Effects of Acute Psychosocial Stress on Prospective Memory among Male Students

Christina J. Barnes and Courtney J. Lewis

ACSENT Laboratory

Department of Psychology

University of Cape Town

Author Note:

This research project was funded by the National Research Foundation. We give special thanks to Dr Kevin Thomas, Robyn Human, and Nicholas Reid for their contributions.

Supervisor: Gosia Lipinska

Co-supervisor: Robyn Human

Word count:

Abstract: 239

Main Body: 9 994

PLAGIARISM DECLARATION

1. I know that plagiarism is wrong. Plagiarism is using another's work and to pretend that it is one's own.
2. I have used the American Psychological Association (APA) as the convention for citation and referencing. Each significant contribution to, and quotation in, this literature review from the work, or works of other people has been attributed and has cited and referenced.
3. This literature review is my own work.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

Name: Christina Barnes (BRNCHR027) Courtney Lewis (LWSCOU001)

SIGNATURE:

DATE: 05 November 2015

Abstract

Background and aims: Successful prospective memory (PM) is the ability to execute a previously encoded intention in the future, and is crucial for everyday functioning. Only two studies have investigated the effects of acute psychosocial stress on PM performance, and their results were inconsistent. Our research aimed to expand the available literature and evaluate the effects of acute psychosocial stress on different phases of the PM process. Both event- and time-based PM performance were investigated within laboratory and naturalistic tasks.

Method: Participants were placed into one of four experimental conditions (n = 9). For the two stress conditions, the Fear Factor Stress Test (FFST) was used as the acute psychosocial stressor. The FFST was introduced either immediately before encoding or immediately before retrieval following a 24-hour delay. Both event- and time-based PM tasks were administered.

Results: We found no statistically significant differences in PM performance between stress and control groups. There were, however, statistically significant differences in PM performance in groups who had the stressor introduced at different PM phases. We found that stress at retrieval is more detrimental to PM than stress at encoding.

Discussion: The multi-processing framework of PM retrieval can explain our finding that while PM was generally robust, retrieval processes were susceptible to impairment. Further research on stress and PM is necessary, as it would have important implications in multiple situations one encounters on a daily basis, from remembering to keep appointments to medical adherence.

Keywords: prospective memory; acute psychosocial stress; FFST

Effects of Acute Psychosocial Stress on Prospective Memory among Male Students

Memory is a cognitive process that has been studied for more than one hundred years, yet is still not completely understood (Cohen, 1989). Memory is not a unitary construct, but rather an overarching cognitive process that is comprised of multiple, interacting systems (Glisky, 1996). Prospective memory (PM) is defined as the ability to remember to perform a specific action or activity in the future (Kvavilashvili & Ellis, 1996). Successful PM is crucial for everyday functioning and is used in various situations, from remembering to fetch one's children from school to remembering to take medication. Psychological interest in PM dates back to the beginning of the twentieth century (Freud, 1901), however as a distinct cognitive construct, PM has only been investigated empirically for little over two decades (Einstein & McDaniel, 1990, 1996; Shum, Fleming, Gill, Gullo, & Strong, 2011).

In both cognitively intact and cognitively impaired individuals, up to half of all memory complaints are prospective in nature. There are many causes and consequences of PM impairment, making it imperative that this cognitive process be examined under the most common conditions experienced on a daily basis that may alter cognition (Hannon & Daneman, 2007; Walser, Fischer, Goschke, Kirschbaum, & Plessow, 2013).

Prospective Memory

Successful PM requires the intact functioning of both retrospective memory components (i.e., remembering the contents of the intention) and prospective memory components (i.e., executing the intention at the appropriate time; Einstein & McDaniel, 1996). PM entails the encoding, retention (without active rehearsal), retrieval, and execution of delayed intentions. In contrast to retrospective memory (RM) retrieval, PM retrieval is not prompted by an explicit request to carry out the delayed intention. Rather, PM retrieval is self-initiated following either an event- or time-based cue (Rothen & Meier, 2014). PM requires intact working memory (WM) functioning, and in order for a PM intention to be

executed, the intention needs to be held in a global workspace long enough to be executed. A person needs to disengage from an on-going task in order to execute a PM intention before they can resume the on-going task again (Kidder, Park, Hertzog, & Morrell, 2007).

A distinction can be made between the different types of PM (event- and time-based), as well as between the different types of PM tasks used in research (i.e., naturalistic and laboratory). *Event-based* PM is the ability to retrieve and execute a delayed intention when a specific event (e.g., a person or place) is encountered. *Time-based* PM is the ability to retrieve and execute a delayed intention at a specific point in time. Event-based PM is less cognitively demanding than time-based PM, because external cues typically aid retrieval (Einstein & McDaniel, 1990).

In *naturalistic* PM tasks, participants retrieve and execute an intention within the context of their everyday lives. In *laboratory* PM tasks, the retrieval and execution of an intention occurs within an on-going task specific to the experiment. Research using naturalistic and laboratory PM tasks among the aging population yields conflicting results, which may be a reflection of task differences rather than general differences between naturalistic and laboratory studies (Rendell & Thomson, 1999). Therefore, further research incorporating both tasks is necessary for a more complete understanding of PM performance in all settings.

Neural bases of prospective memory. PM relies on general neurocognitive resources. This is evidenced by the increased activity in brain regions commonly associated with attention-demanding cognitive tasks and WM functioning during PM tasks. These areas include the parietal and parahippocampal regions, the anterior cingulate, and the prefrontal cortex (PFC; Owen, McMillan, Laird, & Bullmore, 2005). The most consistently reported brain region implicated in PM is the frontopolar PFC (Fish, Wilson, & Manly, 2010; Simons, Schölvinck, Gilbert, Frith, & Burgess, 2006). This area plays an important role in holding

the intention to execute a delayed action, irrespective of whether or not the opportunity to execute the action occurs (Burgess, Quayle, & Frith, 2001). The parietal and left parahippocampal regions are responsible for detecting environmental cues, while the hippocampal regions are responsible for retrieving intentions that have been associated with detected cues (Burgess, Gonen-Ysscovi, & Volle, 2011; McDaniel & Einstein, 2011).

From a cognitive neuropsychological viewpoint, most empirical PM investigations have focused on events and processes that render the frontal and medial temporal regions susceptible to injury and malfunction, such as traumatic brain injuries and aging (Einstein & McDaniel, 1990; McDaniel & Einstein, 2011; Mioni, McClintock, & Stablum, 2014). However, another factor that alters neural processing in these brain regions, and is relevant to both cognitively intact and cognitively impaired individuals, is acute stress (Wolf, 2003).

Acute Stress

As the demands of daily life increase, stress is an omnipresent issue that can have detrimental effects on both mental and physical health. When a person encounters a stressor, there are two primary visceral reactions: (1) a rapidly occurring activation of the sympathetic nervous system, from which catecholamines are released that produce autonomic responses; and (2) a slower activation of the hypothalamic-pituitary-adrenal (HPA) axis. HPA-axis activation is initiated by the secretion of corticotrophin releasing hormone by the hypothalamus, which stimulates the release of adrenocorticotropic hormone from the anterior pituitary, which then triggers the release of glucocorticoids (i.e., cortisol in humans) into the bloodstream by the adrenal cortex (Alderson & Novack, 2002; Kemeny, 2003).

Cortisol crosses the blood-brain barrier and binds to glucocorticoid receptors in regions throughout the brain, including the hippocampus, PFC, and the amygdala, thereby affecting cognitive performance (Walser et al., 2013; Wolf, 2003). The presence of increased levels of glucocorticoids modifies neuronal excitability, and in doing so alters structural and

neurochemical brain features. Specifically, neuronal firing is inhibited in the PFC and medial temporal regions, neuronal responsiveness is altered in the hippocampus, and neuronal excitability is enhanced in the amygdala (Cornelisse, van Stegeran, & Joëls, 2011; Lupien & McEwan, 1997).

Stress-induced elevations in cortisol disrupt RM encoding of neutral but not emotional information as a result of inhibited neuronal firing in frontal and hippocampal regions (Payne et al., 2007). Additionally, RM consolidation, particularly of emotionally arousing information, can be enhanced by glucocorticoid agonists and their interactions with noradrenergic activation in the amygdala and other areas of the brain (Payne et al., 2007; Roozendaal, 2002). Finally, an abundance of glucocorticoid agonists in the hippocampus and PFC makes RM retrieval susceptible to impairment (de Quervain, Aerni, Schelling, & Roozendaal, 2009; Nater et al., 2006; van Ast et al., 2013). Since cortisol affects RM and the brain regions that PM relies on, namely the prefrontal and medial temporal cortices, it is reasonable to believe that acute stress may affect all aspects of the PM process.

Prospective Memory and Acute Stress

Previous research regarding the effects of stress on memory has been equivocal, as memory performance can be either weakened or strengthened under conditions of stress. While evidence suggests that stress affects long-term RM, there is a paucity of data regarding the effects of acute stress on PM (Nater et al., 2006; Walser et al., 2013).

Three studies have investigated the effects of elevated cortisol levels on PM functioning, the first of which did not investigate acute stress. Nakayama, Takahashi, and Radford (2005) studied the effects of chronically elevated cortisol levels on event-based PM performance, as well as RM performance, among male students within a laboratory setting. While results indicated a significant positive correlation between salivary cortisol levels and

RM, no correlation with PM was found. One limitation of this study was the reliance on baseline cortisol levels as opposed to examining stress-related cortisol effects.

The limitations of Nakayama and colleagues' (2005) protocol was addressed in a study that examined the effects of stress-related elevations in cortisol on both event- and time-based laboratory PM tasks in healthy male students (Nater et al., 2006). Acute psychosocial stress was induced before PM encoding using the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). No significant relationship between elevated cortisol levels and event-based PM was found. However, time-based PM accuracy performance was significantly better in the participants exposed to the stressor.

The third study (Walser et al., 2013) extended the investigation into the effects of acute psychosocial stress on PM in both male and female students. Stress was induced using the TSST immediately after PM encoding, and then a computerised event-based PM task was administered to participants. The task involved the display of target cues within an on-going task, namely categorising nouns as either animate or inanimate. Using this task, both PM performance and the ability to inhibit a response to a PM cue when the intention had been previously executed (i.e., intention deactivation [ID]) were assessed. ID is important to consider because a failure to successfully deactivate no-longer relevant intentions could interfere with future tasks. The study found no significant effects of acute psychosocial stress on PM task performance, on-going task performance, or ID, irrespective of gender.

As demonstrated above, research into the effects of acute psychosocial stress on PM is inconsistent. One study suggests that time- as opposed to event-based PM performance is enhanced by stress-induced elevated cortisol levels (Nater et al., 2006). The other two studies found that acute psychosocial stress does not have a significant effect on event-based PM performance (Nakayama et al., 2005; Walser et al., 2013). These findings fail to support the argument that time-based PM is more cognitively demanding than event-based PM, and

that stress-induced elevated cortisol levels have a generally detrimental effect on PM. As a result of these inconsistencies, further investigation is needed to understand the relationship between acute psychosocial stress and PM performance.

