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On the effect of stress on cognitive failures in everyday life: A look into prospective memory errors

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Abstract:

Stress is a strong modulator of memory functioning and it seems to produce diverse effects depending on the memory type under study. The rather scant research on the harmful effect of stress on prospective memory has yielded somewhat inconsistent results. The present study was designed to explore, in a population-based sample of healthy adults, the relationship between perceived daily stress and cognitive failures, namely, general cognitive failures and prospective memory errors. Participants completed a battery of self-report questionnaires, including the Perceived Stress scale, the Cognitive Failures Questionnaire, the Prospective and Retrospective Memory Questionnaire, three scales derived from the Memory Compensation Questionnaire, the Ego-Resiliency scale, and the General Health Questionnaire. In addition, all participants were administered an objective test of prospective memory, modelled after the Continuous Lab Measure of Event Cued ProM. Results indicated that stress was associated with more severe everyday cognitive complaints and both subjective and objective prospective memory failures. Furthermore, high-stressed individuals complained more about psychological symptoms (e.g., anxiety, depression) and reported less resilience compared to low-stressed participants. The hierarchical regression

model revealed that, besides stress, variance in prospective memory errors was also explained by age and individual differences in both negative symptoms and use of memory strategies. Moreover, these latter moderated the relationship between stress and prospective memory. These findings reinforce the view that everyday stress can be highly disruptive for prospective memory functioning and highlight the potential relevance of individual factors in modulating the harmful consequences associated to daily stress.

Key words: daily stress, prospective memory errors, cognitive failures, moderating variables

Introduction

Prospective memory (PM) involves the mechanisms and characteristics of memory for actions that have to be performed in the future (Brandimonte 2006). Specifically, it refers to the ability to recall a previously formed intention at a specific time (*time-based* PM) or in response to a specific cue in the future (*event-based* PM), without being encouraged to recall the intention (McDaniel and Einstein 2000). Our everyday lives are filled and sometimes overflowing with prospective memory demands. Remembering to attend meetings in our work activities, to have dinner with a friend to maintain our social relations, or to take medication to handle our health-related needs, are just a few of the unequivocal examples showing how good prospective memory is essential for normal functioning (McDaniel and Einstein 2007). Indeed, Woods et al.'s (2014) recent meta-analysis revealed that both time- and event-PM are significantly associated with a wide array of real-world outcomes (e.g., general activities of daily living, medication adherence, quality of life, and engagement in risk behaviours) and encouraged future research to examine the potentially moderating influence of compensatory strategies, motivation, and clinical co-factors (e.g., depression) on these relationships.

This seems particularly important for practical reasons, as prospective memory errors can cause serious problems in effectiveness and efficiency or be even devastating. For instance, non-adherence to prescribed medication schedules due to a prospective memory failure can be somewhat problematic for patients with asymptomatic conditions like hypertension (Insel and Cole 2005), leading to severe health problems. Direct and pervasive consequences of prospective memory errors are also evident in work contexts. Reason (1990), in his classic book on human error, underlined that human frailty is one of the main causes of work accidents, also stressing that "failures of prospective memory…are among the most common forms of human fallibility" (p. 107). Yet, in spite of its relevance and implications for real-world functioning, thus far empirical literature on prospective memory has been somewhat inconsistent (Woods et al. 2014). For instance, it seems surprising that the effectiveness of prospective memory functioning has only recently attracted research with respect to experiencing stress, a fairly pervasive condition in daily life which may affect how we perform, how we feel, and many of our bodily functions (Bourne and Yaroush 2003).

