

Acute Stress Impairs Visual Narrative Comprehension in Younger but Not Older Adults

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Abstract

Visual narrative comprehension is crucial in today's visually driven world, yet research on aging and this ability remains inconclusive. The role of stress in this process is largely unexplored, despite stress becoming an ever-present factor in modern life. This online study investigated how acute stress affects visual narrative comprehension in younger (N = 203, 18-57 years) and older adults (N = 212, 60-85 years). Participants were assessed under stress and neutral conditions. Stress was induced through timed mathematical and logical tasks with social stress elements. Pictorial stories, consisting of three panels with the second intentionally left blank, were presented. On the next page, participants judged whether the given inference for the blank panel was correct. Results showed that acute stress impaired comprehension and confidence in younger adults, while older adults remained unaffected. These findings suggest that with age and experience, individuals develop more differentiated event schemas, enhancing resilience to stress.

Keywords: inference generating; discourse processing; memory; acute stress; aging; perception

Introduction

People are surrounded by narratives in many aspects of their everyday life. Narratives convey information, instructions, explanations, and stories. We cannot effectively participate in society without comprehending the meaning of conveyed information (Schröter & Bar-Kochva, 2019). The importance of narrative comprehension becomes evident when traveling to a country with a different language or writing system. Even if travelers can recognize individual letters, they often struggle to derive meaning from unfamiliar words and sentences. In such scenarios, people often rely on visual stimuli, which are considered more universal and accessible for understanding (Cohn, 2019). With the rapid advancements in digital technology and increasing

globalization, visual modes of information transmission have become a dominant feature of today's world.

Narrative comprehension is the process of constructing meaning from incoming information to create a cohesive mental representation (Quintero Johnson & Sangalang, 2017; Bilandzic et al., 2019). The ability to derive meaning from visual narratives — such as comics, storyboards, and educational diagrams — is substantiated by cognitive frameworks like the Structure-Building Framework (Gernsbacher et al., 1990), the Scene Perception and Event Comprehension Theory (SPECT) (Loschky et al., 2020), and Visual Narrative Grammar (Cohn, 2013, 2014). Comprehension begins with establishing a foundation and subsequently categorizing and mapping new information into it. New substructures are generated if new information is not related to existing structures. (Gernsbacher et al., 1990). The Scene Perception and Event Comprehension Theory (SPECT) (Loschky et al., 2020) divides narrative comprehension into “front-end” processes, such as attentional selection and initial information extraction, and “back-end” processes, like inferencing and event-model construction. These processes interact with working memory, long-term memory, and pre-existing schemas to build a dynamic representation of events. Front-end processes lead to the computation of the event model representing the “now” moment in a narrative. The event model will then be developed by the back-end processes to comprehend the dynamic structure of the narrative (Magliano et al., 2013). The concept of Visual Narrative Grammar (VNG) suggests that consecutive images assume narrative roles comparable to the grammatical roles of words in sentences (Cohn, 2013; Cohn, 2014). The sequence of image follows a hierarchical narrative grammar and the processes of updating perceptual-semantic information and grammar interact with each other (Cohn, 2013; Cohn & Kutas, 2017). In this context, it is particularly intriguing to explore the extent to which

comprehenders can maintain the sense of narratives when parts of the structure are omitted or to examine how factors as age and stress might impair narrative comprehension and the underlying processes. Further, we elaborate more on why it is crucial to investigate these factors.

Numerous studies have explored age-related comprehension and the cognitive mechanisms that underlie it, such as working memory, attention, and the construction and maintenance of situation models. While age-related declines in cognitive functions like memory and processing speed are well-documented (Salthouse, 2010; Stine-Morrow & Radvansky, 2017), knowledge-based faculties, including accumulated expertise, semantic memory, and crystallized verbal abilities (e.g., vocabulary), are generally well maintained into later adulthood, often up to the eighth decade (Baltes, 1997; Li et al., 2004; Stine-Morrow & Radvansky, 2017). Studies suggest that older adults process narrative boundaries differently and may segment events more distinctly than younger adults (Smith et al., 2023). Character-tracking abilities and comprehension of grammatically complex sentences decline with age (Noh & Stine-Morrow, 2009; Lee et al., 2014), but global inferencing and basic comprehension skills often remain intact (Ulatowska et al., 1998; De Beni et al., 2003).

