychology and Psychoeducation at the University of Quebec in Trois-Rivières. Participants weren't compensated for their participation but were offered the chance to enter a raffle for prepaid credit cards.

Table 1. Demographic and clinical characteristics of sample divided by level of SMCs

	Low complaint (n = 22)	High complaint (n = 25)	Group comparison
	M (SD)	M (SD)	
Sex (male/female)	2/20	2/23	Fisher's exact test p = 1.000
Testing format (remote/in-person)	13/9	19/6	χ^2 (1, N = 47) = 0.86, p = .354
Age (years)	68.73 (6.29)	65.20 (5.67)	t(45) = 2.022, p = .049
Education (years)	16.91 (3.59)	15.94 (2.25)	t(45) = 1.122, p = .268
Subjective memory complaints (QAM-A)	15.82 (2.28)	25.72 (7.19)	t(45) = 6.18, p < .001
Anxiety symptoms (BAI)	4.50 (5.50)	4.50 (3.20)	t(45) = .015, p = .988
Depression symptoms (BDI-II)	5.68 (5.33)	8.16 (5.30)	t(45) = 1.596, p = .118
Global cognitive functioning (MoCA)	28.05 (1.50)	28.24 (1.48)	t(45) = .448, p = .657

Abbreviations. SMCs = Subjective memory complaints, M = Mean, SD = Standard deviation, QAM-A = Abbreviated version of Self-Evaluation Questionnaire, BAI = Beck Anxiety Inventory, BDI-II = Beck Depression Inventory-II, MoCA = Montreal Cognitive Assessment

Measures

Self-Evaluation Questionnaire

The shortened version of the original memory assessment (QAM) evaluates perceived memory difficulties across various aspects of everyday memory functioning (Clément et al., 2008). It includes 11 items, rated on a Likert scale ranging from 1 (never) to 6 (always). The QAM has demonstrated substantial test-retest reliability (r = .80) and convergent validity (Van Der Linden et al., 1989) and is widely employed in clinical environments (Juillerat Van der Linden, 2003).

Emotional n-back task

The emotional n-back task in this study was designed using PsychoPy3 (v2021.1.4; Peirce, 2007; https://www.psychopy.org), based on the task developed by Ladouceur et al. (2005), which is a modified version of the n-back task originally described by Cohen et al. (1994). Participants were instructed to respond to a series of letters presented on the screen by pressing the space bar on the keyboard if the current letter matched the one presented *n* trials earlier.

The stimuli consisted of two main components: black consonant letters, presented individually in the center of a white square, and emotional images that served as distractors. A total of 135 emotional scenes were selected from the EmoMadrid database (Carretié et al., 2019). These images were categorized into three emotional conditions (n = 45 per condition): positive, negative, and neutral, based on their valence and arousal scores provided in the original validation article of the EmoMadrid database. The conditions differed significantly in terms of valence [$F(2, 132) = 1747.45$, $p < 0.001$, $\eta^2 = 0.96$]. Arousal levels of the positive and negative images did not differ significantly from one another [$t(88) = 1.62$, $p = 0.109$], but the arousal levels of neutral images differed significantly from both positive [$t(88) = -20.24$, $p < 0.001$] and negative images [$t(88) = 25.91$, $p < 0.001$]. There was no significant difference in luminosity across the emotional conditions [$F(2, 132) = 2.47$, $p = 0.088$]. Luminosity values, based on brightness measurements taken in Photoshop, are available in the original article (Carretié et al., 2019).

Participants completed three levels of cognitive load during the task: 0-back, 1-back, and 2-back. In the 0-back condition, they were instructed to press the space bar whenever the letter "X" appeared on the screen. In the 1-back condition, they pressed the space bar on the keyboard if the current letter matched the one presented one trial earlier, and in the 2-back condition, they pressed the space bar if the letter matched the one presented two trials earlier. Each cognitive load condition was paired with one of the three emotional distractor conditions (positive, negative, or neutral), resulting in a total of nine blocks. The 0-back blocks were presented first, followed by the 1-back and 2-back blocks. Within each cognitive load level, the emotional conditions were presented in random order.

