

DO PROSPECTIVE AND RETROSPECTIVE MEMORY CONCERNS PREDICT STEM STUDENTS' PERFORMANCE?

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Abstract— The present study aimed to examine the extent to which self-reported concerns about prospective and retrospective memory functioning, anxiety related to worrying, and academic self-efficacy can predict academic achievement (as measured by GPA) in undergraduate students during the first year of university studies. Purposive sampling was utilized to select participants from an understudied population of bilingual Saudi Arabian female STEM students. Participants were asked to report concerns about prospective and retrospective memory lapses, the extent to which they were confident in their ability to carry out academic tasks (i.e., academic self-efficacy), and the frequency and impact of anxiety-linked worrying. Responses illustrated greater prospective than retrospective memory concerns. Nevertheless, GPA increased as reports of retrospective memory lapses and distracting worries decreased. The relationship was modest, suggesting that awareness of retrospective memory failures and distractions does not correspond to an inability to satisfy academic demands. Instead, it may result in compensatory strategies that minimize the impact of both memory failures and distractions. Students also exhibited a modest relationship between memory concerns and academic self-efficacy, which suggested that memory issues play a minor role in the confidence students possess in their academic abilities. Taken together, these findings illustrate that although prospective memory lapses may be more noticeable in students' everyday lives, the ability to retain and retrieve past information and skills is more likely to impact performance on tasks that contribute to students' GPAs. The implications for teaching and learning of STEM undergraduate students are examined.

Keywords—academic self-efficacy, anxiety, GPA, prospective memory, retrospective memory, worrying

I. INTRODUCTION

Prospective memory generally refers to one's ability to carry out intentions at a particular time or during a specific event in the future [1-2]. It relies on attentional control mechanisms that maintain the intention activated in one's memory and that monitor the environment for cues that indicate when and where the intention is to be executed. For students, a common instance of prospective memory is remembering to submit work at predetermined times, days, and locations during a particular academic semester. Retrospective memory, instead, is the ability to preserve a record of past events and retrieve it as needed, such as remembering studied materials during an exam. Both types of memory may be considered relevant to academic life, particularly to students' ability to complete the variety of academic tasks that are demanded by their programs [3-4].

Evidence exists that anxiety is negatively related to performance in a variety of cognitive tasks [5]. More broadly, anxiety has been linked to academic difficulties, such as low GPA, standardized test scores, and graduation rates [5-6]. Academic performance relies on a host of

cognitive operations, of which memory is the common denominator. Thus, it is not surprising that evidence exists that memory performance and overall academic performance are affected by anxiety [7, 8, 9]. However, evidence also exists that anxiety may selectively affect prospective rather than retrospective memory performance [10].

How can anxiety affect human performance? Anxiety refers to an array of distracting, task-irrelevant symptoms, including irrational and uncontrollable feelings of tension, fear, dread, or danger, which are expressed through worries. The latter may be defined as concerns about future events, which are usually viewed as uncertain and negative in their outcomes [11-12]. Thus, worries are intrusive, unavoidable, and task-irrelevant thoughts, whereas worrying is a cognitive process and the principal mechanism through which anxiety can disrupt memory performance. Disruption occurs through working memory, a limited-capacity device devoted to the processing of information in real time. Important to note is that the retention and retrieval of information that is necessary for the execution of prospective and retrospective memory tasks rely on working memory. The functioning of this device is easily disrupted by worries, which occupy its limited operational space.

On the other side of negative emotions and undesirable behaviors such as procrastination, there are positive emotions that are supported by self-efficacy [13-14]. Academic self-efficacy is generally described as the belief students possess in their capability to perform academic tasks. Self-efficacy entails a subjective judgment about one's ability to structure and execute the actions necessary to attain specific outcomes. It is connected with motivated, intentional behaviors and, consequently, with academic success [15]. Individual differences exist in self-efficacy beliefs. For instance, young women in STEM fields, such as chemistry, computer science, and engineering, have been found to report lower self-efficacy beliefs than men [16].