Magliano et al. (2012) investigated how story modality influences event segmentation—a key element of narrative understanding—among younger (ages 18–22) and older adults (ages 62–92). Their findings revealed comparable segmentation patterns across age groups, whether the stories were presented in text or pictures. This suggests that older adults continue to rely on situation-level cues similarly to younger adults when parsing narrative events.

Recent large-scale studies (Huff et al., 2025; Varkentin et al., 2024) suggest that, despite cognitive aging, narrative comprehension remains stable in older adults. This stability may stem from life experience and well-established event schemas that compensate for age-related cognitive changes. However, how stress interacts with these factors in older adults is less understood, even though stress has become an ever-present aspect of modern life.

Stress and Narrative Comprehension

Cognitive processes can be influenced not only by age or some internal processes, but also by external factors such as stress. Stress, particularly acute stress, is known to influence cognitive functions such as working memory, attention, and episodic memory—all critical to narrative comprehension. Research shows that acute stress often impairs working memory (Oei et al., 2006; Schoofs et al., 2008), a key component of the Structure-Building Framework (Gernsbacher et al., 1990). Impaired working memory may hinder information suppression, leading to difficulties in constructing coherent narratives.

Conversely, some studies indicate that acute stress enhances attention and response speed (Domes & Zimmer, 2019; Shields et al., 2019), potentially aiding processes like inferencing, which we utilize as a measure of narrative

comprehension in our study. This raises the question of how these findings translate to the relationship between stress and narrative comprehension. No studies to date have directly examined the effects of acute stress on visual narrative comprehension or inference generation, especially in both younger and older adults, to understand how aging interacts with these processes, leaving a critical gap in our understanding.

The Present Study

Our study addresses this gap by investigating the effects of acute stress on visual narrative comprehension in younger (experiment 1) and older adults (experiment 2). Using a stress induction tool involving time-constrained mathematical and logical tasks with social stress elements, participants evaluated three-panel pictorial stories where one panel was missing. Their task was to determine whether a proposed inference for the missing event was correct and additionally rate confidence in their responses. This design allowed us to assess the impact of stress on both comprehension accuracy and confidence. The control group performed an easy filler task before narrative comprehension measurement.

Experiment 1 and 2

Experiment 1 aimed to assess the effect of acute stress on narrative comprehension in younger adults. Considering the lack of prior evidence about the effect of acute stress on narrative comprehension, we stated a non-directional hypothesis and expected narrative comprehension to differ between the stress condition and the control condition (H1). In addition, we exploratorily tested whether there is a difference in confidence responses between the stress and control conditions.

Anticipating the results of Experiment 1 - acute stress reduced narrative comprehension in younger adults - we formulated a directional hypothesis in Experiment 2 and expected acute stress to affect narrative comprehension negatively in older adults (H2). In addition, we exploratorily tested whether there is a difference in confidence responses between the stress and control conditions.

Method

Participants In Experiment 1, we tested participants in a younger student sample ($N=203$, 18–57 years; $M=23$ years). The participants participated in exchange for course credit, or they had a chance to win one of two vouchers from a local bookstore. 24 participants were excluded for having previously participated in an experiment using the same stimuli. Additionally, 2 participants were excluded for not providing consent, and 3 participants requested to withdraw their data.

In Experiment 2, we recruited a sample of participants over 60 years old ($N=216$, 60–85 years; $M=67.32$ years) with an online-panel provider, which compensated participants for

their participation. Participants younger than 60 years old were excluded, resulting in the removal of 19 participants. Additionally, 22 participants were excluded for not providing consent, and 2 participants requested to withdraw their data.