Each trial consisted of a consonant letter displayed for 500 ms in the center of the screen, superimposed on an image background, followed by a fixation cross for 1500 ms. This provided participants with a total of 2000 ms to respond by pressing the space bar if they detected a target. The sequence then repeated with a new letter and image. Each image was displayed twice during the entire task. Figure 1 provides an example of a 1-back task with neutral distractors.

Each block consisted of 30 trials, including 8 target trials. Four different versions of each block were created, and participants were randomly assigned to one of the versions.

Instructions were provided before each cognitive load condition. Participants completed three practice blocks (10 trials each, including one target) for the 0-back, 1-back, and 2-back conditions. Although no feedback was given during the practice blocks, participants were required to repeat the three practice blocks if they failed to identify the target in any of them on their first attempt.

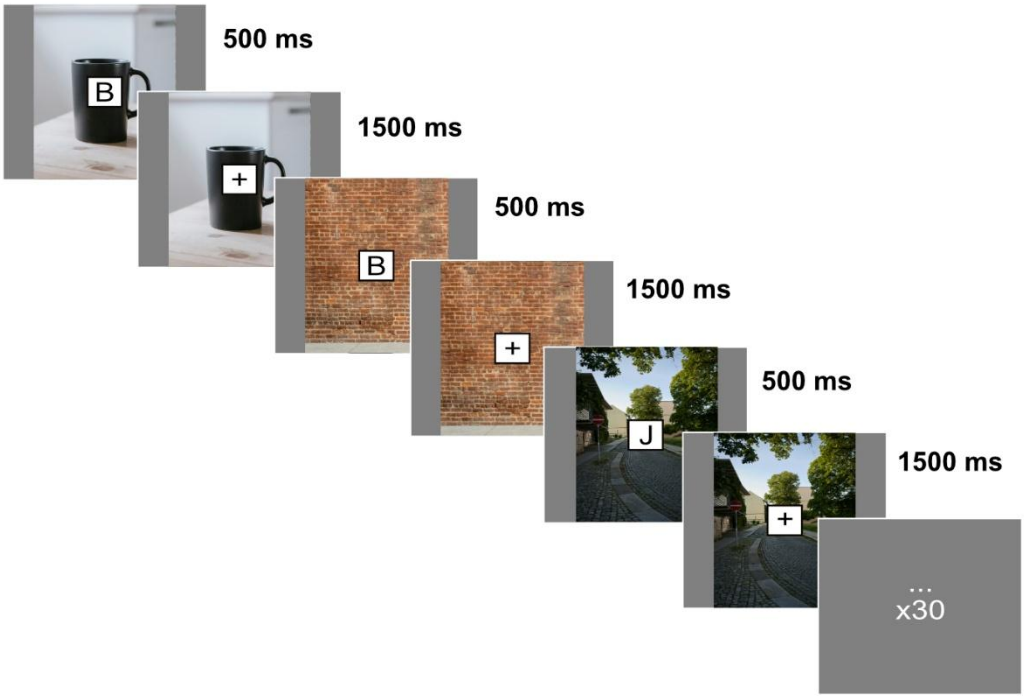

Figure 1. Illustration of the emotional n-back task designed in this study. This is an example of a neutral 1-back block.

Note. Images shown in the background are royalty-free examples; all experimental stimuli were selected from the EmoMadrid database (Carretié et al., 2019).

Data analysis

Analyses were conducted with R Statistical Software (v4.3.0; R Core Team, 2023) and the following packages: dplyr (Wickham et al., 2023), purrr (Wickham & Henry, 2023), stats (R Core Team, 2023), rstatix (Kassambara, 2023), emmeans (Lenth, 2023) and ggplot2 (Wickham, 2016).

Groups of low and high complaint were compared across all demographic and clinical variables. Nominal variables (sex, testing format) were compared using the chi-squared test or Fisher's exact test when group sizes were small. Quantitative variables (age, education, anxiety symptoms, depressive symptoms, cognitive screening score) were compared using independent t-tests.

