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The Effects of Perceived Daily Stress on Spatial Orientation Skills

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The Effects of Perceived Daily Stress on Spatial Orientation Skills

by

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Abstract

Daily perceptions of stress over time are thought to negatively impact structures in the brain that are essential to the ability of individuals to form cognitive maps. Cognitive map formation is the ability to create mental representations of the spatial layout of the external world and is necessary for spatial orientation. The objective of this study is to investigate how perceived daily experiences of stress are related to the ability of healthy young adults to form cognitive maps and their self-reported sense of direction. We recruited 145 healthy young adults between 18-25 years of age. We evaluated participants twice throughout the school semester on their perceived levels of stress, sense-of direction, and performance on cognitive map formation, spatial perspective taking ability, and mental spatial manipulation tasks. We performed analyses using a growth curve model with a within-subjects design. We included affect, adverse childhood experiences, sleep quality, and sex as moderators for each analysis. Results found no association between perceived stress and task performance or self-reported sense of direction. Outcomes were associated with sex and negative affect, where negative affect and females are associated with worse performance and worse perceptions of sense-of-direction. Perceptions of sense-of-direction associated with positive affect, where increased positive affect was associated with increased perceptions of sense-of-direction. Perceptions of sense-of-direction are also associated with adverse childhood experiences, where higher ratings on adverse childhood experiences were associated with decreased perceptions in sense-of-direction. This project provides insight into the effect that daily nonclinical stress has on the ability to form cognitive maps in healthy young adults. Further, this study helps to describe contributing factors leading to the natural variability observed in these cognitive processes between otherwise healthy individuals.

Keywords: perceived stress, navigation, orientation, cognitive map, student, young adult

Preface

This thesis is original, unpublished, independent work by the author, P. Townes. The experiments reported were covered by the Ethics Board Certificate number REB22-1758, issued by the University of Calgary Conjoint Health Ethics Board for the project *The Effect of Perceived Daily Stress on Cognitive Map Formation Abilities* on January 26, 2023.

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Background

Cognitive Maps

Forming cognitive maps is an essential part of an individual's ability to navigate and orient themselves within an environment. These skills emerge in development around nine years of age and are necessary for individuals to perform tasks and achieve goals (Burles et al., 2020). Prior to age 9, children tend to follow previously learned paths and are less likely to take shortcuts to get to a desired destination (Burles et al., 2020). Cognitive maps are defined as the ability to create mental representations of the spatial layout of the external world (Epstein et al., 2017). Navigation is the ability to use representations, both self (egocentric) and external objects (allocentric) to move through space and reach a desired goal (Brodbeck & Tanninen, 2012). Lastly, orientation is determining a location in space relative to a reference frame (Benton & Tranel, 1993). The ability to form cognitive maps is highly correlated with basic navigation, orientation, and spatial processing strategies (Arnold et al., 2013).

The hippocampus, located in the medial temporal lobe, is a primary neuroanatomical structure implicated in the encoding and retrieval of spatial information, and the formation of cognitive maps (Eichenbaum, 2015; Wikenheiser & Schoenbaum, 2016). The parietal cortex also helps to process spatial information from multiple sensory modalities (Kesner & Long, 1998), and the prefrontal cortex is involved in planning and decision-making during navigation (Wikenheiser & Schoenbaum, 2016; Bottini & Doeller, 2020). Connecting these neuroanatomical structures often involves pathways through the anterior thalamic nuclei as part of the Papez' circuit (Jankowski et al., 2013). Pathways that have been implicated in the integration and transformation of spatial information across different scales and reference frames include the retrosplenial cortex-hippocampal pathway (Mitchell et al., 2018) and the thalamo-cortical loop (Wolff et al., 2021).

A number of factors contribute to the natural variability observed in cognitive map formation abilities between individuals including age, sex, bias, adverse childhood experiences, and emotional affect. Younger individuals generally exhibit better performance than older individuals. This decline in cognitive map ability with age may be due to age-related structural changes in the brain, such as reduced hippocampal volume, and functional changes in attention, memory, and processing speed (Iaria et al., 2009). Males often perform better than females on cognitive map formation tasks, though the results in the literature are mixed (Liu et al., 2011; Pagkratidou et al., 2020; Youngson et al., 2019). This difference may be related to differences in brain structure and function, such as greater hippocampal volume in males and differences in strategy use and experience (Cocquyt et al., 2022). Bias can also affect cognitive map formation ability, where individuals' prior beliefs, social networks and expectations influence their perception and memory of spatial information (Napoles et al., 2022). For example, individuals may hold a bias towards a particular direction or landmark or may rely on specific cues more than others. This bias can lead to distortions in cognitive maps and errors in spatial navigation. Adverse childhood experiences (ACEs), such as abuse or neglect, can also have lasting effects on cognitive map formation abilities, where individuals who have experienced ACEs may exhibit impaired performance on cognitive map tasks, as well as have reduced hippocampal volume and function (Smith et al., 2015). These effects may be due to changes in stress response systems, how individuals cope with stress, and brain development (Garfin et al., 2018). Affect, or emotional state, can also impact cognitive map ability, where negative affect in the form of anxiety and stress impairs cognitive map formation, while positive affect, such as happiness or excitement, may enhance it (Burles & Iaria, 2020).

Stress

Negative affect in the form of perceptions of stress are an unavoidable aspect of life, however, not all stress is the same. There are two distinct types of stress: distress, and eustress. Distress refers to the negative impact stress has on mental and physical well-being (Barry et al., 2020). Eustress refers to stress that leads to positive affect, such as the excitement and motivation felt before an important event or challenge (Bienertova-Vasku et al., 2020). By understanding the different types of stress and how they impact us, we can take steps to manage stress more effectively and even use it to our advantage.

Lazarus and Folkman's Transactional Model of Stress and Coping defines stress as the body's internal reaction to external stimulus that is deemed as harmful (Lazarus & Folkman, 1984). The Transactional Model of Stress and Coping further delineates that the way we interpret and react to an event can have a greater impact on an individual's stress level than the event itself (Lazarus & Folkman, 1984). Further, the level of stress experienced by an individual is directly related to how confident they feel about dealing with the threat (Lazarus & Folkman, 1984). Lazarus and Folkman have created the Transactional Model of Stress and Coping as a framework to help individuals manage their stress using objective appraisal and coping strategies (Lazarus & Folkman, 1984). Hans Selye, known as the father of stress research, was the first to define stress as a nonspecific biological response to any demand and that stress is therefore associated with physical disease (Tan & Yip, 2018). Selye defined three stages of stress: Alarm, Resistance, and Exhaustion, where resistance to stress causes exhaustion and the body becomes more susceptible to inflammation, chronic fatigue, and a shortened lifespan as a result (Tan & Yip, 2018). This process is known as General Adaptation Syndrome or Selye's Syndrome (Tan & Yip, 2018).

Daily stressors refer to minor interruptions or difficulties such as minor arguments or work overload that can accumulate over time, leading to persistent stress (Thoits, 2013). Prolonged daily persistent stress can lead to chronic stress, which is a feeling of overwhelm and pressure over an extended period of time (Mariotti, 2015). Persistent stress has a profoundly negative impact on an individual's life and is associated with the development of mental illnesses including anxiety and depression (Thoits, 2013), alcohol and substance abuse (Ruisoto & Contador, 2019), and detriments to physical health (Larzelere & Jones, 2008).

Stress is a complex physiological and psychological response that can be measured in several ways. Cortisol, a hormone released in response to stress, can be measured through saliva, blood, or urine samples, amongst other methods (Cay et al., 2018). Heart Rate Variability (HRV) is another physiological marker of stress that assesses the variation in the time intervals between heartbeats, where higher HRV in response to a stressor is generally associated with higher levels of stress (Kim et al., 2018). Blood Pressure Variability (BPV) can also be used as a biomarker of stress, with higher blood pressure indicating greater stress levels (Tomitani et al., 2021). Lastly, the Perceived Stress Scale (PSS) is a commonly used self-report questionnaire that assesses individuals' subjective perception of stress retrospectively over a predefined length of time (Lee, 2012). Cortisol, HRV, and BPV are all measures of biological responses to stress, however, they do not adequately measure the extent to which individuals perceive experiences in their life as stressful. The PSS is therefore an effective measure of persistent daily perceptions of stress.