Simply defined, stress refers to a disturbance of bodily homeostasis caused by a mismatch between situational demands and the individual's perceived resources to cope with such demands (Lazarus and Folkman 1984). Adverse effects of prolonged stress on physical (e.g., heart disease, cancer, stroke, etc.; Cohen, Janicki-Deverts, and Miller 2007) and mental health (e.g., depression, post-traumatic stress disorder, pathologic aging, etc.; Kendler, Karwoski, and Prescott 1999; Hammen 2005; Marin et al. 2011) are well-documented and a great deal of research suggests that stress can also tax cognitive functions, including memory (Staal 2004; Rönnlund et al. 2013). In particular, stress seems to force the individual to focus on the here-and-now, with consequent potential degradation of retrospective and prospective memory

performance (Bourne and Yaroush 2003). Indeed, stress is a strong modulator of memory functioning but it is also well-know that memory is not a unitary process and, therefore, stress can exert different effects depending on the memory type under study (Luethi, Meier, and Sandi 2008).

Across the board, previous works have found that everyday stress was the most perceived cause of everyday memory problems, as individuals reported a greater number of memory failures on stressor days than on non-stressor days (Neupert et al. 2006; Neupert, Mroczek, and Spiro 2008; Vestergren and Nilsson 2011). Specifically, Rönnlund et al. (2013) revealed that high-stressed individuals reported a higher frequency of retrospective and prospective memory failures. Similarly, Gupta and Pande (2015) revealed that daily stress was a significant predictor of mindfulness, attentional errors, prospective and retrospective memory errors. Instead, Luethi et al. (2008) found that exposure to stress was associated with a pronounced working memory deficit and this seems particularly interesting because of the unclear relationship between the latter and prospective memory (Nater et al. 2006). Also a substantial body of neurophysiological evidence seems to substantiate the detrimental effect of stress on prospective memory. Indeed, it clearly appears that prospective memory performance is closely related to prefrontal cortex (PFC) functioning (Arnsten 2009) and that stress-induced increased sympathetic nervous-system (SNS) activity is associated with increased catecholamine release, which, in turn, decreases firing of PFC neurons (Ramos and Arnsten 2007). Thus, one would reasonably expect that stress has the potential to strongly affect prospective memory performance. However, recent studies in which stress was experimentally induced in laboratory settings (e.g., Walser et al. 2013; Schnitzspahn et al. 2014) showed that prospective memory performance was not impaired under stress. Nater et al. (2006) even found that

stress might enhance time- (but not event-) based prospective memory.

Conceivably, the inconsistency in the available evidence is due, among other things, to the different classes of stressors each time at stake as well as to the diverse cognitive performances examined and their objective or subjective evaluation. It should also be noted that the threshold level at which stress begins to have an impact on cognitive performance is likely to vary with several individual factors that are often overlooked in the literature (Rönnlund et al. 2013).

For instance, consider how the simple use of compensatory strategies to meet cognitive challenges under stress and support everyday habitual performance and competence can enhance memory performance. In addition, there are specific personality factors that seem to play an important role in determining resistance to stress. In this regard, resilience has increasingly become a focus of research in the behavioural and medical sciences, conceived as a universal coping ability to bounce back or recover from stress, to adapt to stressful circumstances, and to function in spite of stress or adversity by virtue of a positive engagement with the world (Carver 1998; Caprara, Steca, and De Leo 2003). Indeed, its buffering effect in relation to the adverse impact of stress on psychological functioning is well-established (e.g., Beasley, Thompson, and Davidson 2003) but there is not substantial empirical evidence supporting its protective effect as referred to cognitive functioning. Additionally, there seem also to exist particular individual mood factors, such as depression or anxiety, that are associated not only with stress but also with memory performance (Rönnlund et al. 2013; Eysenck et al. 2007), even though their relevance for prospective memory is still to establish.

To address these gaps, the general purpose of the present study was to examine the relationship between daily stress and prospective memory in everyday life, as well as to

explore the potential moderating effect of individual factors (i.e., compensatory memory strategies, resilience and mental health) on the above relationship.