Rationale and Significance

Stress is a frequently experienced phenomenon and acute stressors are some of the most important factors that affect our day-to-day performance (Walser et al., 2013). PM is relied on for normal everyday functioning, and PM complaints are common in both healthy and cognitively impaired individuals (Shum et al., 2011; Walser et al., 2013). Since glucocorticoids influence brain processes and regions associated with PM, it is important that the possibility of PM impairments due to stress be investigated (Wolf, 2003). While PM failures can cause frustration and embarrassment, they can impact on health and even be life threatening when these failures, for example, result in non-adherence to prescription medication (Shum et al., 2011).

There is a large burden of infectious disease, including tuberculosis and Human Immunodeficiency Virus (HIV) in South Africa, where more people are currently on antiretroviral treatment than any other country in the world (World Health Organization, 2015). Successful PM is of utmost importance as these diseases necessitate high levels of adherence to complicated regimes of prescription medication (Park & Kidder, 1996). For practical applications to emerge out of this line of research, such as enhanced medication adherence, stress and PM need to be investigated more fully.

The effect of acute stress on PM functioning is clearly under-researched given the prevalence of acute stress and the importance of PM for daily functioning. The three studies that have investigated this effect were conducted using laboratory PM tasks, omitting naturalistic PM tasks and reducing ecological validity. Additionally, these studies did not attempt to explicitly examine the effects of stress on different phases of PM. Nater and

colleagues (2006) were unable to differentiate between PM encoding, retention, retrieval, and execution because the stressor was introduced before encoding. Walser and colleagues (2013) were unable to differentiate between PM retention, retrieval, and execution because the stressor was introduced immediately after encoding. While Walser and colleagues (2013) also investigated ID performance, WM ability was not controlled for. By assessing PM and ID, participants would have to hold the content of the intention while adjusting their response according to the required task. Therefore, in controlling for WM performance we ensured that observed variations in PM performance could not be attributed to differences in WM ability.

Aims and Hypotheses

In order to address the abovementioned gaps in the literature, we investigated the effects of acute psychosocial stress across different phases of PM processing (i.e., encoding and retrieval) in both event- and time-based laboratory and naturalistic PM tasks. Additionally, the effects of acute psychosocial stress on ID was investigated.

The hypotheses for both laboratory and naturalistic PM tasks in our study were:

1. Under conditions of acute psychosocial stress, participants would perform more poorly on both event- and time-based PM tasks than under non-stressful conditions.
2. Under conditions of acute psychosocial stress, participants' ability to deactivate previously executed intentions would be poorer than under non-stressful conditions.
3. Participants experiencing acute psychosocial stress at the encoding stage of the PM process would perform more poorly on both event- and time-based PM tasks than participants experiencing acute psychosocial stress at the retrieval stage of the PM process.
4. Under both stressful and non-stressful conditions, participants' performance on time-based PM tasks would be poorer than on event-based tasks.

Method

Study Design and Setting

We used a 2 x 2 x 2 factorial quasi-experimental design. The independent variables were: (1) experimental manipulation (stressed vs. control); (2) the phase of memory process at which stress was induced (encoding vs. retrieval); and (3) type of PM task (event- vs. time-based). The outcome variables were derived from the participants' performance on both laboratory and naturalistic PM tasks: (1) accuracy for both naturalistic and laboratory time-based tasks; (2) reaction time (RT) and error rate (ER) for the laboratory event-based task; and (3) accuracy for the naturalistic event-based task.

The study took place in ACSENT and Sleep Laboratories in the Department of Psychology at the University of Cape Town (UCT). The Sleep Laboratory was used for the experimental manipulation and the remainder of the testing took place in ACSENT Laboratory. Each participant attended two sessions over two consecutive days, to allow a 24-hour consolidation period for information participants encoded in the first session. Sessions commenced at 14h00, 16h00, or 18h00 to control for diurnal cortisol rhythms, so that there would be no significant differences in baseline cortisol levels among participants (Kudielka, Hellhammer, & Wüst, 2009).

Our study adhered to the ethical guidelines outlined by the Health Professions Council of South Africa. Ethical approval was granted by the Faculty of Health Sciences Human Research Ethics Committee at UCT (Appendix A), and by the Department of Psychology Research Ethics Committee at UCT (Appendix B).

Participants

Thirty-six South African male students aged 18 to 26 years ($M = 21.06 \pm 1.77$) from UCT were recruited using the Department of Psychology's Student Research Participation Programme (SRPP) and the UCT Student Invitation Initiative. Participants signed up for the

research sessions via email correspondence. Each participant was randomly assigned to one of four experimental groups (n = 9) prior to the start of his first session (see Table 1). As compensation, participants were either awarded 4 SRPP points or entered into a raffle for one of three Cavendish Square Shopping Centre vouchers (R1000, R500, or R250).

Table 1

Experimental Conditions

Group	Procedure Order				Stage of Memory Process Under Investigation
	Stage 1	Stage 2	Stage 3	Stage 4	
SEDR	Stress	Encoding	24-hour delay	Retrieval	Encoding / Consolidation
CEDR	Control	Encoding	24-hour delay	Retrieval	–
EDSR	Encoding	24-hour delay	Stress	Retrieval	Retrieval
EDCR	Encoding	24-hour delay	Control	Retrieval	–

Note. SEDR = Stress-Encode-Delay-Retrieve; CEDR = Control-Encode-Delay-Retrieve; EDSR = Encode-Delay-Stress-Retrieve; EDCR = Encode-Delay-Stress-Retrieve.

Exclusion criteria. The exclusion criteria for our study were: (a) smoking, (b) the presence of a DSM-5 disorder (American Psychiatric Association, 2013), (c) a score of ≥ 29 on the Beck Depression Inventory (2nd ed., BDI-II; Beck, Steer, & Brown, 1996), (d) the use of any steroid-based medication, and (e) female gender. The exclusion criteria were chosen based on their influence on basal cortisol levels and cortisol responsiveness to acute psychosocial stress (Kudielka et al., 2009). Significantly higher salivary cortisol responses are found in males, and particularly in older males and healthy young males using steroid-based medication. Smoking is also associated with chronically elevated cortisol levels. Finally, altered cortisol response is seen in both clinically depressed and anxious populations (Almeida, Piazza, & Stawski, 2009; Kudielka et al., 2009).

Materials

Self-report measures.

Beck Depression Inventory-II (BDI-II). We used the BDI-II (Beck et al., 1996), a 21-item self-report questionnaire, to screen for depressive symptomatology. In this measure,

participants chose one of four possible responses to each item that best described how they had been feeling in the previous 2 weeks. Higher scores indicate higher levels of depressive symptomatology (Beck et al., 1996). The BDI-II has a high internal consistency (α = .91; Dozois, Dobson, & Ahnberg, 1998), good test-retest reliability (α = .93; Beck et al., 1996), and adequate factorial and content validity (Dozois et al., 1998).

State-Trait Anxiety Inventory (STAI). The STAI (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) measures both state anxiety (levels of anxiety at a specific time point) and trait anxiety (i.e., general levels of anxiety) on different forms (i.e., the STAI-State form and the STAI-Trait form, respectively). Each form contains 20 statements that are answered on 4-point Likert-type scales. Positive items were reverse scored to eliminate response sets. Scores range from 20 to 80 with no specific cutoff scores provided, therefore while higher scores indicate higher anxiety levels, we did not exclude any participants on the basis of their anxiety scores.

The STAI-Trait was used to ensure equivalence across experimental groups, as differences in anxiety levels could confound our results. The STAI-State was used to measure changes in subjective anxiety levels during the experiment. The STAI has a reliable factor structure, high internal consistency (α = .86 - .95) and test-retest reliability coefficients (r = .69 - .89), as well as good construct and concurrent validity (Spielberger & Vagg, 1984).

Physiological measures.

Salivary cortisol. We obtained saliva samples to measure cortisol, as it was a simple, non-invasive and non-stressful method for participants (Garde & Hansen, 2005). Participants chewed SARSTEDT Salivette® Cortisol swabs (Sarstedt, Nümbrecht, Germany) for 1 minute, at three time-points throughout the experimental manipulation session (i.e., baseline, post-manipulation, and end of session). We immediately placed the swabs in individually labeled test tubes and froze them (- 3ºC) until analysis by the National Health Laboratory Services.

Heart rate. We used the Vrije Universiteit Ambulatory Monitoring System, version 5fs (VU-AMS; Vrije Universiteit, Amsterdam, Holland) to record electrocardiograms. The VU-AMS is non-invasive and portable, and therefore did not constrict participants' movement. Three heart rate (HR) measurements were taken throughout the experimental manipulation session (i.e., baseline, post-manipulation, and end of session).

Experimental manipulation.

Fear-Factor Stress Test (FFST). We used the FFST (du Plooy, Thomas, Henry, Human, & Jacobs, 2014), an acute psychosocial stressor, as the experimental manipulation in this study. The FFST contains a combination of a social-evaluative threat (as seen in the TSST; Kirschbaum et al., 1993), and a physiological stressor (as seen in the Cold Pressor Test; Hines & Brown, 1932). The FFST is an ecologically valid way to elevate cortisol levels, as it incorporates both psychosocial and physiological aspects from two well-established stressors, and creates a believable stress experience (du Plooy et al., 2014).

Participants in experimental stress groups were asked to imagine that they were auditioning for the reality television show *Fear Factor*. They were told that they would have to complete three tasks in front of two judges (one male and one female), a video camera, and a bright light: (1) a motivational speech lasting 5 minutes (which they were given 10 minutes to prepare for); (2) a verbal arithmetic task (subtracting 17 from 2043 continuously); and (3) submerging their dominant arm in ice water for as long as possible (2 minutes maximum). Participants believed that the judges were behavioural specialists, studying both their verbal and non-verbal behaviour. Risks of lasting psychological distress associated with the FFST (i.e., being placed in a mildly stressful situation involving public speaking and the physical discomfort of submerging a hand in ice water) were avoided by using the BDI-II as a screening measure to exclude those with any pre-existing depressive symptomatology.

Control condition. Participants in the control condition completed four tasks of equivalent cognitive load to the FFST. After writing about their day's activities for 10 minutes, participants were asked to: (1) read aloud, in a room alone, from a National Geographic© magazine for 5 minutes; (2) count aloud, in a room alone, in multiples of five for 5 minutes; and (3) submerge their dominant hand in warm water for 2 minutes (du Plooy et al., 2014).

Prospective memory tasks.

Laboratory event-based PM task. We created an English version of the German computerised event-based PM task used by Walser and colleagues (2013) using E-Prime 2.0 software (Psychology software Tools, Pittsburgh, PA). The on-going task was to classify animate (e.g., barber) and inanimate (e.g., barrel) words using the *F* key and the *J* key, respectively. We administered a practice on-going task to familiarise participants with the task. To ensure that the participants understood the instructions, they were only allowed to proceed to the full laboratory event-based PM task once they achieved a minimum accuracy of 85%.