Informed consent was obtained in both experiments and both experiments received ethical approval by the local ethics commission of the [blinded] (LEK 2022/043).

Materials We initially developed 24 textual stories to assess narrative comprehension. Each story included a beginning state, an end state, and a missing bridging event. Difficulty levels were varied by storyline complexity and the number of characters. Textual versions of these stories were pretested for difficulty and affect using a student sample ($N = 28$), confirming significant differences across difficulty levels ($p < .05$). A comic artist created equivalent pictorial versions of each textual story for consistent measurement across modalities (see Figure 1 for an example of a story).

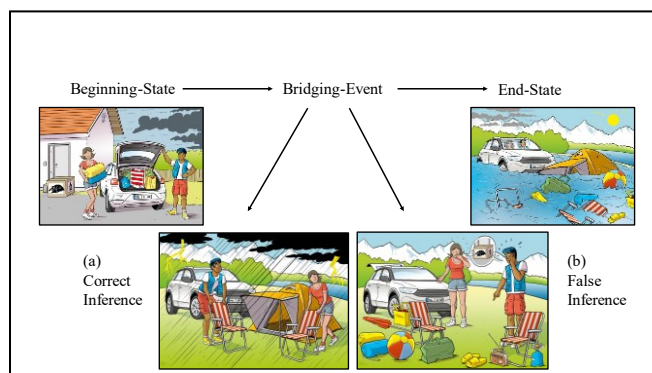


Figure 1: Example of a story. The upper row depicts the beginning and end states shown to participants, with a blank panel replacing the bridging event. The lower row illustrates two possible inferences for the missing event.

In our studies, we used only pictorial versions of the stories, as our focus was on visual narrative comprehension. For each of the 24 experimental clips, we presented either a true (12 trials) or a false (12 trials) inference. The selection of the 24 clips and the combination with true/false inferences was counterbalanced across participants.

Procedure Both experiments were almost identical, with only the level of induced stress and the presentation time in Experiment 2 (older sample) being minimally adjusted due to the requirements of the ethical committee (presentation time in younger sample 9 seconds, presentation time in older sample 11 seconds). The experiment was programmed as an online study, and participants were randomly assigned either to the stress or control condition. The experiment was conducted in German and began with providing general information about the study goals. However, participants were initially not told that stress induction was part of the experimental design. Instead, they were only told that mathematical and cognitive tasks would be presented.

Participants who agreed with the conditions provided consent. Afterward, demographic data were collected, including age, gender, education, and stress-coping strategies (based on the Stress Coping Inventar; Satow, 2012). Furthermore, participants provided information about their experience with comics in their adolescence and nowadays (7-point Likert scale). The online experiment began with stress induction or filler tasks, followed by the narrative comprehension task. Participants first completed two practice trials to familiarize themselves with the task.

Stress Induction The stress condition involved a six-minute task sequence using an online tool (Richer et al., 2023). Tasks included math, numerical Stroop, and mental rotation exercises with high time pressure and negative performance feedback. A subjective stress measurement using visual analog scale (1 to 100) and the Positive and Negative Affect Schedule (PANAS; Breyer & Bluemke, 2016) were used to measure subjective stress before and after the stress/control task. The control group completed filler tasks such as categorizing fruits and vegetables.

Narrative Comprehension Task Participants viewed 24 stories. The pictures were shown simultaneously in a row while the middle picture (bridging event) of each story was replaced by an empty frame. After viewing each story, they judged whether a presented inference picture for the missing bridging event— either correct or false — matched the story. Moreover, they rated their confidence in the answer. The set story viewing time was adjusted by age group: nine seconds for younger adults and 11 seconds for older adults. The task included an equal number of correct and false inferences, counterbalanced across participants. Older participants were additionally asked about viewing adequacy post-experiment. At the end of Experiments 1 and 2, all study participants were debriefed regarding the study aims. Thus, we could reduce their distress level, which should have been induced in the experimental group.

Analysis First, we will describe the results of Experiment 1 conducted with the younger adults. Second, we will present the findings from Experiment 2, conducted with the older adults. Finally, we will statistically compare the two datasets.