Method

Participants

The sample comprised 52 (56.5%) men and 40 women (43.5%) and included 4 subjects (4.3%) aged under 26 years, 16 (17.4%) aged between 26 and 35 years, 36 (39.1%) aged between 36 and 45 years, 21 (22.8%) aged between 46 and 55 years, and 15 (16.3%) aged over 55 years. The great majority of the participants (n = 48, 52.5%) had a degree or a post degree (n = 21, 22.8%), while 23 (25%) subjects had a high school degree.

Measures

After collecting a brief demographic profile (sex, age, educational level), participants were administered several self-report questionnaires and an objective test of prospective memory. These instruments are described below.

Psychological stress was evaluated using the Perceived Stress Scale (PSS-10; Cohen and Williamson 1988) (Cronbach's $\alpha = .86$; $M = 19.82$, $SD = 7.05$) which measures the degree to which situations in one's life are appraised as stressful. Item were designed to tap how unpredictable, uncontrollable, and overloaded individuals find their lives. A sample item is: "In the last month, how often have you been upset because of something that happened unexpectedly?". Responses were based on a five-point Likert scale (from 0 = never to 4 = very often). PSS scores are obtained by reversing the scores on the four positively stated items (items 4, 5, 7, and 8) and then summing across all scale items. It is possible to obtain a range of scores ranging from 0 to 40. Higher scores indicate a higher level of stress perceived by each individual.

Self-reported everyday cognitive failures were assessed via the Cognitive Failure Questionnaire (CFQ; Broadbent et al. 1982; Di Fabio, Giannini, and Martelli 2004) (Cronbach's α = .95; M = 45.63, SD = 18.07) which examines the level of slips of action, inattentiveness, and forgetfulness in daily life. The scale comprises 25 items on a five-point Likert format (from 0 = never to 4 = very often). A sample item is: "Do you read something and find you haven't been thinking about it and must read it again?". All questions are worded in the same direction. CFQ scores are obtained summing across all items and it is possible to obtain a range of scores ranging from 1 to 100. Higher scores indicate more self-reported cognitive failures.

Self-reported prospective and retrospective memory failures were evaluated using the Prospective and Retrospective Memory Questionnaire (PRMQ; Smith et al. 2000) which is a 16-item questionnaire assessing the frequency of memory failures on two main subscales: the Prospective Memory subscale (PRMQ ProM; sample item: "Do you fail to mention or give something to a visitor that you were asked to pass on?") (Cronbach's α = .88; M = 19.4, SD = 6.44) and the Retrospective Memory subscale (PRMQ RetM; sample item: "Do you forget something that you were told a few minutes before?") (Cronbach's α = .91; M = 19.59, SD = 6.7). Respondents rate the frequency of their ProM and RetM failures on a five-point Likert scale (from 1 = never to 5 = very often), resulting in minimum and maximum scores on either scale of 8 and 40, respectively. Higher scores indicate more self-reported memory failures.

A *paper-and-pencil measure of prospective memory* was obtained adapting the Continuous Lab Measure of Event Cued ProM (Lab EC ProM/C; Uttl and Kibreab 2011) which provides a more objective measure of prospective memory performance that is nearly reliable as standardized tests of episodic retrospective memory (Uttl, Hodgson, and White 2014).

Participants were instructed to circle all occurrences of a prospective memory cue while filling the various questionnaires. The prospective memory cue appeared four times in an increasingly intrusive visual form and location (e.g., increased font size, vertical lift, and horizontal spacing). The first prospective memory cue circled was used as an index of prospective memory ability; participants who circle the 1st occurrence of the prospective memory cue will receive 4 points, 3 points if the first circled cue is the 2nd cue, 2 points if it is the 3rd cue, 1 point if it is the 4th cue, and lastly 0 points if participants will not circle any cues. In the present study the cue word was "*punto*" and it appeared in the following visual form and spatial location: 1) in lower case, normal font, non-prominent location, embedded in the last question of the PSS; 2) in lower case, normal font, more prominent location, as part of question #3 in the MCQ; 3) in lower case, bold, more prominent location, appearing as part of question #11 of the Ego-Resiliency scale (this question was added for this purpose but was not included in the scoring of the scale); 4) in capitals, bold, more prominent location, appearing as part of the instruction of the GHQ-12.