The full task comprised of four cycles, each containing one PM block and one ID block. In each block, 11 animate and 11 inanimate words were randomly presented two times. We created our dataset using the neutral set of Affective Norms for English Words List (Bradley & Lang, 1999). In the PM block, when a PM cue was presented (either *eagle* [animate] or *candle* [inanimate]), the participant needed to respond by pressing the spacebar key. In the ID block assessing deactivation of completed intentions, the participant completed the on-going task without responding differently to PM cues.

Laboratory time-based PM task. A colleague created an Android© application (version 5.0.2), compatible with a 10-inch Samsung© Galaxy Tab 4, to assess time-based PM. The application displayed a running clock on the screen of the device, with a log-button

underneath. Participants needed to monitor the time and press a log-button every 1 minute as accurately as possible. This task ran simultaneously to the laboratory event-based PM task, whereby the event-based task served as an on-going task for this time-based PM task.

Naturalistic event-based PM task. During encoding in the first session, we instructed participants to state their name and student number aloud after the completion of each cognitive task they performed in their second session. Before each task, we told participants that they would be completing a cognitive task, which acted as the environmental PM cue.

Naturalistic time-based PM task. During encoding in the first session, participants were asked to send us an email at a specific time on the next day. For groups completing the experimental manipulation at encoding, the time was set at 09h00 on the day of their second session. For groups completing the experimental manipulation at retrieval, the time was set at 1 hour after participating in their second session. The email needed to contain their name, student number, and session time.

***Working memory task*.** E-Prime 2.0 software (Psychology software Tools, Pittsburgh, PA) was used to create our *N*-Back task, which assessed participants' WM capacity. Participants were presented with sequences of letters and needed to determine if the letter presented matched the one presented *n*-letters earlier (Kane, Conway, Miua, & Colflesh, 2007; Owen et al., 2005). If the presented letter matched the one presented *n*-letters earlier, participants had to press the *F* key on the keyboard; if it did not, participants had to press the *J* key. Our study used the 3-Back level of difficulty. Before administering the experimental *N*-Back task, participants completed a practice *N*-Back task with comprehensive examples and instructions. Participants needed to achieve a minimum of 80% in the practice *N*-Back task to move on to the experimental *N*-Back task. This was done to ensure that participants understood the *N*-Back instructions.

Procedure

Before participants received the experimental manipulation, they were instructed not to eat, drink (except water), or do strenuous exercise for a minimum of 2 hours before the relevant session. These restrictions aimed to control for variations in baseline cortisol levels (Kudielka et al., 2009). Upon arrival for the first session, we obtained written informed consent from participants (Appendix C), before administering the BDI-II and STAI-Trait questionnaires. The BDI-II was scored (while participants completed the STAI-Trait) to ensure that only participants with a score of ≤ 29 would continue.

Experimental manipulation before encoding.

First session. Once we fitted the VU-AMS to participants and allowed for a 5 minute stabilisation period, participants completed the first STAI-State questionnaire and we collected the first saliva sample. Following this, we took a 2 minute baseline HR recording. Participants then completed the on-going categorisation, the practice *N*-Back and the experimental *N*-Back tasks.

Following these baseline tasks, participants either: (1) completed the 22 minute FFST procedure followed by a 5 minute relaxation period (EDSR); or (2) completed the control procedure (CEDR). All participants then completed the second STAI-State questionnaire and then we collected the second saliva sample. Participants then encoded the target words for the laboratory event-based PM task, the instructions for the laboratory time-based PM task, as well as the instructions for both the naturalistic PM tasks. To ensure that all of the necessary information was encoded correctly, we asked participants to repeat the instructions back to us and told them that they were not allowed to write any of the information down to remind themselves. The first session ended with participants completing the third STAI-State questionnaire and us collecting the third saliva sample.

Second session. Participants needed to have emailed us at 09h00 with all the correct information. Upon arrival, participants completed the laboratory event- and time-based PM tasks simultaneously, without external cues. For the event-based naturalistic PM task, participants needed to state their name and student number at the end of each cognitive task.

Experimental manipulation before retrieval.

First session. Participants completed the on-going categorisation, the practice *N*-Back, and the experimental *N*-Back tasks. After these baseline tasks, participants encoded the PM target words for the laboratory event-based PM task, and were given the instructions for the laboratory time-based and both naturalistic PM tasks.

Second session. Once we fitted the VU-AMS to participants and allowed for a 5 minute stabilisation period, participants completed the first STAI-State questionnaire and we collected the first saliva sample. We then took a 2 minute HR recording, following which, participants either underwent: (1) the 22 minute FFST procedure followed by a 5 minute relaxation period (EDSR); or (2) the control procedure (EDCR). After the experimental manipulation, participants completed the second STAI-State questionnaire and we collected the second saliva sample. Next, the laboratory event- and time-based PM tasks were administered simultaneously, without external cues. For the event-based naturalistic PM task, participants needed to state their name and student number at the end of each cognitive task. Participants then completed the third STAI-State questionnaire, and we collected the third saliva sample. One hour after the session ended, participants needed to email us with all the correct information.

Debriefing. We debriefed all participants at the end of the second testing session. We told participants who underwent the FFST procedure that the video camera was a prop, that they were not being recorded, and that the judges were not behavioural specialists. We also explained that this deception was necessary in order to achieve the required increase in

cortisol levels. Details of a clinical psychologist were available for participants feeling subjectively distressed after debriefing (See Appendix D for Debriefing Form).

Data Analysis

Statistical analyses were run using Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM. Corporation, 2013, Chicago, IL). The level of statistical significance used was $\alpha = .05$.

The statistical analysis plan is presented below, prior to the analysis of the data. The required assumptions of each statistical analysis were upheld, unless stated otherwise.

Results

Final Sample

Despite recruiting a substantial number of participants ($n = 51$), we experienced a high attrition rate ($n = 15$) during data collection (see Figure 1). Four participants did not arrive for the first session, and two participants did not for the second session. One participant was excluded at the beginning of the first session on the basis of the BDI-II exclusion criteria. One participant withdrew at the beginning of the first session for religious reasons. Despite confirming during email screening that they met all the necessary inclusion criteria, seven participants had to be excluded at the beginning of the first session on the basis of the study's exclusion criteria. Three participants were female, two were on steroid-based medication, one was above the required age range, and one was not a South African citizen.

Figure 1. Diagram of participant attrition during the experimental sessions.

Final sample characteristics. As a result of the exclusions and attrition stipulated above, the final number of participants included in the data analysis was 36 (SEDR group: *n*

= 9; CEDR group: *n* = 9; EDSR group: *n* = 9; EDCR group: *n* = 9). The descriptive statistics for the final sample characteristics can be seen in Table 1.

To analyse final sample characteristics, 2 x 2 (Experimental Manipulation [Stress vs. Control] x Memory Phase [Encoding vs. Retrieval]) factorial ANOVAs were conducted on the data for participants' ages, BMI scores, BDI-II scores, STAI-Trait scores, and their WM scores. Analysis of these characteristics acted as control measures, ensuring that all participants were drawn from a similar population. The BDI-II and STAI-Trait scores of the sample were compared to the relevant normative data using single-sample *t*-tests. WM data were missing for five participants due to technical failures of the testing programme.

Table 1

Descriptive Statistics for Final Sample Characteristics

Measure	Experimental Condition			
	SEDR	CEDR	EDSR	EDCR
	n = 9	*n* = 9	*n = 9*	*n* = 9
Age	20.67 (2.06)	21.78 (1.72)	21.44 (1.74)	20.33 (1.41)
BDI-II	4.44 (3.13)	11.11 (6.66)	6.00 (4.92)	8.89 (5.23)
STAI-Trait	33.11 (8.78)	42.56 (11.87)	36.22 (9.16)	39.67 (7.81)
WM Data				
Reaction Time	902.71 (444.72)[a]	636.56 (135.52)[b]	788.69 (324.92)[b]	1026.41 (472.56)[b]
Accuracy	87.76 (8.63)[a]	89.29 (8.73)[b]	85.12 (10.00)[b]	85.12 (8.61)[b]

Note. Data presented are means with standard deviations in parentheses. [a] *n* = 7. [b] *n* = 8.

Age. Participants' ages ranged from 18 to 26 years ($M = 21.06 \pm 1.77$). The factorial ANOVA showed no statistically significant main effect for Experimental Manipulation, $F(1, 32) = .00$, $p = 1.00$, $\eta_p^2 = .00$, or for Memory Phase, $F(1, 32) = .327$, $p = .571$, $\eta_p^2 = .010$. There was also no interaction effect for Experimental Manipulation x Memory Phase, $F(1, 32) = 3.626$, $p = .066$, $\eta_p^2 = .102$. As the mean ages across the four experimental groups did

not differ statistically significantly, it suggests that the participants' ages were unlikely to confound the results of this study.

BDI-II. Based on the mean BDI-II scores for each of the four experimental groups, all groups fell into or below the 'minimally' depressed range (< 19), which suggests low levels of depressive symptomology in our sample (Beck et al., 1996). However, there was a statistically significant main effect for Experimental Manipulation, $F(1, 32) = 7.771$, $p = .009$, $\eta_p^2 = .195$, but no significant main effect for Memory Phase, $F(1, 32) = .038$, $p = .847$, $\eta_p^2 = .001$. There was no significant Experimental Manipulation x Memory Phase interaction effect, $F(1, 32) = 1.215$, $p = .279$, $\eta_p^2 = .037$. While there was a statistically significant difference between participants who had been exposed to the stress condition ($M = 5.22 \pm 4.03$) and participants who had been exposed to the control condition ($M = 10 \pm 5.95$), all BDI-II scores were below the exclusion criteria of this study (≥ 29).

When comparing our sample ($M = 7.61 \pm 5.57$) to normative data provided by the BDI-II manual for college students ($M = 12.56 \pm 9.93$; Beck et al., 1996), a statistically significant difference was found, $t(35) = -5.334$, $p < .001$, $d = 1.803$. While interesting, this significant difference was not problematic for the purposes of our study since: (a) the mean BDI-II of our sample was lower than the normed mean; and (b) the difference is likely due to our BDI-II exclusion criteria, preventing a larger range of BDI-II scores in our sample.

STAI-Trait. STAI-Trait scores across participants ranged from 22 to 57 ($M = 37.89 \pm 9.79$). The analysis did not show a significant main effect for Experimental Manipulation, $F(1, 32) = 4.121$, $p = .051$, $\eta_p^2 = .114$, or for Memory Phase, $F(1, 32) = .001$, $p = .927$, $\eta_p^2 = .00$. In addition, there was a no significant interaction effect for Experimental Manipulation x Memory Phase, $F(1, 32) = .893$, $p = .352$, $\eta_p^2 = .027$. This indicates that the four experimental groups had similar levels of general anxiety and that pre-existing general anxiety levels were therefore unlikely to confound our results.