Participants' performance on the n-back task was assessed using several performance variables. Performance accuracy (d') was used to reflect participants' ability to distinguish between targets and non-targets, and response bias (*C*) quantified participants' tendency to respond regardless of the stimulus, with higher values indicating a more conservative response pattern (more likely to not respond). To calculate these variables, we used formulas commonly used in signal detection theory (Kane et al., 2007):

$$d' = ln\left(\frac{H(1-FA)}{(1-H)FA}\right)$$

$$\mathrm{C} = 0.5\left[ln\left(\frac{(1-FA)(1-H)}{(H)(FA)}\right)\right]$$

Where ln = natural log, H = proportion of hits, and FA = proportion of false alarms. Hits rates and false alarms rates equal to either 0 or 1 were adjusted by .01.

To gain further insight into accuracy and response bias, we also analyzed the proportion of hits and the proportion of false alarms separately. Proportion of hits refers to the percentage of targets correctly identified, whereas proportion of false alarms refers to the percentage of incorrect responses when no target was present (i.e., when no response was expected).

Mean reaction times were calculated for correct responses to measure participants' response speed. Trials with reaction times exceeding ±3 median absolute deviations (MAD) from the median by participant and condition were excluded as outliers.

Given that the 0-back condition involves simple target detection, it is often too easy to capture meaningful cognitive differences. Participants tend to perform near perfectly, resulting in substantial ceiling effects. We addressed this issue by calculating the difference between the 1-back and 0-back conditions (Δ1back) and between the 2-back and 0-back (Δ2back) conditions, using the 0-back condition exclusively as a control and focusing on the relative changes in performance across the different cognitive load conditions. For all performance variables (accuracy, response bias, proportion of hits, proportion of false alarms, and mean reaction times), extreme scores were excluded using a threshold of ± 3 standard deviations from the mean by condition. Next, we conducted a series of mixed-design 2 x 2 x 3 analyses of variance (ANOVAs) for each performance variable, using level of complaint (low complaint, high complaint) as a between-subjects factor, and cognitive load (Δ1back, Δ2back), and emotional conditions (positive, negative, neutral) as within-subject repeated measures. Partial eta-squared (η^2_p) was reported as an effect size estimate. For significant interactions, we conducted simple effects analyses, followed by pairwise comparisons using Tukey's HSD to identify specific differences between factor levels. A p value $< .05$ was considered as statistically significant.

Results

Demographics

See Table 1 for demographic and clinical characteristics of participants and corresponding statistical comparisons between the low and high levels of SMCs groups. No significant differences were observed between the groups in terms of sex distribution, experimental setting, education, anxiety symptoms, depressive symptoms or cognitive screening score. However, significant age differences were observed between the groups, with the low complaint group being slightly older than the high complaint group. Therefore, age was included as a covariate in subsequent analyses of task performance.

Task performance

See Table 2 for details of task performance across all conditions.

Accuracy

For performance accuracy (d'), results for the mixed-design 2 (low complaint, high complaint) x 2 (Δ1back, Δ2back) x 3 (positive, negative, neutral) ANOVA revealed significant main effects of cognitive load ($F(1, 41) = 182.76$, $p < .001$, $\eta^2_p = .817$) and emotion ($F(2, 82) = 4.901$, $p = .010$, $\eta^2_p = .107$). A significant interaction effect of cognitive load x emotion x complaint group was found ($F(2, 82) = 5.873$, $p = .004$, $\eta^2_p = .125$), which allowed us to separate our analyses as a function of the group. For the low complaint group, simple effect analyses revealed significant main effect of emotion in the Δ1back condition ($F(2, 38) = 5.966$, $p = .006$; see Figure 2). Tukey's post-hoc comparisons revealed significant differences between negative and positive emotional conditions, with higher accuracy for negative condition ($p = .010$; see Figure 2). No other pairwise comparisons were significant (all *p*s > .05). For the high complaint group, a significant main effect of emotion was also found in the Δ2back condition ($F(2, 42) = 3.803$, $p = .030$). Post-hoc comparisons indicated significant differences between negative and positive emotional conditions, with higher accuracy for negative condition ($p = .029$; see Figure 2). Again, no other comparisons reached significance (all *p*s > .05)