Memory strategies were evaluated via the Memory Compensation Questionnaire (MCQ; Dixon and Bächman 1992) which assesses the extent to which individuals compensates for memory losses and deficits. In order to reduce participant burden for the present investigation, three out of seven original scales of the MCQ have been selected, featuring 23 items. The External scale (Cronbach's α = .84; M = 2.04, SD = .78) comprises 8 items concerning the use of external memory aids (e.g., notes, calendars, and bookmarks) for enhancement of everyday memory performance. A sample item is: "Do you post notes on a board or other prominent place to help you remember things for the future (e.g., meetings or dates?)". The Internal scale (Cronbach's α = .90; M = 1.91, SD = .81) includes 10 items focusing on the use of mnemonic strategies (e.g.,

imagery and rehearsal) for promoting effective memory performance. A sample item is: "Do you repeat telephone number to yourself in order to remember them well?". Finally, the Reliance scale (Cronbach's α = .81; M = 2.02, SD = .85) consists of 5 items concerning the extent to which the respondent recruits or uses other people as memory aids. A sample item is: "When you want to remember an important appointment do you ask somebody else (e.g., spouse or fiend) to remind you?". Responses are based on a five-point Likert scale (from 0 = never to 4 = always), with higher scores representing more frequent use of the indicated compensatory behaviour.

Resilience was assessed via the Ego-Resiliency scale (Block and Kremen 1996; Caprara et al. 2003) (Cronbach's α = .92; M = 4.6, SD = 1.07) whose items tap the ability to recover from stress and return to individual's ego-control after the temporary stressing influence is no longer acutely present. A sample items is: "I get over anger with someone reasonably quickly". The scale comprises 14 items on a four-point Likert scale (from 1 = never to 7 = always). Higher scores mean higher individual resilience.

Mental health was evaluated using the shortest version of the General Health Questionnaire (GHQ-12, Piccinelli et al. 1993; Goldberg and Williams 1998) (Cronbach's α = .89; M = 12.32, SD = 7.22) which is a well-known measure for the screening of non-psychiatric mental problems. Items tap factors as somatic symptoms, anxiety, insomnia, social dysfunction and depression. Participants report whether they have experienced a particular symptom of mental distress over the past few weeks according to a four-point Likert scale, ranging from 0 (= better than usual) to 3 (= much less than usual) for the six positively worded items and from 0 (= no) to 3 (= much more than usual) for the other six negatively worded items. Hence, the questionnaire gives a total score ranging from 0 to 36. The higher the score, the more symptoms an individual is experiencing.

Data analysis

First, following the procedure by Gupta and Pande (2015), independent sample t-tests and correlations between study variables were conducted to account for results. Then, multiple hierarchical regression was used to identify possible predictors of prospective memory. Next, variables were standardized and, subsequently, prospective memory and a single moderator at a time were entered into the second step of the regression equation (after control variables inserted at the first step), while the interaction term was added at the third step. When the interaction term was statistically significant, that is provided additional significant variance, Jeremy Dawson's Excel worksheet (2014) was used to graphically represent the interaction.

Results

Independent sample t-tests

Table 1. ***Median of perceived stress scores***

Variable	Median
Perceived Stress	20

Table 1 shows the median value of perceived stress scores. The perceived stress scores were divided into two groups (*low-perceived stress group* and *high-perceived stress group*) by using median split technique. The median was found to be 20.