Evidence is lacking on the extent to which self-reported prospective and retrospective memory concerns, academic self-efficacy, and worrying account for academic performance (as measured by GPA) in female undergraduate students at the completion of the first year of university studies. Of particular interest are undergraduate female students enrolled in science, technology, engineering, and mathematics (STEM) programs. They face gender stereotypes that discourage them from entering and persisting in STEM fields [17-18]. Thus, they are more likely than men to suffer from symptoms of anxiety, which may serve as an additional handicap to their success in STEM fields [4]. In the Kingdom of Saudi Arabia, female students in STEM fields are a key component of the economy proposed by the Vision 2030 programmatic plan. Yet, they remain an understudied population whose individual differences may determine the success of the plan.

The present field study rests on the acknowledgment that the first year of university studies is critical to the academic success of such students and their persistence in their chosen fields [19]. To this end, the study tests the following hypotheses for female undergraduate students as they are completing their first year of university studies:

H1 Self-reports of prospective and retrospective memory failures may differ in salience. For instance, not remembering a studied concept during an exam may not be so unusual in an undergraduate student's experience, whereas failing to remember that an exam is scheduled for today may be rather notable. If prospective and retrospective memory failures differ in salience, undergraduate students will report more prospective than retrospective memory lapses.

H2 If prospective and retrospective memory concerns, as well as worrying, are indices of disruptions of working memory processing, they will be found to increase as GPA decreases.

Instead, if academic self-efficacy reflects students' motivation, it will be found to increase with GPA.

H3 If memory is a key component of tasks that define academic performance, prospective and retrospective memory concerns will also be found to increase with worries and decrease with academic self-efficacy.

The relationships between GPA and any of the individual differences assessed here can support the development of targeted interventions for female STEM students at risk of academic failure. Knowledge of these relationships might also support the development of machine learning programs specifically devoted to the timely detection of academic difficulties in the selected underrepresented student population.

II. METHODS

A. *Participants*

The participants were 887 female undergraduate freshmen who were recruited through purposive sampling during the second part of their first year of university studies. Their ages ranged from 18 to 25 years. They were of Saudi Arabian descent with Arabic as their first language and English as their second language. English competency was assessed through IELTS (International English Language Testing System) and found to be equal to or higher than 6 (i.e., competent user of the English language). Participants were enrolled in STEM programs (computer science or engineering).

B. *Material and Procedure*

During the span of three semesters, students were recruited from the written English communication courses of the general education curriculum. Participants were asked to complete four questionnaires presented in randomized order to avoid carryover effects. Informed consent was collected prior to participation.

The Prospective and Retrospective Memory Questionnaire (PRMQ) [20-21] served as a self-report measure of prospective and retrospective memory concerns. The questionnaire contained 16 statements of memory lapses to be rated on a scale from 'never' (1) to 'very often' (5). Its reliability (as per Cronbach's Alpha) was 0.84 and 0.83, respectively.

The Generalized Anxiety Disorder (GAD-7) scale [22] was used to assess anxiety. It displayed 7 items describing anxiety symptoms, each to be rated for its frequency of occurrence on a scale from 'not at all' (0) to 'nearly every day' (3). Thus, the severity of the anxiety reported by students could range from 0 to 21. Cronbach's Alpha was 0.90. If participants indicated for any of the items a frequency higher than 0, they were asked to report the extent to which it made it difficult for them to perform activities in three different areas of everyday functioning: school, home, and social settings (i.e., interact with people). The scale to be used ranged from 'not difficult at all' (0) to 'extremely difficult' (3). Of particular interest were two items on the scale that reflected cognitive anxiety: 'not being able to stop or control worrying' and 'worrying too much about different things'.

The General Academic Self-Efficacy (GASE) scale [23-24] was used to assess participants' confidence in their abilities to perform academic tasks. It consisted of 5 items describing confidence in such activities to be rated on a 5-point scale ranging from 'strongly disagree' (1) to 'strongly agree' (5).

The Office of the Registrar provided the first-year GPA of the participants. As soon as the data from the questionnaires and GPA were matched, the data were anonymized before statistical analyses were carried out. The study was approved by the Deanship of Research as complying with the American Psychological Association's guidelines for the ethical treatment of research participants.