When comparing our sample (M = 37.89 $\pm$ 9.79) to normative data provided by the STAI manual for males (M = 38.30 ± 9.18; Spielberger et al., 1983), no statistically significant difference was found, $t(35) = -.252$, $p = .803$, $d = .09$.

Working memory. Participants' WM ability was measured using the 3-Back condition of the *N*-Back, where accuracy and RT were separate outcome variables. For accuracy, there was no statistically significant main effect for either Experimental Manipulation, $F(1, 27) = .055$, $p = .861$, $\eta_p^2 = .002$, or Memory Phase, $F(1, 27) = 1.099$, $p = .304$, $\eta_p^2 = .039$. In addition, there was no interaction effect for Experimental Manipulation x Memory Phase on accuracy, $F(1, 27) = .055$, $p = .861$, $\eta_p^2 = .002$. For RT, there was no statistically significant main effect for both Experimental Manipulation, $F(1, 27) = .012$, $p = .915$, $\eta_p^2 = .00$, and Memory Phase, $F(1, 27) = 1.096$, $p = .304$, $\eta_p^2 = .039$. The interaction effect was also not significant, $F(1, 27) = 3.659$, $p = .066$, $\eta_p^2 = .199$. This suggests that WM performance was unlikely to confound the results of our study as no statistically significant differences in performance were found across the four experimental groups.

Experimental Manipulation

Table 2 shows the descriptive statistics for all the relevant self-reported and physiological measures. Analyses of participants' STAI-State scores, salivary cortisol measurements, and HR data were conducted to determine if the experimental manipulation (i.e., FFST procedure or control procedure) was effective in elevating subjective anxiety in the FFST but not control groups. For each of the relevant outcomes, 2 x 2 x 3 (Experimental Manipulation x Memory Phase x Stage of Testing [baseline/post-manipulation/end of session]) repeated measures ANOVAs were conducted to establish between- and within-group differences. HR measurements were lost for seven participants, due to hardware malfunction.

Table 2

Descriptive Statistics for Self-Report and Physiological Measures

Measure	Group			
	SEDR	CEDR	EDSR	EDCR
	n = 9	*n* = 9	*n = 9*	*n* = 9
STAI-State				
Baseline	29.33 (7.25)	37.00 (7.87)	33.67 (8.68)	30.89 (5.01)
Post-manipulation	39.22 (10.85)	37.22 (9.44)	42.89 (11.34)	30.33 (4.15)
End of Session	35.44 (9.76)	39.00 (11.14)	34.78 (10.46)	30.67 (5.85)
Cortisol Level				
Baseline	5.77 (5.29)	5.56 (5.51)	8.89 (8.31)	7.82 (5.40)
Post-manipulation	12.79 (8.05)	3.88 (3.91)	16.53 (13.99)	5.84 (3.46)
End of Session	12.34 (7.28)	3.73 (3.66)	18.52 (12.13)	5.06 (3.13)
Heart Rate				
Baseline	83.32 (14.47)[b]	81.24 (20.22)[c]	95.36 (20.30)[d]	81.65 (15.11)[d]
Post-manipulation	103.69 (27.00)[b]	84.93 (19.18)[c]	110.13 (18.86)[d]	82.72 (11.24)[d]
End of Session	82.33 (14.80)[b]	79.32 (18.69)[c]	88.64 (12.65)[d]	75.19 (10.80)[d]

Note. Data presented are means with standard deviations in parentheses. Cortisol levels were measured in nanomoles per litre (nmol/l); heart rate levels were measured in beats per minute (bpm); [b] *n* = 7; [c] *n* = 6; [d] *n* = 8.

Self-reported anxiety: STAI-State. The analysis showed a statistically significant main effect for Stage of Testing, $F(2, 64) = 7.818$, $p = .001$, $\eta_p^2 = .196$. The interaction effect for Stage of Testing x Experimental Manipulation was significant, $F(2, 64) = 8.919$, $p < .001$, $\eta_p^2 = .218$, but the interaction effect for Stage of Testing x Memory Phase was not, $F(2, 64) = 1.295$, $p = .281$, $\eta_p^2 = .039$. The interaction effect for Stage of Testing x Experimental Manipulation x Memory Phase was also not significant, $F(2, 64) = .237$, $p = .789$, $\eta_p^2 = .007$.

Levene's test value was significant for the one-way ANOVA used to conduct the planned contrasts, $F(11, 96) = 1.944$, $p = .043$. Therefore the planned contrasts assumed unequal variance. Planned contrasts showed that stress (SEDR/EDSR) and control

(CEDR/EDCR) conditions did not differ statistically significantly at baseline, $t(27.536) = -1.329$, $p = .195$, $d = -.507$. Participants in the stress conditions had statistically significant elevations in subjective anxiety from baseline to post-FFST, $t(27.82) = -3.229$, $p = .003$, $d = -1.224$, but there was no difference between stress-encode and stress-retrieve post-FFST, $t(15.964) = -.70$, $p = .494$, $d = -.350$. Those in the control conditions did not statistically significantly differ in subjective anxiety from baseline to post-FFST, $t(24.808) = -.155$, $p = .878$, $d = -.062$, nor were there any differences in control-encode and control-retrieve post-FFST, $t(12.111) = 1.641$, $p = .126$, $d = .943$.

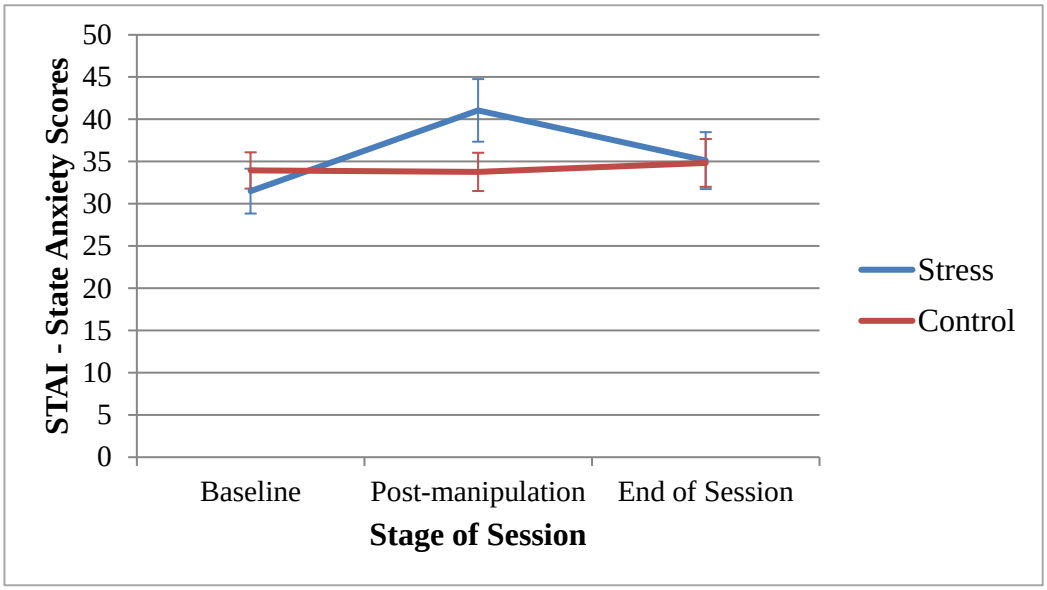

Figure 1. Change in subjective anxiety for the combined stress and control groups. Error bars show the standard error of the means.

Salivary cortisol. The analysis showed a statistically significant main effect for Stage of Testing, $F(2, 64) = 5.617$, $p = .006$, $\eta_p^2 = .149$. The interaction effect for Stage of Testing x Experimental Manipulation was significant, $F(2, 64) = 16.844$, $p < .001$, $\eta_p^2 = .345$, but the interaction effect for Stage of Testing x Memory Phase was not, $F(2, 64) = .170$, $p = .844$, $\eta_p^2 = .005$. The interaction effect for Stage of Testing x Experimental Manipulation x Memory Phase was also not significant, $F(2, 64) = .579$, $p = .563$, $\eta_p^2 = .018$.

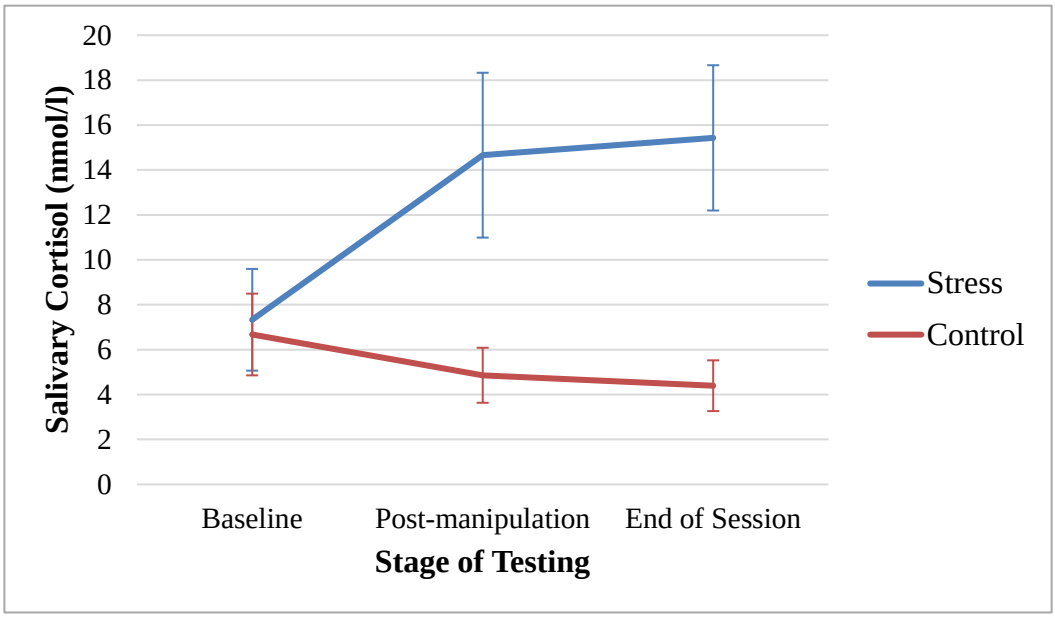

Figure 2. Changes in salivary cortisol levels for the combined stress and control groups. Error bars show the standard error of the means.

Levene's test value was significant for the one-way ANOVA used to conduct the planned contrasts, $F(11, 96) = 2.178$, $p = .022$. Therefore the planned contrasts assumed unequal variance. Planned contrasts showed that stress and control conditions did not statistically differ at baseline, $t(26.865) = .418$, $p = .679$, $d = .161$. Participants in the stress conditions had statistically significant elevations in cortisol levels from baseline to post-FFST, $t(21.721) = -2.234$, $p = .036$, $d = -.959$, but there was no difference in stress-encode and stress-retrieve post-FFST, $t(12.774) = -.695$, $p = .500$, $d = -.389$. Those in the control conditions did not statistically significantly differ in cortisol levels from baseline to post-FFST, $t(27.822) = 1.299$, $p = .205$, $d = .493$, nor was there any difference in control-encode and control-retrieve post-FFST, $t(16.145) = -.929$, $p = .366$, $d = -.462$. Taken together, this indicates that our experimental manipulation was successful in elevating cortisol levels in stress conditions, but not in control conditions.