Table 2. ***Means, standard deviations and t-values of low- and high-perceived stress groups on study variables***

Dependent variables	Mean		SD		t	Sign.
	M1 Low-perceived stress group	M2 High-perceived stress group	SD1	SD2		
Cognitive failures	40.3	53.21	16.6	17.55	-3.59**	.001
Prospective memory	17.11	22.66	5.3	6.57	-4.48***	.000
Retrospective memory	17.3	22.82	5.15	7.36	-3.99***	.000
Prospective memory test	2.89	2.24	.98	1.17	2.89**	.005
External memory strategies	2.3	1.68	.74	.7	3.98***	.000
Internal memory strategies	2.22	1.47	.72	.72	4.9***	.000
Reliance memory strategies	2.35	1.55	.73	.79	4.98***	.000

Resilience	4.94	4.11	.88	1.13	3.99***	.000
Mental health	10.3	15.18	6.63	7.13	-3.37**	.001

Note: *** p < .001, ** p < .01

Table 2 presents the independent sample t-tests between low- and high-perceived stress groups. When the two groups were compared, several significant differences emerged.

When it comes to cognitive failures, individuals experiencing high perceived stress reported more cognitive errors. Indeed, there was a significant difference in the scores for the low- (M = 40.13, SD = 16.6) and high-perceived stress (M = 53.21, SD = 17.55) groups; t (90) = -3.59, p < .01.

Likewise, as regards self-reported prospective memory, individuals experiencing high perceived stress reported more prospective memory errors. In fact, there was a significant difference in the scores for the low- (M = 17.11, SD = 5.3) and high-perceived stress (M = 22.66, SD = 6.57) groups; t(90) = -4.48, p < .01. Similarly, high-stressed participants also reported more retrospective memory errors. Again, there was a significant difference in the scores for the low- (M = 17.3, SD = 5.15) and high-perceived stress (M = 22.82, SD = 7.36) groups; t (90) = -3.99, p < .01. In fact, we further remember that, according to the scoring pattern of the Prospective and Retrospective Memory Questionnaire (PRMQ), the lower the score, the better the memory for both subscales.

Afterward, referring to the paper and pencil prospective memory test, the performance of individuals experiencing low perceived stress was slightly better than the one of high-stressed participants. Indeed, there was a significant difference in the scores for the low- (M = 2.89, SD = .98) and high-perceived stress (M = 2.24, SD = 1.17) groups; t (90) = 2.89, p < .01.

Subsequently, t-tests for memory compensation strategies suggested that low-stressed individuals drew upon them more than high-stressed ones. Indeed, in relation to external memory strategies, there was a significant difference

in the scores for the low- (M = 2.3, SD = .74) and high-perceived stress (M = 1.68, SD = .7) groups; t (90) = 3.98, p < .01. Similarly, regarding internal memory strategies, there was a significant difference in the scores for the low- (M = 2.22, SD = .72) and high-perceived stress (M = 1.74, SD = .72) groups; t (90) = 4.9, p < .001. Again, as concerns reliance memory strategies, there was a significant difference in the scores for the low- (M = 2.35, SD = .73) and high-perceived stress (M = 1.55, SD = .79) groups; t (90) = 4.98, p < .001

Next, in respect to resilience, low-stressed participants were slightly more resilient than high-stressed ones. In fact, there was a significant difference in the scores for the low- (M = 4.94, SD = .88) and high-perceived stress (M = 4.11, SD = 1.13) groups; t (90) = 3.99, p < .001.

Finally, low-stressed individuals' mental health was remarkably better than high-stressed ones. Indeed, there was a significant difference in the scores for the low- (M = 10.3, SD = 6.63) and high-perceived stress (M = 15.18, SD = 7.13) groups; t (90) = -3.37, p < .01.

Correlations

Table 3 depicts Pearson correlations between study variables.