Chronic perceptions of daily stress over time lead to chronically elevated cortisol levels and are especially impactful on cognitive functioning (de Souza-Talarico et al., 2011; Yaribeygi et al., 2017). The hippocampus, prefrontal cortex, and parietal cortex are sensitive to stress and cortisol, and prolonged exposure can cause structural changes in these regions (Ito et al., 2018; McEwen et al., 2016; Lucassen et al., 2014). Chronic stress has been shown to reduce hippocampal volume, impair hippocampal-dependent spatial memory, and alter the connectivity between the hippocampus and other brain regions involved in spatial processing (Chen et al., 2019). Stress and cortisol can also affect neurotransmitters involved in cognitive map formation including serotonin, norepinephrine, and glutamate (Kumar et al., 2013). They can also activate stress-related pathways, such as the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system, which can affect the expression of genes involved in synaptic plasticity and memory consolidation (Kumar et al., 2013).

Existing research on stress and navigation

Existing research has found that individuals with higher levels of early-life stress had poorer performance on a spatial memory task (Ricker et al., 2018). Other studies have found that daily stress can impair spatial learning and decision-making abilities, leading to poorer navigation performance in complex environments (Kleen et al., 2006). Higher levels of perceived stress are associated with increased disorientation and impaired spatial updating abilities, which can lead to errors in navigation and increased anxiety in unfamiliar environments (Brown et al., 2020). The exact mechanisms underlying the effects of daily perceived stress on cognitive map formation are not fully understood. However, stress-related physiological and psychological factors, such as increased cortisol levels, alterations in attention and working memory, and changes in strategy use and decision-making are thought to contribute to these effects. More specifically, cortisol release as a result of the biological stress response impacts the hippocampus and may therefore have an effect on cognitive map formation abilities.

Objective

The ability to form cognitive maps is essential to survival. Without it, individuals would be unable to navigate spatial surroundings effectively leading to poor performance on essential tasks, failure to achieve goals, and further feelings of distress (Burles & Iaria, 2020). Despite the scientific evidence of the neurological impact stress has on brain regions critical for spatial orientation, study designs have typically followed an evaluation of acute stress introduced by the study team in both human (Brown et al., 2020; Delahaye et al., 2015; Thomas et al., 2010; van Gerven et al., 2016) and rodent models (Blokland et al., 2006; Faraji et al., 2013). To date, no study has investigated how the day-to-day perception of stress in healthy young adults is associated with their ability to form cognitive maps, which is the main aim of this observational longitudinal study. An assessment of the association between the individual factors of affect, sleep, sex, and adverse childhood experiences and cognitive map formation abilities is the secondary aim of the study. Lastly, an evaluation of the combined effect that both perceived stress and the individual factors mentioned previously is the tertiary aim of this study.

Hypothesis

I hypothesize that the relationship between daily stress and cognitive map formation abilities and related tasks will follow a downward trend, where heightened levels of perceived stress will be associated with a significant decrease in an individual's performance on each task. Further, I hypothesize that male sex will be associated with better performance on tasks. Negative affect will be associated with worse scores on outcome variables. Positive affect will have a positive association where higher positive affect will be associated with better performance. Sleep quality will be associated with worse cognitive map formation abilities. Lastly, I hypothesize that a greater number of adverse childhood experiences will be associated with greater fluctuations in stress and worse performance on tasks.

Methods

Participants

A convenience sample was used to recruit participants. Healthy young adults with no existing neurological or neuropsychological condition 18-25 years of age were recruited through the University of Calgary undergraduate Psychology Research Participation System (RPS). This system is open to all undergraduate psychology students at The University of Calgary who are enrolled in a course that requires research participation to fulfill part of the credits for the course. Students were eligible for participation if they met the above criterion which was determined through a self-report questionnaire once they created an account for RPS. Students were also ineligible for participation of they were also participating in another study being conducted by the same laboratory. This was an original study population not previously used in prior research. The total sample size of the study necessary is 111 participants as decided through a one-tailed power calculation using a power of 0.95, an alpha error probability of 0.05, and a moderate effect size of 0.3 using the G*Power application (Faul et al., 2009). A one-tailed power calculation was chosen due to the directionality of the hypothesis. The effect size of 0.3 relates to the primary analysis of the study and was chosen as a product of the recommendations by senior lab members and what has been found in existing literature. G*Power calculates the necessary sample size as a function of the required significance level α, the desired statistical power $1-\beta$, and the to-be detected population effect size measured as a tetrachoric correlation under H1, ρ1 (Faul et al., 2009). A tetrachoric correlation procedure refers to a 2 x 2 contingency table that represents samples of two dichotomous random variables (Faul et al., 2009). This sample size and effect size is also comparable to what has been found in similar research previously published (Maran et al., 2017).

Five participants registered but never began the study, we removed 112 participants due to incomplete data, seven participants due to linearity of responses (quality control procedure), five participants due to reports of neurological impairment, one participant as they reported having brain damage, and one participant because they were above the age limit of the study (37 years old).

One hundred and forty-five participants were included in the study following data cleaning. The population comprised 84 (57.93%) males and 61 (42.07%) females. The participants had a mean age of 19.90 years (SD = 1.70). See Table 1 for demographic information and average scores on the primary independent variable of interest and each dependent variable. Researchers evaluated 15 participants in person at the beginning of the study as a pilot prior to the study proposal seminar being completed. Evaluating participants in person allowed the research team a greater connection to participants to receive feedback and more quickly identify difficulties to the study design prior to moving online. Lack of power prevented further analysis to evaluate if there were differences in scores between those completing the study in person and online. It was decided by the study team to keep both in-person pilot data and the online data because there were no changes to the population or study design beyond data collection moving to the online platform. The first and second visit were on average 32.18 days apart (*SD* = 9.38, Range 10-61).

Experimental Design

Researchers evaluated participants twice with an estimated 25-35 days between evaluations. Participant's first assessments were staggered throughout the semester in attempts to control for natural increases in stress prior to midterm and final exams. This timeframe allowed participants to exemplify their experience of fluctuating stress levels due to variations in workload throughout the semester (i.e. before and following midterm examinations or assignment deadlines). Participants completed both evaluations during the same semester. Data collection was completed throughout the Spring 2023, Summer 2023, and Fall 2023 semesters. Each assessment took approximately one hour to complete. Participants signed a consent form before beginning the study, where they were reminded that completion of the assessments was not mandatory and that they had the right to discontinue their participation at any time. Further, participants had the right to withdraw their data from the study until one week following their visit. Participants completed assessments using an online platform and were asked to complete the questionnaires and tasks in an environment without distractions or help from peers. We deidentified participant data after data collection was complete. We kept consent forms and the identified participant ID on a password-protected account through RPS that was only accessible by the study team. All researchers included in the study have been trained to deal with human participants and have achieved the appropriate TCPS-2 Core ethics certificate. The experiments reported were covered by the Ethics Board Certificate number REB22-1758, issued by the University of Calgary Conjoint Health Ethics Board for the project *The Effect of Perceived Daily Stress on Cognitive Map Formation Abilities* on January 26, 2023.