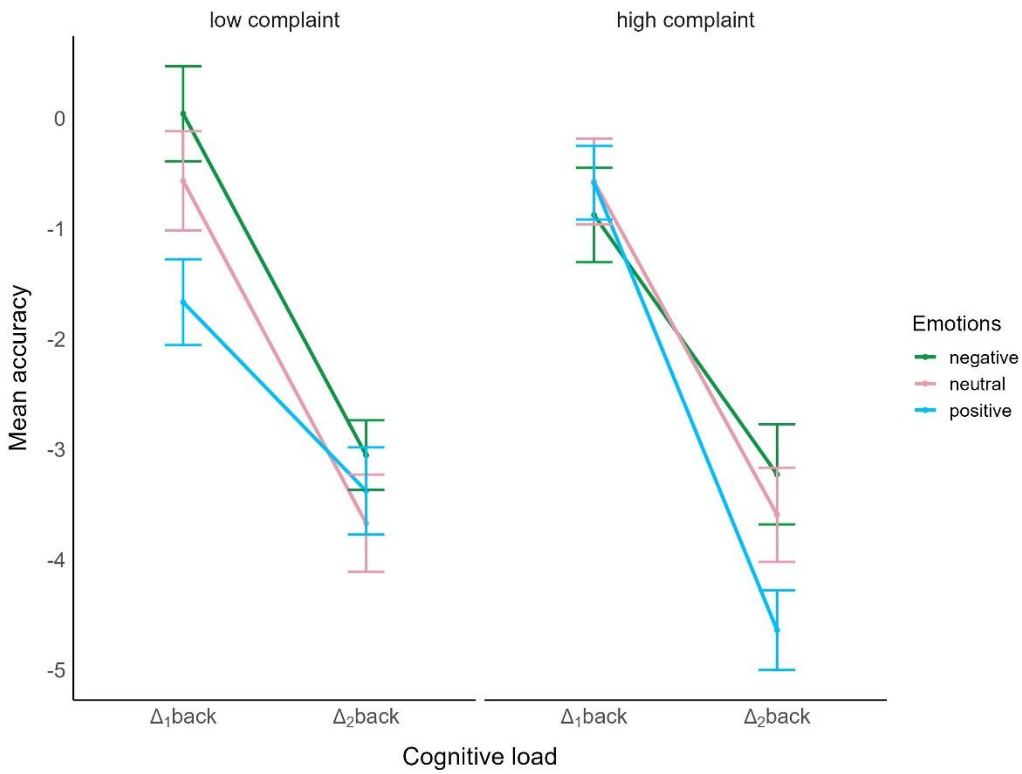

Figure 2. Line graph of mean accuracy by cognitive load and emotion across complaint groups.

For response bias (C), the 2 x 2 x 3 ANOVA revealed a significant main effect of cognitive load ($F(1, 41) = 30.853$, p ¸$< .001$, $\eta^2_p = .429$) and a significant interaction effect of cognitive load x emotion x complaint group ($F(2, 82) = 6.384$, $p = .003$, $\eta^2_p = .135$). However, within-group analyses revealed no significant main effects of emotion for either the Δ1back or Δ2back conditions in both groups (all *p*s > .05).

For proportion of hits, the 2 x 2 x 3 ANOVA revealed a significant main effect of cognitive load ($F(1, 38) = 1.084$, $p < .001$, $\eta^2_p = 0.716$) and a significant interaction effect of cognitive load x emotion x complaint group ($F(2, 76) = 3.804$, $p < .027$, $\eta^2_p = .091$). For the low complaint group, simple effect analyses showed a significant main effect of emotion in the Δ1back condition ($F(2, 40) = 1.412$, $p = .043$). Tukey's post-hoc comparisons revealed no significant differences between emotional conditions, although there was a tendency for a higher proportion of hits in the negative compared to the positive condition. For the high complaint group, a marginally significant main effect of emotion was found in the Δ2back condition ($F(2, 40) = 3.097$, $p = .056$). Post-hoc comparisons showed significant differences between negative and positive emotional conditions, with a higher proportion of hits for the negative condition ($p = .004$). No other comparisons were significant (all *p*s > .05).