Table 3. ***Pearson correlations between study variables***

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Gender (1=m, 2=f)	-												
2. Age	.03	-											
3. Education	.03	-.11	-										
4. Perceived stress	.02	.18	-.07	-									
5. Cognitive failures	.11	.22*	-.04	.35**	(.95)								
6. Prospective memory[a]	.16	.25*	.01	.43**	.78**	(.88)							
7. Retrospective memory[a]	.15	.25*	.02	.41**	.77**	.94**	(.91)						
8. Prospective memory test[b]	-.09	-.26*	.03	-.29**	-.39**	-.46**	-.48**	-					
9. External memory strategies	-.1	-.25*	-.04	-.39**	-.24*	-.32**	-.32**	.37**	(.84)				
10. Internal memory strategies	-.04	-.27**	.04	-.46**	-.34**	-.39**	-.40**	-.45**	.72**	(.90)			
11. Reliance memory strategies	-.05	-.11	.07	-.46**	-.20*	-.17	-.16	.25*	.67**	.58**	(.81)		
12. Resilience	-.04	-.17	-.1	-.39**	-.37**	-.39**	-.38**	.33**	.48**	.56**	.60**	(.92)	
13. Mental health[c]	.06	.12	.01	.33**	.58**	.54**	.54**	-.39**	-.16	-.18	-.26*	-.45**	(.89)

Note: Internal consistencies (Cronbach alphas) between brackets on the diagonal; [a] In both cases, lower scores indicate better memory; [b] Higher scores indicate better memory; [c] Lower scores mean better mental health while higher scores mean worse mental health; ** $p < .01$, * $p < .05$

Age positively correlated with cognitive failures ($r = .22$, $p < .05$), prospective ($r = .25$, $p < .05$) and retrospective memory ($r = .25$, $p < .05$), and negatively with prospective memory test ($r = -.26$, $p < .05$), external ($r = -.25$, $p < .05$) and internal memory strategies ($r = -.27$, $p < .01$).

Perceived stress positively correlated with cognitive failures ($r = .35$, $p < .01$), mental health ($r = .33$, $p < .01$), prospective ($r = .43$, $p < .01$) and retrospective memory ($r = .41$, $p <.01$), while it negatively correlated prospective memory test ($r = -.29$, $p < .01$), resilience ($r = -.39$, $p <.01$), external ($r = -.24$, $p < .01$), internal ($r = -.34$, $p < .01$) and reliance memory strategies ($r = -.20$, $p <.01$).

Cognitive failures positively correlated with mental health ($r = 58$, $p <.01$), prospective ($r = .78$, $p <.01$) and retrospective memory ($r = .77$, $p <.01$), and negatively with prospective memory test ($r = -.39$, $p <.01$), resilience ($r = -.37$, $p <.01$), external ($r = -.24$, $p <.01$), internal ($r = -.34$, $p <.01$) and reliance memory strategies ($r = -.20$, $p <.01$).

Prospective memory positively correlated with retrospective memory ($r = .94$, $p < .01$) and mental health ($r = .54$, $p < .01$), and negatively with prospective memory test ($r = -.46$, $p < .01$), external ($r = -.32$, $p < .01$) and internal memory strategies ($r = -.39$, $p < .01$), and resilience ($r = -.39$, $p < .01$).

Retrospective memory positively correlated with mental health ($r = .54$, $p < .01$), and negatively with prospective memory test ($r = -.48$, $p < .01$), external ($r = -.32$, $p < .01$) and internal memory strategies ($r = -.40$, $p < .01$), and resilience ($r = -.38$, $p < .01$).

Prospective memory test positively correlated with resilience ($r = .33$, $p < .01$), external ($r = .37$, $p < .01$) and reliance memory strategies ($r = .25$, $p < .05$), while it negatively

correlated with internal memory strategies (r = -.45, p < .01) and mental health (r = -.39, p < .01).

In respect to memory compensation strategies, external memory strategies positively correlated with resilience (r = .48, p < .01), internal (r = .72, p < .01) and external memory strategies (r = .67, p < .01). Instead, internal memory strategies positively correlated with reliance memory strategies (r = .58, p < .01) and resilience (r = .56, p < .01). Moreover, reliance memory strategies positively correlated with resilience (r = .60, p < .01) and negatively with mental health (r = -.26, p < .05).

Finally, resilience negatively correlated with mental health (r = -.45, p < .01).