Participants completed a general demographics questionnaire including sex, age, and existing cognitive and/or neurological conditions. The following questionnaires were also completed by participants at each visit before performing the tasks:

The Perceived Stress Scale (PSS), a self-reported 14-item Likert scale questionnaire that measures to what extent individuals appraise situations in their lives as psychologically stressful (Cohen et al., 1983). The items of the scale are designed to evaluate the degree to which an individual perceives their life as unpredictable, uncontrollable, and overloaded over the last month (Lee, 2012). To score the PSS, questions 4,5,7, and 8 are reverse scored. Following this reverse scoring, the scores from all questions are summed together to produce a score between 0-40, where higher scores indicate higher perceived stress. Scores between 0-13 is considered low stress, 14-26 as moderate stress, and 27-40 is high perceived stress (Lee, 2012). The test-retest reliability was evaluated in four studies and all of them met the criterion of >.70 in all cases (Lee, 2017). Cronbach's alpha was evaluated as satisfactory being >.70 in all 12 validity studies where it was evaluated (Lee, 2017).

The Positive and Negative Affect Scale (PANAS) is a 20-item self-report Likert scale questionnaire that provides independent measures of positive and negative affect as a subjective measure of mood and emotion (Watson & Clark, 1988). High negative affect measured by the scale suggests subjective distress and unpleasurable engagement, whereas high positive affect represents pleasurable engagement with the environment (Crawford & Henry, 2004). To score the PANAS, the positive affect score is derived from the sum of items 1,3,5,9,10,12,14,16,17, and 19. Scores range from 10-50 with higher scores representing higher levels of positive affect. The mean score reported by validation studies of the scale is 33.3 (SD = 7.2) (Watson et al., 1988). The negative affect score is derived from the sum of items 2,4,6,7,8,11,13,15,18, and 20.

Scores for negative affect also range from 10-50 with lower scores representing lower levels of negative affect. The mean score reported by validation studies of the scale is 17.4 (SD = 6.2) (Watson & Clark, 1988). The PANAS has shown high scale, item and external validity (Watson & Clark, 1988). The scale has also been found to have high test-retest reliability (Watson & Clark, 1988). Lastly, the Cronbach's alpha for the scale are high between .84-.90 (Watson & Clark, 1988).

The Pittsburgh Sleep Quality Index (PSQI) is a 19-item self-rated Likert scale measure that assesses an individual's sleep quality and disturbances over the past month (Buysse et al., 1989). The scale generates seven component scores of subjective sleep quality, latency, duration, disturbances, habitual sleep efficiency, use of sleeping mediation, and daytime function (Buysse et al., 1989). To score the PSQI, the component scores are summed to produce a global score that ranges from 0-21 where higher scores indicate worse sleep quality (Buysse et al., 1989). Acceptable measures of internal homogeneity, test-retest reliability, and validity have been obtained for the scale (Buysse et al., 1989). Cronbach's alpha was high at .83 as reported for the scale (Buysse et al., 1989).

The Santa Barbara Sense of Direction Scale (SBSOD) is a 15-item self-reported Likert scale measure that evaluates an individual's perceived ability to find their way in an environment and learn the layout of a new environment (Hegarty et al., 2002). Higher scores on the scale indicate an individual's belief that they have a good sense of direction (Hegarty et al., 2002). To score the SBSOD, reverse score items 1,3,4,5,7,9, and 14 then compute the average score across the 15 items. The resulting score will be between 1-7 where a higher score indicates a higher sense of direction. Four studies measuring the validity of the SBSOD found that the scale relates to tasks regarding updating an individual's location in space as a result of self motion and is highly correlated with tests of spatial knowledge and orientations (Hegarty et al., 2002). The questionnaire is also highly correlated with measures of spatial knowledge acquired from direct experience in the environment than with spatial knowledge acquired from virtual environments (Hegarty et al., 2002). Cronbach's alpha has been reported as high at .88 for the SBSOD (Carbonell-Carrera et al., 2020).

Lastly, The Adverse Childhood Events Questionnaire (ACEs) is a 10-item yes-or-no questionnaire to evaluate if participants have experienced stressful life events as children or teens which could have a profound effect on their physical and mental health (Finkelhor et al., 2015). Five of the scale items concern aspects of child maltreatment including physical abuse, neglect, and sexual abuse (Finkelhor et al., 2015). The other five items regard parental and familial incapacities including parental loss, parental mental illness or substance abuse, and violence against the mother (Finkelhor et al., 2015). To score the ACES questionnaire, each response of "yes" is coded as "1" where scores can range from 0-10 with higher scores indicating a greater number of adverse childhood experiences for the participant. Scores of four or more are considered clinically significant (Finkelhor et al., 2015). Adequate internal consistency, internal validity, proper concurrent criterion validity, and test-retest reliability has been found for the scale (Kovacs-Toth et al., 2023). Cronbach's alpha was identified as moderate at .64 for the ACEs scale (Kovacs-Toth et al., 2023).

Three tasks are used to evaluate cognitive map formation abilities along with spatial perspective taking and mental manipulation abilities, the latter two which are critical skills in forming cognitive maps. Participants were given instructions through screen prompts while performing each task. We recorded the participants' accuracy (their number of correct responses) and reaction times (how fast participants completed all of the trials) for each task. Participants were advised to discontinue participation in the study if they felt that they were not comfortable or experienced motion sickness while completing the tasks.

The Spatial Configuration Task (SCT), measures the ability to form cognitive maps by requiring participants to build a mental representation of the environment (Tolman, 1948; Epstein et al., 2017). In this task, there are five geometric objects in a circle and participants must infer what object they are looking from based on the two objects they see in their view. The view switches between objects at each trial (Burles et al., 2017) (See Figure 1 for an example from the task). Participants completed 40 total trials of the task at each visit.

Figure 1

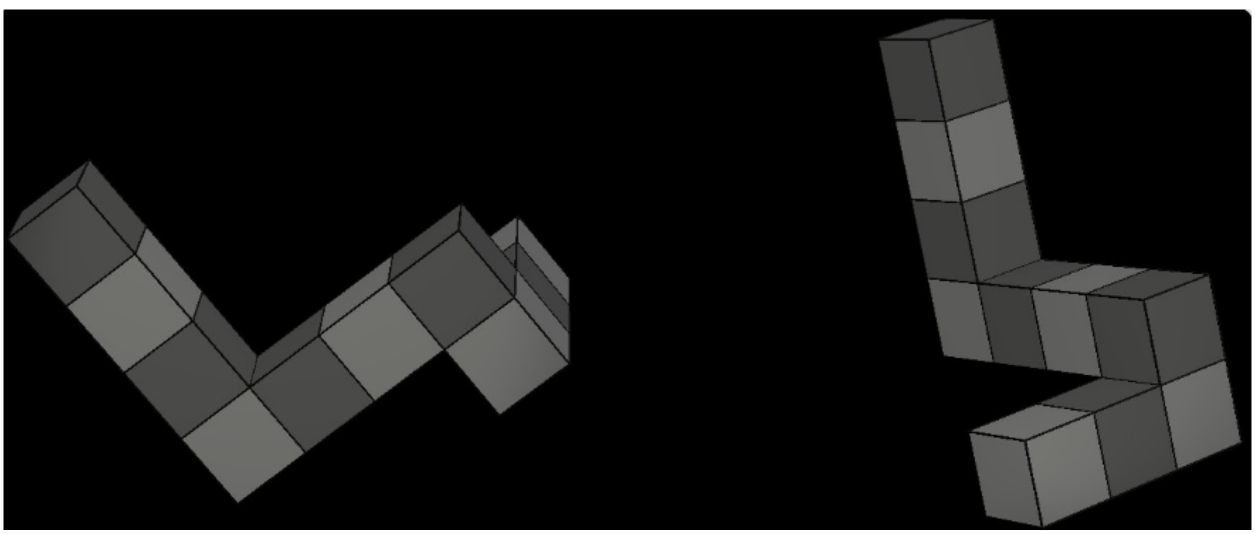
Snapshot example from the Spatial Configuration Task.

Note. Two out of the five objects are visible at one time. the view shifts to a new perspective from another object once a choice has been selected by the participant. Image retrieved from: https://fordburles.com/spatial-configuration-task.html

The Mental Rotation Task (MRT) is an adaptation of the classic Shepard and Metzler mental rotation task where participants view pairs of objects constructed from ten cubes each and must infer if the objects would be the same shape when rotated on their axes (Shepard & Metzler, 1971). The test characterizes the ability to perform mental manipulations of spatial information (Shepard & Metzler, 1971) (See Figure 2 for a screenshot from the task). Participants completed 40 trials of the task at each visit.