For proportion of false alarms, the 2 x 2 x 3 ANOVA revealed significant main effects of cognitive load ($F(1, 35) = 72.728$, $p < .001$, $\eta^2_p = 0.675$) and emotion ($F(2, 70) = 4.599$, $p = .013$, $\eta^2_p = .116$). Significant interaction effects were found for cognitive load x emotion ($F(2, 70) = 3.885$, $p = .025$, $\eta^2_p = .100$) and cognitive load x complaint group ($F(1, 35) = 4.317$, $p = .045$, $\eta^2_p = .110$). The three-way interaction of cognitive load x emotion x complain group was marginally significant ($F(2, 70) = 2.724$, $p = .082$, $\eta^2_p = .072$). For the low complaint group, simple effect analyses showed no significant main effect of emotion in either Δ1back condition or Δ2back condition. For the high complaint group, a significant main effect of emotion was found in the Δ2back condition ($F(1, 48) = 6.253$, $p = .010$). Tukey's post-hoc comparisons revealed significant differences between negative and positive emotional conditions, with a higher proportion of false alarms for the positive condition ($p = .041$). No other comparisons were significant (all *p*s > .05).

Reaction times

For mean reaction times on correctly identified targets, the 2 x 2 x 3 ANOVA revealed a significant main effect of cognitive load ($F(1, 39) = 38.851$, $p < .001$, $\eta 2\ p = .500$), with faster performance in the Δ1back condition. No other main or interaction effects were significant (all *p*s > .05).

Table 2. Means (and standard errors) of accuracy, response bias, proportion of hits, proportion of false alarms and mean reaction times on correctly identified targets as a function of SMCs group, cognitive load and emotional condition

	M (SD)				
	d'	C	hits (%)	fa (%)	RT (ms)
Low complaint					
Δ1back					
Neutral	-.57 (2.06)	.14 (.94)	-2.38 (9.37)	.48 (1.43)	95.87 (78.88)
Positive	-1.67 (1.82)	.55 (.86)	-7.14 (9.33)	.83 (2.28)	45.43 (100.12)
Negative	.04 (2.02)	.02 (.94)	-1.14 (10.14)	-.43 (2.45)	62.94 (74.82)
Δ2back					
Neutral	-3.67 (2.07)	.86 (.91)	-22.73 (17.09)	3.51 (4.85)	167.02 (158.77)
Positive	-3.38 (1.85)	.60 (.97)	-17.05 (16.61)	4.13 (4.42)	200.81 (159.53)
Negative	-3.05 (1.48)	.97 (.67)	-20.45 (14.20)	2.07 (3.05)	224.22 (195.42)
High complaint					
Δ1back					
Neutral	-.57 (1.90)	.32 (.84)	-2.17 (7.20)	-.19 (2.11)	61.56 (79.12)
Positive	-.58 (1.67)	.20 (.70)	-3.00 (7.47)	.00 (2.68)	65.89 (74.87)
Negative	-.88 (2.10)	.31 (.73)	-4.69 (12.67)	.38 (1.86)	62.94 (74.82)
Δ2back					
Neutral	-3.59 (2.05)	.88 (.91)	-17.61 (13.17)	2.48 (3.64)	187.09 (173.48)
Positive	-4.64 (1.81)	.85 (.49)	-26.50 (17.43)	5.45 (4.91)	151.20 (176.58)
Negative	-3.23 (2.22)	.52 (.92)	-14.13 (16.56)	3.16 (2.89)	215.47 (185.80)

Note. Δ1back represents the difference between the 1-back and 0-back condition and Δ2back to the difference between the 2-back and 0-back conditions. Thus, all scores presented in this table are score of differences.

Abbreviations. SMCs = Subjective memory complaints, M = Mean, SD = Standard deviation, d' = Accuracy, C = Response bias, hits = Proportion of hits, fa = Proportion of false alarms, RT = Mean reaction times on correctly identified targets.