Hierarchical regression and moderation

Table 4. ***Hierarchical regression analysis for prospective memory as criterion variable***

	Prospective memory		
	$\beta_{Step\ 1}$	$\beta_{Step\ 2}$	$\beta_{Step\ 3}$
Gender	.15	.15	.11
Age	.25*	.18	.07
Education	.03	.05	-.01
Perceived stress		.54***	.23*
External memory strategies			-.18
Internal memory strategies			-.21
Reliance memory strategies			.37**
Resilience			-.12
Mental health			.43***
R^2	.09*	.24***	.49***
ΔR^2	.09*	.15***	.25***

Note: *** p < .001, ** p < .01, * p < .05

A hierarchical regression analysis was conducted where the criterion variable was prospective memory as subjectively measured via the Prospective and Retrospective Memory Questionnaire (PRMQ). As depicted in Table 4, control variables (i.e., gender, age, and education) were inserted at step 1, perceived stress at step 2, while compensatory memory

strategies (i.e., internal, external, and reliance), resilience and mental health were inserted at step 3.

As regards control variables, only age showed a positive association (ß = .25, p < .05) at step 1, but its beta coefficient lost statistical significance after the insertion of perceived stress (ß = .54, p < .001) at step 2. At step 3, after the insertion of the other predictors, the beta coefficient of perceived stress decreased. A significant positive association emerged for both reliance memory strategies (ß = .35, p < .01) and mental health (ß = .34, p < .01) at step 3, while resilience, internal and external memory strategies did not show any significant association. Total R2 was equal to 49% (p < .01). Age explained 9% (p < .05) of prospective memory, while 15% of variance (p < .001) was attributable to perceived stress and, ultimately, 25% (p < .001) to both mental health and reliance memory strategies.

The decrease in age beta coefficient between step 1 and 2 could be an indicator of a potential moderation effect by perceived stress towards the relationship between age and prospective memory. Similarly, the decrease in perceived stress beta coefficient between steps 2 and 3 could be an indicator of a potential moderation effect by mental health and reliance memory strategies towards the relationship between perceived stress and prospective memory. In an exploratory way, other hierarchical regressions were conducted to check for these interactions.

Table 5. ***Hierarchical regression results for the effect of perceived stress and reliance memory strategies on prospective memory***

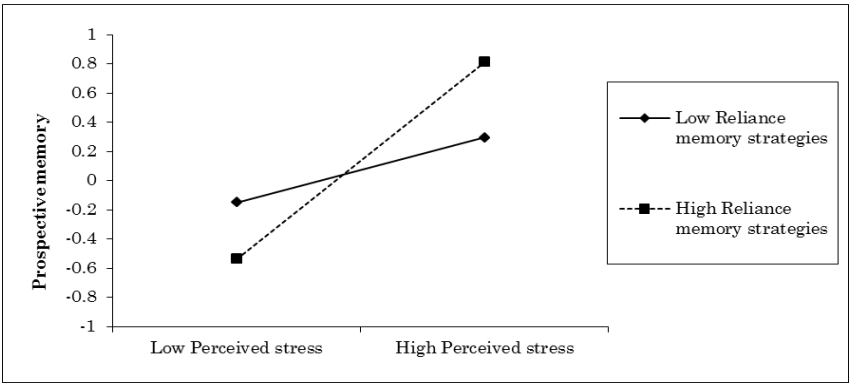
Variable	Model 1 ß	Model 2 ß	Model 3 ß
Step 1: control variables			
Gender	.15	.15	.17
Age	.25*	.18	.16
Education	.03	.05	.05
Step 2: main effects			
Perceived stress		.42***	.45***
Reliance memory strategies		.05	.03

Step 3: interaction effect			
Perceived stress x Reliance memory strategies			.21*
R^2	.09*	.24***	.28***
ΔR^2	.09*	.15***	.04*