Figure 2

Snapshot example from the Mental Rotation Task.

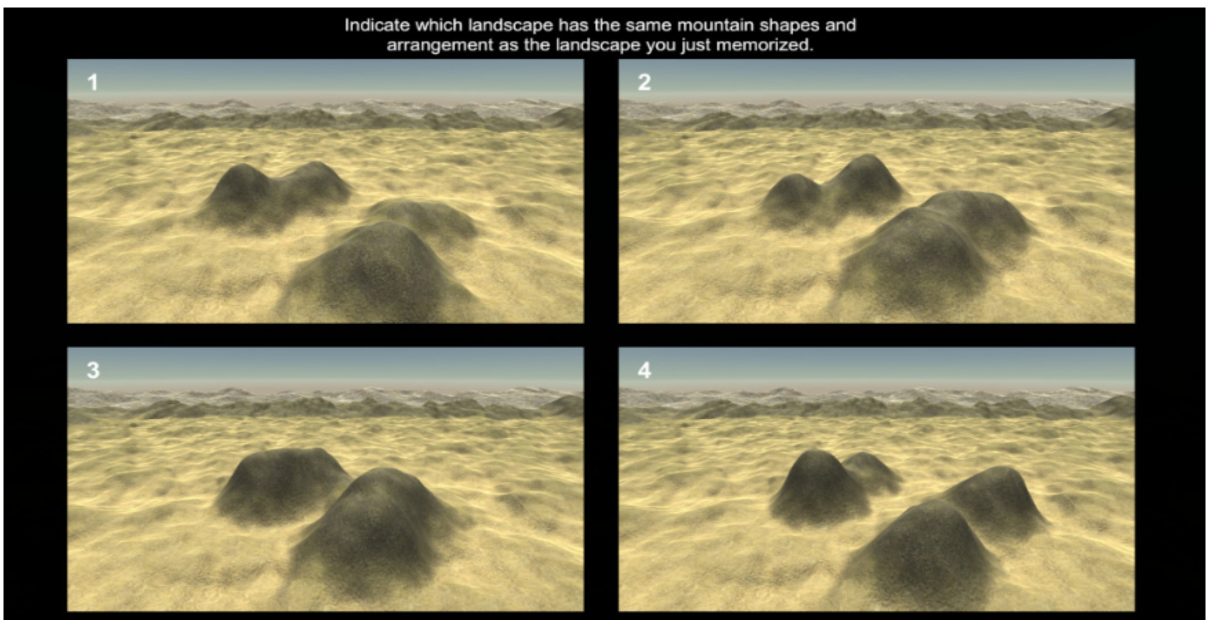


Note: Two objects are shown at once. Participants are instructed to select yes or no if the objects are able to be rotated so that they are the same shape. Two new objects are shown after a selection has been made. Image retrieved from: https://fordburles.com/mental-rotation-task.html

The Four Mountains Task (4MTN) is an adaptation of the original task created by Hartley and colleagues to evaluate spatial perspective-taking abilities (Hartley et al., 2007). Participants view virtual scenes composed of four distinct mountain peaks. After each scene, participants identify the same scene, depicted from a different viewpoint from four response options (See Figure 3 for a screenshot from the task). Participants completed 20 trials of the task at each time point.

Figure 3

Snapshot example from the Four Mountains Task.



Note. Participants are first shown a single scene for eight seconds before the screen goes black for two seconds. Following the blank screen, participants are shown four separate landscapes (as seen here) from different angles than the original and they are instructed to select which landscape is the same as the original image. Image retrieved from: https://fordburles.com/four-mountains-task.html

Compensation

Participants recruited through the RPS system received an additional 2% accredited to their final grade in the undergraduate Department of Psychology course they enrolled in the study through. Participants received one credit upon the completion of each part of the study. We entered all participants into a draw to win $100 upon the completion of both parts of the study, except for those who work directly with the study team such as friends, family, and fellow laboratory members due to conflicts of interest.

Quality Control

Participants must have completed all tests and questionnaires in both the first and second visits to be included in the analysis. Listwise deletion is used to deal with missing data for simplicity. Little's Missing Completely at Random (MCAR) Test rejected the null hypothesis that the missing data is completely at random ($\chi^2 = 422.61$, df = 373, $p = .039$). Linearity of responses is employed to control for participants repeatedly selecting the same response across all questionnaires during a visit, where individuals with a proportion of responses greater than 0.90 that are the same are removed from the study.

The following assumption tests were performed prior to statistical analysis: Shapiro-Wilks test of normality of residuals found wide sweeping violations amongst the dependent variables and with the PANAS negative affect, PSQI, and ACEs questionnaires. However, sample sizes greater than 50 participants such as the one for the current study are typically robust to such assumptions (Curran et al., 2010); Bartlett's test of homoscedasticity to evaluate the homogeneity of variances was violated on the PANAS negative affect and ACEs questionnaires. This test is generally well tolerated by data without too many violations (Curran et al., 2010).

Analysis

Analyses are performed using a within-subject, growth curve model. The first-order effects of the model is the effect of changes in perceived stress on the change in individual performance on each task. Accuracy scores on each task are evaluated as outcome variables. Response times are not included in the model for the sake of brevity. The PANAS, PSQI, ACEs, and SBSOD scales, as well as sex, are used as moderators in each analysis where the first-order effects of each moderator and the slope estimates of the interaction between the PSS and the moderator are evaluated. Each moderator was added to the model individually and their effects were evaluated separately from one-another. Follow-up simple slope analyses are performed when a significant slope estimate of the interaction is identified. PSS scores are person-mean-centered to control for between-person differences, though some between-person differences may still exist (Wang et al., 2019). The PANAS, PSQI, and SBSOD questionnaires are group mean centered. The ACEs questionnaire remains as raw values. Test accuracy scores for each dependent variable are multiplied by ten to create homogeneity between magnitudes of values in the model. The SBSOD is also evaluated as a dependent variable to evaluate if changes in stress have a different association between individual perceptions of sense-of-direction and their actual performance on cognitive map formation, mental representation, and spatial perspective taking tasks. A random intercept model is applied for the current study. The estimator used for the model is restricted maximum likelihood. The advantage of using a growth model is its strength in characterizing changes in an assessment measure over time. Growth modelling takes into account clustering and is more flexible with non-continuous dependent variables, making it more advantageous to use over other statistical methods that do not consider clustering and are unable to account for non-continuous dependent variables, such as repeated measures ANOVA (Boscardin et al., 2022).

Results

Perceived Stress Scale

A within-subjects t-test between PSS scores at the first (*M* = 19.3, *SD* = 6.70) and second visit (*M* = 20.4, *SD* = 6.80) revealed a significant difference ($t(144) = -2.56$, $p = .011$), where individuals were more stressed during the second evaluation (See Table 1 and Figure 4). Individuals overall reported moderate stress as defined in the PSS as a score ranging from 14-26 (Lee, 2012).

Table 1

Demographics of population and collective scores for each test at each time point.