Discussion

The present study explored the effect of emotional distractors on working memory performance in older adults with lower versus higher levels of subjective memory complaints (SMCs). Our findings indicated a significant effect of cognitive load on overall performance, with performance declining as task demands increased. The presence of emotional distractors, specifically positive ones, exerted a differential effect on accuracy variables based on SMCs levels. Participants with higher levels of SMCs exhibited greater susceptibility to distraction by positive stimuli compared to negative stimuli under high cognitive load, while participants with lower levels of SMCs exhibited this pattern under low cognitive load. These results suggest that the positivity bias manifests differently between the two groups, reflecting distinct cognitive processes in how emotional information is managed under varying cognitive demands. These findings are discussed in greater detail in the following sections.

Results revealed that there was a main effect of cognitive load across all performance variables. Participants performed significantly worse as cognitive load increased, regardless of emotional condition and level of SMCs. Specifically, participants demonstrated lower accuracy**,** slower reaction times, and adopted a more conservative response bias in the higher-load condition. These results align with the parametric nature of the n-back task, which is designed to progressively increase demands on working memory and attentional resources as the cognitive load escalates (Miller et al., 2009). As the task becomes more challenging (from 1-back to 2-back), participants' cognitive resources are taxed, leading to a noticeable decline in performance (Bopp & Verhaeghen, 2018). The increase in response conservatism suggests that participants became more cautious about identifying targets, likely to avoid making false alarms in the more difficult Δ2back condition, even if it led to slower responses or missed targets. This conservative bias reflects a strategic adjustment to maintain performance, as the increased cognitive load may cause targets and non-targets to appear more similar, prompting participants to adopt a stricter criterion to avoid the costly error of false alarms (Lynn & Barrett, 2014; Macmillan & Creelman, 1990). Taken together, these results validate the robustness of our dataset, demonstrating classical performance patterns that align with established literature and support the reliability of both remote and in-person testing formats.

More importantly, and in line with our predictions, the level of complaints of participants influenced their performance in the emotional task. Results showed different patterns of performance in the presence of positive emotional distractors compared to negative distractors between the two groups of participants with varying levels of SMCs. The three-way interaction effects revealed that participants with lower and higher levels of SMCs reacted differently to emotional distractors depending on the cognitive load. These differences were observable in accuracy outcomes but not in reaction times.

Specifically, individuals with low SMCs performed worse in accuracy under low cognitive load (Δ1back) when positive distractors were present compared to negative distractors, while no significant performance differences were observed between emotional conditions under the high cognitive load (Δ2back). These findings align, for the low load condition, with the well-documented positivity bias commonly observed in older adults, characterized by a tendency to focus on positive rather than negative information (Carstensen & DeLiema, 2018). According to socioemotional selectivity theory, as people age, they prioritize emotionally meaningful and positive experiences (Carstensen, 2006). Consequently, positive distractors may capture more attention, even when they are irrelevant to the task, leading to decreased performance. This aligns with the concept that emotionally arousing stimuli inherently possess a competitive advantage, drawing attention away from nearby stimuli in space or time (Bradley et al., 2012). Similar effects have been found in studies using a comparable emotional n-back paradigm, where positive distractors have been shown to interfere more with task performance in older adults (Kennedy et al., 2020; Ziaei et al., 2018).

Importantly, under high cognitive load, this effect was not as strong. We believe that the increased task demands may have required greater allocation of cognitive resources to the primary task, leaving fewer resources available to process emotional distractors, which supports the load theory of selective attention and cognitive control (Hur et al., 2017; Lavie et al., 2004). This theory suggests increased focus on task-relevant information effectively reduces the impact of irrelevant stimuli, including emotional distractions (Lavie et al., 2004). As a result, participants with low SMCs behaved as expected for "normal" older adults, performing similarly across emotional conditions when cognitive load was high. This aligns with other studies' results, which have found that emotional biases in aging diminish when cognitive resources are stretched thin (Mather & Knight, 2005; Reed & Carstensen, 2012).