Heart rate. The assumption of sphericity was violated for the main effect of Stage of Testing, $\chi^2(2) = 10.566$, $p = .005$, therefore the degrees of freedom were corrected using the Greenhouse-Geisser estimates of sphericity ($\varepsilon = .737$). The analysis showed a statistically significant main effect for Stage of Testing, $F(1.475, 36.87) = 33.710$, $p < .001$, $\eta_p^2 = .574$. The interaction effect for Stage of Testing x Experimental Manipulation was significant, $F(1.475, 36.87) = 12.210$, $p < .001$, $\eta_p^2 = .328$, but the interaction effect for Stage of Testing x Memory Phase was not, $F(1.475, 36.87) = 1.201$, $p = .300$, $\eta_p^2 = .046$. The interaction effect for Stage of Testing x Experimental Manipulation x Memory Phase was also not significant, $F(1.475, 36.87) = .092$, $p = .092$, $\eta_p^2 = .004$.

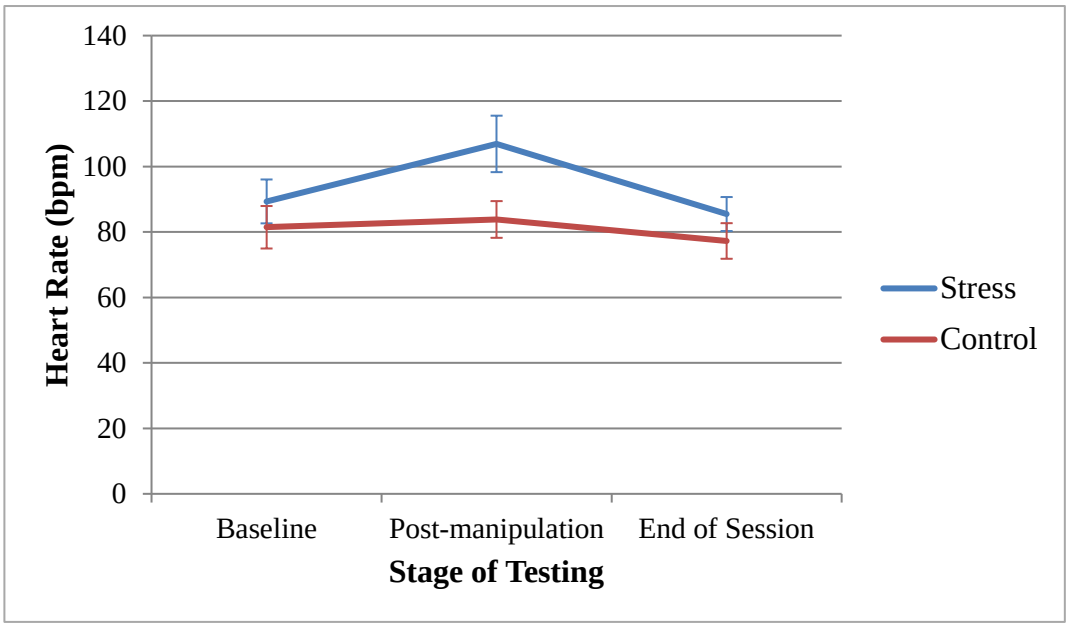

Figure 3. Changes in heart rate for the combined stress and control groups. Error bars show the standard error of the means.

Planned contrasts showed that stress and control conditions did not differ statistically at baseline, $t(75) = 1.077$, $p = .285$, $d = .249$. Participants in the stress conditions had statistically significant increase in HR from baseline to post-FFST, $t(75) = -2.713$, $p = .008$, $d = -.627$, but there was no difference in stress-encode and stress-retrieve post-FFST, $t(75) = -$

.683, p = .496, d = -.158. Those in the control conditions did not change their HRs statistically significantly from baseline to post-FFST, $t(75)$ = -.477, p = .635, d = -.11, nor was there any difference between control-encode and control-retrieve post-FFST, $t(75)$ = .11, p = .913, d = .025.

Taken together, the above analyses indicated that our experimental manipulation was successful in elevating participants' subjective anxiety, salivary cortisol levels, and heart rate in stress conditions, but not in control conditions. We can conclude that participants exposed to the FFST, and not the control procedure, experienced a significant stress response, which resulted in an increased HPA-axis functioning and cardiovascular activity.

Prospective Memory Tasks

Laboratory PM tasks. Descriptive statistics for the laboratory PM tasks can be seen in Table 3. In the event-based PM task, outcome measures included error rate and RT. Error rate was calculated as the percentage of incorrect responses, and RT was measured in milliseconds. In the time-based PM task, accuracy and RT error were used as outcome variables. Accuracy was calculated as the percentage of correctly executed PM intentions (i.e., logging the time every minute). RT error was calculated by the difference in expected log time and executed log time (i.e., how far away from the minute mark the time was logged).

Table 3

Descriptive Statistics for Laboratory PM Performance

Measure	Group			
	SEDR	CEDR	EDSR	EDCR
	n = 9	*n* = 9	*n* = 9	*n* = 9
Event-based Task				
PM error rate	.18 (.35)	.32 (.33)	.65 (.35)	.34 (.42)
PM RT	1094.49 (176.35)	1054.09 (264.70)	956.53 (532.46)	940.63 (143.70)
ID error rate	.43 (.46)	.39 (.39)	.21 (.36)	.17 (.29)
ID RT	1121.36 (220.90)	970.33 (226.57)	1108.19 (560.12)	968.66 (258.37)
Time-based Task				
PM accuracy	.64 (.49)	.88 (.23)	.67 (.50)	.56 (.50)[a]
PM RT error	2.90 (6.37)	1.36 (1.84)	1.28 (2.00)	1.24 (1.93)[a]

Note. Data presented are means with standard deviations in parentheses. [a]*n* = 8.

In order to perform a broad analysis on whether participants in the stress conditions performed worse than participants in the control conditions, a MANOVA was conducted on the outcome variables in both event- and time-based tasks. In the event-based PM task, Experimental Manipulation did not have a statistically significant effect on error rate, $F(1, 33) = p = .519$, $\eta_p^2 = .013$, or RT, $F(1, 33) = .053$, $p = .820$, $\eta_p^2 = .002$. In the time-based PM task, Experimental Manipulation did not have a statistically significant effect on accuracy, $F(1, 33) = .255$, $p = .617$, $\eta_p^2 = .008$, or RT error, $F(1, 33) = .420$, $p = .521$, $\eta_p^2 = .130$.

In order to determine whether the stressor had an effect on the participants' ability to deactivate previously executed PM intentions in the event-based PM task, a single MANOVA was conducted on ID error rate and RT. Experimental Manipulation did not have a statistically significant effect on ID error rate, $F(1, 34) = .047$, $p = .830$, $\eta_p^2 = .001$, or ID RT, $F(1, 34) = 1.538$, $p = .223$, $\eta_p^2 = .043$. These analyses suggest that acute psychosocial

stress does not influence the ability to accurately execute and later deactivate previously encoded PM intentions.

Within the Stress condition, a single MANOVA was run to examine whether or not the memory phase disrupted by the Experimental Manipulation had a significant effect on the outcome variables in both event- and time-based PM tasks. In the event-based task, the analysis showed that Memory Phase had a statistically significant effect on error rate, $F(1, 16) = 8.302$, $p = .011$, $\eta_p^2 = .342$, but not on RT, $F(1, 16) = .544$, $p = .471$, $\eta_p^2 = .033$. When the FFST was introduced immediately before PM retrieval ($M = .653 \pm .347$), participants' error rate was statistically significantly higher than when the stressor was introduced immediately before PM encoding ($M = .181 \pm .349$). In the time-based task, Memory Phase did not have a significant effect on either accuracy, $F(1, 16) = .014$, $p = .906$, $\eta_p^2 = .001$, or RT error, $F(1, 16) = .529$, $p = .478$, $\eta_p^2 = .032$.

Naturalistic PM tasks. Descriptive statistics for the naturalistic event- and time-based PM tasks can be seen in Table 4. For the event-based task, accuracy was measured using an absolute score (0 – 4; one for each cognitive task). For the time-based task, accuracy was measured using binary scores (0 or 1).

Table 4

Descriptive Statistics for Naturalistic PM Performance

Measure	Group			
	SEDR	CEDR	EDSR	EDCR
	n = 9	*n* = 9	*n* = 9	*n* = 9
Event-based task	1.89 (1.69)	2.00 (1.73)	1.56 (1.74)	1.56 (1.74)
Time-based task	.56 (.53)	.89 (.33)	.00 (.00)[a]	.28 (.46)

Note. Data presented are means with standard deviations in parentheses. [a] None of the participants sent the required email.

A single MANOVA conducted to determine if the experimental manipulation had a significant effect on either event- or time-based naturalistic PM performance. Experimental Manipulation did not have a significant effect on event-based PM performance, $F(1, 34) = .010$, $p = .922$, $\eta_p^2 < .001$, however, it did have a statistically significant effect on time-based PM performance, $F(1, 34) = 4.310$, $p = .046$, $\eta_p^2 = .112$. Participants in the stress conditions ($M = .28 \pm .46$) sent the required email less than participants in the control conditions ($M = .61 \pm .50$). This indicates that acute stress negatively affected the ability to perform time-based intentions in the future.

In order to determine whether or not the disrupted memory phase (i.e., encoding or retrieval) had a statistically significant effect on the PM performance of participants in the stress conditions, two one-way ANOVAs were conducted. The effect of Memory Phase on event-based PM performance was not significant, $F(1, 16) = .170$, $p = .686$, $\eta_p^2 = .011$. Although a significant Levene's test value was found for the effect of Memory Phase on time-based PM performance, $F(1, 16) = 640.00$, $p < .001$, it can be accounted for by the lack of variance in the stress-retrieve condition ($M = .00 \pm .00$). This prevented us from running an ANOVA on our data. Instead, we conducted an independent samples *t*-test, assuming unequal variances. Participants performed statistically significantly worse when the stressor was introduced immediately before retrieval ($M = .00 \pm .00$) compared to when it was introduced immediately before encoding ($M = .56 \pm .53$), $t(8) = 3.162$, $p = .013$, $d = 2.236$.

Event- vs. time-based PM performance. Two 2 x 2 (Experimental Manipulation x Type [event- vs. time-based]) factorial ANOVAs were conducted to investigate whether the type of PM task had an effect on PM accuracy, where one was conducted for laboratory tasks and the other for naturalistic tasks. For the laboratory event-based PM task, the error rate (%) was inverted to represent an accuracy percentage for the purposes of comparison to the accuracy percentages in the time-based PM task. For the naturalistic event-based PM tasks,

raw scores were converted into a percentage of maximum score obtainable (i.e., 4) to compare them to the binary scores obtained in the naturalistic time-based PM task.