		Time 1			Time 2		
Variable	N (%)	Mean	Median	SD	Mean	Median	SD
Total	145 (100)						
Female	61 (42.07)						
Age		19.9		1.70			
PSS		19.3		6.70	20.4*		6.80
ACES		1.21		1.66			
PSQI		6.08		2.61	6.12		2.44
SBSOD		4.44		1.12	4.23***		1.11
PANAS PA		32.00		7.12	29.60***		7.19
PANAS NA		23.60		7.51	24.30		6.91
4MTN Acc		60.6		13.7	58.7		13.7
SCT Acc		51.0		20.0	60.8***		23.7
MRT Acc		78.2		15.3	79.6		14.9
4MTN RT			7309	3252		5685***	2470
SCT RT			2601	1996		1967***	2084
MRT RT			5156	2533		3641***	2306

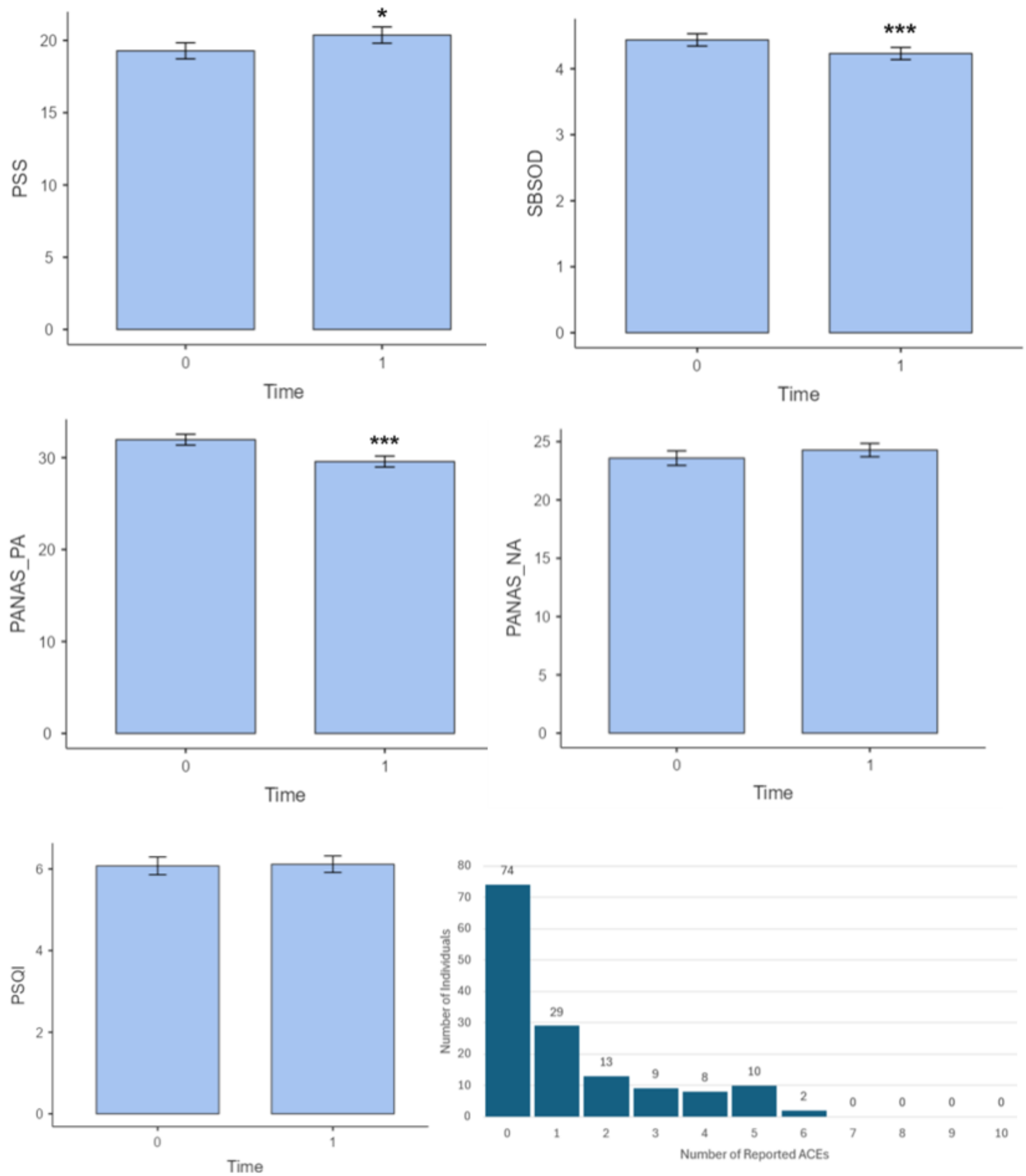
Note. PSS scores range from 0-40. Task accuracy scores are in percentages. Task response times are in milliseconds. T-test performed between all variables evaluated at time point 1 and time point 2. * $p < .05$, ** $p < .01$, *** $p < .001$.

Moderating Variables

Scores on the SBSOD decreased significantly between the first (*M* = 4.44, *SD* = 1.12) and second visit (*M* = 4.23, *SD* = 1.11) indicating a decrease in individuals' perceived sense of direction ($t(144) = 5.15$, $p < .001$). The Positive Affect section of the PANAS also had a significant decrease in scores between the first (*M* = 32.00, *SD* = 7.12) and second visit (*M* = 29.60, *SD* = 7.19), indicating a decrease in the overall positive affect of participants ($t(144) = 5.23$, $p < .001$). The PSQI did not differ significantly between the first (*M* = 6.08, *SD* = 2.61) and second visit (*M* = 6.12, *SD* = 2.44) ($t(144) = -0.29$, $p = .771$). The PANAS Negative Affect score did not significantly differ between the first (*M* = 23.60, *SD* = 7.51) and second visit (*M* = 24.30, *SD* = 6.91) ($t(144) = -1.32$, $p = .187$), however, participant scored higher at both time points compared to the average score reported for the scale (*M* = 17.4, *SD* = 6.2) (Crawford & Henry, 2004) (See Table 1 and Figure 4).

Figure 4

Visual representation of the change in average score across each predictor variable.



Note. * = $p < .05$, ** = $p < .01$, *** = $p < .001$. An ACEs score of four or more is considered clinically significant (Finkelhor et al., 2015).

Four Mountains Task

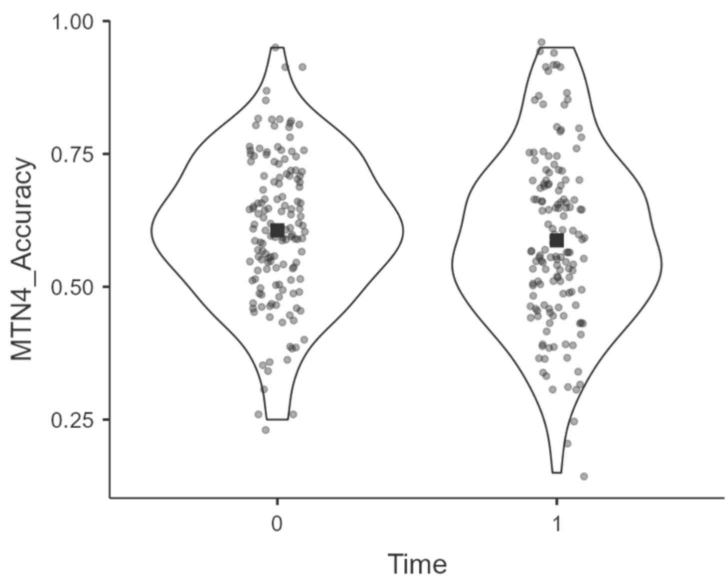
The accuracy of participants decreased non-significantly between the first (*M* = 0.606, *SD* = 0.137) and second (*M* = 0.587, *SD* = 16.30) visits ($t(144) = 1.54$, $p = .125$) (See Figure 5). The response time of participants decreased significantly between the first (*Median = 7309, M =* 7783, *SD* = 3252) and second (*Median = 5685, M* = 5996, *SD* = 2470) visit ($t(144) = 9.81$, $p < .001$) (See Table 1).

The first-order effects revealed a nonsignificant effect of time ($t(142) = -1.76$, β = -0.22, SE = 0.13, $p = .081$), PSS ($t(142) = 0.46$, β = 0.02, SE = 0.04, $p = .647$), and the slope estimate of PSS and time ($t(142) = 0.19$, β = 0.02, SE = 0.09, $p = .849$) (See Table 2).

The second-order effect of moderators did not reveal significance under any analysis (See Table 2). The PANAS NA expressed significant first-order effects ($t(141) = -4.13$, β = -0.05, SE = 0.01, $p < .000$), where greater negative affect was associated with worse performance on the task.