To test H1 and H2 (group difference in narrative comprehension task performance), we calculated proportion of correct inferences and then tested the variance homogeneity. A Welch two-sample t-test in Experiment 1 and a standard t-test in Experiment 2 were conducted. We additionally calculated a Bayesian t-test with a non-informative Jeffrey's prior, enabling the explicit testing of the null hypothesis. Exploratorily, we tested whether there was a between-group difference in participants' confidence in their responses by conducting a t-test for independent samples. We

additionally calculated a Bayesian *t*-test with a non-informative Jeffrey's prior.

Results

Experiment 1 (younger sample) To validate the stress induction, PANAS and subjective stress measurements were taken before and after the stress induction (stress condition) or filler tasks (control condition). A paired *t*-test for negative affect scores in the stress condition showed a significant increase from time point 1 to time point 2, $t(100) = -6.11, p < .001, d = 0.61$, and positive affect significantly decreased, $t(100) = 7.68, p < .001, d = 0.76$. In the control condition, negative affect showed no significant change, $t(101) = 0.99, p = .322, d = 0.10$, but positive affect decreased slightly, $t(101) = 4.58, p < .001, d = 0.45$. Subjective stress levels were significantly higher after stress induction, $t(100) = -6.53, p < .001, d = 0.65$, but unchanged in the control condition, $t(101) = 2.04, p = .978, d = 0.20$.

Furthermore, we compared the negative affect between both conditions with a *t*-test for independent samples. Between-group comparisons showed higher negative affect in the stress (experimental) compared to the control condition, $t(154.9) = -5.74, p < .001, d = -0.80$, and lower positive affect, $t(199.67) = 1.66, p = .049, d = 0.23$. Subjective stress was also higher in the stress condition, $t(193.94) = -5.36, p < .001, d = -0.38$. These findings confirm the effectiveness of the stress manipulation in the stress condition.

To test H1 (group difference in narrative comprehension performance), we calculated the proportion of correct inferences and tested variance homogeneity. An *F*-test revealed a significant variance difference, $F(101, 100) = 0.59, p = .008$. A Welch two-sample *t*-test confirmed a significant difference between conditions, $t(187) = 2.96, p = .004, d = 0.22$. Narrative comprehension was significantly impaired by acute stress ($M = 0.92, SD = 0.07$) compared to the control condition ($M = 0.95, SD = 0.05$) (see Figure 2).

Additionally, a Bayesian *t*-test with a non-informative Jeffrey's prior was conducted to explicitly test the null hypothesis, complementing the frequentist analysis. Following Jeffreys' (1961) heuristic, the test provided substantial evidence for the alternative hypothesis ($BF = 8.47$), indicating a difference between conditions.

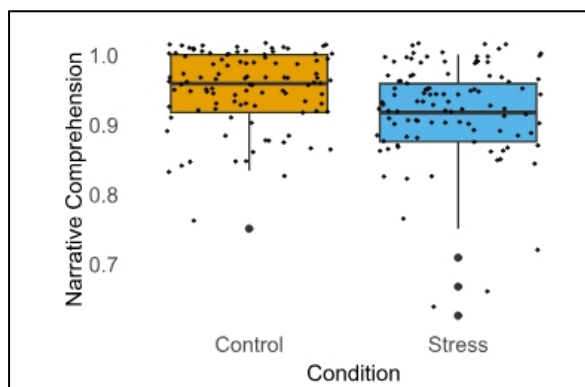


Figure 2: Boxplot depicting the distribution of narrative comprehension as a function of condition (control, stress) for the younger sample.

Exploratorily, we tested for between-group differences in participants' confidence in their responses. A *t*-test for independent samples revealed that participants in the control condition were significantly more confident than those in the stress condition, $t(201) = 2.06, p = .041, d = 0.41$ (see Figure 3).

A Bayesian *t*-test with a non-informative Jeffrey's prior provided indecisive evidence, neither supporting the null nor the alternative hypothesis ($BF = 1.10$).