In the laboratory PM tasks, no significant main effect was found for Experimental Manipulation, $F(1, 67) = .587$, $p = .446$, $\eta_p^2 < .001$, or for Type, $F(1, 67) = .519$, $p = .474$, $\eta_p^2 = .008$. The interaction effect for Experimental Manipulation x Type was also not significant, $F(1, 67) < .001$, $p = .998$, $\eta_p^2 < .001$. In the naturalistic PM tasks, the main effect was not significant for both Experimental Manipulation, $F(1, 68) = 2.648$, $p = .108$, $\eta_p^2 = .037$, and Type, $F(1, 68) = .004$, $p = .948$, $\eta_p^2 < .001$. In addition, the interaction effect for Experimental Manipulation x Type was not significant, $F(1, 68) = 2.241$, $p = .139$, $\eta_p^2 = .032$. Taken together, these analyses suggest that participants do not differ in PM performance across both event- and time-based PM tasks, irrespective of whether the task is laboratory-based or naturalistic.

Discussion

Summary and Implications of Results

After establishing that the experimental manipulation successfully induced acute psychosocial stress in our final sample, as evidenced by self-report and physiological data, we found that PM performance is generally robust under conditions of acute psychosocial stress. Participants exposed to the stressor did not show an overall poorer PM performance compared to participants in the control conditions for either the event- or the time-based PM tasks. Our findings on event-based PM performance support those presented by Nakayama and colleagues (2005) and Walser and colleagues (2013), who reported no difference in PM performance in a laboratory event-based PM task. Participants' ability to deactivate previously executed PM intentions did not differ across experimental conditions, consistent with the findings of Walser and colleagues (2013). In addition, participants in the stress conditions did not perform better on event-based PM tasks compared to time-based PM tasks.

The only exception to this robust performance pattern was found in the naturalistic time-based PM task, where participants in the stress conditions had a poorer PM performance than those in control conditions. This contrasts Nater and colleagues' (2006) results, which suggested better performance in time-based PM tasks compared to event-based PM tasks.

Within the stress conditions, results were somewhat mixed. When the stressor was introduced immediately before retrieval, participants produced more errors during the laboratory event-based PM task than when the stressor was introduced immediately before encoding. Additionally, when the stressor was introduced immediately before retrieval, participants performed significantly worse in the naturalistic time-based PM task than when the stressor was introduced immediately before encoding. No difference was found between experimental conditions in the naturalistic event-based PM task. The poorer PM performance following an acute psychosocial stressor immediately before retrieval is a novel finding, as PM encoding and retrieval processes have not been isolated in previous research into the effects of acute psychosocial stress on PM. While participants exposed to the stressor immediately before retrieval did not have a significantly poorer PM performance than controls, our findings suggest that PM retrieval processes may be particularly susceptible to disruptions after exposure to an acute psychosocial stressor.

As our variable results indicate, PM cannot be considered a uniform construct. Differences in performance across naturalistic event- and time-based tasks, as well as differences in PM performance when either encoding or retrieval of information was interrupted by the stressor highlight this. Research on acute stress and RM suggests that while stress will either impair or enhance the encoding of new information depending on, among other things, the emotional valence of the material, the retrieval of previously encoded and stored information is generally impaired (de Quervain et al., 2009). Since PM incorporates RM components, one would expect this observation to remain consistent in PM

(Einstein & McDaniel, 1996). However, our data show that stress did not significantly impair PM retrieval compared to controls. We did, however, observe that stress was more disruptive when introduced immediately before retrieval than when it was introduced immediately before encoding.

One possible reason for PM retrieval being more susceptible to stress-related impairments is that introducing a psychosocial stressor heightens emotional arousal. When an individual becomes emotionally aroused, noradrenergic mechanisms in the brain are stimulated. Noradrenergic mechanisms then mediate the effect that cortisol has on memory retrieval processes by negatively affecting successful retrieval in the emotionally aroused state (de Quervain et al., 2009). The stimulation of noradrenergic mechanisms could account for the discrepancy we found in PM performance between the participants who experienced the stressor before encoding and the participants who experienced the stressor before retrieval. In isolation, however, this theory does not sufficiently explain the fact that participants exposed to the stressor immediately before retrieval did not perform significantly worse than controls.

Einstein and McDaniel (2005) use a multi-processing framework to elucidate retrieval processes in PM, where the retrieval and execution of PM intentions utilise more than one process. PM consists of both memory and executive components, which is also evidenced by the neural substrates that are implicated in PM processing (e.g., frontopolar PFC and hippocampal regions; Burgess et al., 2011; Fish et al., 2010). One proposition about retrieval processing in PM is that intentions are retrieved through an executive monitoring process. Once this monitoring process is initiated, people enter a ‘retrieval mode’ and monitor the environment for intention cues. This retrieval mode is maintained until the chance to execute the intention occurs (Smith, 2003). In Nater and colleagues’ (2006) study, it was found that participants who had been exposed to an acute psychosocial stressor monitored the time more

often. This monitoring strategy was used to explain the significantly better performance on the time-based PM task. This suggests that monitoring may influence the retrieval processing in PM.

However, continuous monitoring in the retrieval mode is cognitively demanding and incorporates both attention and WM processes. Additionally, monitoring interferes with the ability to process other on-going tasks (Scullin, McDaniel, & Einstein, 2010). While there is evidence that monitoring does occur in PM retrieval, it has been proposed that PM retrieval may also have a less cognitively demanding spontaneous and associative aspect, which would be more adaptive due to the high demand of PM in everyday life. The spontaneous-associative theory describes more automatic processes in PM retrieval, and forms the second aspect of the multi-processing framework. It is thought that an association is formed between the intention and the cue at the time of encoding. When the cue is later encountered, the retrieval of the intention is spontaneously triggered by an associative memory-system (Einstein & McDaniel, 2005; Scullin et al., 2010). The spontaneity of this system aids adaptive PM retrieval.

This multi-processing framework could serve to explain the similarity in PM performance between stress and control conditions. We expected to see poorer performance after participants were exposed to an acute psychosocial stressor, resulting from the effect cortisol has on prefrontal and medial temporal lobes in the brain (Cornelisse et al., 2011). Since we did not observe this effect, we propose that our participants may have formed associative memories at encoding, so that when confronted with a target word, retrieval of the intention was relatively spontaneous.

In further support of this theory, it has been suggested that acute psychosocial stress has the ability to enhance priming and the formation of associative memories (Beylin & Shors, 2003; Hidalgo et al., 2012). Therefore, if a strong association is formed between an

intention and a PM cue at encoding, the appearance of the cue will spontaneously trigger retrieval without the use of cognitive resources susceptible to stress impairments (Scullin et al., 2010). However, although the retrieval of the intention is spontaneous, it is not sufficient for the execution of the intention. Execution relies on both spontaneous initiation and conscious intent (McDaniel & Scullin, 2010). This spontaneous aspect of PM retrieval could have minimised the known negative effects that cortisol has on memory retrieval, as seen in our data.

Limitations

Due to having a relatively small sample size (N = 36), yet having four experimental groups (n = 9), our study did not have sufficient power to detect the more subtle yet still significant differences in our statistical analyses. For this reason, data collection will resume in November 2015 for publication purposes, so that sufficient power can be achieved to enable us to accurately investigate and conclude the hypotheses under study.

Not only did our strict inclusion criteria reduce our final sample size, it also reduced our ability to generalise our findings to other populations (e.g., females), and those who could potentially be at a higher risk of poor PM performance (e.g., TBI patients). This resulted in the restriction of our study's ability to more fully elaborate on the effects of stress on PM performance.

Apart from our sample size and inclusion criteria, the laboratory PM paradigm established by Einstein and McDaniel (1990) may not be sensitive enough to capture PM processes used in everyday life (Mioni et al., 2014). Our laboratory event-based PM task was a modification of the task used by Walser and colleagues (2013), which they propose to be sensitive to subtle impairments in PM performance. Our task was created in consultation with Walser and following a close analysis of the Einstein and McDaniel (1990) paradigm for the purpose of ensuring sensitivity to detect fluctuations in PM performance. The lack of

available psychometric properties for our tasks prevents us from establishing whether or not they were sensitive enough. Therefore, it is imperative that psychometric properties for both our event- and time-based tasks are established.

Another limitation emerged by including a 24-hour delay between PM encoding and retrieval. We were unable to control for rehearsal or memory-aid strategies potentially used by participants (Einstein & McDaniel, 1990). For example, participants could have left the session and written down the PM task intentions. If participants actively rehearsed the PM intentions continuously, it would have aided retrieval and been less representative of everyday PM performance. This lack of control could have confounded our results as some may have used these strategies, while others may not have.

Directions for Future Research

Since research into the effects of acute psychosocial stress is still in its infancy, there is a need to continue laying down solid foundations in this area. In order to improve on the limitations of our study, future research should place emphasis on establishing the psychometric properties of the PM tasks used in studies. This will ensure the reliability and validity of the reported results. By standardising the tasks used, more accurate comparisons between studies can be made which would allow for better synthesis of available literature. Subjective reports of strategies used by participants to remember the PM intentions should be noted and analysed in future studies in order to determine whether differences in performance are due to, or confounded by, these strategies.

Since our study was the first to investigate the effects of acute psychosocial stress on different aspects of PM processing, future research should continue doing so. Our results suggest that retrieval is more susceptible to stress-related impairment than encoding, but our study lacks the ability to reach any definitive conclusions on this matter. Future research should also incorporate the consolidation and retention of PM intentions, as our study

focused exclusively on encoding and retrieval/execution. However, being able to accurately induce stress when the person is consolidating and/or retaining the intention may prove difficult. By understanding the more intricate impairments in PM performance, the mechanisms of PM and how it is affected by stress will be better understood.

We are the first to draw on the multi-processing framework of retrieval formulated by McDaniel and Einstein (2005), as it can be used to explain some of our findings. However, it also explains the findings in previous studies investigating acute psychosocial stress and PM. Future research could seek to elaborate on the effects that acute stress may have on associative memory in humans, as this is proposed to be an important aspect of PM retrieval. Given this, future research should try to establish whether or not this theory remains an adequate explanation of the processes involved in acute psychosocial stress and PM (Einstein & McDaniel, 2005).

Conclusion

The rationale for conducting our study was to address the literature gap on the effects of acute psychosocial stress on PM, given the importance of these factors in everyday life. While we were not able to arrive at any firm conclusions, our data suggest that PM could be a fairly robust construct. This could be due to the fact that multiple cognitive processes could compensate for the negative influences imposed by cortisol, such as associative memory and spontaneous retrieval. Despite our finding that PM remains relatively unchanged under conditions of acute psychosocial stress, more than half of the memory complaints that occur are prospective in nature, indicating that PM is indeed susceptible to failures. Discrepancies between PM performance in the laboratory and in everyday life could be due to the possible insensitivity of laboratory PM paradigms, highlighting the importance for research to clarify and improve on testing measures and methods. Identifying factors that impact PM would be

invaluable to both cognitively intact and impaired individuals, and it would prove beneficial in improving daily activities.