Figure 5

Average score on the MTN4 at each time point



Note. Performance at first visit (M = 60.60, SD = 13.70) was not significantly different than performance at second visit (M = 58.70, SD = 13.70).

Table 2

Results for analyses of the 4 Mountains Task within each moderator.

Moderator		β	t	SE	*p*
Null Model		5.97	54.67	0.11	
PSS		0.02	0.46	0.04	.647
	PSS*Time	0.02	0.19	0.09	.849
	Intercept	6.07	52.00	0.12	.000
	Time	-0.22	-1.76	0.13	.081
Sex		0.37	1.73	0.22	.090
	PSS*Sex	-0.02	-0.39	0.05	.697
	Intercept	5.86	34.77	0.17	.000
	Time	-0.21	-1.70	0.13	.000
PANAS PA		-0.01	-0.58	0.01	.560
	PSS*PANAS PA	-0.00	-0.91	0.00	.366
	Intercept	6.32	14.35	0.44	.000
	Time	-0.24	-1.85	0.13	.070
PANAS NA		-0.05	-4.13	0.01	.000
	PSS*PANAS NA	0.00	0.26	0.00	.796
	Intercept	7.32	22.89	0.32	.000
	Time	-0.22	-1.74	0.12	.084
PSQI		-0.00	-0.03	0.04	.979
	PSS*PSQI	-0.00	-0.38	0.01	.703
	Intercept	6.09	23.19	0.26	.000
	Time	-0.22	-1.76	0.13	.080

ACEs		-0.01	-0.12	0.06	.907
	PSS*ACEs	0.01	0.74	0.02	.460
	Intercept	6.08	43.53	0.14	.000
	Time	-0.21	-1.64	0.13	.104
SBSOD		0.07	0.78	0.09	.437
	PSS*SBSOD	-0.02	-0.90	0.02	.369
	Intercept	5.76	13.61	0.42	.000
	Time	-0.20	-1.59	0.13	.114

Note. N = 145; ICC = 0.515; Females were coded as "1" and males as "0".

Spatial Configuration Task

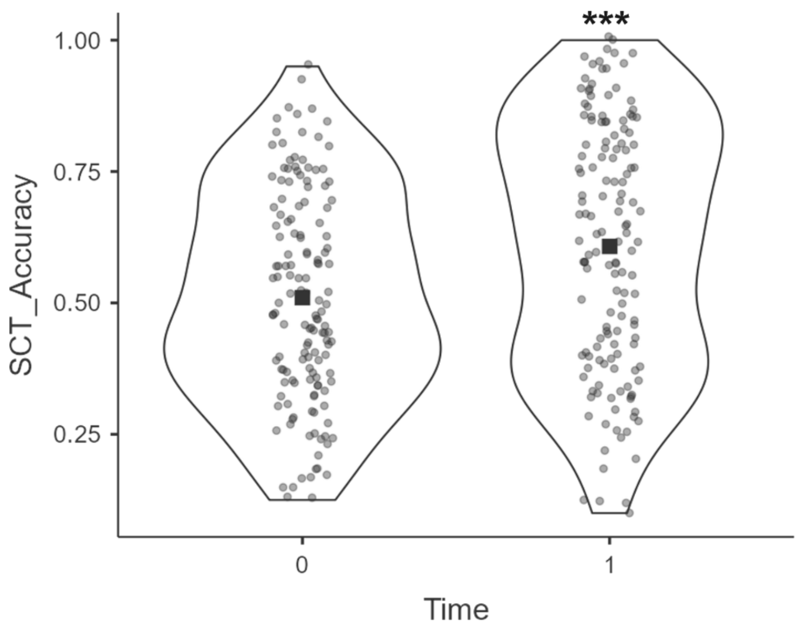
Participant accuracy improved significantly between the first (*M* = 0.510, *SD* = 0.200) and second visit (*M* = 0.608, *SD* = 0.237) on the Spatial Configuration Task ($t(144) = -6.78$, $p < .001$) (See Figure 6). Response times also became significantly faster between the first (*Median = 2601, M* = 3115, *SD* = 1996) and second visit (*Median = 1967, M* = 2616, *SD* = 2084) ($t(144) = 4.34$, $p < .001$) (See Table 1).

Time had a significant first-order effect ($t(142) = 6.77$, $\beta > 0.99$, SE = 0.15, $p < .001$), which is in-line with the significant differences reported from the within-subjects t-test. PSS ($t(142) = -0.04$, $\beta = -0.00$, SE = -0.04, $p = .971$) and the slope estimate of PSS and time was not significant ($t(142) = -0.27$, $\beta = -0.04$, SE = 0.13, $p = .788$) (See Table 3).

Moderators did not express any significant first-order effects or slope estimates in the analysis of the Spatial Configuration Task (See Table 3).

Figure 6

Average score on the SCT at each time point



Note. Performance at first visit (M = 51.00, SD = 20.0) was significantly worse than performance at second visit (M = 0.61, SD = 0.24), p < .001.

Table 3

Results for analyses of the Spatial Configuration Task within each moderator.

Moderator		β	t	SE	*p*
Null Model		5.59	33.38	0.17	
PSS		-0.00	-0.04	0.03	.971
	PSS*Time	-0.04	-0.27	0.13	.788
	Intercept	5.10	29.95	0.17	.000
	Time	>0.99	6.77	0.15	.000
Sex		-0.08	-0.23	0.33	.815
	PSS*Sex	0.05	0.81	0.06	.417
	Intercept	5.14	20.28	0.25	.000
	Time	0.98	6.59	0.25	.000
PANAS PA		0.03	1.39	0.02	.168
	PSS*PANAS PA	-0.01	-1.61	0.00	.110
	Intercept	4.27	7.09	0.60	.000
	Time	1.04	6.97	0.15	.000
PANAS NA		-0.01	-0.67	0.02	.503
	PSS*PANAS NA	-0.00	0.88	0.00	.382
	Intercept	5.39	11.86	0.45	.000
	Time	0.99	6.73	0.15	.000
PSQI		0.00	0.08	0.05	.935
	PSS*PSQI	0.00	0.18	0.01	.860
	Intercept	5.06	13.76	0.37	.000
	Time	>0.99	6.74	0.15	.000

ACEs		0.05	0.51	0.10	.614
	PSS*ACEs	-0.01	-0.50	0.02	.620
	Intercept	5.03	24.41	0.21	.000
	Time	0.99	6.63	0.15	.000
SBSOD		0.15	1.09	0.13	.278
	PSS*SBSOD	0.00	0.16	0.03	.875
	Intercept	4.45	7.24	0.61	.000
	Time	1.02	6.84	0.15	.000

Note. N = 145; ICC = 0.61; Females were coded as "1" and males as "0".

Mental Rotation Task

Participants had a nonsignificant improvement in accuracy between the first (M = 0.782, SD = 0.153) and second time points (M = 0.796, SD = 0.149) on the Mental Rotation Task ($t(144) = -1.41$, $p = .160$) (see Figure 7). Individual response times became significantly faster between the first (*Median = 5156, M* = 5388, SD = 2533) and second visit (*Median = 3641, M* = 4120, SD = 2306) ($t(144) = 7.53$, $p < .001$) (See Table 1).