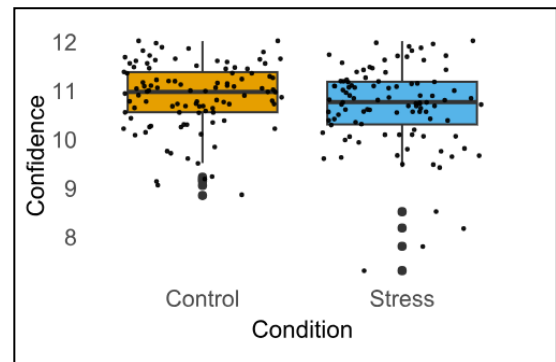


Figure 3: Boxplot describing the distribution of confidence in response in both conditions (control, stress) for the younger sample

Experiment 2 (older sample) To validate the stress induction, PANAS and subjective stress measurements were taken before and after the stress induction (stress condition) or filler tasks (control condition). A paired *t*-test for negative affect scores in the stress condition showed a significant increase from time point 1 to time point 2, $t(89) = -5.58, p < .001, d = 0.46$, alongside a significant decrease in positive affect, $t(89) = 5.67, p < .001, d = 0.59$. In contrast, the control condition revealed no significant changes in negative affect, $t(121) = 1.92, p = .057, d = 0.17$, or positive affect, $t(121) = 0.018, p = .986, d = 0.00$. Subjective stress levels significantly increased in the stress condition, $t(89) = -8.62, p < .001, d = 0.91$, but showed no significant change in the control condition, $t(121) = -0.77, p = .222, d = 0.07$.

Between-group comparisons using independent *t*-tests revealed that, at time point 2, negative affect was significantly higher in the stress condition than in the control, $t(141.6) = -4.87, p < .001, d = 0.68$. Positive affect was higher in the control condition, $t(198.5) = 2.01, p = .046, d = 0.40$. Subjective stress was significantly elevated in the stress condition compared to the control, $t(132.18) = -7.24, p < .001, d = 1.09$. These findings confirm the effectiveness of the stress manipulation in the stress condition.

To test whether acute stress impairs narrative comprehension in the older sample (H2), we first assessed variance homogeneity, which showed no significant

difference, $F(121, 8) = 0.94, p = .751$. A standard t -test revealed no significant difference in performance between the stress and control conditions, $t(210) = 0.25, p = .805, d = 0.03$ (Control: $M = 0.84, SD = 0.12$; Stress: $M = 0.84, SD = 0.12$).

A Bayesian t -test using Jeffrey's prior provided substantial evidence for the null hypothesis ($BF = 0.16$), supporting no performance difference between conditions (see Figure 4).

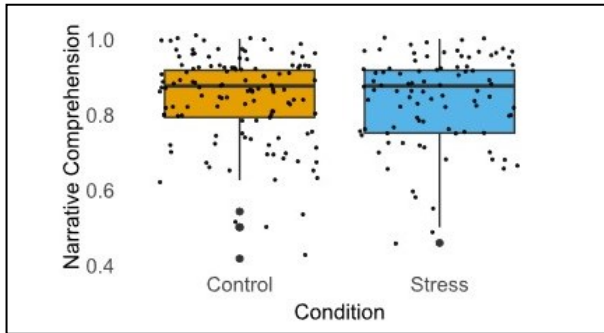


Figure 4: Boxplot describing the distribution of narrative comprehension test performance in both conditions (older sample)

Exploratorily, we tested for between-group differences in participants' confidence in their responses. The control group ($M = 9.06, SD = 1.22$) and stress group ($M = 9.23, SD = 1.11$) showed no significant difference, $t(210) = -1.03, p = .305, d = -0.14$.

A Bayesian t -test showed substantial evidence for the null hypothesis ($BF = 0.25$), indicating no effect of stress on confidence ratings.