References

Alderson, A. L., & Novack, T. A. (2002). Neurophysiology and clinical aspects of glucocorticoids and memory: A review. *Journal of Clinical and Experimental Neuropsychology, 24*(3), 335-355. doi: 1380-3395/02/2403-335

Almeida, D. M., Piazza, J. R., & Stawski, R. S. (2009). Interindividual differences and intraindividual variability in the cortisol awakening response: An examination of age and gender. *Psychology and Aging, 24*(4), 819-827. doi: 10.1037/A0017910

American Psychiatric Association. (2013). *The diagnostic and statistical manual of mental disorders* (5 ed.). Washington, DC: Author.

Beck, A. T., Steer, R. A., & Brown, G. (1996). *Manual for the Beck Depression Inventory-II*. San Antonio, TX: Psychological Corporation.

Beylin, A. V., & Shors, T. J. (2003). Glucocorticoids are necessary for enhancing the acquisition of associative memories after acute stressful experience. *Hormones and Behavior, 43*(1), 124-131. doi: 10.1016/s0018-506x(02)00025-9

Bradley, M. M., & Lang, P. J. (1999). Affective norms for English words (ANEW): Instructions and affective ratings (pp. 1 - 45). Technical report C-1. The Center for Research in Psychophysiology. University of Florida.

Burgess, P. W., Gonen-Ysscovi, G., & Volle, E. (2011). Functional neuroimaging studies of prospective memory: What have we learnt so far? *Neuropsychologia, 49*(8), 2246-2257. doi: 10.1016/j.neuropsychologia.2011.02.014

Burgess, P. W., Quayle, A., & Frith, C. D. (2001). Brain regions involved in prospective memory as determined by positron emission tomography. *Neuropsychologia, 39*(6), 545-555. doi: 10.1016/S0028-3932(00)00149-4

Cohen, G. (1989). *Memory in the real world*. Hove, UK: Lawrence Erlbaum Associates.

Cornelisse, S., van Stegeran, A. H., & Joëls, M. (2011). Implications of psychosocial stress on memory formation on a typical male versus female student sample. *Psychoneuroendocrinology, 36*(4), 569-578. doi: 10.1016/j.psyneuen.2010.09.002

de Quervain, D. J.-F., Aerni, A., Schelling, G., & Roozendaal, B. (2009). Glucocorticoids and the regulation of memory in health and disease. *Frontiers in Neuroendocrinology, 30*(3), 358-370. doi: 10.1016/j.yfrne.2009.03.002

Dozois, D. J. A., Dobson, K. S., & Ahnberg, J. L. (1998). A psychometric evaluation of the Beck Depression Inventory-II. *Psychological Assessment, 10*(2), 83-89. doi: 10.1037/1040-3590.10.2.83

du Plooy, C., Thomas, K. G. F., Henry, M., Human, R., & Jacobs, W. J. (2014). The fear-factor stress test: An ethical, non-invasive laboratory method that produces consistent and sustained cortisol responding in men and women. *Metabolic Brain Disease, 29*(2), 385-394. doi: 10.1007/s11011-014-9484-9

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*(4), 717-726. doi: 10.1037/0278-7393.16.4.717

Einstein, G. O., & McDaniel, M. A. (1996). Retrieval processes in prospective memory: Theoretical approaches and some new empirical findings. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 115-152). Mahwah, NJ: Lawrence Erlbaum Associates.

Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science, 14*(6), 286-290. doi: 10.1037/0096-3445.134.3.327

Fish, J., Wilson, B. A., & Manly, T. (2010). The assessment and rehabilitation of prospective memory problems in people with neurological disorders: A review. *Neuropsychological Rehabilitation: An Internaltional Journal, 20*(2), 161-179. doi: 10.1080/09602010903126029

Freud, S. (1901). *The psychopathology of everyday life: Forgetting, slips of the tongue, bungled actions, superstitions and errors* (J. Strachey, Trans.). London, UK: Ernest Benn Limited.

Garde, A. H., & Hansen, A. M. (2005). Long-term stability of salivary cortisol. *Scandinavian Journal of Clinical & Laboratory Investigation, 65*(5), 433 - 436. doi: 10.1080/00365510510025773

Glisky, E. L. (1996). Prospective memory and the frontal lobes. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 249-261). Mahwah, NJ: Lawrence Erlbaum Associates.

Hannon, B., & Daneman, M. (2007). Prospective memory: The relative effects of encoding, retrieval, and the match between encoding and retrieval. *Memory, 15*(5), 527-604. doi: 10.1080/09658210701407281

Hidalgo, V., Villada, C., Almela, M., Espin, L., Gomez-Amor, J., & Salvador, A. (2012). Enhancing effects of acute psychosocial stress on priming of non-declarative memory in healthy young adults. *Stress, 15*(3), 329-338. doi: 10.3109/10253890.2011.624224

Hines, E. A., & Brown, G. E. (1932). A standard stimulus for measuring vasomotor reactions: Its application in the study of hypertension. *P Staff M Mayo Clin, 7*(1), 332-335.

Kane, M. J., Conway, A. R. A., Miua, T. K., & Colflesh, G. J. H. (2007). Working memory, attention control, and the *n*-back task: A question on construct validity. *Journal of*

Experimental Psychology: Learning, Memory, and Cognition, 33(3), 615-622. doi: 10.1037/0278-7393.33.3.615

Kemeny, M. E. (2003). The psychobiology of stress. *Current Directions in Psychological Science, 12*(4), 124-129. doi: 10.1111/1467-8721.01246

Kidder, D. P., Park, D. C., Hertzog, C., & Morrell, R. W. (2007). Prospective memory and aging: The effects of working memory and prospective memory task load. *Aging, Neuropsychology, and Cognition, 4*(2), 93-112. doi: 10.1080/13825589708256639

Kirschbaum, C., Pirke, K.-M., & Hellhammer, D. H. (1993). The 'Trier Social Stress Test' - A tool for investigating psychological distress. *Neuropsychobiology, 28*(1-2), 76-81. doi: 10.1159/000119004

Kudielka, B. M., Hellhammer, D. H., & Wüst, S. (2009). Why do we respond to differently? Reviewing determinants of human salivary cortisol responses to challenge. *Psychoneuroendocrinology, 34*(1), 2-18. doi: 10.1016/j.psyneuen.2008.10.004

Kvavilashvili, L., & Ellis, J. (1996). Varieties of intention: Some distinctions and classifications. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 23-52). Mahwah, NJ: Lawrence Erlbaum Associates.

Lupien, S. J., & McEwan, B. S. (1997). The acute effects of corticosteriods on cognition: Intergration of animal and human studies. *Brain Research Reviews, 24*(1), 1-27. doi: 10.1016/S0165-0173(97)00004-0

McDaniel, M. A., & Einstein, G. O. (2011). The neuropsychology of prospective memory in normal aging: A componential approach. *Neuropsychologia, 49*(8), 2147-2155. doi: 10.1016/j.neuropsychologia.2010.12.029

McDaniel, M. A., & Scullin, M. K. (2010). Implementation intention encoding does not automatise prospective memory responding. *Memory & Cognition, 38*(2), 221-232. doi: 10.3758/MC.38.2.221

Mioni, G., McClintock, S. M., & Stablum, F. (2014). Understanding, assessing and treating prospective memory dysfunctions in traumatic brain injury patients. In F. Sadaka & T. Quinn (Eds.), *Traumatic Brain Injury* (pp. 401-436): InTech.

Nakayama, Y., Takahashi, T., & Radford, M. H. (2005). Cortisol levels and prospective and retrospective memory in humans. *Neuro Endocrinology Letters, 26*(5), 599-602.

Nater, U. M., Okere, U., Stallkamp, R., Moor, C., Ehlert, U., & Kleigel, M. (2006). Psychosocial stress enhances time-based prospective memory in healthy young men. *Neurobiology of Learning and Memory, 86*(3), 344-348. doi: 10.1016/j.nlm.2006.04.006

Owen, A. M., McMillan, K. M., Laird, A. R., & Bullmore, E. (2005). N-back working memory paradigm: A meta-analysis of normative functional neuromaging studies *Human Brain Mapping, 25*(1), 46-59. doi: 10.1002/hbm.20131

Park, D. C., & Kidder, D. P. (1996). Prospective memory and medication adherence. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and application* (pp. 369-390). Mahwah, NJ: Lawrence Erlbaum Associates.

Payne, J. D., Jackson, E. D., Hoscheidt, S., Ryan, L., Jacobs, W. J., & Middel, L. (2007). Stress administered prioir to encoding impairs neutral but enhances emotional long-term episodic memories. *Learning & Memory, 14*(1), 861-868. doi: 10.1101/LM.743507

Rendell, P. G., & Thomson, D. M. (1999). Aging and prospective memory: Differences between neturalistic and laboratory tasks. *Journal of Gerontology, 54B*(4), P256-P269. doi: 10.1093/geronb/54b.4.p256

Roozendaal, B. (2002). Stress and memory: Opposing effects of glucocorticoids on memory consolidation and memory retrieval. *Neurobiology of Learning and Memory, 78*(3), 578-595. doi: 10.1006/nime.2002.4080

Rothen, N., & Meier, B. (2014). Psychophysiology of prospective memory. *Memory, 22*(7), 867-880. doi: 10.1080/09658211.2013.847106

Scullin, M. K., McDaniel, M. A., & Einstein, G. O. (2010). Control of cost in prospective memory: Evidence for spontaneous retrieval processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36*(1), 190-203. doi: 10.1037.a0017732

Shum, D., Fleming, J., Gill, H., Gullo, M. J., & Strong, J. (2011). A randomized controlled trial of prospective memory rehabilitation in adults with traumatic brain injury. *Journal of Rehabilitation Medicine, 43*(3), 216-223. doi: 10.2340/16501977-0647

Simons, J. S., Schölvinck, M. L., Gilbert, S. J., Frith, C. D., & Burgess, P. W. (2006). Differential components of prospective memory? Evidence from fMRI. *Neuropsychologia, 44*(8), 1388-1397. doi: 10.1016/j.neuropsychologia.2006.01.005

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: investigating the capacity demands of delayed intention performance *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*(3), 347-361. doi: 10.1037/0278-7393.29.3.347

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Spielberger, C. D., & Vagg, P. R. (1984). Psychometric properties of the STAI: A reply to Ramanaiah, Franzen, and Schill. *Journal of Personality Assessment, 48*(1), 95-97. doi: 10.1207/s15327752jpa4801_16

van Ast, V. A., Cornelisse, S., Marin, M.-F., Ackerman, S., Garfinkel, S. N., & Abercrombie, H. C. (2013). Modulatory mechanisms of cortisol effects on emotional learning and memory: Novel perspectives. *Psychoneuroendocrinology, 38*(9), 1874-1882. doi: 10.1016/j.psyneuen.2013.06.012