It appears that the level of complaints shaped these observations. Indeed, participants in the high complaint group showed similar performance across emotional conditions under low cognitive load but exhibited increased distraction under high cognitive load. In this condition, positive distractors led to a noticeable decline in accuracy. This effect was primarily driven by a heightened proportion of false alarms in this condition, indicating that participants were more prone to mistakenly identifying non-targets as targets when confronted with positive stimuli. The performance of the high SMCs group in the presence of emotional distractors, particularly under high cognitive load, presents an intriguing finding that, to our knowledge, has not been extensively replicated. Given the lack of studies addressing this specific context, it is difficult to pinpoint a singular cause, prompting us to explore several potential hypotheses that future research will need to investigate.

One plausible explanation involves the concept of cognitive resource allocation. Under low cognitive load, participants with higher levels of SMCs likely possess sufficient inhibitory control to manage emotional distractors and, contrary to the low complaint group, actively allocate resources to do so. Indeed, their heightened concerns about cognitive performance might motivate them to allocate more attentional resources toward avoiding distraction. This heightened focus on task performance may help explain why they show no significant differences between emotional conditions in the Δ1back task.

However, as cognitive load increases in the Δ2back condition, their performance declines, particularly in the presence of positive emotional distractors. In such cases, the higher cognitive demands may overwhelm their available resources, leaving them less capable of inhibiting distracting stimuli – especially positive ones, which tend to be more salient for older adults (Reed & Carstensen, 2012). These findings suggest that while participants with higher SMCs may be able to compensate for their cognitive concerns under low cognitive loads, their ability to do so diminishes as task complexity surpasses their cognitive capacity.

Alternatively, the increase in difficulty of the task under high cognitive load may result in a decline in motivation. Faced with a more challenging task that they are less likely to succeed at, participants with higher SMCs may reduce their effort, becoming more susceptible to distractions. This motivational shift could lead to a disengagement from the task, allowing positive stimuli to capture more attention. Given their concerns about cognitive performance, participants with higher SMCs may perceive the task as irrelevant to their primary goal of avoiding failure. Germain and Hess (2007) found that tasks with higher personal relevance increased inhibitory control, particularly in older adults. Thus, if participants perceive the task as too difficult or irrelevant, their ability to inhibit distractions may decline, making them more susceptible to emotional interference under high cognitive load.

Another hypothesis involves a shift in cognitive strategy. Under low cognitive load, these participants with higher SMCs may apply more cognitive control to inhibit emotional distraction. However, under high cognitive load, they may switch to a strategy that relies more on familiarity-based processing – a less effortful and less precise retrieval mechanism relying on a general sense of knowing rather than detailed recollection. This pattern has been observed in patients with mild cognitive impairment, but not yet studied in the context of SMCs (Wang et al., 2013). Importantly, research indicates that both recollection and familiarity are impaired in mild cognitive impairment (Wolk et al., 2013), suggesting that even this fallback strategy may be suboptimal. Given that SMCs may represent an early or preclinical stage of cognitive decline, similar mechanisms could be at play. In our context, relying on a less robust retrieval process may render participants with higher SMCs more susceptible to interference emotional distractors, particularly positive ones, which are more salient due to the positivity bias (Reed & Carstensen, 2012). This may partly explain the trend toward increased false alarms and faster reaction times observed in the high complaint group in the positive Δ2back condition (Schmiedek et al., 2009), although these differences were not statistically significant.

It is also possible that individuals with higher SMCs, may turn to positive stimuli as a coping strategy, particularly under high cognitive load. Given that SMCs are frequently associated with emotional distress (e.g., Burmester et al., 2016), such as anxiety or depression, participants may unconsciously focus more on positive distractors to regulate their mood (Isaacowitz & Blanchard-Fields, 2012). This focus on positive information could reflect a compensatory mechanism to counteract negative emotions, but at the cost of performance on the primary task. Studies have shown that individuals experiencing emotional distress may be more likely to engage in emotion-focused coping strategies, such as attending to positive stimuli to reduce negative feelings (Carstensen & Mikels, 2005; Gross & Thompson, 2007).