Cross-experimental analysis: Comparison of two samples

We conducted a cross-experimental analysis comparing the two experiments to test for the interaction effect of age (younger vs. older sample) and condition (stress vs. control). We fitted a GLMM (generalized linear mixed models) with condition (stress, control) and age group (younger vs. older sample) as fixed effects (main effects and interaction), and participants and item as random intercepts. We submitted the resulting model to a type 2 Anova using the Anova function of the car package (Fox & Weisberg, 2019). Besides a significant main effect of condition (lower performance in stress condition, $\chi^2(1) = 3.78, p = .052$), and a significant effect of age group (lower performance for the older participants, $\chi^2(1) = 128.6, p < .001$), we observed a significant interaction effect of condition (stress, control), and age (younger, older), $\chi^2(1) = 4.62, p = .032$. While acute stress did not influence narrative comprehension in the older sample, it substantially impaired performance in the younger sample (see Figure 5). These findings align with and confirm the results of Studies 1 and 2.

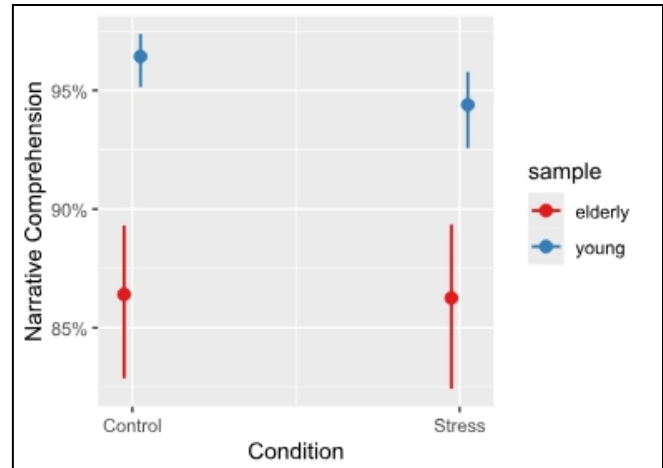


Figure 5: Predicted probabilities in the interaction model of condition and age

General Discussion

In this study, we examined narrative comprehension of pictorial stories in younger and older groups under stress and in a control condition. While stress affected narrative comprehension negatively in the younger group (supporting H1), narrative comprehension remained unaffected by stress in older adults (not supporting H2). This finding supports research, indicating the general stability of narrative comprehension skills in the elderly (Huff et al., 2025, Varkentin et al., 2024, Ulatowska et al., 1998). Comprehension of pictorial and textual narratives, measured with bridging inference generation remains stable and unaffected by age progression, even though cognitive skills and working memory are generally understood to show signs of decline as people age (Huff et al., 2025, Varkentin et al., 2024). The previous studies by Huff et al. (2025) and Varkentin et al. (2024) also employed a bridging event generation task to measure narrative comprehension. However, a key limitation in their research lies in the materials they used, which comprised only eight stories primarily tailored for the multilingual assessment of children. The consistency of our findings, using new and improved materials, with the previous results of Huff et al. (2025) and Varkentin et al. (2024) reinforces the idea that narrative comprehension remains stable with age. Future studies still should consider increasing the task difficulty, as in the present study, overall performance on narrative comprehension task was quite high.

The stability of narrative comprehension across age can be explained by a shift in comprehension processes. For instance, older adults may develop more differentiated event schemas or event models through age and experience. The structure-building framework (Gernsbacher et al. 1990) posits that when new information is related to previously acquired knowledge, it is integrated into pre-existing structures and schemas. It can be assumed that older individuals possess a greater number of schemas, which are more differentiated, allowing them to be more resilient to

stress during comprehension. Also SPECT theory (Loschky et al., 2020) emphasizes that the current event model is influenced by formed event models stored in episodic long-term memory. Maybe the amount of stored event models can compensate for the negative effect of stress. The idea of stability of narrative comprehension in age is also supported by the psychometrically-based theory of fluid intelligence and crystallized intelligence (Cattell R., 1963). Cattell describes (1963; 1971) fluid intelligence, which refers to the capacity to solve new reasoning challenges. In contrast, crystallized intelligence refers to the ability to apply fundamental relational concepts acquired earlier (Cattell, 1987), involving accumulated experience, gained knowledge, and the capacity to use that knowledge and skills in appropriate situations. Interestingly, both types of intelligence have their peaks. It is commonly assumed that peak of the fluid intelligence development happens at a young age, typically around the age of 20 (Schubert et al., 2019), while crystallized intelligence typically increases gradually and stays relatively stable across most of adulthood, and then begins to decline only after age 65 (Cavanaugh et al., 2006).