III.RESULTS

Table 1 displays the descriptive statistics of the data collected. In the table, GAD-7 scores are limited to the impact of worrying on school activities. Thus, the data of the two items of the GAD-7 scale involving worrying were multiplied by the extent to which anxiety made it difficult to perform activities in each domain. Scores ranged from 0 to 18 (6 x 3).

TABLE 1.
DESCRIPTIVE STATISTICS

Variables	Range	<i>M</i>	<i>SD</i>
Worrying (School Activities)	0-18	4.10	3.89
Prospective Memory Concerns	1-40	22.72	6.08
Retrospective Memory Concerns	1-40	21.09	5.92
Academic Self-Efficacy	1-25	19.73	3.42
GPA	0-4	3.31	0.57

All results of inferential statistics were considered significant at the 0.05 level. Below, analyses are organized by the hypotheses that were tested.

H1 predicted differences in the frequency of reporting memory lapses based on their salience. Students were more concerned about prospective memory lapses than retrospective memory lapses [$F(1, 886) = 181.26$, $MSE = 6.52$, $p < 0.001$, $partial \eta^2 = 0.170$]. During debriefings, students often remarked that although both prospective and retrospective memory failures were costly and unpleasant, the former were more unusual and thus more often the topic of conversation among peers and family members. It follows that salience might be responsible for the higher reports of prospective memory lapses, supporting H1.

Table 2 illustrates the relationship of each individual difference variable (i.e., worrying about school activities, prospective and retrospective memory concerns, and academic self-efficacy) with GPA. In the table, Pearson correlation coefficients are accompanied by coefficients of determination (CoD; % of the variance in GPA accounted for by self-reports).

TABLE 2
CORRELATION ANALYSES

Variables	GPA	CoD
Worrying (School Activities)	-0.32	10%
Prospective Memory Concerns	-0.21	4%
Retrospective Memory Concerns	-0.25	6%
Academic Self-Efficacy	<i>ns</i>	

The separate contribution of each individual difference variable to GPA was rather minor

or null (as in the case of academic self-efficacy). Pearson analyses, however, offered a window into binary relationships. To examine the contribution of each individual difference variable to GPA in the context of the contribution of the other variables, a linear regression analysis was performed. In this analysis, individual difference variables served as the predictors and GPA served as the outcome variable. The results of this analysis are displayed in Table 3. Only worrying about school activities and retrospective memory concerns negatively contributed to GPA, partially supporting H2.

TABLE 3
REGRESSION ANALYSIS WITH GPA AS THE OUTCOME VARIABLE

GPA	<i>B</i>	<i>SE b</i>	<i>Beta</i>	<i>p</i>
Constant	3.70	0.14		
Worrying (School Activities)	-.04	0.01	-.027	<.001
Prospective Memory Concerns	0.01	0.01	-.007	<i>ns</i>
Retrospective Memory Concerns	-.02	0.01	-.020	<.001
Academic Self-Efficacy	0.00	0.01	-.000	<i>ns</i>

Note: $R = 0.35$

The relationship between memory concerns and either worrying or academic self-efficacy was also explored to test H3. Anxiety related to worrying increased with both prospective memory concerns [$r = +0.44$, $n = 887$, $p < 0.05$] as well as retrospective memory concerns [$r = +0.43$, $n = 887$, $p < 0.05$]. As academic self-efficacy increased, both memory concerns decreased [$r = -0.16$, $n = 887$, $p < 0.05$; and $r = -0.11$, $n = 887$, $p < 0.05$, respectively]. Important to note is that the relationship between memory concerns and anxiety was much greater [18% and 19%] than the relationship between memory concerns and academic self-efficacy [1% and 3%].

Table 4 illustrates the regression analyses with worrying and academic self-efficacy as the predictors and either prospective or retrospective memory lapses as the outcome variable. Worrying predicted both types of lapses, but academic self-efficacy only predicted prospective memory lapses when combined with worrying. Of course, the direction of the contribution of these individual differences varied. Worrying exhibited a negative contribution, whereas academic self-efficacy exhibited a positive contribution. This pattern of results partially supported H3.