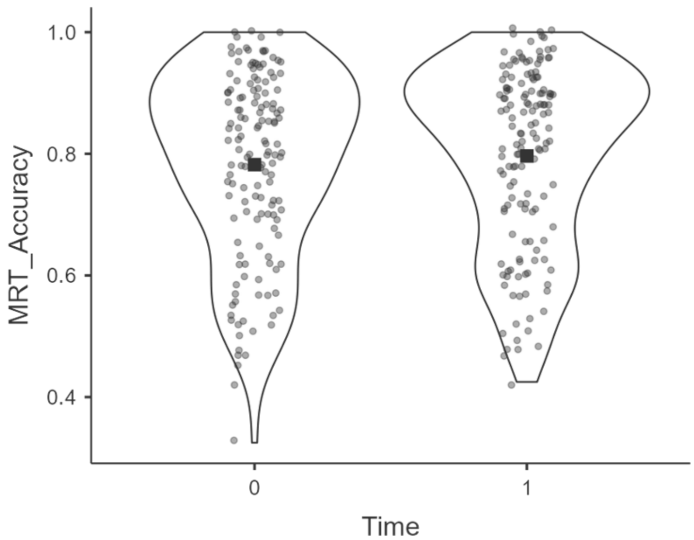
The PSS ($t(142) = -0.78$, β = -0.04, SE = 0.05, $p = .435$), time ($t(142) = 1.72$, β = 0.18, SE = 0.10, $p = .088$) and the slope estimate of PSS and time ($t(142) = 0.18$, β = 0.02, SE = 0.09, $p = .857$) did not express significant first-order effects (See Table 4).

Moderators did not have any significant slope estimates in the analysis of the Mental Rotation Task. Analyses revealed significant first-order effects of moderators for Sex ($t(141) = 2.06$, β = 0.47, SE = 0.23, $p = .041$), where males performed better than females, and the PANAS

NA ($t(141) = -2.07$, $\beta = -0.03$, SE = 0.01, $p = .041$), where greater negative affect was associated with worse performance on the task (See Table 4).

Figure 7

Average score on the MRT at each time point



Note. Performance at first visit (M = 78.20, SD = 15.30) was not significantly different than performance at second visit (M = 79.60, SD = 14.90).

Table 4

Results for analyses of the Mental Rotation Task within each moderator.

Moderator		β	t	SE	*p*
Null Model		7.89	68.60	0.12	
PSS		-0.04	-0.78	0.05	.435
	PSS*Time	0.02	0.18	0.09	.857
	Intercept	7.80	59.87	.013	.000
	Time	0.18	1.72	0.10	.088
Sex		0.48	2.09	0.23	.040
	PSS*Sex	-0.04	-1.01	0.04	.316
	Intercept	7.52	41.04	0.18	.000
	Time	0.19	1.84	0.10	.068
PANAS PA		0.00	0.18	0.01	.860
	PSS*PANAS PA	-0.00	-1.69	0.00	.094
	Intercept	7.72	17.92	0.43	.000
	Time	0.18	1.70	0.10	.091
PANAS NA		-0.02	-2.08	0.00	.039
	PSS*PANAS NA	0.00	0.72	0.00	.471
	Intercept	8.43	25.62	0.33	.000
	Time	0.18	1.73	0.10	.087
PSQI		-0.04	-1.12	0.04	.266
	PSS*PSQI	-0.00	-0.10	0.01	.919
	Intercept	8.07	30.36	0.27	.000
	Time	0.17	1.68	0.10	.095

ACEs		0.03	0.49	0.07	.627
	PSS*ACEs	0.01	0.35	0.02	.727
	Intercept	7.76	50.57	0.15	.000
	Time	0.18	1.74	0.10	.083
SBSOD		0.14	1.53	0.09	.128
	PSS*SBSOD	-0.03	-1.55	0.02	.123
	Intercept	7.16	16.44	0.44	.000
	Time	0.21	2.06	0.10	.042

Note. N = 145; ICC = 0.680; Females were coded as "1" and males as "0".

Santa Barbara Sense of Direction Scale as a dependent variable

As mentioned previously, participant scores on the SBSOD decreased significantly between the first (M = 4.44, SD = 1.12) and second visit (M = 4.23, SD = 1.11) indicating a decrease in individuals' perceived sense of direction.

The first-order effects revealed a significant effect of time (t(142) = -5.01, β = -0.21, SE = 0.04, p < .001), which is congruent with results from the within-subjects t-test. The PSS (t(142) = -1.31, β = -0.05, SE = 0.04, p = .193), and the slope estimate of PSS and time (t(142) = 1.34, β = 0.09, SE = 0.07, p = .182) did not express significant first-order effects (See Table 5).

There were no significant second-order slope estimates for the moderators when evaluating the SBSOD as a dependent variable. Sex had significant first-order effects (t(143) = 4.92, β = 0.84, SE = 0.17, p < .001) where males performed significantly better than females. The PANAS PA (t(141) = 3.76, β = 0.03, SE = 0.01, p = .001) also expressed significance where higher positive affect was associated with better individual ratings for sense of direction. The PANAS NA ($t(141) = -3.23$, $\beta = -0.02$, SE = 0.01, $p = .002$) had the opposite association with the SBSOD, where higher negative affect scores were correlated with worse ratings in sense of direction. Lastly, ACEs also had a significant negative association ($t(143) = -2.68$, $\beta = -0.14$, SE = 0.05, $p = .008$), where a higher number of adverse childhood experiences was associated with a worse reported sense of direction (See Table 5).

Table 5

Results for analyses of the SBSOD within each moderator.

Moderator		β	t	SE	*p*
Null Model		7.89	68.60	0.12	
PSS		-0.05	-1.31	0.04	.193
	PSS*Time	0.09	1.34	0.07	.182
	Intercept	4.41	46.39	0.10	.000
	Time	-0.21	-5.01	0.04	.000
Sex		0.84	4.92	0.17	.000
	PSS*Sex	-0.02	-1.13	0.02	.262
	Intercept	3.95	30.07	0.13	.000
	Time	-0.20	-4.83	0.04	.000
PANAS PA		0.03	3.76	0.01	.000
	PSS*PANAS PA	-0.00	-0.13	0.00	.900
	Intercept	3.63	15.60	0.23	.000
	Time	-0.16	-3.56	0.04	.001
PANAS NA		-0.02	-3.23	0.01	.002
	PSS*PANAS NA	0.00	0.11	0.00	.910
	Intercept	4.94	27.36	0.18	.000
	Time	-0.21	-5.00	0.04	.000

PSQI		-0.02	-1.12	0.02	.266
	PSS*PSQI	-0.00	-0.95	0.00	.344
	Intercept	4.58	29.10	0.16	.000
	Time	-0.21	-5.05	0.04	.000
ACEs		-0.14	-2.68	0.05	.008
	PSS*ACEs	0.01	1.41	0.01	.160
	Intercept	4.61	40.91	0.11	.000
	Time	-0.20	-4.80	0.04	.000

Note. N = 145; ICC = 0.891; Females were coded as “1” and males as “0”.

Discussion

This study sought to identify if perceived stress is associated with cognitive map formation abilities, spatial perspective taking, mental manipulation, and reported sense-of-direction using a within-subjects design. This study is unique from existing literature in that we used a self-reported questionnaire rather than biological measures to measure stress in a population that experiences frequent fluctuations in levels of stress over time (undergraduate students). By looking at psychological stress on a general environment scale instead of the acute onset of stress by the study team, the results of this study are a representative case of an individual’s appraisal of to what extent they perceive their life as stressful.

Time had a significant positive effect on individual performance of the SCT, which is congruent with the significant change in scores found between the first and second visit using a two-tailed paired samples t-test. This significant increase in performance suggests potential learning effects for the SCT and has been observed in previous studies using the task (Burles et al., 2017). Overall, all three of the tasks revealed significantly faster response times at the second compared to the first visit suggesting possible widespread learning effects, though the 4MTN task and MRT did not reveal significant differences in accuracy between time points. Time had a significantly negative effect on individual scores on the SBSOD as a dependent variable, suggesting individuals perceived their sense-of-direction as worse at the second visit compared to the first.