The unexpected finding that older adults' performance in narrative comprehension remains unaffected by stress could be partially attributed to their more efficient coping mechanisms. Applying effective and active coping mechanisms is essential for functional health and social relations. Older adults apply a combination of coping and defense strategies, suggesting enhanced impulse control and a propensity to view conflicts situations positively. In contrast, adolescents and younger adults tended to utilize strategies characterized by outward aggression and more psychological undifferentiation (Diehl et al., 1996). Coping capacities, exemplified by support-seeking, problem-solving, and distraction increase with age; moreover studies could find advancements in the utilization of various coping strategies based on their effectiveness in different situations (Zimmer-Gembeck & Skinner, 2011). Also, in the working context older workers utilize greater active problem-focused and active emotion-focused coping strategies compared to their younger colleagues (Hertel et al., 2015). However, there are also controversial findings, showing opposite results, for example, Chen and colleagues found that older adults were less likely than younger adults to use problem-focused coping and showed lower levels of positive affect (Chen et al., 2018). Even while aging may be associated with declines in memory, processing speed, and executive functioning (Harada et al., 2013), older individuals continue to discover methods to compensate for age-related deficits and remain active physically and cognitively. It was found that the use of compensation strategies (mental imagery, greater concentration or slowing down while doing cognitive tasks or including external aids) is associated with higher levels of functioning in daily life among older adults (Tomaszewski Farias et al., 2018). Compensation strategies are typically used proactively to postpone or reduce the decline in functionality, and in certain instances, they may also reflect

an amplification of long-term habits (Tomaszewski Farias et al., 2018).

The heightened impact of stress observed in the younger group may be linked to their perception of difficulties. Our study revealed that the younger group began the study with already notably higher levels of perceived stress, as measured by PSS ($M = 29.99$ in the younger group compared to $M = 23.05$ in the older group) and by subjective stress assessment using the visual analog scale ($M = 37.54$ in the younger group compared to $M = 12.37$ in the older group). Additionally, stress was found to significantly decrease confidence in responses among younger adults, while the confidence levels of older adults remained unaffected. This finding highlights the broad negative impact of stress on the younger sample. Stress not only impaired comprehension in younger adults but also led to increased feelings of insecurity. Our findings are in line with previous research (Heereman & Walla, 2011), which shows that stress results in reduced decision confidence when decisions involve moderate levels of uncertainty but has no effect in cases of either high or low uncertainty. Furthermore, ambiguity is less accurately assessed under stress conditions (Heereman & Walla, 2011). The APA's 2023 Stress in America survey found that young adults (ages 18 to 34) reported higher stress levels than those aged 65 and older. Young adults rated their average stress level as 6 out of 10, compared to 3.4 among the older generation (American Psychological Association; 2023). Similar patterns have been observed in previous studies, for instance, Aldwin et al. (1996) found that middle-aged men were more likely to view their problems as both challenges and annoyances compared to older men. Moreover, older people showed a lower stress-induced cortisol response than young people (Hidalgo et al., 2015). This can explain why the younger group was more negatively affected by stress in their narrative comprehension. Interestingly, in her study, Hidalgo and colleagues (2015) found a similar effect of stress, but in a memory recall task. Stress impaired the free recall of emotional (both positive and negative) and neutral pictures the next day after encoding, but only in the group of young men. This negative impact of stress was not observed in older adults. These findings, along with our results, indicate that the younger generation may be more sensitive to the negative effects of stress.

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