In summary, while participants with high levels of SMCs can maintain performance under low cognitive load, the increased demands of the Δ2back task likely strain their cognitive and emotional resources, leading to greater susceptibility to positive distractors. Whether this is due to inhibitory deficits, motivational declines, a shift in strategy, or mood regulation mechanisms remains to be determined, but these hypotheses offer a foundation for future research to further explore.

Additionally, our findings revealed a dissociation between accuracy and response speed, with significant effects emerging in accuracy but not in reaction times. Substantial interindividual variability in reaction times may have masked subtle effects. Nevertheless, this pattern aligns with prior research suggesting that accuracy and speed reflect distinct processes in working memory (Meule, 2017), with emotional effects often more pronounced in accuracy-based outcomes. Hur et al. (2017) also reported that participants tend to prioritize accuracy over speed, which could account for stronger effects in accuracy-based measures.

Finally, our study did not reveal a significant main effect of complaint group, meaning participants with high SMCs did not perform worse than those with lower SMCs. This contrasts with previous findings linking SMCs to cognitive deficits (Bassel et al., 2002; Cespón et al., 2018; Esmaeili et al., 2022; Matotek et al., 2001; Saunders & Summers, 2010), particularly in working memory and attention. However, the effects of SMCs may be more context-dependent, manifesting under certain task demands. Our paradigm differed from those that previously demonstrated strong SMCs and performance links. Furthermore, the absence of a group effect may suggest compensatory mechanisms among high-SMC participants, masking objective differences. Our results are in line with many studies that have also failed to demonstrate a clear relationship between SMCs and cognitive decline (Weber & Maki, 2016).

The interpretation of our study findings must be considered in light of several limitations. Our sample was relatively small, which may limit the generalizability of the results. Additionally, participants were highly educated, and there were significant age differences between the low and high SMCs groups. Although age was statistically controlled, the possibility of residual age effects cannot be completely ruled out. Moreover, the high SMCs group exhibited a substantial variability in subjective memory complaint scores, as reflected by a large standard deviation in QAM scores. This suggests the potential presence of subgroups within the high SMCs group that may exhibit distinct cognitive and emotional patterns, leading to different responses to emotional distractors. In this regard, it is also important to note that although we used the MoCA as an objective cognitive screening tool, a more comprehensive cognitive assessment would have been valuable for better characterizing participants' cognitive functioning. Future research should aim to include broader neuropsychological evaluations and larger, more diverse samples to explore these potential subgroups more effectively. Also, even though we screened for anxiety and depression, we did not obtain a detailed understanding of participants' emotional states during the task. Given the well-establish relationship between emotional distress and SMCs, the absence of more nuanced emotion-related measurements may constrain the interpretation of our results. A more thorough assessment of participants' emotional states could provide deeper insight into how emotional processing interacts with cognitive performance in individuals with SMCs, especially considering that emotional states can significantly influence how emotional information is processed (Levine & Pizarro, 2004; Rusting, 1998). Additionally, the inclusion of both remote and in-person testing formats represent another limit. Although no significant performance differences were observed between formats, it is likely that the uncontrolled variability was introduced by the testing context. However, it is worth emphasizing that this aspect also represents a strength of the study, as it provides promising evidence supporting the feasibility of remote cognitive assessments. To date, there are still relatively few validated tools capable of measuring both accuracy and reaction times in an online setting. Our findings suggest that the n-back task, as implemented here, is both effective and reliable in in-person and remote administration context.

In conclusion, to the best of our knowledge, this is the first study to investigate the differential effects of emotional distractors on working memory performance in older adults with subjective memory complaints. As such, it contributes to the limited but growing literature on this population, offering valuable insights into how emotional processing and cognitive performance may differ in individuals with SMCs. Future research should aim to elucidate the mechanisms underlying the interaction between cognitive load and the positivity bias in this group. Specifically, studies could explore the potential roles of inhibitory control, motivational shifts, strategy changes, and emotional regulation processes, to provide a deeper understanding of the practical implications of these dynamics for aging populations.

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No potential conflict of interest was reported by the authors.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author, AP. Supplementary materials are available on the OSF repository at Supplementary Materials.

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