Walser, M., Fischer, R., Goschke, T., Kirschbaum, C., & Plessow, F. (2013). Intention retrieval and deactivation following an acute psychosocial stressor. *PLoS ONE, 8*(2), e85685. doi: 10.1371/journal.pone.0085685

Wolf, O. T. (2003). HPA axis and memory. *Best Practice & Research Clinical Endocrinology and Metabolism, 17*(2), 287-299. doi: 10.1016/S1521-690X(02)00101-X

World Health Organization. (2015). Antiretroviral therapy: Graphs and tables. Retrieved from http://www.who.int/hiv/topics/treatment/data/en/index2.html

Appendix A

Faculty of Health Science Human Research Committee: Ethical Approval

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

Form FHS006: Protocol Amendment

HREC office use only (FWA00001637; IRB00001938)			
☐ Approved	☑ Type of review Expedited	☐ Full committee	
This serves as notification that all changes and documentation described below are approved			
Signature Chairperson of the HREC		Date	4/3/15

Note: All amendments should include a Synopsis justifying the changes for the amendment (please see notice dated 23 April 2012)

Principal Investigator to complete the following:

1. Protocol Information

HUMAN RESEARCH ETHICS COMMITTEE
- 4 MAR 2015
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN

Date form submitted	04 March 2015
HREC REF Number	420/2011
Protocol title	Hippocampal disruption and memory impairments: Stage of memory process and type of material.
Protocol number (if applicable)	N/A
Principal Investigator	Miss Robyn Human
Department / Office Internal Mail Address	Department of Psychology, PD Hahn Building, Upper Campus, University of Cape Town

1.1 Is this a major or a minor amendment? (see FHS006hlp)	☐ Major	✓ Minor
1.2 Does this protocol receive US Federal funding?	☐ Yes	✓ No
1.3 If the amendment is a major amendment and receives US Federal Funding, does the amendment require full committee approval?	☐ Yes	✓ No

2. List of Proposed Amendments with Revised Version Numbers and Dates

Please itemise on the page below, all amendments with revised version numbers and dates, which need approval.
This page will be detached, signed and returned to the PI as notification of approval Please add extra pages if necessary

1. This study will now be including a test of prospective memory (most probably the Cambridge Prospective Memory Test; Groot, Wilson, Evans, & Watson, 2002).

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938) This serves as notification of annual approval, including any documentation described below.			
☑ Approved	Annual progress report	Approved until/next renewal date	
☐ Not approved	See attached comments		
Signature Chairperson of the HREC		Date Signed	4/3/15.

Comments to PI from the HREC

HUMAN RESEARCH ETHICS COMMITTEE
- 4 MAR 2015
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN

Principal Investigator to complete the following:

1. Protocol information

Date form submitted	04 March 2015		
HREC REF Number	420/2011	Current Ethics Approval was granted until	28 October 2014
Protocol title	Hippocampal disruption and memory impairments: Stage of memory process and type of material.		
Protocol number (if applicable)	N/A		
Are there any sub-studies linked to this study?	☐ Yes ✓ No		
If yes, could you please provide the HREC Ref's for all sub-studies? Note: A separate FHS016 must be submitted for each sub-study.			
Principal Investigator	Miss Robyn Human		
Department / Office Internal Mail Address	Department of Psychology, PD Hahn Building, Upper Campus		

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

Appendix B

Department of Psychology: Ethical Approval

UNIVERSITY OF CAPE TOWN

Department of Psychology
Research Ethics Committee
Rondebosch, 7701
Tel: 27 21 6504607 Fax: 27 21 6504104

17 July 2015

REFERENCE NUMBER: 2015_07_17

Researcher Name: Courtney Lewis and Christina Barnes
Researcher Address: Department of Psychology, University of Cape Town

Dear Ms Lewis and Ms Barnes

PROJECT TITLE: Effects of Acute Psychosocial Stress on Prospective Memory

Thank you for your submission to the Department of Psychology Research Ethics Committee.

It is a pleasure to inform you that the Committee has **granted approval** for you to conduct the study.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote your REFERENCE NUMBER in all your correspondence.

Yours sincerely,

Dr Lauren Wild
Department of Psychology Research Ethics Committee

Appendix C

Consent Form

Informed Consent to Participate in Research

and Authorisation for Collection, Use, and

Disclosure of Protected Health Information

This form provides you with information about the study and seeks your authorisation for the collection, use and disclosure of your protected health information necessary for the study. The Principal Investigator (the person in charge of this research) or a representative of the Principal Investigator will also describe this study to you and answer all of your questions. Your participation is entirely voluntary. Before you decide whether or not to take part, read the information below and ask questions about anything you do not understand. By participating in this study you will not be penalised or lose any benefits to which you would otherwise be entitled.

1. Name of Participant ("Study Subject")

_____

2. Title of Research Study

The moderating variables of acute psychosocial stress on cognitive performance.

3. Principal Investigators, Ethics Committee, and Telephone Numbers

Kevin G. F. Thomas, Ph.D.
Department of Psychology
University of Cape Town
021-650-4608

Robyn Human, MA
PhD Candidate
Department of Psychology
University of Cape Town
021-788-5536

Christina Barnes
Honours Candidate
Department of Psychology
University of Cape Town
072-493-8686

Courtney Lewis
Honours Candidate
Department of Psychology
University of Cape Town
072-918-6584

Faculty of Health Sciences
Research Ethics Committee
Room E52-24, Groote Schuur Hospital, Old Main Building
Observatory 7925
Tel: 021-406-6338
Fax: 021-406-6411
Email: lamees.emjedi@uct.ac.za

4. What is the purpose of this research study?

The purpose of this research study is to better understand how exposure to acute psychological stress affects cognitive performance. More specifically, we are interested in what variables may moderate this relationship.

5. What will be done if you take part in this research study?

This study requires you to take part two research sessions on two consecutive days. During this study, you will be required to complete a number of memory based tasks and may be required to complete a 20 minute presentation. Your levels of stress will be assessed through the collection of self-report data, heart rate measurements, skin conductance measurements

and saliva samples with the aid of a cotton swab. These saliva samples will be used to analyse levels of cortisol, a stress hormone.

6. What are the possible discomforts and risks?

If you are one of the participants selected to complete the 20 minute presentation, you may be placed in a mildly stressful situation involving public speaking. There are no other discomforts and risks associated with participation in the study.

7. What are the possible benefits of this study?

One major benefit of this study is that scientists and society in general, will have better understanding of the effects of acute psychological stress on cognitive performance, and what variables moderate this relationship. This knowledge can then be applied to many different individuals and situations, including students who are taking exams, business managers who have to present to their boards, and so on.

8. Can you withdraw from this research study and if you withdraw, can information about you still be used and/or collected?

You may withdraw your consent and stop participation in this study at any time. Information already collected may be used.

9. Once personal information is collected, how will it be kept confidential in order to protect your privacy and what protected health information about you may be collected, used and shared with others?

Information collected will be stored in locked filing cabinets or in computers with security passwords. Only certain people - the researchers for this study and certain University of

Cape Town officials - have the legal right to review these research records. Your research records will not be released without your permission unless required by law or a court order. If you agree to be in this research study, it is possible that some of the information collected might be copied into a "limited data set" to be used for other research purposes. If so, the limited data set may only include information that does not directly identify you.

Signatures

As a representative of this study, I have explained to the participant the purpose, the procedures, the possible benefits, and the risks of this research study; the alternatives to being in the study; and how the participant's protected health information will be collected, used, and shared with others:

_____ _____

Signature of Person Obtaining Consent Authorisation Date

You have been informed about this study's purpose, procedures, and risks; how your protected health information will be collected, used and shared with others. You have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree to participate in this study. You hereby authorise the collection, use and sharing of your protected health information. By signing this form, you are not waiving any of your legal rights.

_____ _____

Signature of Person Consenting Authorising Date

Please indicate below if you would like to be notified of future research projects conducted by our research group:

_____ (initial) Yes, I would like to be added to your research participation pool and be notified of research projects in which I might participate in the future.

Method of contact:

Phone number: _____

E-mail address: _____

Mailing address: _____

_____

_____

Appendix D

Debriefing Form

Effects of Acute Psychosocial Stress on Prospective Memory:

Debriefing Form

Thank you for participating in the research study.

This form provides you with information about the study in which you have just participated, and explains in full the methods of collection of data for this research study. The Principle Investigator (the person in charge of this research) or a representative of the Principle Investigator will also explain this study to you in full and answer your questions.

1. Name of Participant ("Study Subject")

_____

2. Title of Research Study

The effects of acute psychosocial stress on prospective memory.

3. Principal Investigators, Ethics Committee, and Telephone Numbers

Christina Barnes

Honours Candidate

Department of Psychology

University of Cape Town

072-493-8686

Courtney Lewis

Honours Candidate

Department of Psychology

University of Cape Town

072-918-6584

Robyn Human, MA

PhD Candidate

Department of Psychology

University of Cape Town

021-788-5536

Faculty of Health Sciences

Research Ethics Committee

Room E52-24, Groote Schuur Hospital, Old Main Building

Observatory 7925

Tel: 021-406-6338

Email: lamees.emjedi@uct.ac.za

4. What is the purpose of this research study?

The purpose of this research study is to better understand how exposure to acute psychological stress affects cognitive performance. More specifically, we are interested in how it can affect memory.

5. What was done during this research study?

During this study, you were required to complete a number of memory based tasks and may have been required to complete a 20 minute presentation. Your levels of stress were assessed through the collection of self-report data, heart rate measurements, skin conductance measurements and saliva samples with the aid of a cotton swab. These saliva samples will be used to analyse levels of cortisol, a stress hormone.

6. Was there any deception used in this research study?

If you were one of the participants selected to complete the 20 minute presentation, you will have been told that your verbal and non-verbal behaviour was being judged by a panel, and that you were being filmed in order to facilitate this evaluation. However, the panel was not judging you in any way, nor was the video camera actually recording your behaviour.

Anything you said or did in the “interview” will be kept confidential. This deception was necessary in order to achieve the required increase in cortisol levels.

7. Is there anything further required of you?

Please do not disclose anything that happened during these research sessions to anyone else, as this may bias future participants and their performance.

If you are still feeling stressed at the end of the research study, please inform us so that we can provide you with the contact details of a clinical psychologist who can provide you with post-session counselling.

Signatures

As a representative of this study, I have explained to the participant, in detail, the purpose, the procedures, and any deception used in this research study.

_____ _____

Signature of Person Obtaining Consent Authorisation Date

I have been informed, in detail, about this study’s purpose, procedures, and deceptions. I have been given the opportunity to ask questions before I sign. By signing this form, I am not waiving any of my legal rights.

_____ _____

Signature of Person Consenting Authorising Date