TABLE 4
REGRESSION ANALYSES WITH PROSPECTIVE OR RETROSPECTIVE MEMORY LAPSES AS THE OUTCOME VARIABLE

Prospective Memory	<i>B</i>	<i>SE b</i>	<i>Beta</i>	<i>p</i>
Constant	23.75	1.11		
Worrying (School Activities)	+0.67	0.05	+0.43	<.001

Academic Self-Efficacy	-0.19	0.05	-0.11	<.001
Retrospective Memory	<i>B</i>	<i>SE b</i>	<i>Beta</i>	<i>p</i>
Constant	20.45	1.10		
Worrying (School Activities)	+0.64	0.05	+0.42	<.001
Academic Self-Efficacy	-0.10	0.05	-0.06	<i>ns</i>

Note: Prospective Memory: $R = 0.47$; Retrospective Memory: $R = 0.43$

IV. DISCUSSION

The results of the present field study can be summarized into three points: First, students worried more about prospective memory lapses than retrospective ones. Second, GPA increased with declines in retrospective memory concerns and worrying about school activities. Academic self-efficacy did not appear to play a relevant role in students' GPA, perhaps because most students displayed elevated levels. Taken together, these findings are consistent with those of the extant literature showing that the responses to the PRMQ can predict actual memory performance [25]. They are also consistent with evidence showing that anxiety is detrimental to memory performance and, more broadly, to academic performance [6-5]. Third, as expected, memory concerns, irrespective of whether prospective or retrospective, increased with worrying. Prospective memory concerns also decreased with academic self-efficacy, suggesting that noticeable unpleasant events have more of a chance to be counteracted by self-efficacy beliefs.

The current study has limitations that need to be addressed in future research. For instance, it included only female undergraduate students, thereby questioning whether male students would display the same pattern of results. The examination of performance was limited to first-year GPA. The study did not examine the specific cognitive activities and challenges that students faced during their first year of university studies. Most importantly, the study did not contain a direct measure of memory failures. Self-reports of prospective and retrospective memory lapses may be biased by the salience of such lapses (as noted by students in debriefings). Thus, their actual frequency may not correspond to the frequency reported by students in the PRMQ. Furthermore, high academic self-efficacy beliefs, which question extant evidence of STEM women's deficiencies in self-efficacy [26], are likely to reflect the optimism bias [25], a form of wishful thinking through which self-regulation is performed by the selected sample of women [27].

Notwithstanding its limitations, the results of the present study have applications for teaching and learning in higher education. Self-reported prospective memory concerns can be used to predict students' academic difficulties [28]. To overcome such difficulties, workshops about goal setting, time management, and self-assessment [29-30] can be offered to freshmen before the start of the first semester of university studies. Such workshops may reduce anxiety related to worrying.

V. CONCLUSION

Although in the selected student population, prospective memory concerns are more acute than retrospective ones, the latter concerns appear to have a greater impact on academic success. These concerns exist in an ecosystem in which technological devices serve as reminders of intentions. Thus, although failing to execute an intention (e.g., forgetting to attend a makeup exam) may be a noticeable and memorable event, it is also likely to be an

infrequent occurrence given cell phones, smartwatches, and electronic calendars that remind students of things to carry out in the future. These devices serve as compensatory strategies intended to minimize errors. Without them, it is reasonable to expect prospective memory lapses to be more frequent but less memorable.

Failing to complete a retrospective memory task, such as forgetting studied information during an exam, may be considered a more frequent and less memorable occurrence, but a more impactful one if its consequences on students' GPAs are measured. In a society transitioning towards gender-equitable employment and a diversified economy, STEM female students are under intense pressure to succeed. Grades can open or close the door to available opportunities, making GPA a critical component of their career trajectory. Our findings illustrate that impressions held by students about their memory functioning can be selectively predictive of academic performance if considered in the context of the technological ecosystem in which students operate. Compensatory strategies, such as the use of electronic calendars, can diminish the impact of prospective memory lapses on academic activities, thereby explaining the null finding for academic performance uncovered in the present study.

ACKNOWLEDGMENT

We are grateful to Dr. Hanadi Mohamed Abdelsalam for her support and guidance in the development of this study. Her contribution was invaluable.

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