Overall, perceptions of stress were not associated with performance on cognitive map formation, spatial perspective taking, or mental manipulation tasks, or an individual's perceived sense of direction in this study. However, it is to be emphasized that the population of the current study reported overall moderate stress levels on the PSS on both time points, blunting the ability to evaluate individual cognitive map formation abilities while in a low perceived stress state. Had there been a greater increase in stress, an effect may have been detected. Further, individuals reported an increase in stress on average between the two time points. While the research design staggered individual start times within the semester, participants could have become progressively more stressed as the semester progressed toward final exams. In the literature, increased perceived stress has been associated with increased disorientation and impaired spatial updating abilities (Brown et al., 2020). Further, lower scores on spatial orientation were associated with increased HRV in a study where researchers generated acute stress in participants via the Trier Socal Stress Test protocol (Delahaye et al., 2015). In rodents, chronic stress has been found to impair spatial working memory, decision-making, and spatial learning (Chiba et al., 2012; Conrad, 2010; Kleen et al., 2006). However, the results are mixed because while evoking arousal components from fear, chronic stress may actually facilitate spatial learning (Conrad, 2010).

Participant sex had a significant effect on the performance of the MRT and on ratings of the SBSOD exemplifying that males performed better on the task and thought of themselves as having a better sense of direction than females. Sex also had a large effect on the 4MTN task – though nonsignificant. In the literature, it has been found that males often perform better than females on cognitive map formation tasks, though the results are mixed (Youngson et al., 2019; Pagkratidou et al., 2020; Cocquyt et al., 2022; Liu et al., 2011). Differences between males and females may be due to differing navigational strategies, where previous literature has suggested that acute stress initiated by the study team disrupted cognitive-map-guided navigation but not landmark-guided navigation in women only (Thomas et al., 2010).

Negative affect had a significant effect on the MRT, 4MTN task, and the SBSOD, suggesting that as negative affect increases, performance on the tasks and perceptions of an individual's sense of direction decreases. Similarly to the levels of perceived stress reported by participants, the average negative affect was higher than the average reported by the scale (Crawford & Henry, 2004). This report of heightened negative affect is in line with previous research where high PSS scores displayed blunted reward responsiveness and reported elevated anhedonic symptoms, which may help to partially explain why the current study identified a higher-than-average score on both variables (Pizzagalli et al., 2007). Positive affect was a significant factor when the SBSOD was evaluated as a dependent variable, where increases in positive affect were associated with increases in the self-reported sense of direction. These results are supported by previous literature where negative affect in the form of anxiety and stress impairs cognitive map formation, while positive affect, such as happiness or excitement, may enhance it (Burles & Iaria, 2020).

Sleep quality was not associated with any outcome measures in the current study, which is contrary to what is known in the literature. Previous studies on the association of sleep with cognitive map formation, spatial memory, and spatial orientation found a positive association where participants with regular sleep patterns performed better than those who had a disrupted period of sleep (Coutanche et al., 2013; Simon et al., 2022; Valera et al., 2016). However, reduced sleep was not found to negatively affect spatial navigation (Nguyen et al., 2013). Overall, existing evidence suggests poor sleep quality has widespread negative associations with cognition (Goel et al., 2009), memory (Ferrara et al., 2008; Moroni et al., 2014; Rasch & Born, 2013;), learning (Maquet, 2001), and emotional empathy (Guadagni et al., 2018).

Adverse childhood experiences were a significant negative factor in their first-order effects while measuring the SBSOD as a dependent variable, exemplifying that a greater number of reported adverse childhood experiences are associated with reporting a worse sense of direction. Contrary to findings in the current study, ACEs such as abuse or neglect, can also have lasting effects on cognitive map formation abilities, where individuals who have experienced ACEs may exhibit impaired performance on cognitive map tasks, as well as have reduced hippocampal volume and function (Garfin et al., 2018; Smith et al., 2015). Post-traumatic stress disorder (PTSD) is a potential result of severe ACEs and is associated with deteriorations in spatial memory processing and cognitive map formation abilities (Ferrara et al., 2016; Tempesta et al., 2012). This relationship is postulated to be caused in part by how PTSD causes sleep disturbances (Ferrara et al., 2016; Tempesta et al., 2012).

The SBSOD was not associated with any of the three tasks when included in statistical models as a predictor variable. The SBSOD has evidence to support its predictive value with objective measures of finding one's way in an environment and learning environmental layouts (Hegarty et al., 2002). However, existing research suggests self-reported sense of direction is more highly correlated with measures of spatial knowledge acquired from direct experience in the real-world environment than with measures of knowledge acquired from maps, video, or virtual environments (VE) (Hegarty et al., 2002). This difference in correlation could potentially explain why an association was not found in the current study. Interestingly, written and computer-based laboratory tests of spatial ability have been shown to lack ecological validity in capturing environmental sense of direction compared to scores on the SBSOD (Gandhi et al., 2021).

In conclusion, the hypothesis that daily stress had a negative association with cognitive map formation abilities was disproved, where no association between the two variables were found. The hypothesis that males would perform better than females on each task was partially true, where men performed better than women on the MRT and rated themselves as more proficient navigators than females did on the SBSOD. The hypothesis that negative affect had a negative association with the outcome variables was true. The hypothesis that positive affect would have a positive association with the outcome was true when the SBSOD was the outcome variable. The hypothesis that sleep quality had a negative association with cognitive map formation abilities was false, where no association was found. Lastly, the hypothesis that reported ACEs would have a negative association with outcome variables was only true when the outcome variable was the SBSOD.

Limitations

Firstly, there was a high attrition rate. Had the study been conducted in person, there may have been a lower rate of attrition similarly to what is seen in online versus in-person post-secondary classes (Bawa, 2016). An additional limitation as a result of online data collection is the possibility of poor data quality due to participants not being supervised while completing the tasks and questionnaires. This was taken into account by the study team and was determined a worthy exchange for a much higher study population probable with the online data collection design. Further, the team employed strict controls for participant data quality through the evaluation of their linearity of responses. Lastly, online data collection may have an additional limitation in that participants used different devices with variations in internet speed and device processor capabilities. However, this does not have a large effect on the results of the study as the researchers did not evaluate response times statistically. A considerable learning effect was revealed through both the higher accuracy scores on the SCT and the widespread faster response times on all the tasks at the second evaluation. This learning effect may have confounded the effect of stress and the moderators on task performance. Had participants completed evaluations with a greater timeframe between assessments, learning effects may have been mitigated to some extent. Limitations exist in using an undergraduate population that make them unique and limit the generalizability of results. These limitations of the population include that they tend to have a higher IQ than the average population and that they are used to performing cognitively challenging tasks. Having more than two time points may have also allowed for a more accurate model of the association of stress on cognitive map formation abilities over time because growth models typically involve more than two time points (Curran et al., 2010). Regarding partially missing data, listwise deletion was used, however the study team is aware this may introduce bias because missing data was found to not be missing completely at random. The study team determined this was a worthy exchange for the data to be representative of the entire population included. Furthermore, additional potential confounding variables that were not included in the study that could be included in future studies to help explain individual differences in performance include the time of day individuals completed evaluations, their medication use, and what the causes of their stress was. There is also a limitation in using self-report and perception-style questionnaires where social desirability bias and a tendency for participants to exaggerate their responses may possibly confound results. This questionnaire-style limitation is an accepted limitation by the study team in order to answer the research question on hand that is dealing specifically with self-perceptions of individuals. Lastly, race and ethnicity information was not gathered for participants. This information would have helped to increase the generalizability of results.

Future Directions

Future studies would benefit from the use of different tasks, particularly evaluating participant navigation in real-world environments while under stress. Additionally, future studies should combine the PSS with biological measures of stress such as cortisol levels, blood pressure variability, and heart rate variability to evaluate if the effect of perceived stress on cognitive map abilities is similar to the effect of biological stress. Lastly, as mentioned before, a greater number of evaluations over a longer period would be beneficial, not only for seeing more robust trends in stress and task performance but also for increasing the age range of study participants.

Significance

This study provides evidence for the lack of effect that daily nonclinical stress has on cognitive map formation abilities in undergraduate psychology students at The University of Calgary. Further, this study helps to describe contributing factors leading to the natural variability observed in these cognitive processes between otherwise healthy individuals, such as sex and negative affect (Wolbers & Wiener, 2014). The knowledge gained through this study helps to increase awareness of the detrimental impact daily stress has on the general functioning of young adults.

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