Note: *** p < .001, ** p < .01, * p < .05

Table 5 shows the only significant interaction detected, namely those between perceived stress and reliance memory strategies on prospective memory (ß =.21, p < .05). Perceived stress indicated a significant association (ß = -.41, p < .01) but reliance memory strategies did not (ß = .03, p < .77), while the interaction term was significant (ß = .21, p < .05). The interaction term explained an additional R2 equal to .04 (p < .05; overall R2 = .28). In order to analyse this relationship properly, a graphic representation was made (see Figure 1). Perusal of this interaction suggested that individuals with high resilience reported less prospective memory errors only in the condition of low stress. Indeed, individuals experiencing a higher level of stress reported more prospective memory errors when using more reliance memory strategies.

Figure 1. ***Significant interaction effect between perceived stress and reliance memory strategies on prospective memory***



Discussion

Although for a long time has received scarce attention by memory researchers, prospective memory is essential for a wide array of everyday activities and its breakdown may be as disruptive as the impairment in retrospective memory (Graf and Uttl 2001). Drawing on a fairly inconclusive debate about its decline under stress conditions, the main objective of the current study was to examine the adverse effects of perceived stress on prospective memory errors.

The present results showed that high-stressed individuals reported a substantial higher frequency of both general cognitive failures and prospective memory errors compared to low-stressed ones. Therefore, the detrimental impact of stress also applies to proper prospective memory functioning. Confirmatory evidence of this negative effect was also provided by the association between perceived stress and both objective and subjective prospective memory measure. Indeed, to achieve a comprehensive assessment of prospective memory, this study evaluated both prospective memory as reported subjectively by the participants and objectively via a self-made test, observing a high concordance between the two measures.

Besides these cognitive performance discrepancies between high- and low-stressed individuals, pronounced differences were also found regarding the use of compensatory memory strategies, as it clearly appears that they were more frequent among less stressed individuals, and mental health, because participants who reported higher level of stress also complained about greater negative symptoms. Also resilience negatively related to perceived stress, suggesting that higher levels of resilience matched with lower levels of stress.

By means of a hierarchical regression analysis, it was observed that, when age was controlled, perceived stress accounted for the 15% of variance in prospective memory (as

subjectively evaluated). Moreover, mental health (e.g., negative symptoms as anxiety and depression) and reliance memory strategies, combined, explained the 25%. In addition, consistently with the literature suggesting that memory complaints are common among the elderly or increase with age (e.g., Jonker, Geerlings, and Schmaud 2000; Reid and MacLullich 2006; Vestergren and Nilsson 2011), also age related to prospective memory failures, accounting for the 9% of variance. Instead, nor resilience nor external and internal memory strategies were associated with prospective memory.

An interaction effect between perceived stress and reliance memory strategies on prospective memory was also detected, indicating that, in the case of moderate stress, leaning on reliance memory strategies might help in reducing prospective memory errors. However, the same did not seem true in high-stress situations, in which other more useful resources might come into play. Clearly, further research on the buffer effects of individual factors is overdue, in particular referring to these situations where persistent stressors linger.

Among the limitations of the current investigation, it is worthwhile highlighting that the nature of the study was cross-sectional, meaning that no reliable conclusions can be drawn regarding the casual directions of the effects. Second, we use self-report measures for all the study variables except prospective memory, which may increase the risk of misinterpret relationships owing to common method variance. However, this is not likely to give rise to false interactions as common method variance tends to attenuate rather than to inflate interactions (Spector 2006).

In conclusion, the present study provided a further look into the relationship between everyday stress and memory problems, shedding light on the adverse effect of stress on prospective memory functioning. From a practical standpoint, the results obtained could be useful for therapeutic interventions among individuals who report feeling stressed to

overcome potential memory failures. Future population-based studies on this issue could benefit from longitudinal designs to take into account casual chains effects and, as the current study may be considered only a first contribution for a more exhaustive examination of the moderation effects of individual factors, future research should also address in more depth the buffering role of other variables (i.e., personality traits) that may weaken the disruptive effect of stress on memory.

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